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ABOUT SINTEZA 2022

The 9th International Scientific Conference Sinteza 2022 was held online following the current epidemiological measures due to the pandemic caused by the Covid 19 virus.

International Scientific Conference SINTEZA provided an ideal platform for exchanging information and disseminating best practices, ideas, and advancements in the state-of-the-art and technical improvements in Information Technology and data-related research.

Rapid advances in Information Technologies (IT) in recent decades have had a considerable impact on numerous facets of everyday life and have created tremendous opportunities for economic, technological and social gains on a global scale. In particular, the advances in data science, blockchain technology, and optimisation techniques are becoming the driving force behind many changes in both technology and business. The emergence of new technologies has caused widespread expansion of the internet of things. At the same time, problems related to cybersecurity, security of communications, and security in the cloud are becoming essential topics.

New technologies and scientific breakthroughs have already altered the working and living environments making them safer, more convenient and more connected. These scientific advances are also used to solve some of the most pressing problems our society faces today, such as climate change and environmental issues.

The conference sought submissions from academics, researchers, and industry professionals presenting novel research on all practical and theoretical aspects of Information Technology and Data Related Research and their applications in a range of business, engineering, environmental and research fields. Traditionally held each year, the conference features several prominent keynote speakers and presentations organised in thematic sessions covering topics such as computer science, information systems, IT security, IT and data science in environmental engineering, education and sports. In addition, there was a student session reserved for research work done by students (undergraduate, master and PhD level).

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ABSTRACT

THEORETICAL COMPUTER SCIENCE AND ARTIFICIAL INTELLIGENCE SESSION

ANALYSIS OF BAYESIAN SYMBOLIC REGRESSION APPLIED TO CRUDE OIL PRICE

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Abstract:

Forecasting crude oil spot prices even in moderate time horizon, like, 1-month, is not an easy task. Herein, the Bayesian Symbolic Regression (BSR) is applied to forecast the WTI spot prices. This novel method applies Bayesian symbolic trees methods to the Symbolic Regression. This type of econometric model can be especially useful when variable (feature) selection is necessary, as well as, model uncertainty emerges. Indeed, the literature claims that there can be several important crude oil price predictors. The great advantage of Symbolic Regression is its potential to "discover" the suitable functional form of a forecasting model.

In particular, world oil production, OECD petroleum consumption, U.S. stocks, MSCI World index, Chinese stock market index, VXO index, U.S. short-term interest rate, the Kilian global economic activity index and U.S. exchange rate were taken as explanatory variables. The period between 1989 and 2021 was analysed. Monthly data were taken.

Several models were taken as benchmarks. In particular, Dynamic Model Averaging (DMA), LASSO, RIDGE, the least-angle regressions, time-varying parameters regression, ARIMA and the no-change (NAÏVE) methods. Forecast accuracy was measured by Root Mean Square Error (RMSE) and other commonly used measures. Besides, forecasts were examined with the Diebold-Mariano test and Model Confidence Set testing procedure.

A strong evidence was found in favour of DMA and ARIMA as superior models (in a sense of forecast accuracy). However, BSR forecasts were found at least not less accurate than those from many competing (benchmark) models.

Keywords:

Bayesian Econometrics, Forecasting, Genetic Programming, Model Uncertainty, Symbolic Regression.

INTRODUCTION

Forecasting crude oil spot price is not an easy task. The problems addressed in this research are two folds. First, there exist numerous potentially important oil price drivers. Up to 1980s researchers were mostly focusing on supply and demand factors. Later, the impact of exchange rates was noticed. In 1990s much more has been observed about interactions with financial markets, for instance, stock market indices, market stress indices, etc. During 2000s and especially during the global financial crisis much attention has been brought to speculative pressures. However, nowadays it is common to consider numerous factors to be important oil price drivers. Besides those mentioned already, several uncertainty

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indices has been also constructed, etc. As a result there exists uncertainty about the variable selection (feature selection) when an econometric model, like, for example, a multilinear regression, is constructed [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12].

The second problem is that numerous researchers observed that the impact of the given driver on the oil price can be different in different time periods. Moreover, the set of the most important oil price drivers can vary in time. As a result, it is desired for the modelling scheme to be able to capture these two features: time-varying parameters and time-varying structure of the model itself [13] [14].

Besides, non-linear effects and complicated oil market structure are also linked with the functional form specification of a model. For example, whether some non-linear terms should be include in a regression model or not [15] [16].

Symbolic Regression is a method in which in the initial stage a set of operators is created. Then, mimicking the evolutionary processes of cross-over, mutation and selection, the suitable functional form of a model is discovered [17] [18]. Indeed, the standard approach to Symbolic Regression is with Genetic Algorithms [19]. However, recently, it was proposed to replace Genetic Algorithms in Symbolic Regression with Bayesian Symbolic Trees.

First, the evolutionary discovering of a suitable functional structure is then replaced by prior-posterior inference. Secondly, this methods seems to be computationally more efficient [20].

Herein, 1-month ahead crude oil spot prices are forecasted with the novel method of the Bayesian Symbolic Regression (BSR).

2. DATA

Monthly data between Jan 1989 and Apr 2021 were analysed. In particular, the time-series taken for the analysis are reported in Table 1. The motivation for the particular selection of explanatory variables is similar as in [21]. In particular, the transformation codes mean: 0 – no transformation: $Y_t \rightarrow Y_t$; 1 – 12-month logarithmic difference: $Y_t \rightarrow \log Y_t - \log Y_{t-12}$; 2 – logarithmic difference: $Y_t \rightarrow \log Y_t - \log Y_{t-1}$. Three different oil prices were taken as response variables to check for robustness of the outcomes. Before inserting into the models, the variables were also standardized [22]. Means and standard deviations for this transformations were computed on the basis of first 100 observations. Later, first 100 observations were taken as the in-sample period, and the next observations as the out-of-sample period.

Abbreviation	Description	Source	Transformation
WTI	Cushing, OK WTI spot price FOB (dollars per barrel)	[23]	2
Brent	Europe Brent spot price FOB (dollars per barrel)	[23]	2
Dubai	Crude oil, Dubai (dollars per barrel)	[23]	2
Prod_glob	World production of crude oil including lease condensate (Mb/d)	[24]	1
Cons_OECD	OECD refined petroleum products consumption (Mb/d)	[24]	1
Stocks	U.S. ending stocks excluding SPR of crude oil and petroleum products (thousand barrels)	[24]	1
MSCI_World	MSCI World (developed markets, standard, large + mid cap, dollars)	[25]	2
CHI	Chinese stock markets (Hang Seng and Shanghai Composite glued at Dec 1990)	[26]	2
VXO	VXO (month-end closing values)	[27]	0
R_short	U.S 3-month treasury bill: secondary market rate, percent, not seasonally adjusted (TB3MS)	[28]	0
Ec_act	Kilian index	[29]	0
FX	Real Narrow Effective Exchange Rate for United States, index 2010=100, not seasonally adjusted (RNUSBIS)	[28]	2

Table 1 – Time-series description.

3. METHODOLOGY

The models estimated in this research are listed in Table 2. If not stated otherwise, the models were estimated recursively, i.e., since the the in-sample period the forecast for time t+1 were computed with all the data available up to the time t [30]. The detailed description of the applied models can be found in the original papers cited.

In the Bayesian Symbolic Regression (BSR) the functional form is assumed to be a linear composition of (potentially non-linear) component functions. In other words, let $x_{1,t},\ldots,x_{n,t}$ be the explanatory time-series (after transformations). Then, it is assumed that the response time-series is modelled as

$$y_t=\beta_0+\beta_1*f_1(x_{1,1,t-1},\ldots,x_{1,i,t-1})+\cdots+\beta_K*f_K(x_{K,1,t-1},\ldots,x_{K,i,t-1})$$

with $x_{i,j,t}$ being some of explanatory variables out of $N = 9$ available ones, present in the i-th component, i.e., f_i, with $j=\{1,\ldots,N\}$ and $i=\{1,\ldots,K\}$. The number of components, K, must be kept fixed and set up in the first, initial stage of the BSR. Coefficients β_i are estimated by Ordinary Least Squares [20].

The following operators were used: $neg(x) = -x$ and standard addition +. This minimal set of operators let us focus on variable selection issue, not on aspects with non-linearities or variable transformation [31]. In the Metropolis-Hastings algorithm in the BSR models $M = 50$ iterations were done.

The original BSR considers the outcome derived in the last iteration. For the model averaging schemes the outcomes from all M iterations can be applied. In particular, let $y_1,\ldots,y_{50}$ be the forecasts obtained from 50 iterations. Then, let $w_1,\ldots,w_{50}$ be the weights ascribed to each of these forecasts. The weighted average forecast is defined then by $w_1*y_1+\cdots+w_{50}*y_{50}$ [32] [33] [34].

For the Symbolic Regression with Genetic Programming the population size was taken as 100 and generations were taken equal to 10. The cross-over probability was set up at 0.95 and subtree, hoist and point mutations probabilities were set up at 0.01. Root Mean Square Error (RMSE) was taken as the metric [35].

The cut-off limit for the Dynamic Model Averaging (DMA) and the Bayesian Model Averaging (BMA) with the dynamic Occam's window [36] [37] was set up at 0.5 and number of models in the combination scheme was limited to 1000 [30].

Variance in the state space equation was updated with Exponentially Weighted Moving Average method with the parameter $\kappa = 0.97$ [38]. In case of time-varying parameters regression two models were estimated. The first one with the forgetting factor $\lambda = 1$ (TVP), which corresponds to the BMA scheme. The second one with λ=0.99, which corresponds to the standard recommended forgetting values and the usual implementation of the DMA method.

The λ parameter (another kind of a parameter, specific for penalized regressions) in the LASSO and the least-angle regression (LARS) method was selected by the t-fold cross-validation using Mean Square Error (MAE) measure (with t denoting the time period). In the elastic net the following mixing parameters were considered: 0.1, 0.2, …, 0.9 [39] [40].

The forecast accuracy was measured with Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and Mean Absolute Scaled Error (MASE) [41]. It was measured for raw time-series (after backward transformations of the outcomes derived from the models). Two competing forecasts were compared with the Diebold-Mariano test [42] with the modification of Harvey et al. [43] and the Giacomini and Rossi fluctuation test [44] [45]. Three values of the parameter μ (corresponding to the part of the sample used in the rolling testing procedure) of the Giacomini and Rossi fluctuation test were checked: $\mu = \{0.3,0.4,0.5\}$. They represent approximately 7, 10 and 12 years windows. If more forecasts were considered at the same time, they were compared with the Model Confidence Set (MCS) testing procedure with Squared Errors (SE) loss functions and TR statistic [46] [47].

All computations were done in R and Python [48] [49] [50] [51] [52].

Abbreviation	Description	Source
BSR rec	Bayesian Symbolic Regression (BSR) estimated recursively	[20] [53]
BSR av MSE rec	BSR model averaging with weights inversely proportional to Mean Square Error (MSE) estimated recursively	[20]
BSR av EW rec	BSR model averaging with equal weights estimated recursively	[20]
BSR av LL rec	BSR model averaging with weights inversely proportional to log-likelihood estimated recursively	[20]
GP rec	Symbolic Regression with Genetic Programming estimated recursively	[35]
GP av MSE rec	Symbolic Regression with Genetic Programming with weights inversely proportional to MSE estimated recursively	[35]
GP av EW rec	Symbolic Regression with Genetic Programming with equal weights estimated recursively	[35]
BSR fix	BSR with fixed parameters estimated over the in-sample period	[20] [53]
BSR av MSE fix	BSR model averaging with weights inversely proportional to MSE with fixed parameters estimated over the in-sample period	[20]
BSR av EW fix	BSR model averaging with equal weights with fixed parameters estimated over the in-sample period	[20]
BSR av LL fix	BSR model averaging with weights inversely proportional to log-likelihood with fixed parameters estimated over the in-sample period	[20]
GP fix	Symbolic Regression with Genetic Programming with fixed parameters estimated over the in-sample period	[35]
GP av MSE fix	Symbolic Regression with Genetic Programming with weights inversely proportional to MSE with fixed parameters estimated over the in-sample period	[35]
GP av EW fix	Symbolic Regression with Genetic Programming with equal weights with fixed parameters estimated over the in-sample period	[35]
Abbreviation	**Description**	**Source**
DMA	Dynamic Model Averaging with dynamic Occam's window	[36] [37] [30]
BMA	Bayesian Model Averaging with dynamic Occam's window	[36] [37] [30]
DMA 1V	Dynamic Model Averaging over one-variable models	[36] [30]
DMS 1V	Dynamic Model Selection over one-variable models	[36] [30]
BMA 1V	Bayesian Model Averaging over one-variable models	[36] [30]
BMS 1V	Bayesian Model Selection over one-variable models	[36] [30]
LASSO	LASSO regression estimated recursively	[39]
RIDGE	RIDGE regression estimated recursively	[39]
EN	Elastic net estimated recursively	[39]
B-LASSO	Bayesian LASSO regression estimated recursively	[54]
B-RIDGRE	Bayesian RIGDE regression estimated recursively	[54]
LARS	Least-angle regression estimated recursively	[40]
TVP	Time-Varying Parameters regression ($\lambda = 1$)	[36] [30]
TVP f	Time-Varying Parameters regression ($\lambda = 0.99$)	[36] [30]
ARIMA	Auto ARIMA	[55]
HA	Historical Average (recursive)	[56]
NAÏVE	No-change forecast	[56]

Table 2 – Models used in the research.

4. RESULTS

Table 3 reports forecast accuracy measures for the in-sample period, which was used to select the number of components K. In case of the WTI price RMSE was minimised for $K = 6$, but two other measures were minimised with $K = 5$. As a result, $K = 5$ was taken for the further analysis. In case of the Brent and the Dubai prices $K = 9$ was preferred.

The out-of-sample forecast accuracy is reported in Table 4. In case of the WTI price all measures were minimised by the DMA model. The BSR models tend to generate smaller errors than the corresponding GP models and the NAÏVE method. However, quite a few models were able to generate smaller errors than the BSR models. Similar conclusions can be derived for the Brent and the Dubai prices. Anyways, the BSR errors were smaller than those from the NAÏVE method. Secondly, it seems that applying model averaging schemes slightly improved the forecast accuracies.

Table 5 reports the outcomes of the Diebold-Mariano test. The DMA model was chosen as "the best" one. In case of the DMA model the alternative hypothesis of the test was that the DMA forecasts are more accurate than those from the competing tested model. In case of the BSR rec model the alternative hypothesis was that the BSR forecasts were less accurate than those from the competing tested model. The null hypothesis was that both forecasts have the same accuracy. Assuming 5% significance level, for the WTI price forecasts generated by the DMA model were significantly more accurate than all other forecasts except those from the ARIMA model. On the other hand, the forecasts from the BSR rec model can be said to be significantly less accurate only comparing with the forecasts generated from the DMA model. They cannot be said to be significantly less accurate than the forecasts from the other models. The same conclusions can be derived for the Brent price. In case of the Dubai prices, additionally, the BSR rec forecasts were significantly less accurate than those from the ARIMA model.

Table 6 reports the outcomes from the Diebold-Mariano test, in which forecasts from the recursively estimated version of a given model were compared with the corresponding fixed estimations. The alternative hypothesis was that the recursive version generated more accurate forecasts than the fixed version of a model. In case of the WTI price it can be said that, indeed, for BSR av MSE, BSR av LL and GP models recursive estimations improved forecast accuracy comparing with the fixed estimations. The same conclusions are valid for the Brent and the Dubai prices.

The MCS procedure generated the superior set of models in which the DMA and the ARIMA models remained in case of the WTI price. The corresponding p-value was 0.4534. The same sets of models were generated by the MCS procedure in case of the Brent and the Dubai prices. The corresponding p-values were 0.1466 for the Brent price and 0.1372 for the Dubai price.

The outcomes from the Giacomini and Rossi fluctuation test are presented in Figure 1. Only the outcomes for the WTI price and one value of μ are reported. However, for other oil prices or values of μ the outcomes were quite similar. Therefore, to keep this text concise only this selected outcome is reported.

	WTI			**Brent**			**Dubai**		
K	RMSE	MAE	MASE	RMSE	MAE	MASE	RMSE	MAE	MASE
1	2.4876	1.3295	1.1349	2.4739	1.3536	1.1295	2.1942	1.1858	1.1092
2	2.4809	1.3255	1.1316	2.4189	1.3292	1.1092	2.1788	1.2162	1.1376
3	2.4674	1.3244	1.1306	2.3824	1.3554	1.1310	2.1818	1.2135	1.1351
4	2.4420	1.3593	1.1604	2.4002	1.3062	1.0900	2.1931	1.1871	1.1104
5	2.4092	**1.3067**	**1.1155**	2.3946	1.3066	1.0903	2.1859	1.1964	1.1191
6	**2.3949**	1.3117	1.1198	2.4120	1.3669	1.1406	2.1668	1.1960	1.1187
7	2.4496	1.3074	1.1161	2.3358	1.3316	1.1112	2.1865	1.2153	1.1368
8	2.4207	1.3497	1.1522	2.4055	1.3833	1.1543	2.1595	1.2094	1.1313
9	2.4190	1.3462	1.1492	**2.3244**	**1.2863**	**1.0733**	**2.0969**	**1.1768**	**1.1007**

Table 3 – Forecast accuracies (in-sample).

	WTI			Brent			Dubai		
Model	RMSE	MAE	MASE	RMSE	MAE	MASE	RMSE	MAE	MASE
BSR rec	5.0792	3.6857	0.9961	5.1259	3.7679	0.9839	4.8835	3.3938	0.9724
BSR av MSE rec	5.1073	3.6441	0.9848	5.1672	3.7598	0.9818	4.8248	3.3822	0.9690
BSR av EW rec	5.1016	3.6307	0.9812	5.1582	3.7490	0.9790	4.8322	3.3900	0.9713
BSR av LL rec	5.1022	3.6368	0.9828	5.1606	3.7431	0.9774	4.8413	3.3877	0.9706
GP rec	5.4779	**3.8469**	**1.0396**	5.6416	4.0173	1.0490	5.3440	3.7039	1.0612
GP av MSE rec	**5.3892**	3.7878	1.0236	5.5263	3.9548	1.0327	5.2311	3.6452	1.0444
GP av EW rec	5.3946	3.7799	1.0215	5.5369	3.9450	1.0302	5.2370	3.6313	1.0404
BSR fix	6.1367	4.2968	1.1612	9.2911	6.5745	1.7168	5.5289	4.0240	1.1530
BSR av MSE fix	6.5785	4.7687	1.2887	**7.2963**	**5.3265**	**1.3909**	**6.5456**	**4.7037**	**1.3477**
BSR av EW fix	6.4214	4.6812	1.2651	**7.2407**	**5.2980**	**1.3835**	**6.4014**	**4.5997**	**1.3179**
BSR av LL fix	6.5152	4.7128	1.2736	**6.9637**	**5.0966**	**1.3309**	**6.3896**	**4.5697**	**1.3093**
GP fix	5.3620	3.9174	1.0587	**5.4922**	**4.0507**	**1.0578**	**5.1852**	**3.7224**	**1.0665**
Model	RMSE	MAE	MASE	RMSE	MAE	MASE	RMSE	MAE	MASE
DMA	**4.9166**	**3.5932**	**0.9711**	**4.9258**	**3.6853**	**0.9624**	**4.5489**	**3.2399**	**0.9283**
BMA	5.1548	3.6720	0.9923	5.1569	3.7849	0.9884	4.8004	3.3708	0.9658
DMA 1V	5.1657	3.6960	0.9988	5.1978	3.7946	0.9909	4.8517	3.3393	0.9568
DMS 1V	5.0884	3.6901	0.9972	5.1461	3.7903	0.9898	4.8482	3.3641	0.9639
BMA 1V	5.2508	**3.7007**	**1.0001**	5.2682	3.8158	0.9964	4.9505	3.4093	0.9768
BMS 1V	**5.2799**	3.7278	1.0074	5.2792	3.8371	1.0020	4.9581	3.4332	0.9837
LASSO	5.1600	3.6683	0.9913	5.1897	3.7746	0.9857	4.8655	3.4006	0.9743
RIDGE	5.1451	3.6522	0.9870	5.1583	3.7473	0.9785	4.8571	3.3842	0.9696
EN	5.1510	3.6638	0.9901	**5.1846**	**3.7702**	**0.9845**	**4.8785**	**3.4035**	**0.9751**
B-LASSO	5.2384	3.6677	0.9912	**5.2712**	**3.7894**	**0.9895**	**4.9649**	**3.4153**	**0.9786**
B-RIDGRE	5.1657	3.6475	0.9857	**5.2548**	**3.7959**	**0.9912**	**4.9187**	**3.3923**	**0.9720**
LARS	5.1502	3.6911	0.9975	**5.1288**	**3.7992**	**0.9921**	**4.8053**	**3.4520**	**0.9890**
TVP	5.1557	3.7284	1.0076	**5.1519**	**3.8355**	**1.0016**	**4.7752**	**3.4534**	**0.9895**
TVP f	5.0883	3.7089	1.0023	**5.1169**	**3.8350**	**1.0014**	**4.7424**	**3.4034**	**0.9751**
ARIMA	5.0009	3.6229	0.9791	**5.1405**	**3.7417**	**0.9771**	**4.6827**	**3.3023**	**0.9462**
HA	33.2715	24.5524	6.6352	**37.4096**	**27.4032**	**7.1559**	**36.7332**	**26.9924**	**7.7338**
NAIVE	5.2934	3.7003	1.0000	**5.3930**	**3.8295**	**1.0000**	**5.0807**	**3.4902**	**1.0000**

Table 4 – Forecast accuracies (out-of-sample).

It can be seen that definitely HA method generated significantly less accurate forecasts than the DMA method over almost all analysed period. Between 2008 and 2014 also GP models generated significantly less accurate forecasts. However, for the other models it seems that the significance of generating more accurate forecasts by the DMA model was mostly temporary.

This feature is the most clearly seen for periods around 2011 and 2014. The outcomes from the Giacomini and Rossi fluctuation test weaken the evidence provided by the Diebold-Mariano test already reported previously in this text.

	WTI		Brent		Dubai	
BSR rec	**0.0332**		**0.0289**		**0.0083**	
BSR av MSE rec	**0.0231**	0.7057	**0.0115**	0.7972	**0.0075**	0.1359
BSR av EW rec	**0.0256**	0.6673	**0.0134**	0.7202	**0.0054**	0.1722
BSR av LL rec	**0.0234**	0.6859	**0.0150**	0.7318	**0.0071**	0.2007
GP rec	**0.0055**	0.9890	**0.0013**	0.9988	**0.0007**	0.9968
GP av MSE rec	**0.0097**	**0.9792**	**0.0025**	0.9978	**0.0012**	0.9927
GP av EW rec	**0.0111**	0.9761	**0.0029**	0.9972	**0.0016**	0.9907
BSR fix	**0.0001**	0.9999	**0.0000**	1.0000	**0.0000**	0.9978
BSR av MSE fix	**0.0000**	0.9999	**0.0000**	1.0000	**0.0000**	0.9998
BSR av EW fix	**0.0000**	0.9999	**0.0000**	1.0000	**0.0000**	0.9997
BSR av LL fix	**0.0000**	0.9999	**0.0000**	1.0000	**0.0000**	0.9998
GP fix	**0.0043**	0.9896	**0.0005**	0.9992	**0.0002**	0.9895
GP av MSE fix	**0.0047**	0.9884	**0.0005**	0.9991	**0.0003**	0.9883
GP av EW fix	**0.0079**	0.9802	**0.0011**	0.9983	**0.0006**	0.9796
DMA		**0.0332**		**0.0289**		**0.0083**
BMA	**0.0256**	0.7901	**0.0396**	0.6146	**0.0066**	0.1821
DMA 1V	**0.0137**	0.8418	**0.0082**	0.8116	**0.0107**	0.3722
DMS 1V	**0.0341**	0.5469	**0.0117**	0.5813	**0.0077**	0.3828
BMA 1V	**0.0035**	0.9800	**0.0050**	0.9442	**0.0026**	0.8008
BMS 1V	**0.0026**	0.9816	**0.0096**	0.9076	**0.0012**	0.7580
LASSO	**0.0096**	0.8375	**0.0106**	0.8115	**0.0062**	0.3795
RIDGE	**0.0125**	0.8403	**0.0120**	0.7223	**0.0080**	0.3186
EN	**0.0128**	0.8271	**0.0113**	0.8082	**0.0052**	0.4625
B-LASSO	**0.0101**	0.9569	**0.0073**	0.9785	**0.0057**	0.8650
B-RIDGRE	**0.0211**	0.8251	**0.0069**	0.9410	**0.0117**	0.6692
LARS	**0.0047**	0.8135	**0.0094**	0.5144	**0.0040**	0.1323
TVP	**0.0024**	0.8102	**0.0061**	0.6039	**0.0047**	0.1357
TVP f	**0.0015**	0.5325	**0.0036**	0.4723	**0.0042**	0.1687
ARIMA	0.2327	0.2060	0.0554	0.5598	0.1012	**0.0414**
HA	**0.0000**	1.0000	**0.0000**	1.0000	**0.0000**	1.0000
NAIVE	**0.0199**	0.9565	**0.0063**	0.9938	**0.0035**	0.9602

Table 5 – The Diebold-Mariano test outcomes (p-values).

5. CONCLUSIONS

Herein, the novel Bayesian Symbolic Regression (BSR) method was applied to forecasting 1-month ahead the WTI, the Brent and the Dubai oil spot prices. Also, the usual Symbolic Regression, i.e., based on the Genetic Programming was applied. Besides, several models dealing with variable uncertainty were also estimated. Common and standard benchmark models, like, the no-change (NAÏVE) or ARIMA models were also estimated. First of all, some small improvement in forecast accuracies can be found from model averaging schemes (i.e., applying forecast combination as the final prediction, instead of model selection approach,

	WTI	Brent	Dubai
BSR	0.2943	0.2028	0.8641
BSR av MSE	0.6662	0.6601	0.1100
BSR av EW	**0.0092**	**0.0022**	**0.0020**
BSR av LL	**0.0001**	**0.0000**	**0.0010**
GP	**0.0153**	**0.0018**	**0.0157**
GP av MSE	0.5803	0.5887	0.6178
GP av EW	0.6879	0.7158	0.7386

Table 6 - The Diebold-Mariano test outcomes (p-values): recursive vs fixed estimations.

in which the final prediction is taken from exactly one component model). Secondly, it could be found that, statistically significantly, the Dynamic Model Averaging and the ARIMA generated more accurate forecasts than all other models. If the common Diebold-Mariano test (considering the whole out-of-sample period at once) supports this conclusion, the Giacomini-Rossi fluctuation test (which distincts sub-periods in the analysed period) provides less evidence towards such a conclusion. However, there is also no significant evidence to state that the BSR models generated less accurate forecasts than the competing benchmark models. Finally, in moderate number of cases recursive estimations significantly improved forecast accuracy over fixed parameters estimation.

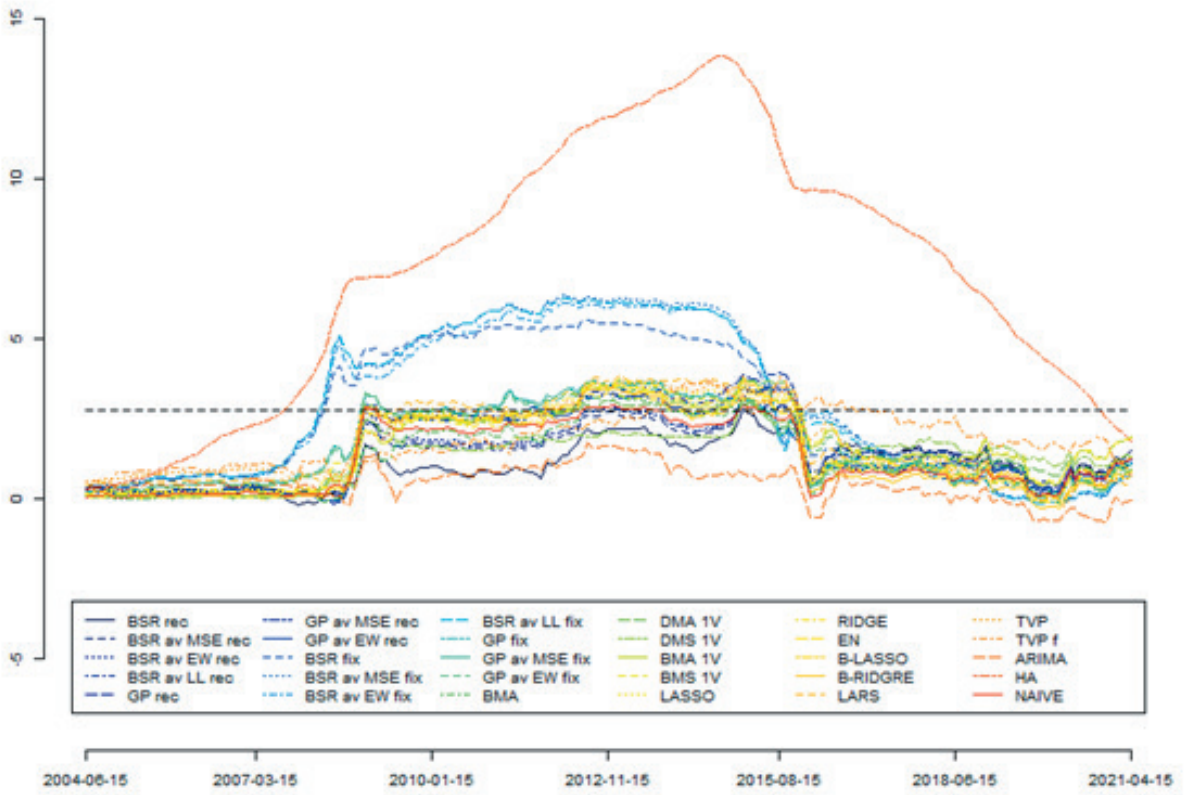

Figure 1 – The outcomes from the Giacomini and Rossi fluctuation test for the WTI price with $\mu = 0.3$.

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ANALYSIS OF SOCIAL MEDIA POSTS RELATED TO POSTPARTUM DEPRESSION A SUMMARY PROTOCOL ON HOW TO DEVELOP A REMOTE LABORATORY

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Abstract:

Analysing the content of posts from social networks related to specific health problems can contribute to improving the health of the general population. This study gives an analysis of posts related to postpartum depression, which was performed to automatically detect content that correlates with postpartum depression. Machine learning methods can be used to detect posts that correlate with postpartum depression. The specificity of the language in which the posts are written reduces the availability of training corpora and processing tools. In this paper, a topic analysis is provided and a model for the prediction of postpartum depression in posts using a corpus composed of posts from the Reddit and ana.rs forums is presented.

Keywords:

Social media, Postpartum depression, Machine learning, Topic analysis.

INTRODUCTION

Caring for women in the postpartum period is very important, but due to the care of the baby, women often neglect their physical and mental health. Very often, health problems are tried to be solved through advice on social networks.

How do recognize the state of postpartum depression? This question should be answered by psychiatrists and psychologists. Postpartum depression signs and symptoms may include: depressed mood or severe mood swings, excessive crying, difficulty bonding with the baby, withdrawal from family and friends, loss of appetite or eating much more than usual, inability to sleep (insomnia) or sleeping too much, overwhelming fatigue or loss of energy, reduced interest and pleasure in usual activities, intense irritability and anger, fear of unsuccessful parenting, hopelessness, feelings of worthlessness, shame, guilt or inadequacy, etc.

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To determine postpartum depression (PPD), the Edinburgh scale is used, with a score greater than 12 indicating postpartum depression. EPDS is one of the most commonly used scales for assessing depressive symptoms of women who have given birth. The respondent estimates the weight for ten different depressive symptoms in the past seven days on a scale of 0 to 3 [1]. The possible range of results is from 0 to 30, where higher scores refer to more difficult symptomatic.

Detection of posts in which the symptoms of postpartum depression are described is one of the goals of this paper. Such research has already been done, but for posts in English. However, people express themselves most sincerely in their mother tongue, so it is necessary to adapt these analyses to other languages as well. In this paper, we will perform an analysis of posts in English and posts in Serbian translated into English. The presented methodology uses the tools available for the English language and adapts their use to the Serbian language.

The second section presents an overview of similar research related to the application of machine learning in predicting postpartum depression in fasts. The third section provides an overview of the materials used and the method. An analysis of the topic of the posts as well as the results of the methods for predicting postpartum depression in the posts are given in the fourth section. Finally, a conclusion is given and ideas for further research are presented.

2. RELATED WORK

In the era of the Internet and the social network of Facebook, Twitter, and Reddit, conditions have been created to collect large amounts of textual data through which it is possible to monitor personality behavior in posts on social networks. Thus, the context of the analysis of depression-related chatter on Twitter to glean insight into social networking about mental health was performed [2]. In particular, the authors in [3] analysed the posts on social networks that correlated with postpartum depression and showed that very good results can be obtained in predicting postpartum depression in posts.

Social support in the postpartum period directly affects the birth rate. Through social networks and PPD support groups, opportunities are created for women to share their experiences and receive support [4]. An analysis of changes in the mood of mothers before and after childbirth on Twitter created a model for predicting mood [5]. The possibility of applying machine learning to predict postpartum depression was investigated over the corpus created from Reddit posts in [6]. The characteristic of that most similar research is that they are related to the English language, and non-English social media are quite unexplored. A model for diagnosing postpartum depression via the crowdsourcing platform has been proposed for Serbian, which also includes an automated test for determining the degree of postpartum depression using the Edinburgh scale [7]. This model has been expanded with the detection system of posts that are correlated with postpartum depression by detecting potential users of the crowdsourcing PPD platform on various social networks [8].

3. DATA AND METHODS

For this research, two sources were used: the Reddit forum for posts in English and the ana.rs forum for posts in Serbian (Table 1). Data were collected from both sources according to two criteria:

1. posts related to postpartum depression;
2. posts related to pregnancy and the postpartum period that are not related to postpartum depression.

Data set	Label	Source	URL	Post language
1.	DS1	Reddit	https://www.reddit.com/	English
2.	DS2	ana.rs	https://www.ana.rs/forum/	Serbian

Table 1 – Data sources

The first data set (DS1) consists of Reddit posts from the postpartum depression section (community about: “A non-judgemental place for you to ask for help and vent your frustrations on anything related to issues postpartum, be they hormonal, parental or other mental health issues. PPD, PND, PPA, PPOCD, APD etc. ”) and happy sections (community about: “Too many depressing things on the main page, so post about what makes you warm and fuzzy inside! ") which contain the word “pregnancy ". They were collected using the Pushshift API. 150 posts from the postpartum depression group were singled out, and 150 posts from the happy group.

The second set of data (DS2) is from the forum ana.rs, which is one of the largest women's forums in Serbian. This forum contains the topic of postpartum depression from which 150 posts have been selected.

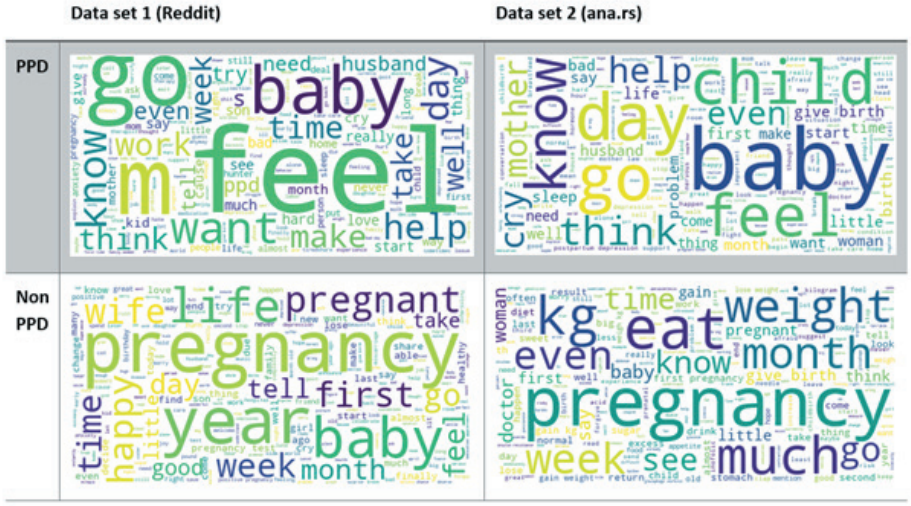

Figure 1 – Word clouds for contents of PPD post and non-PPD from datasets DS1 and DS2

Also, 150 posts unrelated to postpartum depression were singled out from the sections in "Pregnancy and Weight" and "Pregnancy Chat Corner".

Posts are marked according to the section to which they belong to the group of PPD-related posts and the group of posts not related to PPD. Both sets were manually checked, and posts related to postpartum depression are marked.

3.1. DATA PRE-PROCESSING

Data collected from Reddit are in JSON format, while data from the ana.rs forum are manually processed to CSV format. To achieve data uniformity, both sets went through the preprocessing step.

1. JSON data set (DS1) is transformed into CSV format;
2. The set of data in Serbian (DS2) has been translated into English;
3. Punctuation marks are removed from the data
4. Removals are stop words;
5. Lemmatization

Before processing, it was done using python libraries (*nltk, pandas, gensim, spacy*...). A neural machine translation service[1] that is part of the Azure Cognitive Services family of REST APIs was used for the language translation Serbian post into English. The quality of Microsoft Translator's machine translation outputs are evaluated using a method called the BLEU score.

BLEU is a measurement of the differences between an automatic translation and one or more human-created reference translations of the same source sentence. In the medical domain that corresponds to the topic of Microsoft Translator's posts, it has a BLEU score of approximately 50, which is considered high-quality translation.[2]

3.2. TOPIC ANALYSIS

To analyse the contents of the posts, the topic analysis was done for all four groups (two datasets DS1 and DS2 divided by groups if they are related to PPD or not). The topic analysis is performed by using the currently most used LDA (Latent Dirichlet Allocation) topic model developed by David Blei, Andrev Ng i Michael I. Jordan [9]. The python library - *gensim* to construct an LDA model is used.

3.3. CLASSIFICATION METHODS

For the classification of posts into PPD posts and non-PPD posts, methods of classification using Weka tools were performed. Tokenization was performed on the textual data. Sequential minimal optimization (SMO), J48, and RandomForest machine learning methods were applied. Accuracy (Equation 1) was used as the primary measure to gauge the performance of each model. In equation TP, TN, FP, and FN are the number of true positives, true negatives, false positives, and false negatives, respectively.

1 api.cognitive.microsofttranslator.com

2 microsoft.com/en-us/translator

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

Equation 1 - Accuracy

4. RESULTS

This paper aims to analyse the posts related to postpartum depression. Figure 1 contains visual results of the most common words in all four groups of data: PPD and non-PPD posts from DS1 and DS2.

The python *wordcloud* library was used to display the most common words. We can notice that translating from the Serbian data set into English gives a similar word set as in the corresponding word set of English posts from Reddit. The keywords that predominate in PPD-related posts are: feel, baby help think know... While posts that come from groups that have non-PPD refer to: baby, pregnancy...

Using the LDA topic analysis, we attempted to extract topics within datasets. The high degree of coherence (DS1: 0.49, DS2: 0.42) is obtained at high alpha and beta parameters, which indicates a great connection of posts within the set. The best results (high coherence and separation of posts by topic) were obtained for 4 topics (Figure 2, Figure 3).

However, the words that appear in them are still elements of other topics. We obtained similar results at both sets for posts related to postpartum depression. Visualizations of the results show that the terminology is slightly different in posts written in Serbian and posts written in English. English posts contain abbreviations, so they have PPD, while Serbian posts have postpartum depression.

The alpha parameter has values of 0.31 in dataset DS1 and 0.61 for DS1 while the beta parameter has values of 0.9 in both cases. From this we can conclude that each topic will probably contain a mixture of most words.

On a given dataset of posts, classification models were made using methods SMO, J48, and RandomForest (RF). A set of 52 posts from ana.rs from the sections "Postpartum depression", "Pregnancy and Weight" and "Pregnancy Chat Corner" were taken for verification.

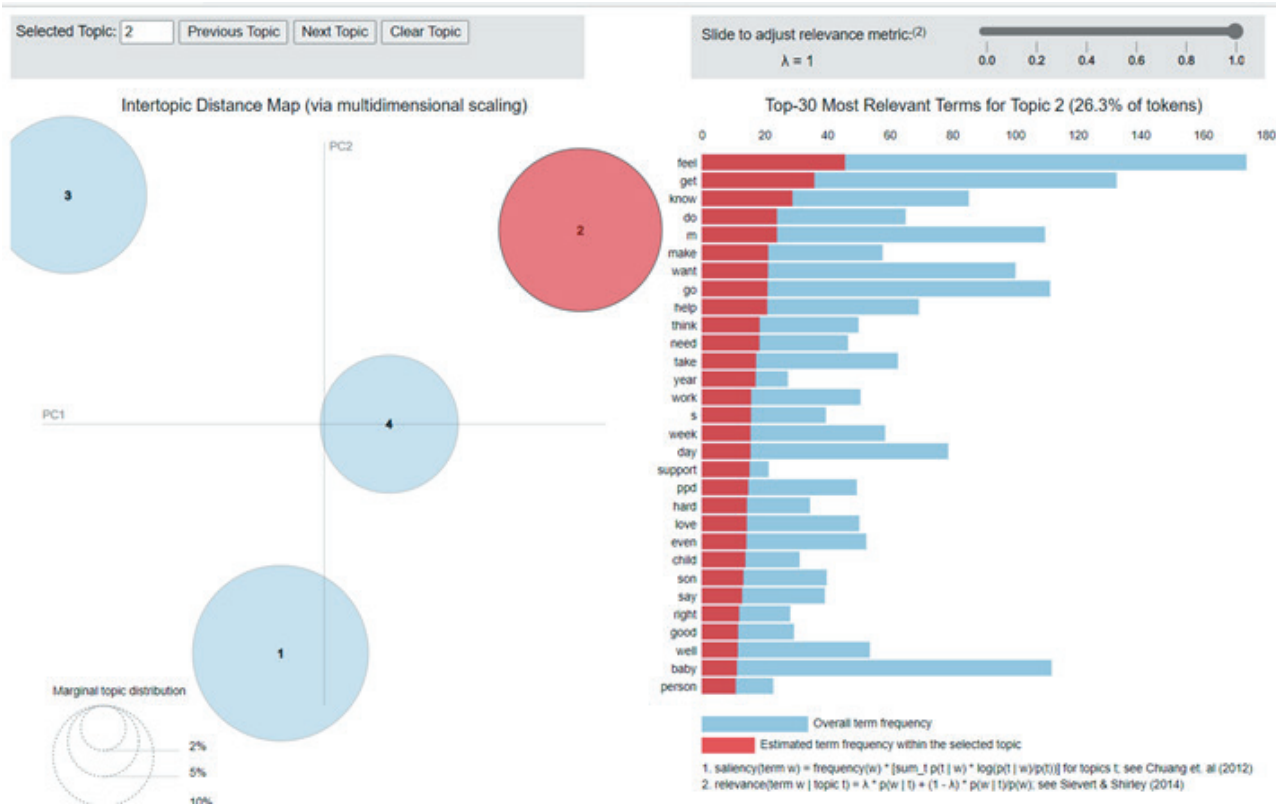

Figure 2 – 4 topics from PPD posts (dataset DS1)

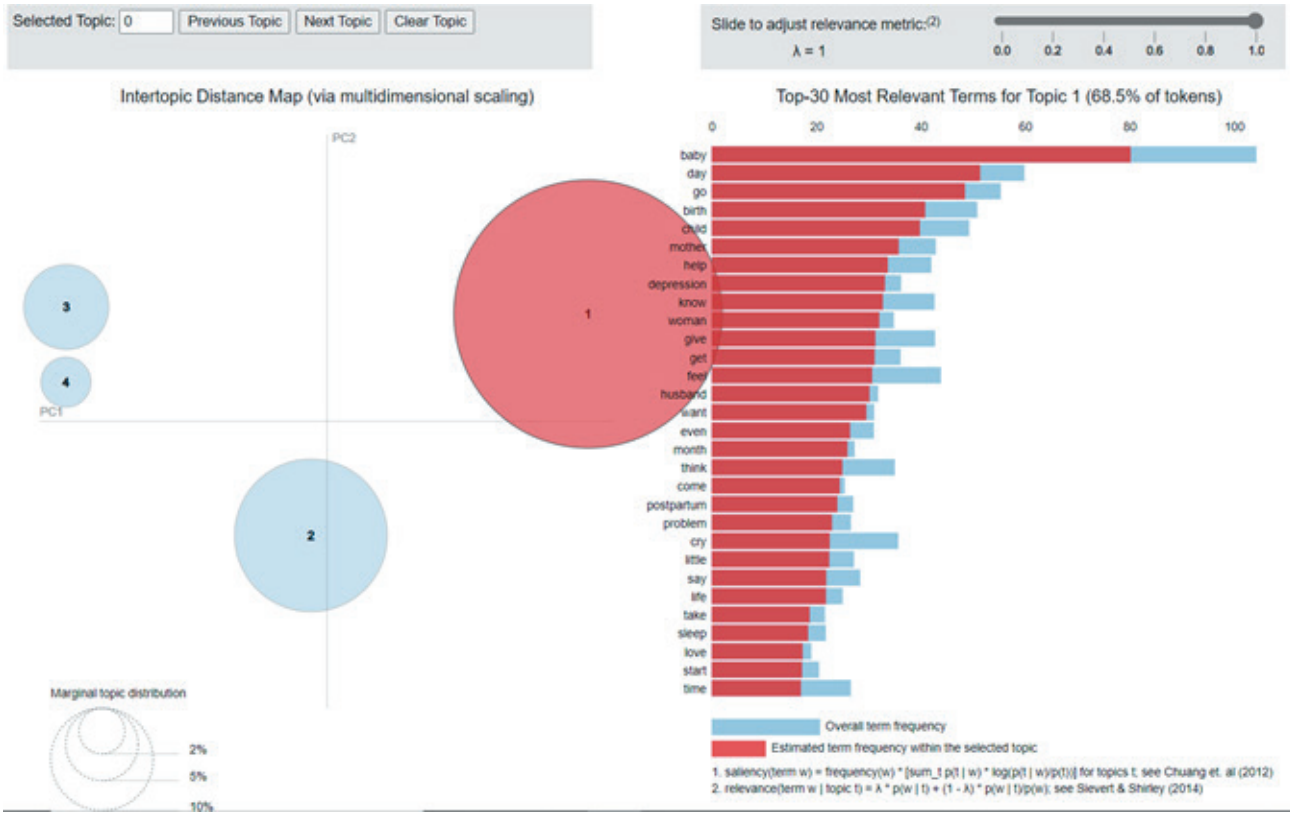

Figure 3 – 4 topics from PPD posts (dataset DS2)

The first model M1 was made over the posts of the Serbian forum ana.rs (DS2) while the second model M2 was made with posts from both forums (DS1 + DS2).

Model	Dataset	SMO	J48	RF
M1	ds2	92.16	**86.27**	90.20
M2	ds1+ds2	**94.12**	70.59	**92.16**

Table 2 – Classification models

Table 2 shows that by expanding the model with posts from Reddit, better results are obtained. This justifies the fact that for languages with fewer resources, English corpora and tools can alternatively be used. Translation errors affect the results of the classification and should be considered with caution. Anyway, the obtained accuracy is satisfactory and comparable to the results of PPD posts detection in English [3].

5. CONCLUSION

This paper presents an analysis of posts related to postpartum depression from the Serbian and English forums. Data processing was done in English. The datasets showed mutual similarity in content. The obtained classification models on a set of posts from the English and Serbian forums gave satisfactory results. The following research is related to the expansion of the set and the application of more detailed preprocessing methods to more accurately detect posts that are correlated with postpartum depression.

6. ACKNOWLEDGEMENTS

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APPLICATION OF NEURAL NETWORKS IN VIDEO GAME SIMULATION

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Abstract:

The subject of this paper is the development of 2D/3D video games using neural networks. The simulation method was used to design and program the video game Super Mario, which with its well-known functionality enables the application of artificial intelligence methods and neural networks. This paper aims to understand the relationship between the use of video games and their neural correlates, taking into account the whole range of cognitive factors that they include. The results of the research indicate the importance of using artificial neural networks in video games, bearing in mind that prediction is closely related to learning and that the existence of feedback allows game participants to evaluate their performance and increase the quality of future prediction of situations and moves. Despite the heterogeneity of the field of study, the research results indicate that it is possible to establish links between neural and cognitive aspects, especially in terms of attention, cognitive control, visual-spatial skills, cognitive load. However, many aspects could be improved. The lack of standardization in various aspects of video game-related research, such as participant characteristics, characteristics of each video game genre, and different goals, could contribute to disagreements with some related research.

Keywords:

Neural networks, video games, FeedForward, neuron.

INTRODUCTION

Video games are an increasingly popular activity in modern society, especially among young people, and are becoming increasingly popular not only as a research tool but also as a field of study. Many studies have focused on the neural and behavioural effects of video games, providing much of the brain correlation from video games in recent decades. There is a large amount of information, obtained through countless methods, providing neural correlates of video games.

Artificial Neural Networks (ANN - *Artificial Neural Networks*) are one of the most popular artificial intelligence techniques. In recent years, they have been applied in many areas and have become indispensable in solving increasingly complex problems that arise in the modern world. Starting from the fact that artificial neural networks are a family of statistical learning models based on biological neural networks, more

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precisely neurons, the basic idea of using artificial neural networks in this paper is that computer simulation enables learning concepts, pattern recognition and decision making in a human-like way.

For a neural network (NN - *Neural Networks*) to learn to recognize and classify concepts, there must be feedback. The connection between biological and artificial neurons can be seen in the example of the human brain because all people use feedback at all times. In this case, the brain of the player playing the video game for the first time observes the way the opponent moves and creates an image of what would be the simplest way to reach the goal, recording good and bad moves. The next time he plays, the brain remembers what he did wrong and corrects it, hoping to achieve better results. Feedback is used to compare the desired outcome with the outcome that occurred.

It is expected that the Super Mario video game will work on that principle, by improving the application by maintaining the quality of the game at the level of each player's decision, without disturbing the balance and basic principles of AI-Artificial Intelligence functionality. The reason for the improvement is that even more experienced players, who have mastered the mechanics of the game, will continue to be proportionately interested because simple mechanical behaviour will change and adapt, adding an element of surprise.

The paper uses a feedforward neural network. This network was the first, and also the simplest neural network. The flow of information is one-way, from input units, data passes through hidden units (if any) to output units. There are no cycles in the network, unlike recurrent neural networks.

2. VIDEO GAMES AND NEURAL NETWORKS

Artificial intelligence appeared in the video game back in 1992 in Wolfenstein 3D [1] by representing in certain video games supporting characters who come in contact with a human-controlled character. A non-player character (NPCs) with well-programmed artificial intelligence can follow you at your own pace as you run or walk [2]. Some video games determine the level of difficulty depending on whether the player is good or not so good, or adapt the video game depending on the player's style of play. By improving artificial intelligence and its implementation, video games are more interesting and customized depending on how the player plays or behaves in them. Also, artificial intelligence in video games can motivate a player and teach him perseverance so that he can be as good as possible.

Artificial neural networks are one form of implementation of artificial intelligence systems. They are made up of process elements that we call artificial neurons. The body of a neuron is called a node or unit. Each of the neurons has a local memory in which it remembers the data it processes. Patterns that neural networks recognize are presented numerically, so all real-world data, such as images, sounds, or text, must be translated. [3] In video games, they serve as a platform for learning how to communicate with the environment and solve complex problems as in real life. [4]

Reflections on the human brain have contributed to expanding the reach of technical ideas. Among the first works published in the field of artificial intelligence, McCulloch and Pitts published the first attempts to create artificial neural networks in the early 1940s [5]. After that period, more detailed and realistic models began to develop. Today, neural networks are one of the most popular and effective forms of training systems and deserve independent study. They are suitable for solving distinctly nonlinear problems [6]. They can learn certain non-dynamic properties of the system, and then take control of it.

Neural networks are often used to simulate an opposing player in various video games. The techniques used range from the use of evolutionary algorithms in combination with neural networks, through supportive learning and assigning grades, to the use of neural network techniques in combination with game theory. Namely, according to Karl Kapp, Lucas Blair and Rich Mesh [7], one of the definitions of video games is that they represent a system in which players participate in abstract challenges, defined by certain rules, whose feedback often results in some form of emotional reaction.

Mathematical model of the neurons on which the FeedForward network is based

Neural network architecture represents the specific connection of neurons into one whole. Each neuron consists of a cell body that contains a nucleus. A certain number of fibres are called dendrites and one long fibre called an axon branch from the body of the cell. A neuron makes connections with 103 to 104 other neurons, and their connections are called synapses [8]. The structure of the neural network differs in the number of layers. The first layer is input, and the last is output, while the layers in between are called hidden layers. There are usually three of them, but this mainly refers to smaller projects because the larger the number of neurons in the hidden layer, the more time it takes to overcome complex situations.

The first layer, ie. the input is the only layer that receives data from the external environment, which then further excites the layers of the hidden units, from where the relevant data is further passed to the third (output) layer. The final result was obtained at the output of the third layer. More complex neural networks have more hidden layers that are completely interconnected. This common design is called a feedforward network. In the example presented in the paper on the input layer, 2 neurons are used.

Layers communicate by connecting the output of each neuron from the previous layer to the inputs of all neurons in the next layer. So, each node has several inputs and one output. The strength of the connections by which neurons are connected is called the weight factor.

The learning of NN is reduced to learning from examples, which should be as many as possible so that the network can behave more precisely in later exploitation. The learning process leads to the correction of synaptic weights. When the patterns presented to the network no longer lead to a change in these coefficients, the peak of learning is considered to have been reached. There are three types of training:

- supervised training - the network presents input data and expected output data.
- evaluation training - the network is not presented with the expected output data, but after some time it is presented with the evaluation of previous work. One example is a net that learns to balance a rod. Whenever the rod falls, an evaluation of previous work is forwarded to the net, for example, in the form of an angular deviation of the rod from equilibrium.
- self-organization - networks are the only entrance.

The network with all inputs directly connected to the outputs is called a single-layer neural network or perceptron. Perceptrons are the best understood and most widely used of all the neural networks. The term perceptron was first used by Frank Rosenblatt in 1958. His idea was to make a functional description of how a real neuron works and then implement it as a software algorithm [9].

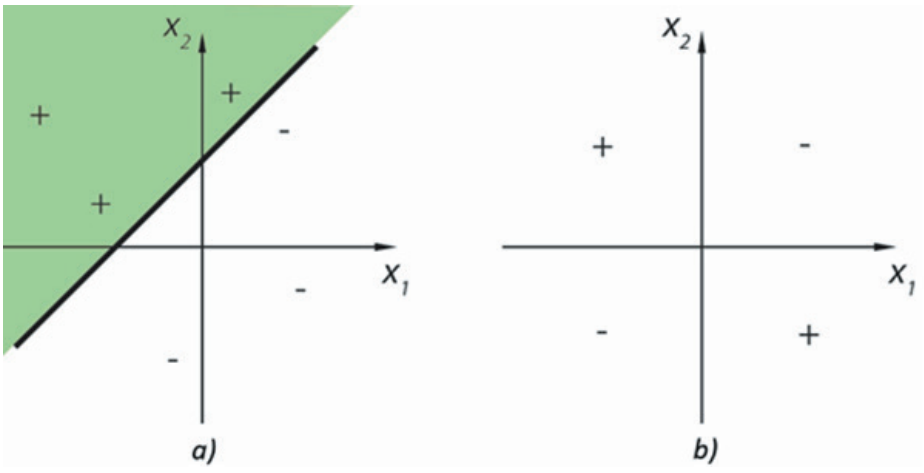
To best understand the use of perceptron, it is necessary to look at a practical example. If a set of points is given that has either a positive or negative value (each of them is represented by + or -), the perceptron can be trained to determine a line that will divide the set into positive and negative values. The set of input data for which it is possible to determine a line that divides it into two sets is called a linearly separable set (Graph 1 a)). Of course, there will always be sets that cannot be divided homogeneously (Graph 1 b)).

Neural networks consist of nodes connected by directional connections (Figure 2). The connection from unit i to unit j serves to spread the activation denoted by ai from i to j. Each connection has an associated and numerical weight wi, j. All units have one input a0 = 1 with the corresponding weight w0, j. Each unit j first calculates the weighted sum of its inputs [10,11]:

$$in_1 = \sum_{i=0}^{n} w_{ij} a_i .$$

Then the activation function f is applied to this sum to get the output:

$$a_1 = fi(n \quad _1) = f \quad \left(\sum_{i=0}^{n} w \; a_{ij} \quad _i \right).$$



Graph 1 – Division of the input set using perceptron. (Adapted from: Mitchell T., Machine Learning, McGraw Hill, Boston, 1997, p. 87)

4. SOLUTION DESCRIPTION

The programming language in which the video game was developed is C #, MS Visual Studio 2017, the design environment is Unity, and Unity Engine packages have been used for certain functions. The program consists of several parts, a separate program code is written for each instance, while in the end all instances are merged and form a single program unit. In the main instance-NeuralNetwork.cs, there is a general algorithm by which all special parts work.

The main goal is to find a way to keep the video game interesting no matter how much the player reports in it. All opponents have a simple pattern of behaviour on which it is easy to insert an element of surprise that adapts and changes with the skill level of the player. It can be equivalently applied to the more complicated ANN, but, as already mentioned, the video game Super Mario was simulated for easier visibility.

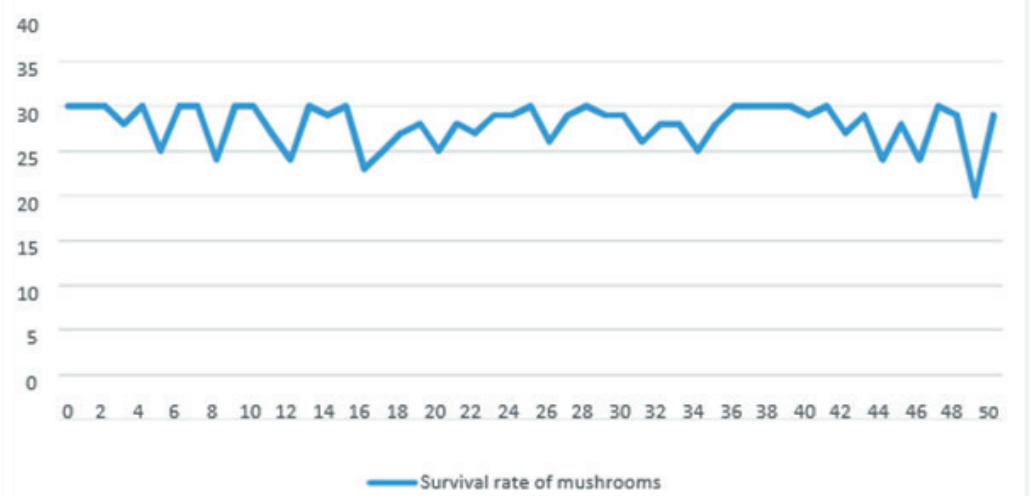
The main obstacle for Mario is the "mushroom", which is relatively easy to manage and is controlled by the neural network. During the first generation of starting the program, the "mushroom" moves only to the left, until it encounters the first obstacle, ie the wall ("end of the screen"). From generation to generation, the "mushroom" is moving more and more toward Mario intending to win over him. Of course, she can easily be eliminated with one jump from Mario. Namely, from generation to generation, "mushroom" (by using NN) "creates awareness" that she should be at a short distance from Mario to be able to avoid a potential attack, or manage to defeat Mario.

5. EXPERIMENTAL RESULTS

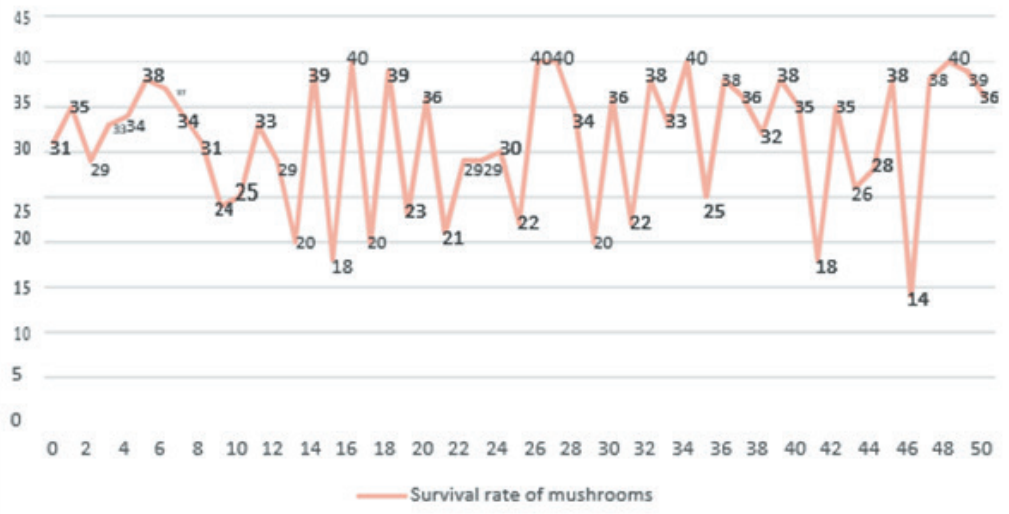
The video game was tested by experimental methods based on the opinions of the players and the observations of observers who, by participating in the game, made it possible to reach concrete conclusions. Starting from the fact that the experiences of the players and the way of playing changed from generation to generation, the goal was to establish the influence of ANN on the changes and improvements of the described video game.

The following graphics show the behaviour of all actors in this video game. Thus, we mean their change of behaviour from generation to generation (in this case 50 generations), which depends on the experience of the player and his abilities, but also on the fact that the "mushrooms" are getting smarter as time goes by. A neural network was used whose neurons have one input layer, and the goal is to define the relationship of the "mushroom" in the state of motion concerning Super Mario. More precisely, based on the distance formula: $D= [\sqrt{(x1^2- x2^2)-(y1^2- y2^2)}]$, which determines the shortest distance between two points in a two-dimensional plane, defines the distance in 2D space where x is the difference between x1 mushroom coordinates and x2 coordinates of Mario, and y is the difference of y1 coordinates of mushrooms and y2 coordinates of Mario.

Graph 2 shows that the elimination of "mushrooms" varies. We conclude that the game becomes more complicated over time because the "mushrooms" gain the ability to avoid attacks and eliminate Mario more efficiently and more easily. At the same time, the players' experience is a bit worse, which increases their speed of adaptation and observation at a certain level of the game.



Graph 2 – A survival rate of mushrooms, by generation, D - player 1



Graph 3 – Mushrooms death by generation, D - player 2

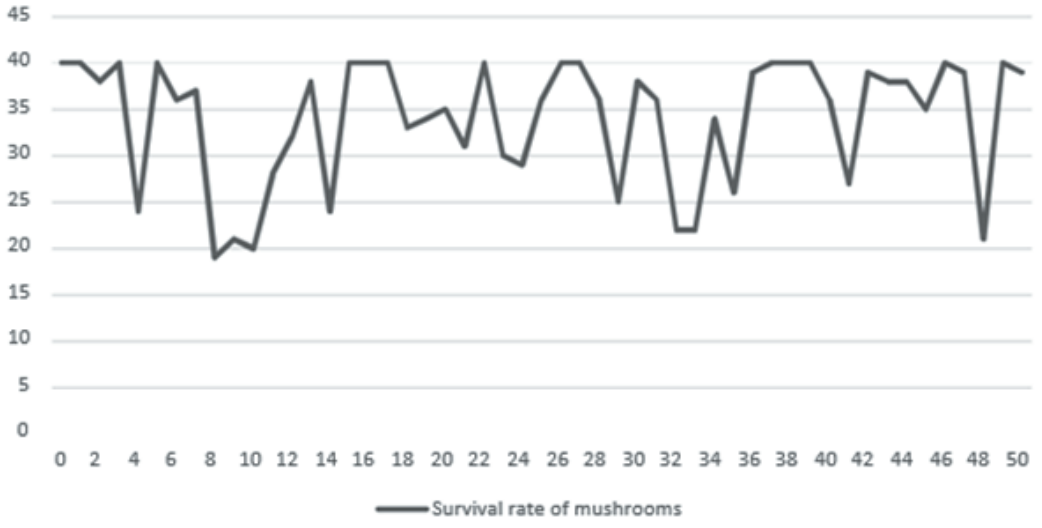
Graph 3 shows that the skill of the player is much higher, which additionally enabled him to learn effectively and to adapt to the game, which also applies to ANN from the aspect of improvement.

As in the previous case, the learning speed of the "mushrooms" is proportional to the learning speed of the player, with the fact that the player, in terms of skills and learning, is at an intermediate level (Graph 4).

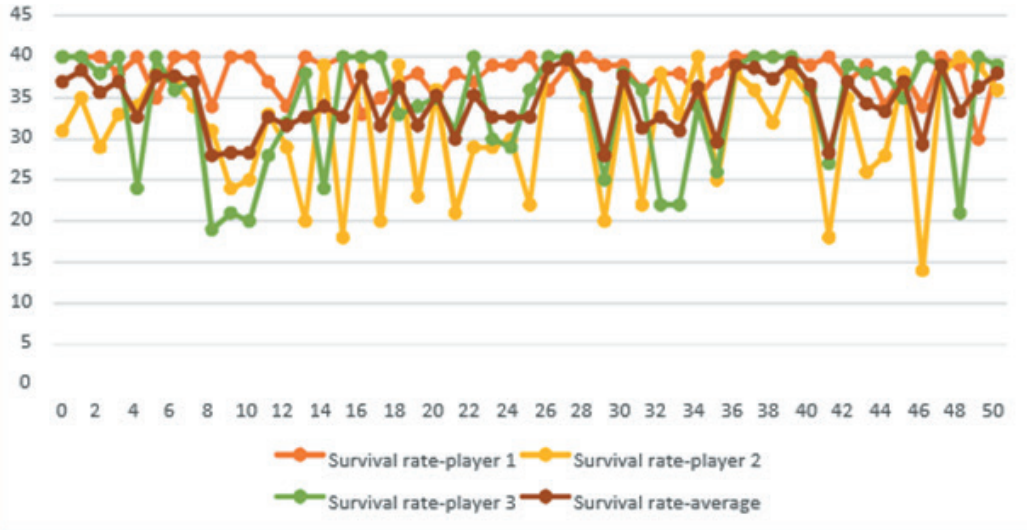
After testing the game with 3 different players, an average was made, because all three previous players have different skill levels. As can be seen in Graph 5, even though these are three players with different skills and experiences, the average line (brown line) shows both falls and rises in an almost uniform order. This proves that the process of "mushrooms" getting used to players, as well as the process of players getting used to "mushrooms" is a recurring cycle.

In the following graphs, a neural network is used whose neurons have two input layers, which means that the "mushrooms" move and observe Mario's position. Player distance is defined using the Distance formula.

With this approach, it can be seen that the "mushrooms" have acquired a higher degree of ability to perceive the environment around them, from generation to generation they become smarter, but this time at a higher level. Based on learning from previous situations, they react faster to potential attacks by Mario and eliminate their opponents more efficiently.



Graph 4 – Mushrooms death by generation, D - player 3



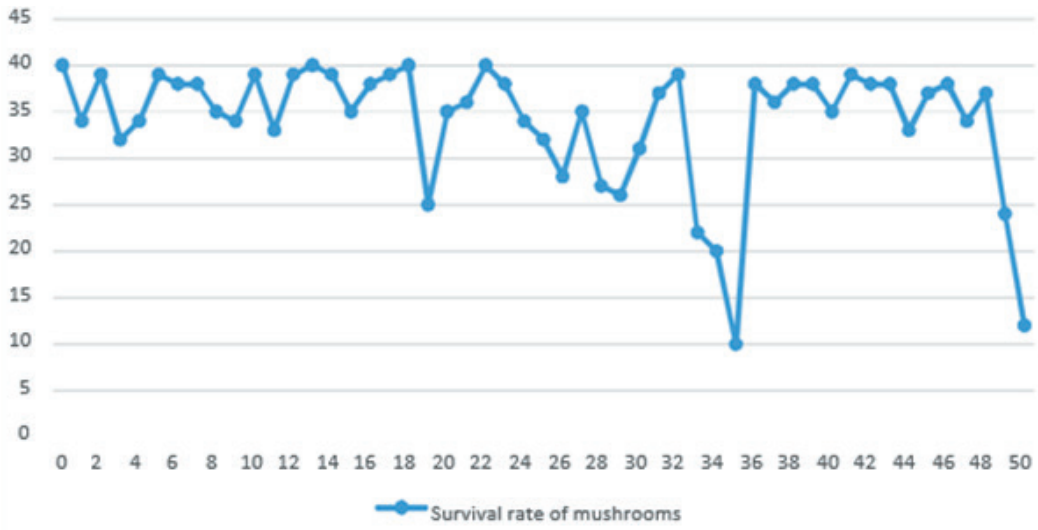
Graph 5 – Mushrooms death by generation, D - average

Graph 6 shows that in the beginning the player only gets acquainted with the game, so the result does not vary much, while after a certain number of attempts, the player's abilities to react increase, which leads to a better result. At the same time, there is an improvement in the ability of the "mushroom" to react.

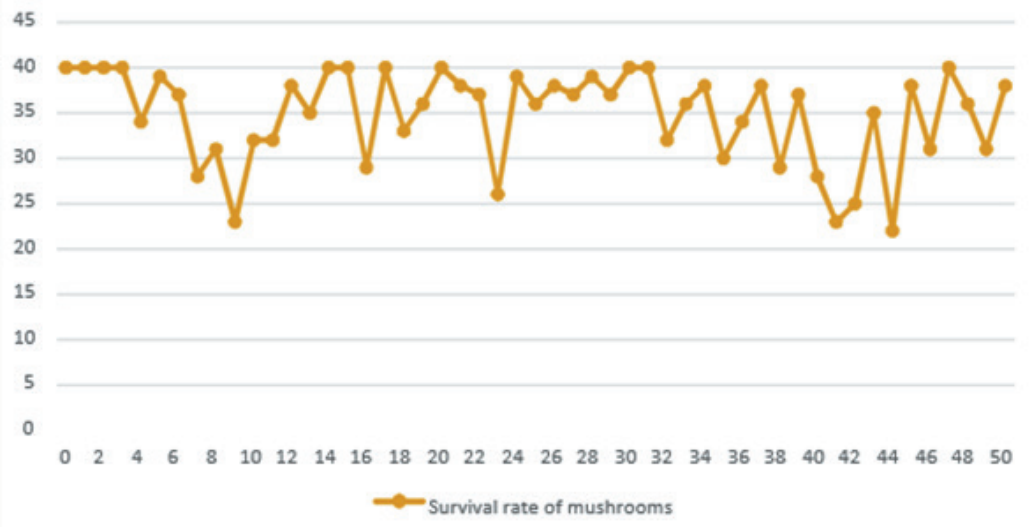
In the case of another player, at the beginning of the game, the result varies, and then during the game, it remains at a higher level, which leads to improving the responsiveness of the "mushroom" in avoiding attacks.

After testing the game with 2 different players, an average was made, which is marked in green on Graph 8.

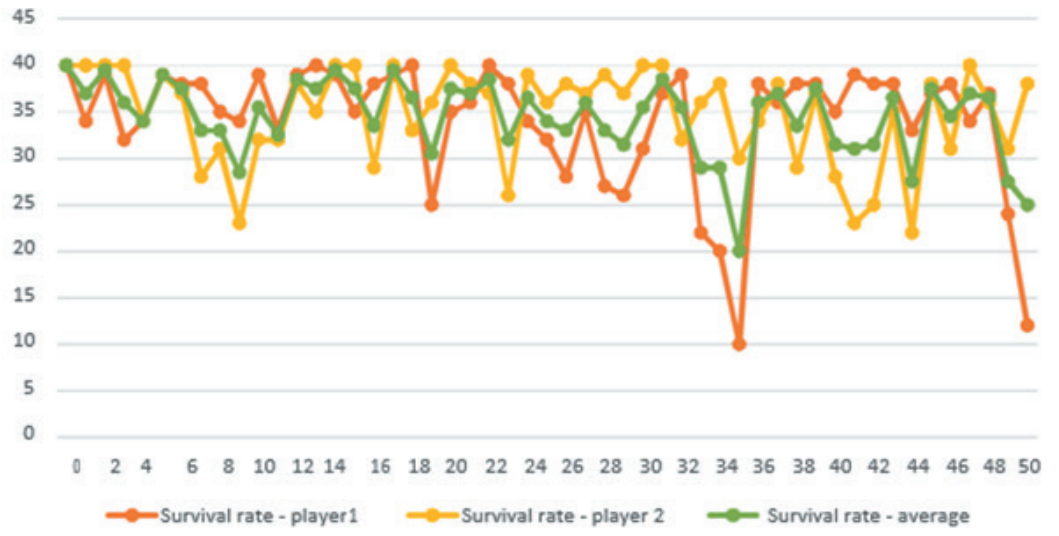
Graph 9 shows how the player gets used to the "mushrooms" in situations where they raise the level of difficulty of the game to adapt to the player. It is noticed that the player survives for a longer period, based on learning how the "mushrooms" behave and the way they move. A significant drop in the intensity of the defence, causes the behaviour of the mushroom to change in the next stage of the game. In this test, Mario behaves the same as in the first test, by trying to eliminate as many "mushrooms" as possible, but this time the goal is to stay in the game as long as possible. This, as well as the previous experiment, gives a clear picture of the interaction in the learning process on the relation "mushroom" - player and player - "mushroom".



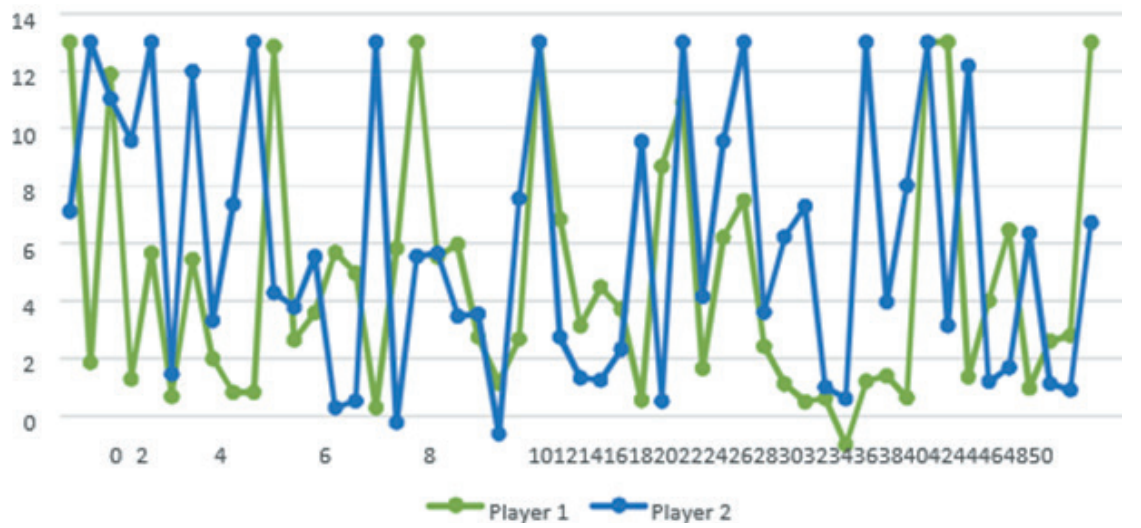
Graph 6 – Mushrooms death by generation, X-Y - player 1



Graph 7 – Mushrooms death by generation, X-Y - player 2



Graph 8 – Mushrooms death by generation, X-Y - average



Graph 9 – Mario death timers

6. CONCLUSION

Based on testing, algorithmic analysis that defines the behaviour of certain elements in the video game Super Mario, as well as based on experimental results, it is clear that neuron-based agents can overcome some of the shortcomings associated with classical AI techniques in video game design. In this thesis, artificial intelligence should be trained with the help of supervised, unsupervised and reinforced learning (machine learning methods) to beat human records in the game Super Mario. That is, it describes how the algorithm accurately recognizes and treats a particular game and its elements and what effects it has on players.

The paper points out the importance of applying an algorithm that uses supervised learning and assisted learning methods, which confirms the sustainable implementation of AI-controlled neural networks in the simulation of 2D and 3D video games. Supervised learning is effective in applying best practices to existing data, and applicable to the functionality of the Super Mario video game, given that players' behaviour, through multiple testing phases, is used to learn the NN algorithm. The algorithm can first be trained using pre-existing data, as far as the basic functions of the game are concerned. In Super Mario, this would be running, squatting, jumping, collecting coins and avoiding opponents.

As an additional confirmation of the objectives of the work, we can mention Ellon Musk's OpenAI which is based on ANN and uses the same approach to learning AI, which was used in the example of the video game shown in the paper. The basic rule is that there are no game rules, only monitoring (input/visual data that players would have).

It is clear that the current 3D video games are more complex than Super Mario, they have more variables, but equal freedom for creativity (all have rules that keep them within certain limits, but within them a high level of freedom). Such complex and diverse behaviours can hardly be described in lines of code, linear algorithms, behaviour trees, or similar methods. However, focusing on ANN design can influence the complexity of ANN, the speed of learning, and the behaviour of video game actors, as can be seen from the D and X-Y experiments, where players are seen to learn and adapt faster in the X-Y version.

Neural networks can be used in many different ways in video games, from agent control, environmental evolution to content generation. As stated in the paper, monitoring the process of neural network development, for example, can be a very useful process. Despite proving sustainable for agent design, there are still many unexplored directions of application and use of neural networks in video games, especially in 2D and 3D graphics environments. The potential is that neural networks can generate entire worlds or complex video games based on the preferences of human players.

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CONVOLUTIONAL NEURAL NETWORKS FOR REAL AND FAKE FACE CLASSIFICATION

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Abstract:

This paper deals with the problem of classifying images of real and fake faces as it is impossible to distinguish them with the bare eye. Two different convolutional neural networks architecture models are applied. The first one is pre-trained VGG16 model, where transfer learning method is applied on our dataset. The architecture of the second model is based on VGG16 and represents its smaller and lighter version. Techniques such as learning rate decay, dropout and batch normalization was applied in training process. Comparison of obtained results of both models is made.

Keywords:

Convolutional Neural Network, Deep Learning, Fake Face Image Classification, Transfer Learning, VGG16.

INTRODUCTION

Artificial intelligence (AI) represents scientific filed that constantly improves. Deep neural networks (DNN) have purpose in many fields such as medicine, pharmacy, automatic control, robotic, entertainment, language processing, etc. Special type of technology, that uses deep learning for creating fake videos, images, texts or events is called 'deepfakes' [1]. Term 'deepfakes' was first used in 2017. on Reddit and since than the use of deepfakes increased. Usually, there are two ways to create deepfakes. The first one is called face-swapping method. Basically, this method revolves replacing person's face from the input image with another face, usually from large set of faces, like in [2]. The second method is by using generative adversarial network (GAN). GAN was firstly proposed in [3] and represents two artificial neural networks (ANN) that compete to each other in order to give the best solution, which is, in this case, the most realistic fake face. The first ANN generates new image from random instances contained in dataset while the role of the second ANN is to evaluate generated image for authenticity. As a result of technology improvement, high resolution images and videos, and development of AI algorithms created deepfakes look very realistic and it is almost impossible to determine are they real or not.

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Even though nowadays deepfakes can be used for good purposes, such as in movie and chemical industries, material science, medicine, entertainment, etc. which is better explained in [4], they also represent a threat that can have serious consequences. Many scientists of different science fields worn of the danger of malicious use of deepfakes. For example, GAN created images can be used to deceive facial recognition system or for hiding identity on social networks. Video, voice or image manipulation can be used for blackmailing people and there is no need to explain what kind of political consequences can be caused by abusing deepfake technology. There is obvious need to recognize deepfakes to prevent their abuse.

Research about visual processing by observing primary visual cortex of a cat, where it was shown that changing the angle of a line causes activation of different neuron groups and that the same group of neurons is in charge of edge detection regardless of their position, served as an inspiration for creating first ANN that was used for pattern recognition. That ANN is called neocognitron, proposed by Kunihiko Fukushima in 1980. [5]. Neocognitron was the basis of the further research that led to the creation of the first convolutional neural network (CNN). In 1989. backpropagation algorithm was used to train CNN in order to recognize handwritten numbers [6]. This was a prototype for LeNet architecture of CNN. The huge step forward in researching CNN was achieved by developing AlexNet [7] in 2012. This type of CNN won the ImageNet Large Scale Visual Recognition Challenge in the same year with achieved error of 15.3% on test set which was significantly less than error of other competitors. Nowadays we are familiar with many different CNN architectures. One of the most famous and most commonly used architecture is VGG16 [8]. VGG16 was created as a result of the research how network depth affects accuracy on large-scale image dataset. With novelties such as depth of 16 weight layers and convolutional filters sized 3 x 3, this network was used at the ImageNet Challenge 2014, where it achieved 7.5% top-5 error. It is important to mention that VGG16 is large, heavy model, sized around 530MB. That is caused by many weight parameters and leads to slow training process.

Solution for the problem of detecting fake faces is presented in [9], where new architecture of CNN, Local Binary Pattern-Net is designed and detection is based on the texture features of fake faces as it is different than the texture of real faces. Few different CNN models are used in [10] and it is concluded that deep-learning algorithms and models are propriate for recognizing fake faces. The best results are obtained by using VGG19 architecture. In [11] authors firstly use Kalman Filter for preprocessing images, then use amalgamation of fisherface algorithm for face recognizing with Local Binary Pattern Histogram for space dimension reduction of face. Deep Belief Network is used for final classification. This method is applied on four different datasets and the results showed that this method is very effective, and that executes very fast.

In this study we propose solution for classifying real and fake faces, created by GAN network, by using pretrained VGG16 model and custom VGG-like network, with smaller and lighter architecture.

2. DATASET

Dataset, that is used for the research consists of 140000 images of human faces. Half of the total number of data are images of real human faces, retrieved by Nvidia from the Flickr-Faces-HQ dataset [12], while the other half of data are images of fake faces. Fake face images are all generated by StyleGAN and they are part of huge dataset of 1 million fake faces [13]. Combined, they represent one of the largest datasets available online. All of the images in this dataset are resized to 256 × 256 pixels and divided into three folders – train, test and validation folder. Train folder contains 100000 images, while test and validation folder have 20000 images, each. The ratio between fake and real images in all folders is always 1:1. This dataset can be found in [14]. Few random data samples from both classes are shown in Figure 1. As it can be seen, it is almost impossible to find the difference between real and fake faces with bare eye.

Figure 1 – Random samples of fake and real faces from dataset.

Data augmentation, such as zooming, flipping, rotating images, etc. is avoided in this research, because there is already a large amount of data in this dataset.

3. APPLIED METHODS AND ARCHITECTURES OF CONVOLUTIONAL NEURAL NETWORKS

3.1. CUSTOM CONVOLUTIONAL NEURAL NETWORK

There are three types of layers that form CNN – convolutional, pooling and fully connected layers. Convolutional layer contains filter kernels whose weights need to be learned in learning process. Role of pooling layer is to reduce size of the output from convolutional layer which leads to reducing number of weights that should be learned and reducing computation process. Fully connected layer connects all outputs from one layer to all inputs from next layer. Usually, this type of layer is placed at the end of neural network in order to perform classification of flatten output from the last convolutional or pooling layer.

Input layer of the created CNN consists of RGB images with height and width resized to 224 pixels, which gives them dimension 224×224×3 pixels. There are three convolutional layers, one with 64, two with 128 filters. The size of all filters is 3×3. A Rectified Linear Unit (ReLU) is used after convolutional layers as activation function to eliminate all negative weights after filtering image and replace them with zero value. ReLU function can be described as

$$f(x) = \begin{cases} 0, x < 0 \\ x, x \geq 0 \end{cases}$$

Equation 1 – ReLU function

After every activation function, batch normalization method is applied. It was proposed in [15] and it is used for normalization of inputs in layers. According to [16], this method provides acceleration of training process because it allows using higher learning rate. Proposed CNN model contains three pooling layers that have pool size 2×2, and with stride 2. Maximum pooling operation is applied for reducing number of learning parameters. Output from the last pooling layer is flattened in order to convert data into vector. Following, there are two fully connected layers, one with 256 nodes, and one with 1 node. For predicting probability that input data belongs to certain class sigmoid activation function is used. Sigmoid function is determined as

$$f(x) = \frac{1}{1+e^{-x}}.$$

Equation 2 – Sigmoid function

Fully structure of designed CNN is shown in Figure 2.

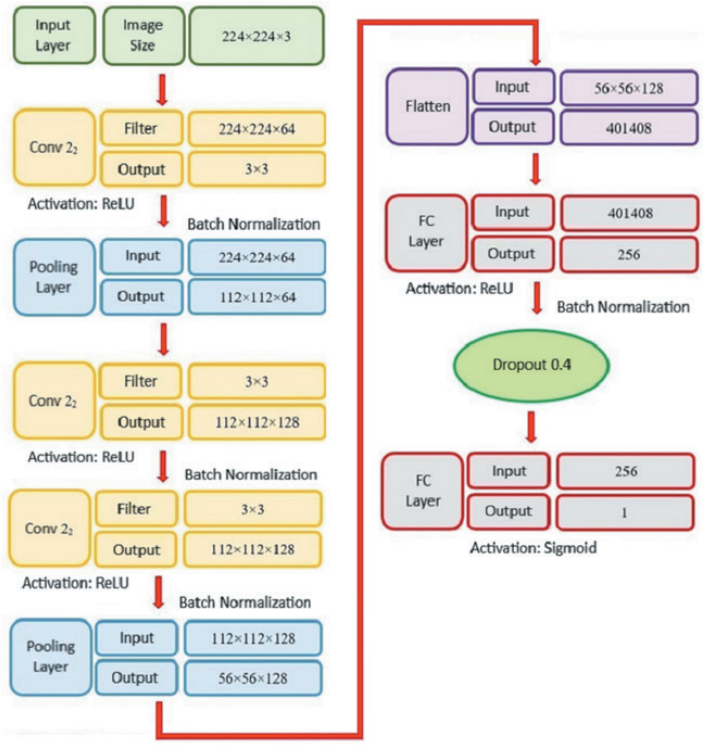

Figure 2 – Structure of proposed, VGGNet inspired CNN.

Regularization covers few techniques that can help avoid overfitting and getting higher accuracy when ANN works with unknown data. As form of regularization, dropout method is applied. This method implies randomly selecting and ejecting some neurons and its weights from learning process according to previously determined probability level. By applying dropout, it is possible to prevent high dependence between certain neurons that leads to activation of only few neurons for solving problem. In this research dropout technique is used after first fully connected layer with probability 0.4.

3.2. PRE-TRAINED VGG16 MODEL

Transfer learning is a method in deep learning which implies using already trained model for solving new but similar problem, [16]. Fine-tuning is technique in transfer learning that allows changing model in order to adjust it to new task. It means that some of pre-trained parameters are frozen or non-trainable, but some of them should be trained in learning process. The structure of pre-trained VGG16 model on ImageNet dataset is presented in [8]. All layers are kept and all parameters were frozen, except for the last three fully connected layers that are removed from original structure. Flatten was added after last pooling layer, and two new fully connected layers are added, first with 512 nodes and second with 1. Between them, dropout was applied with probability 0.4. Images in input layer are resized to 224×224 pixels in order to match with the size of images that was originally used for training VGG16 model.

4. TRAINING OF THE DESCRIBED MODELS

For implementing, evaluating and training our two models, Python programming language was used with Keras library.

As we are dealing with the binary classification problem, which implies determining the affiliation of a sample to the class, binary cross entropy was defined as loss functions for both models. Loss function calculates the distance between target value of model's output and obtained output's value. In order to find minimum of the loss function Adaptive Moment Estimation (ADAM optimizer) is used. This optimization technique compute learning rate for every parameter and does not require a lot of memory, so it is suitable for large dataset. Number of training examples per iteration defines batch size. In training of both models, 100 images are processed in one iteration and after each iteration weights were updated.

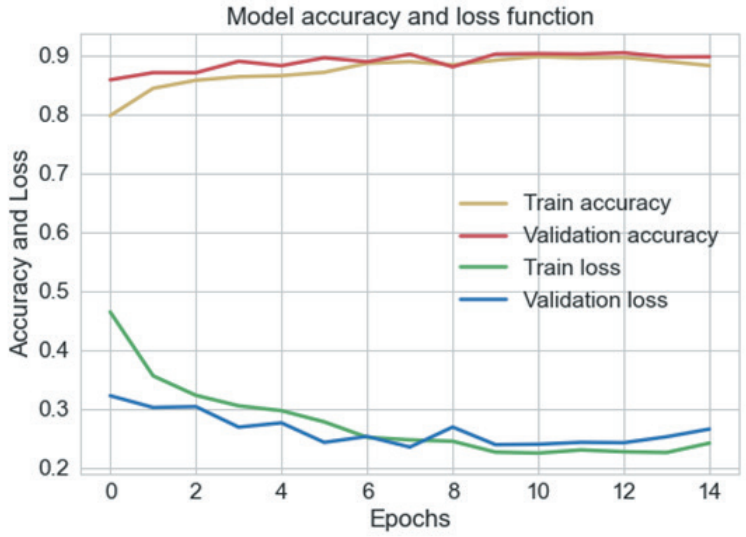

Figure 3 – Accuracy and loss function obtained in training and validation of pre-trained VGG16 model.

Learning rate decay is method in model training where the learning rate slowly decreases at the beginning of each epoch. In training of custom CNN model learning rate was set to 0.01 with decay that is equal to the quotient of the initial learning rate and number of epochs.

Defined number of epochs for both models is set to 15, and during training process function for saving best results was used. It means that best weights are saved and used in model testing which is a great way to avoid overfitting and bad generalization.

5. RESULTS AND DISCUSSION

The best way to analyse training process is to observe change of the loss function and accuracy during epochs.

In Figure 3, accuracy and loss function for training and validation of VGG16 model during 15 epochs training are shown. It is clearly that minimizing loss and increasing accuracy were successful until 7th epoch and after that loss started to grow in validation process. In other words that is the moment when overfitting started. Graph that shows same functions for second, custom CNN is given in Figure 4. In this case, model make progress in learning during first 6 epochs right before overfitting started.

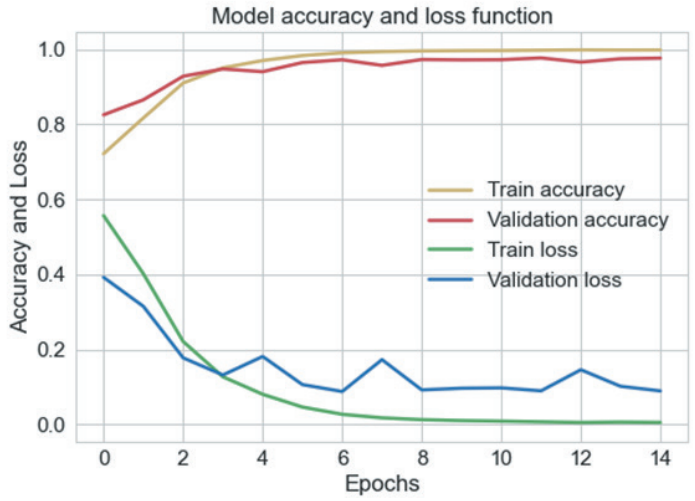

Figure 4 – Accuracy and loss function obtained in training and validation of proposed, custom model.

Trained models are tested on set of images that was excluded from training, which means that they are unknown for them. Criteria for comparison and obtained results are given in the below.

In case of binary classification, predicted output can be included in one from the following categories:

- True positive (TP), if predicted fake face class is correct for the input image,
- True negative (TN), if predicted real face class is correct for the input image,
- False positive (FP), if predicted fake face class is incorrect for the input image,
- False negative (FN), if predicted real face class is incorrect for the input image.

For performance evaluation few parameters are considered – accuracy, precision, recall and F1 score. Accuracy is performance measure that shows ratio between correctly classified samples and total number of samples.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}.$$

Equation 3 – Accuracy

Precision can be calculated as:

$$Precision = \frac{TP}{TP + FP}.$$

Equation 4 – Precision

Recall or sensitivity measures the model's capability to correctly classify true positives. It can be represented by following expression:

$$Recall = \frac{TP}{TP + FN}.$$

Equation 5 – Recall

Finally, F1 score is measure of model's performance that combines precision and recall into following equation:

$$F1 = \frac{2 \cdot Precision \cdot Recall}{Precision + Recall}.$$

Equation 6 – F1 Score

Obtained performance measures, rounded on four decimal places are given in Table 1.

	Pre-trained VGG16	Proposed model
Accuracy	0.8998	0.9718
Precision	0.9038	0.9789
Recall	0.8949	0.9644
F1 Score	0.8993	0.9715

Table 1 – Obtained results

As it can be seen from Figures 3 and 4, in training and validation process less loss and higher accuracy are obtained by proposed, custom model. In testing, both models scored acceptable and high values of the selected parameters for performance measurement. However, custom model showed better performance in testing, which means that more of the samples were correctly classified, so it achieved significantly greater all values – accuracy, recall, precision and F1 Score. Although training process time is shortened by using transfer learning strategy, for this particular case, smaller, shallower ANN that was proposed in this paper, undoubtedly represents better choice.

6. CONCLUSION

In this research the problem and potential treat of malicious use of deepfake technology is described. Potential solution for identifying fake faces that was created by GAN networks, is found by using CNN.

Two different strategies in CNN training were applied. The first one was transfer learning, and the second one was custom CNN with lighter and smaller structure. Some of the optimization and regularization methods were applied in order to obtain the best possible results in the training process.

Learning process of both models took 15 epochs and it was shown that overfitting started at similar moment. Also, custom CNN showed better results after learning process, so it was expected that it gives better result in testing as well.

The goal of this paper was to compare performance of these two models in testing, were they had task to classify data samples that was unknown for them. As it was expected, second CNN achieved incomparably better results, with accuracy of around 97%. This is valid argument to recommend using this type of CNN for solving this particular problem.

The next step in research is to try applying different optimization methods and regularization techniques.

Also, changing defined parameters such as learning rate, dropout probability may result in a change in model's performance.

7. ACKNOWLEDGEMENTS

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GREY WOLF OPTIMIZATION FOR POSITION CONTROL OF A DIRECT CURRENT MOTOR DRIVEN BY FEEDBACK LINEARIZATION METHOD

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Abstract:

Several studies dealing with position control of the DC motor have reported issues concerning friction force. This article demonstrates a nonlinear control and optimization strategy for position control of a series servo motor. Once it is empirically verified that the linear model does not adequately reflect the system, the model is upgraded from linear to nonlinear. In the course of the research, the nonlinear feedback linearizing the controller's behavior is examined. A grey wolf metaheuristic optimization algorithm is used to find the coefficients of the controller's gains. In this way, modern methods are applied to take a fresh look at the existing problem. Furthermore, performance for various targeted output signals is compared to show the approach proposed in the study. Also, a comparative analysis with whale optimization algorithm is performed. The experimental results acquired on the stated system are shown, and they validate the usage of the nonlinear control, demonstrating the effectiveness of using optimum feedback linearization in electrical machines.

Keywords:

Nonlinear Model and Control, Grey Wolf Optimization, Feedback Linearization Approach.

INTRODUCTION

The position of the output series DC motor shaft may be controlled using a variety of approaches. Traditional feedback control systems, such as proportional-integral-derivative (PID-like) controllers, are very widely utilized. They are inexpensive (in comparison to more complex control systems), simple, and variations of these manage to maintain the system's output within error limitations. They, on the other hand, suffer from a lack of resilience [1]. There are various nonlinear controllers in addition to standard ones. Some of them employ adaptive control techniques [2], while others are constructed using Artificial Neural Networks (ANN) [3]. The significant nonlinear features of the system make control challenging in general. Another approach, such as Fuzzy Logic Controller (FLC), can be designed to avoid this challenge [4]. Because of their high nonlinearity and various local optima, global optimization issues are difficult to solve efficiently. Finding the optimal minimum error function is a fundamental and difficult topic. For researchers in this field, nature has been an important source of inspiration [5].

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The genetic algorithm (GA), particle swarm optimization (PSO), whale optimization algorithm (WOA), grey wolf optimization (GWO) [6], and others are examples of these algorithms. For instance, nonlinear evolution and genetic algorithms have been utilized to optimize the design of a phase controller for tracking the trajectory of moving robots [7]. Other strategies can be used in conjunction with other nonlinear control systems. The GWO approach demonstrates its superiority for step and stochastic load disturbances in a wide range of situations. On the other hand, there is the nonlinear method whose basic idea is to algebraically convert a nonlinear system's dynamics into a (fully or partially) linear one, allowing linear control techniques to be used. Feedback linearization (FBL) is a strong nonlinear strategy that works by cancelling nonlinearities. This strategy has been effectively utilized in a variety of control tasks, including robotic systems, high-performance aeroplanes, helicopters, biomedical devices, and industry in general [8].

To a large extent articles dealing with comparable themes built the nonlinear model by flux and motor current nonlinearities [9], [10] a [11]. To control the position of the DC motor, the FBL was carried out in this work utilizing a mathematical model that takes into consideration friction-induced nonlinearity (Tustin model). Furthermore, a unique model was developed in which the discontinuous nonlinearity was approximated by a differentiable nonlinearity of the hyperbolic tangent, guaranteeing that the FBL application requirements were satisfied. After the feedback linearization strategy was successfully applied to algebraically change the nonlinear states of the system to their linear forms, a conventional linear system technique was adopted. To solve the problem of finding controller gains, the GWO and others optimization approaches were applied.

The experimental evidence of the efficiency of nonlinear system control is the paper's last contribution.

The rest of the paper is organized as follows: in Section 2, modeling and a schematic diagram of the object is provided. Contrary to many articles where nonlinearities are based on flux or motor current, modeling was performed using function that is suitable for the FBL and which takes into account the nonlinearity resulting from friction. Then, linear and nonlinear models are verified and compared. Sections 3 and 4 are overview of the theoretical derivations of the FBL and the GWO. In Section 5 we obtain the control signal based on the FBL and optimize its coefficients using the GWO. Finally, coa mparative analysis with another nature-inspired algorithm (whale optimization algorithm) is presented.

2. OBJECT DESCRIPTION AND MODELING

The creation of a mathematical model is among the first stages in the development of a control system. This saves time and profit in the long run. Contradictorily, accurate mathematical models are difficult to come by. Figure 1 shoof ws a schemamotorsepresentation of series wounded DC motor. Choosing motor voltage V_m as input variable $V_m=u$, and position of the load shaft θ_l as the output variable, $\theta_l=y$ the system's linear model is:

$$J_{eq}\ddot{y}(t)+B_{eq,v}\dot{y}(t)=A_m u(t)$$

Equation 1 – A linear model of the DC motor

In Eq. (1) J_{eq}, $B_{eq,v}$, and A_m are a total moment of inertia, equivalent damping term, and actuator gain.

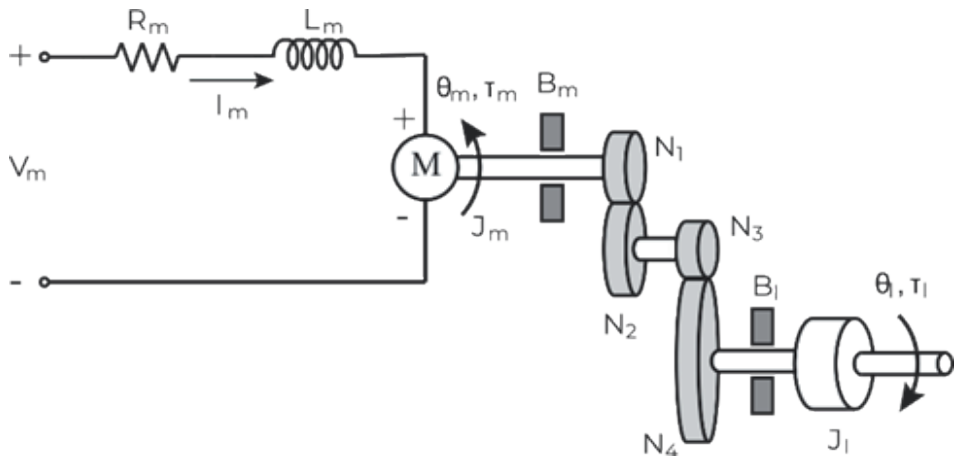

Figure 1 – A schematic representation of this series wounded DC motor.

The DC motor's nonlinear mathematical model was created using the speed-dependent friction nonlinearity. Many friction models, which have been extensively researched in the literature, differ primarily in how they describe the moment of friction. The friction torque is described as a static and/or dynamic function of rotational velocity in these models [12]. First, the friction model Tustin was used in this study:

$$J_{eq}\ddot{y}(t) + T_{st}(\dot{y}(t)) + B_{eq,n} = A_m u(t)$$

Equation 2 – A nonlinear model of the DC motor

where $T_{st} = T_{st}(\theta l) = T_{st}(y) = 0.0174 sgn(\dot{y}) + 0.0087 e - \frac{\dot{y}}{0.064} sgn(\dot{y})$ is the nonlinear part of the Tustin friction model. To avoid the jump discontinuity of the suggested friction model and because the FBL approach demands differentiable functions (as it will be apparent from the supplied definitions in the following section), the approximation is achieved using the tangent hyperbolic function. Only Coulomb and viscous friction are modeled in this manner, and the exponential section of the Stribeck curve (static friction) is ignored [13].

$$f(\theta_l) = f(y) = \lambda_1 \left(\frac{2}{1 + e^{-\lambda 2 \dot{\theta}_l}} - 1 \right)$$

Equation 3 – Approximation of the part of the friction function

The state equation of the system was produced by choosing to designate nonlinearity as f(x).

$$\dot{x} = \begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & \frac{-B_{eq,n}}{J_{eq}} \end{bmatrix} x + \begin{bmatrix} 0 \\ -1 \end{bmatrix} f(x) + \begin{bmatrix} \dot{x}_1 \\ \frac{A_m}{J_{eq}} \end{bmatrix} u \quad (1)$$

$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} x \quad (2)$$

Equation 4 – State equation of the system

In Eq. (4) state variables are given as $x_1=\theta_l$ and $x_2=\dot{\theta_l}$ and $B_{eq,n}$ is an equivalent damping term with linear viscous friction already comprehended.

2.1. VERIFICATION OF THE MATHEMATICAL MODELS

The object's real operation is demonstrated during the experiment, Figure 3.

For step and sinusoidal inputs, comparisons were done with the responses obtained from the linear and nonlinear models. The real object's and linear model's reactions to step and sinusoidal excitations do not match well. The model does not reflect the system's actual behavior for the step input. The sine wave also exhibits nonlinearity in the form of the dead zone. The effect of friction is represented by this nonlinearity. It's particularly important when stated in low-frequency sinusoidal functions (and when the rotation direction changes), because the friction impact is amplified.

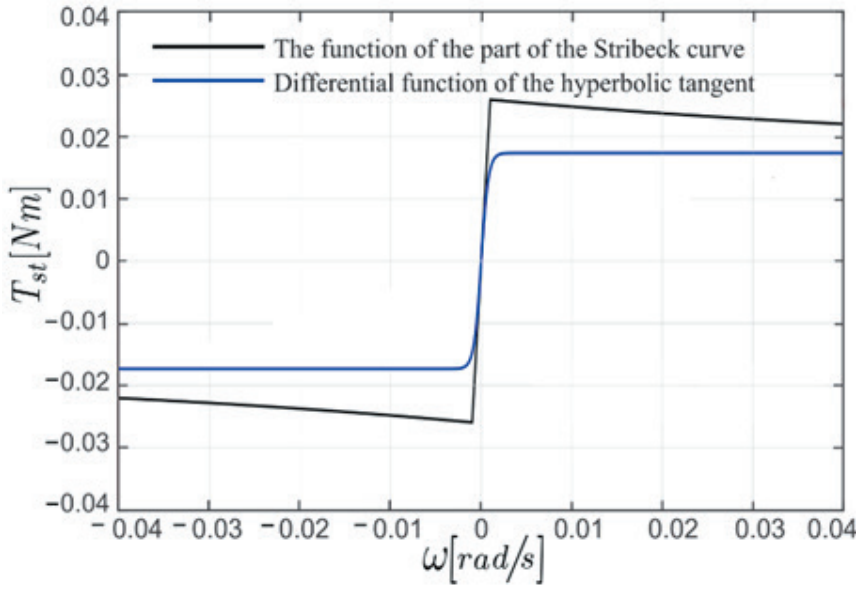

Figure 1 – A schematic representation of this series wounded DC motor.

Parameters	Values and Units	Parameters	Values and Units
J_{eq}	0.0021 kgm^2	$B_{eq,n}$	0.0721 Nm/(rad/s)
$B_{eq,v}$	0.0840 Nm/(rad/s)	First coefficient from Eq. (3) – Approximation of the part of the friction function λ_1	0.0173607
A_m	0.1284 Nm/V	Second coefficient from Eq. (3), λ_2	2500

Table 1 – Numerical values.

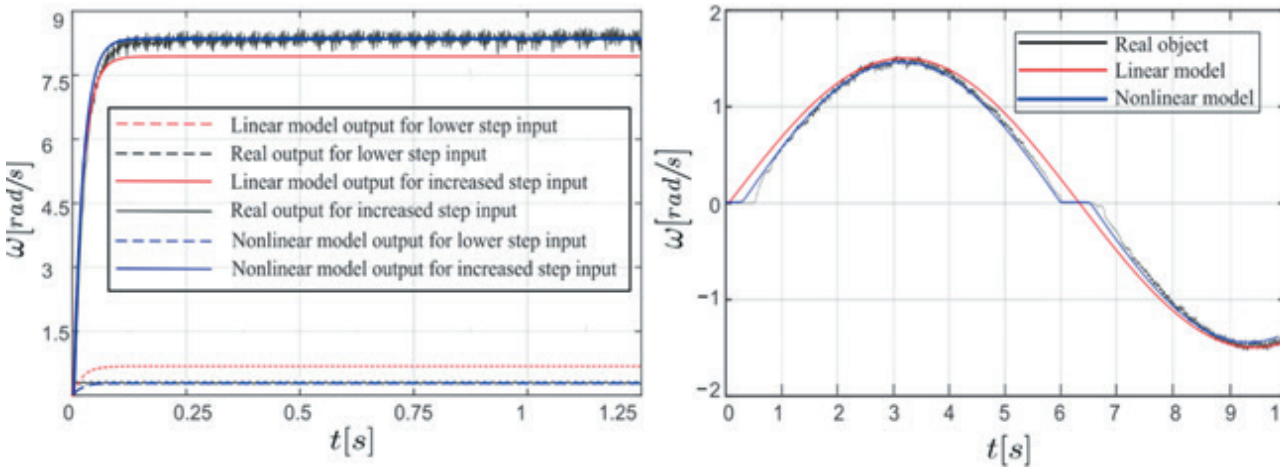

Figure 3 – Comparison between real behaviour and two models.

The nonlinearity of friction must be considered to produce the most realistic model of the DC motor and to permit a decent synthesis of the control system afterward. From Figure 3 a significant conclusion may be derived: the plant's simulated linear model does not match the reaction of the real system. The mathematical model of a series DC motor is nonlinear.

3. FEEDBACK LINEARIZATION LIMITATIONS

In order to eliminate nonlinearities from the system, the theoretical foundation for implementing the recommended FBL method will be presented in this section. The theoretical derivation is based on [14]. Designing the control signal with the feedback linearization rule, which cancels the nonlinearity, will be very important. This method does not rely on approximation in any way but, without a doubt, generalization of this concept is not always possible - there must be a unique set of systemic characteristics that allows cancellation. To reach this level of control, four restrictions must be met.

1. State equation of the system requires the following form Eq. (5).

$$\dot{x} = A_x + B_y(x)\left[u - a(x)\right],$$

Equation 5 – The appropriate form for applying the FBL

where A is $n \times n$ matrix, while B is $n \times p$ matrix. The functions: α: $R^n \longrightarrow R^p$, γ: $R^n \longrightarrow R^{p \times p}$ are defined on the domain that contains the origin and reflect possible nonlinearities in the system. Sometimes, when system is not in the form of the Eq. (5) it may be adjusted, because state space model of system is not unique and depends on the choice of state variables.

2. Differentiability is required for all functions;

3. It's easy to see that to cancel a nonlinear component by subtraction $\alpha(x)$, the control signal u and the nonlinearity must appear as the sum. To reverse the nonlinear member $\gamma(x)$ by division, on the other hand, control and nonlinearity must appear as the product. So, the third condition is that $\gamma(x)$ must be nonsingular for all $x \in D$; and

4. Pair (A,B) has to be controllable.

With these requirements met, the following control law might be generated:

$$u = a(x) + \frac{1}{y(x)} v \ ,$$

Equation 6 – Control law for the FBL

with a new control signal v.

4. GREY WOLF OPTIMIZER - OVERVIEW

Due to its great qualities, the GWO has been widely customized for a broad variety of optimization problems: it has extremely few parameters, and no derivation information is necessary for the first search. It mimics the hunting technique, as well as the grey wolves highly ordered pecking order and social scale in the wild [6]. In a group, there are four different wolf ranks: α, β, δ, and ω. The α is the pack's leader, and the other members of the pack obey him. Furthermore, all wolves participate in the major activity of prey hunting, which is divided into two steps: seeking for the prey and attacking. The following Eq. (7) of the distance vector **D** and the vector for position updating **X** $(t+1)$:

$$\mathbf{D} = \left|\mathbf{C}\mathbf{X}_{\mathrm{p}}(t) - \mathbf{X}(t)\right|, \ \ \mathbf{X}(t+1) = \mathbf{X}_{\mathrm{p}}(t) - \mathbf{A}\mathbf{D} \ ,$$

Equation 7 – Encircling the prey

are used to create a mathematical model of prey encirclement [6]. The coefficient vectors **A** and **C** may be computed as follows: $\mathbf{A}=2\boldsymbol{a}\boldsymbol{r}_1-\boldsymbol{a}$ and $\mathbf{C}=2\boldsymbol{r}_2$. $\boldsymbol{r}_1$ and $\boldsymbol{r}_2$ are the random vectors in the range [0, 1]. Component a decreases from 2 to 0. Finally, t is the current iteration, $\mathbf{X}_{\mathrm{p}}$ is the prey's location, and X is the agent's position vector. A mathematical simulation of hunting behavior is given with:

$$\mathbf{D}_{\alpha} = \left|\mathrm{C}_1\mathbf{X}_{\alpha} - \mathbf{X}\right|, \ \ \mathbf{X}_1 = \left|\mathbf{X}_{\alpha} - \mathrm{A}_1\mathbf{D}_{\alpha}\right| \qquad (1)$$

$$\mathbf{D}_{\beta} = \left|\mathrm{C}_2\mathbf{X}_{\beta} - \mathbf{X}\right|, \ \ \mathbf{X}_2 = \left|\mathbf{X}_{\beta} - \mathrm{A}_2\mathbf{D}_{\beta}\right| \qquad (2)$$

$$\mathbf{D}_{\delta} = \left|\mathrm{C}_3\mathbf{X}_{\delta} - \mathbf{X}\right|, \ \ \mathbf{X}_3 = \left|\mathbf{X}_{\delta} - \mathrm{A}_3\mathbf{D}_{\delta}\right|, \qquad (3)$$

Equation 8 - Hunting

and

$$\mathbf{X}(t+1) = \frac{\mathbf{X}_1 + \mathbf{X}_1 + \mathbf{X}_3}{3} \ .$$

Equation 9 – Position update

$\mathbf{X}_{\alpha}$, $\mathbf{X}_{\beta}$, $\mathbf{X}_{\delta}$ denote position vectors of the α, β, and δ wolves respectively, and A_1, A_2, A_3, C_1, C_2, C_3 are the elements expressed in the column vector. To put it another way, the agents separate to look for the prey, then converge to assault the prey. This is what encourages exploration and allows the GWO algorithm to search worldwide, or in other words, to have a broad search [6]. It's also simple, straightforward to use, adaptable, and scalable, with a unique capacity to find the correct balance between exploration and exploitation during the search, resulting in favorable convergence.

5. EXPERIMENTAL RESULTS

In order to meet all the conditions for the application of the method, from Eq. (4) and Eq. (5) follows:

$$\boldsymbol{A} = \begin{bmatrix} 0 & 1 \\ 0 & \dfrac{-B_{eq,n}}{J_{eq}} \end{bmatrix}, \boldsymbol{B} = \begin{bmatrix} 0 \\ \dfrac{A_m}{J_{eq}} \end{bmatrix}, a(x) = \frac{J_{eq}}{A_m} f(x), y(x) = 1,$$

Equation 10 – FBL model of the system

so the system has the required form. As function $f(x)$ is hyperbolic tangent and $\gamma(x)=1$, conditions 2 (differentiability) and 3 (nonsingularity) are also met. It remains only to check the controllability matrix:

$$U = \begin{bmatrix} B & AB \end{bmatrix} = \begin{bmatrix} 0 & \dfrac{A_m}{J_{eq}} \\ \dfrac{A_m}{J_{eq}} & -\dfrac{B_{eq,n}}{J_{eq}^2} \end{bmatrix}, \ \ rankU = n = 2.$$

Equation 11 – Checking the controllability condition for the FBL

Eq. (11) shows the fulfillment of the fourth condition. The relative degree of the system is $r=2$ so Input-Output Feedback Linearization is feasible and full state linearization can be performed without fear of the internal dynamics. The control signal is chosen to be in the form:

$$u == \frac{J_{eq}}{A_m}\left[\frac{J_{eq,n}}{A_m} x_2 + f(x) + v\right], \ \ v = -K_0 x_1 - K_1 x_2 + K_r x_{ref} .$$

Equation 12 - Proposed control law

In Eq. (12) x_{ref} represents desired output. Traditional control is can be ineffective in dealing with a variety of issues such as steady-state error, rapid position and velocity changes. In this study, the controller gains must be established and optimized for the optimal operation to provide good dynamic behaviour. To compensate the effects of backlash and friction, FBL control approach with gains optimized with the GWO algorithm is used. Furthermore, the aforementioned parameters are all programmed into a single wolf, i.e. a single agent, who is supplied with a vector containing three parameters in our scenario. The integral of absolute errors (IAE) is used for the objective function performance criteria, as $IAE=\int|\varepsilon(\tau)|d\tau$. The number of search agents in the proposed GWO algorithm is fixed at 30, with a maximum number of iterations of 500. Furthermore, one agent represents a single possible optimum controller. The following are the scaling factor parameters acquired after optimization: $K_0=K_r=450$; $K_1=30.8387$. In the experimental part, we compared GWO with another modern optimization algorithm WOA [5]. The parameters of the WOA algorithm are taken from the paper [5]. The objective function, numbers of iterations and search agents are the same for both algorithms, due to a fair comparison. Both algorithms give similar results, with mean absolute error (MAE) shown in Table 5, with GWO being slightly better. With minor variations, the output and intended trajectory signals are essentially similar. On the Figure 4 and Figure 5 results are shown only for GWO. From Figure 4 (left) it is clear that system responds quite quickly. Both the rising and settling times are under 0.35 seconds with overshoot less than 3% and steady state error 0.0170. Sinusoidal signals in which the direction of rotation of the output shaft varies throughout operation are also very essential references for testing the performances of a nonlinear control system. Therefore, sinusoidal reference with amplitude 1 and frequency 0.5Hz is shown on Figure 4 (right). Position tracking for value: π (left) and for arbitrary signal with rapid changes (right) are depicted in the following Figure 5.

Reference	GWO	WOA
Unit step	0.0256	0.0242
Sinusoidal signal	0.0330	0.0324
Constant	0.0824	0.0975
Arbitrary signal with rapid changes	0.0755	0.0766

Table 2 – Comparison of MAE for GWO and WOA.

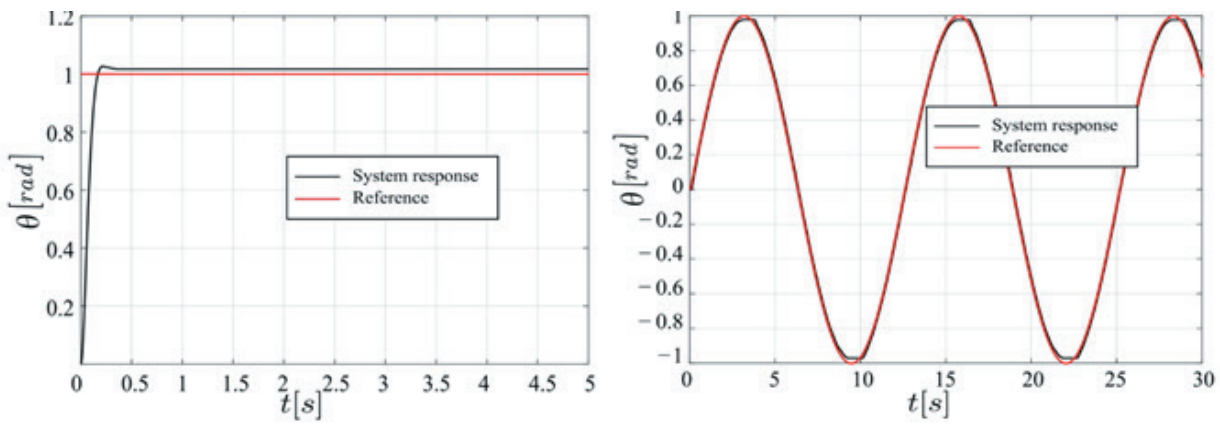

Figure 4 – Position tracking for unit step and sinusoidal signal as reference signals.

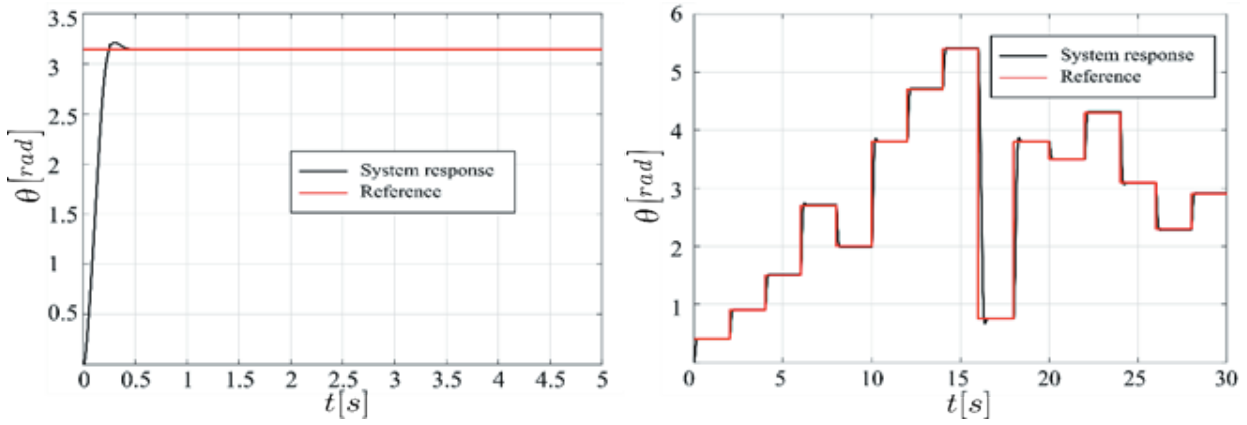

Figure 5 – Position tracking for constant and arbitrary signal with rapid changes as reference signals.

6. CONCLUSION

This paper is a continuation of the research [15], where the velocity of the load shaft of the DC motor is controlled by the FBL method, whose gains were optimized with the GWO algorithm. In this research, a nonlinear control technique was also utilized, but in order to control the load shaft's position of the DC motor. The introduction of Coulomb friction led to the development of a nonlinear mathematical model. Hyperbolic tangent was discovered as an approximation of the portion of the Stribeck friction curve and it was used as the function that represents nonlinearity. Afterward, the requirements for successfully implementing FBL were investigated and the theory of the GWO technique was provided. The fulfillment of the prerequisites for the synthesis of the control law with this technique has been summarized and supplied. Finally, the GWO optimization technique was employed to generate gains of the proposed FBL controller in the Matlab and Simulink environments, according to the IAE performance criterion. The results revealed that the proposed controller was capable of coping with the DC motor's nonlinearities. The desired output was followed by the plant response. Because the major purpose of this research was to get the DC motor to follow a particular position, it's crucial to note that this technique works for a variety of outputs. Provided control method might also be used to operate certain more complicated systems that employ this sort of engine. One interesting topic of future research may be optimization using alternative metaheuristic methods and comparing them.

7. ACKNOWLEDGEMENTS

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ON QUASI-CYCLIC CODES OF INDEX 1½

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Abstract:

Quasi-cyclic codes of index 1½ are considered in this paper. Our main aim is to show how we can obtain generator matrices of such codes. It should be emphasized that generator matrices are not uniquely determined. The method of obtaining generator matrices will be illustrated with examples.

Keywords:

A quasi-cyclic code; a circulant matrix; generator matrices of a code.

INTRODUCTION

In the introduction section of this paper we give some important definitions which are necessary for understanding the text. Suppose that F is a finite field (i.e. a field that have a finite number of elements). The examples of finite fields which are the most common in the literature are the rings $(Z_p, +_p, \bullet_p)$, where p is a prime number. Suppose that n is a natural number. A word (of length n) over F is any $(f_0, f_1, \ldots, f_{n-1})$, where $f_i \in F, i = 0, n-1$. A linear code (of length n) is any subspace C of F^n. If $dim(C)=r$ (i.e. $(c_{0,0},c_{0,1},\ldots c_{0,n-1})$, $(c_{1,0},c_{1,1},\ldots c_{1,n-1})$,...., $(c_{r-1,0},c_{r-1,1},\ldots c_{r-1,n-1})$ is a basis of a linear code C) then the following $r \times n$ matrix

$$\begin{bmatrix} c_{0,0} & c_{0,1} & \cdots & c_{0,n-1} \\ c_{1,0} & c_{1,1} & \cdots & c_{1,n-1} \\ \vdots & \vdots & \ddots & \vdots \\ c_{r-1,0} & c_{r-1,1} & \cdots & c_{r-1,n-1} \end{bmatrix} \quad (1)$$

is a generator matrix of a linear code C.

In the paper [1] the author proved that linear codes are asymptotically good.

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The question is:

"When we say that codes are asymptotically good? "

In order to give the answer to that question we need to define *the rate of C* (the symbol - R(C)) and the *relative minimum distance of C* (the symbol – Δ(C)). Namely,

$$R(C)=\frac{\dim(C)}{n} \quad \text{and} \quad \Delta(C)=\frac{d}{n} \tag{2}$$

where d is the minimum Hamming distance of C (an American mathematician *Richard Wesley Hamming*, 1915 - 1998). Before we continue, let us recall the following: *The Hamming distance* between $c=(c_0,c_1,\ldots,c_{n-1})\in C$ and $c'=(c'_0,c'_1,\ldots,c'_{n-1})\in C$ is the number of positions at which c and c' are different.

Example 1. (*The Hamming distance*) In this example we will determine the Hamming distance between

a) **00000** and **11111**. In this case the Hamming distance is 5;

b) 2564318 and 2769378. In this case the Hamming distance is 3;

c) tara and tama. In this case the Hamming distance is 1. ◊

If the sequence $C_1, C_2, \ldots$ of codes (of length $n_i, i=1,2,\ldots$, going to infinity) over the field F satisfies:

$$R(C_i) \text{ and } \Delta(C_i) \text{ are positively bounded from below} \tag{3}$$

then for such sequence of codes we say that it is a asymptotically good. If inside of some class of codes there exist asymptotically good sequences of codes then for such class of codes we say that it is a asymptotically good class of codes.

Suppose that Π_n is a permutation group on the index set $\{1,2,\ldots,n\}$ of coordinates of F^n. For a linear code C (in F^n) we say that it *is invariant* by the Π_n- action if : $\forall \pi\in\Pi_n$, $\forall c\in C,\ \pi(c)\in C$.

If $\Pi_n=\langle(12\ldots n)\rangle$ is a cyclic group generated by the cycle (12 ... n) and C is invariant by the Π_n- action (in F^n), then C is called *a cyclic code of length n.*

The answer to the question:

„Are the cyclic codes asymptotically good?" (4)

has not been given yet [2].

If $\Pi_n=\langle(12\ldots n)(n+1,n+2,\ldots,2n)\rangle$ is a cyclic group generated by the product of the corresponding two cycle (12 ... n) and (n+1, n+2,..., 2n) and C is invariant by the Π_n - action (in $F^n\times F^n$), then C is called *a quasi-cyclic code of index 2 and co-index n*.

Generaly, if Π_n is a permutation which is the product of m disjoint cycles of length n and C is invariant by the Π_n - action (in $\underbrace{F^n\times\cdots\times F^n}_{m}$), then C is called a *quasi-cyclic code of index m and co-index n.*

2. A QUASI-CYCLIC CODE OF INDEX $1\frac{1}{2}$

The product

$$F_{2n}[X]\times F_n[X] \tag{5}$$

is considered, where $F[X]/\langle x^n-1\rangle$ is denoted by $F_n[X]$ (i.e. $F[X]/\langle x^{2n}-1\rangle$ is denoted by $F_{2n}[X]$).

Each element of (5) is represented (uniquely) as $(g(x),g'(x))$, where

$$g(x)=\sum_{i=0}^{2n-1}g_ix^i \quad \text{and} \quad g'(x)=\sum_{j=0}^{n-1}g'_jx^j \tag{6}$$

and $g_i,g'_j\in F, i=\overline{0,2n-1}, j=\overline{0,n-1}$.

The element $(g(x),g'(x))$ can be identified with the word

$$(g_0,\ldots,g_{2n-2},g_{2n-1},g'_0,\ldots,g'_{n-1})\in F^{2n}\times F^n. \tag{7}$$

Suppose that π is a permutation of the coefficients of $F^{2n}\times F^n$ which is the product of 2 disjoint cycles of length $2n$ and n such that

$$\begin{aligned}&\pi(g_0,\ldots,g_{2n-2},g_{2n-1},g'_0,\ldots,g'_{n-2},g'_{n-1})=\\&(g_{2n-1},g_0,\ldots,g_{2n-2},g'_{n-1},g'_0,\ldots,g'_{n-2})\end{aligned} \tag{8}$$

Hence, the permutation π (on $F^{2n}\times F^n$) is corresponding to the operation by multiplying X (on $F_{2n}[X]\times F_n[X]$).

$$X(g(x),g'(x))=(Xg(x)(\mathrm{mod}\,x^{2n}-1),Xg'(x)(\mathrm{mod}\,x^n-1)) \tag{9}$$

If a linear subspace C of $F_{2n}[X]\times F_n[X]$ is invariant by the permutation π i.e.

$$\forall(g(x),g'(x))\in C \qquad X(g(x),g'(x))\in C \tag{10}$$

then C is *called a quasi-cyclic code over F of index* $1\frac{1}{2}$ *and co-index* $2n$.

The operation by multiplying X (on $F_{2n}[X]\times F_n[X]$). can be extended as follows:

For any $f(x)\in F[X]$ and any $(g(x),g'(x))\in F_{2n}[X]\times F_n[X]$

$$\begin{aligned}&f(x)(g(x),g'(x))=\\&(f(x)g(x)(\mathrm{mod}\,x^{2n}-1),f(x)g(x)(\mathrm{mod}\,x^n-1)).\end{aligned} \tag{11}$$

The previous operation can be abbreviated (on $F_{2n}[X]\times F_n[X]$) as follows:

$$f(x)(g(x),g'(x))=(f(x)g(x),f(x)g'(x)) \tag{12}$$

The product (5) is an $F_{2n}[X]$ - module and its $F_{2n}[X]$ - submodules are just the quasi-cyclic codes of index $1\frac{1}{2}$ and co-index $2n$. An $F_{2n}[X]$ - submodule of (5) is generated by at most two elements.

Let $(g(x),g'(x))$ be any element of the product (5), then the set

$$\{(f(x)g(x),f(x)g'(x))\in F_{2n}[X]\times F_n[X] \mid f(x)\in F_{2n}[X]\} \quad (13)$$

is a quasi-cyclic code of index $1\frac{1}{2}$ and co-index n generated by $(g(x),g'(x))$ and will be denoted by $C_{g(x),g'(x)}$.

We will deal with the following question:

How to get a generator matrix of $C_{g(x),g'(x)}$? (14)

The generator matrix of $C_{g(x),g'(x)}$ will be denoted by $\hat{G}[g(x),g'(x)]$.

Let

$$g(x)=g_0+g_1x+\ldots+g_{2n-1}x^{2n-1} \text{ and}$$
$$g'(x)=g'_0+g'_1x+\ldots+g'_{n-1}x^{n-1}. \quad (15)$$

Using the coefficients $g_i, i=\overline{0,2n-1}$ i.e. a word $(g_0,g_1,\ldots,g_{2n-1})$ (of length $2n$) and the coefficients $g'_j, j=\overline{0,n-1}$ i.e. a word $(g'_0,g'_1,\ldots,g'_{n-1})$ (of length n) the following matrices of the order $2n$ and n, respectively, are constructed:

$$G[g(x)]=\begin{bmatrix} g_0 & g_1 & \cdots & g_{2n-1} \\ g_{2n-1} & g_0 & \cdots & g_{2n-2} \\ \vdots & \vdots & \ddots & \vdots \\ g_1 & g_2 & \cdots & g_0 \end{bmatrix} \text{ and}$$

$$G'[g'(x)]=\begin{bmatrix} g'_0 & g'_1 & \cdots & g'_{n-1} \\ g'_{n-1} & g'_0 & \cdots & g'_{n-2} \\ \vdots & \vdots & \ddots & \vdots \\ g'_1 & g'_2 & \cdots & g'_0 \end{bmatrix}. \quad (16)$$

As we can see the matrices $G[(g(x)]$ and $G'[g'(x)]$ are constructed such that they have the following property: its *i*-th row is the right cyclic shift of its (*i* -1)-th row. The matrices with such property are called *circulant matrices.* We will single out just some of the most important information in relation to these matrices: 1. If A, B are circulant matrices then AB=BA; 2. If A is a circulant matrix A^{-1} then is also a circulant matrix. For more information about these matrices we suggest the following papers: [3] and [4]. Circulant matrices belong to the class of *Toeplitz matrices* (a German mathematician *Otto Toeplitz,* 1881-1940) which have the following form:

$$T=\begin{bmatrix} t_0 & t_1 & \cdots & t_{n-2} & t_{n-1} \\ t_{-1} & t_0 & \ddots & t_{n-3} & t_{n-2} \\ t_{-2} & t_{-1} & \ddots & \ddots & t_{n-3} \\ \vdots & \vdots & \ddots & \ddots & t_1 \\ t_{1-n} & t_{2-n} & \cdots & t_{-1} & t_0 \end{bmatrix} \quad (17)$$

Example 2. (The examples of Toeplitz matrices)

$$T_1=\begin{bmatrix} 1 & 8 & 0 & 2 & 4 \\ 5 & 1 & 8 & 0 & 2 \\ 3 & 5 & 1 & 8 & 0 \\ 7 & 3 & 5 & 1 & 8 \\ 9 & 7 & 3 & 5 & 1 \end{bmatrix} \text{ and } T_2=\begin{bmatrix} 1 & 3 & 0 & 2 & 4 \\ 4 & 1 & 3 & 0 & 2 \\ 2 & 4 & 1 & 3 & 0 \\ 0 & 2 & 4 & 1 & 3 \\ 3 & 0 & 2 & 4 & 1 \end{bmatrix}. \Diamond \quad (18)$$

More information about Toeplitz matrices can be found in [5], [6] and [7].

Using the matrices (16) the following $2n\times 3n$ matrix is constructed:

$$G[g(x),g'(x)]=\begin{bmatrix} g_0 & g_1 & \cdots & g_{2n-1} & g'_0 & g'_1 & \cdots & g'_{n-1} \\ g_{2n-1} & g_0 & \cdots & g_{2n-2} & g'_{n-1} & g'_0 & \cdots & g'_{n-2} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ g_{n+1} & g_{n+2} & \cdots & g_n & g'_1 & g'_2 & \cdots & g'_0 \\ g_n & g_{n+1} & \cdots & g_{n-1} & g'_0 & g'_1 & \cdots & g'_{n-1} \\ g_{n-1} & g_n & \cdots & g_{n-2} & g'_{n-1} & g'_0 & \cdots & g'_{n-2} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ g_1 & g_2 & \cdots & g_0 & g'_1 & g'_2 & \cdots & g'_0 \end{bmatrix}. \quad (19)$$

Namely, it is easy to see that:

$$C_{g(x),g'(x)}=\{(f_0,f_1,\ldots,f_{2n-1})G[g(x),g'(x)] \mid (f_0,f_1,\ldots,f_{2n-1})\in F^{2n}\}. \quad (20)$$

The matrix (19) does not have to be a generator matrix of $C_{g(x),g'(x)}$ because its rank does not have to be equal to *2n*. In order to give the answer to the question (14) we need the following theorem presented and proved in the paper [8] by *Y. Fan and H. Liu.*

Theorem 1. (Theorem 2.4. [8]) Suppose that the polynomials $p_{g(x),g'(x)}(x)$ and $r_{g(x),g'(x)}(x)$, for any, $(g(x),g'(x))\in F_{2n}[X]\times F_n[X]$ are defined as follows:

$$p_{g(x),g'(x)}(x)=\gcd(g(x),x^n+1)\cdot\gcd(g(x),g'(x),x^n-1) \text{ and}$$
$$r_{g(x),g'(x)}(x)=\frac{x^{2n}-1}{p_{g(x),g'(x)}(x)}. \quad (21)$$

Then, $(g(x),g'(x))$ induces an $F_{2n}[X]$ -homomorphism $h_{g(x),g'(x)}: F_{2n}[X]\to F_{2n}[X]\times F_n[X]$ such that:

$$f(x)\xrightarrow{h_{g(x),g'(x)}}(f(x)g(x),f(x)g'(x)) \quad (22)$$

and

$$Ker(h_{g(x),g'(x)})=\left\langle r_{g(x),g'(x)}(x)\right\rangle_{F_{2n}[x]} \quad (23)$$

i.e.

$$\dim(C_{g(x),g'(x)})=\deg(r_{g(x),g'(x)}(x)) \quad (24)$$

Proof.

Namely,

$$q(x)\in Ker\left(h_{g(x),g'(x)}\right)$$

if and only if

$$q(x)g(x) \equiv 0 \,(\mathrm{mod}\, x^{2n}-1) \text{ and } q(x)g'(x) \equiv 0 \,(\mathrm{mod}\, x^{n}-1)$$

if and only if

$$q(x)g'(x) \equiv 0 \,(\mathrm{mod}\, x^{n}+1),\ q(x)g'(x) \equiv 0 \,(\mathrm{mod}\, x^{n}-1)$$

and $q(x)g'(x) \equiv 0 \,(\mathrm{mod}\, x^{n}-1)$

If and only if

$$q(x)g(x) \equiv 0 \,(\mathrm{mod}\, x^{n}+1) \text{ and}$$
$$q(x)\gcd(g(x), g'(x)) \equiv 0 \,(\mathrm{mod}\, x^{n}-1)$$

if and only if

$$q(x) \equiv 0 \ (\mathrm{mod}\frac{x^{n}+1}{\gcd(g(x), x^{n}+1)}) \text{ and}$$
$$q(x) \equiv 0 \ (\mathrm{mod}\frac{x^{n}-1}{\gcd(g(x), g(x), x^{n}-1)})$$

if and only if

$$q(x) \equiv 0 \ (\mathrm{mod}\frac{x^{n}+1}{\gcd(g(x), x^{n}+1)} \cdot \frac{x^{n}-1}{\gcd(g(x), g'(x), x^{n}-1)})$$

i.e.

$$q(x) \in \left\langle r_{g(x),g'(x)}(x) \right\rangle_{F_{2n}[x]}$$

Especially,

$$\dim(C_{g(x),g'(x)}) = \dim(F_{2n}[X]) - \dim(Ker(h_{g(x),g'(x)}))$$
$$= 2n - \deg(p_{g(x),g'(x)}(x)) = \deg(r_{g(x),g'(x)}(x)) \,.\ \blacklozenge$$

Finally, we shall give the two examples and in these examples we shall illustrate the method of obtaining a generator matrix of $C_{g(x),g'(x)}$.

Example 3. Let $n=2$, $F=(Z_2, +_2, \bullet_2)$, $g(x)=1+x^3$ and $g'(x)=x$.

Then,

$$C[1+x^3] = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 \end{bmatrix} \text{ and } C'[x] = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \quad (25)$$

i.e.

$$C[1+x^3, x] = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 \\ 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}. \quad (26)$$

Since,

$$p_{1+x^3,x}(x) = \gcd(1+x^3, x^2+1) \cdot \gcd(1+x^3, x, x^2-1) = 1$$

and

$$r_{1+x^3,x}(x) = \frac{x^4-1}{p_{1+x^3,x}(x)} = \frac{x^4-1}{1} = x^4-1 \,,$$

based on Theorem 1, it follows that

$$\dim(C_{1+x^3,x}) = \deg(r_{1+x^3,x}(x)) = 4 \quad (27)$$

i.e. the generator matrix of $C_{1+x^3,x}$ is equal to the matrix (26). ◊

Example 4. Let $n=2$, $F=(Z_3, +_3, \bullet_3)$, $g(x)=1+x+x^2+x^3$ and $g'(x)=2+x$.

Then,

$$C[1+x+x^2+x^3] = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix} \text{ and } C'[2+x] = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \quad (28)$$

i.e.

$$C[1+x+x^2+x^3, 2+x] = \begin{bmatrix} 1 & 1 & 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 1 & 1 & 2 \\ 1 & 1 & 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 1 & 1 & 2 \end{bmatrix}. \quad (29)$$

Since,

$$p_{1+x+x^2+x^3,2+x}(x) = \gcd(1+x+x^2+x^3, x^2+1) \cdot$$
$$\gcd(1+x+x^2+x^3, 2+x, x^2-1) = x^2+1$$

and

$$r_{1+x+x^2+x^3,2+x}(x) = \frac{x^4-1}{p_{1+x+x^2+x^3,2+x}(x)} = \frac{x^4-1}{x^2+1} = x^2-1 \,,$$

based on Theorem 1, it follows that

$$\dim(C_{1+x+x^2+x^3,2+x}) = \deg(r_{1+x+x^2+x^3,2+x}(x)) = 2$$

i.e. the generator matrix of $C_{1+x+x^2+x^3,2+x}$ is

$$\hat{C}[1+x+x^2+x^3, 2+x] = \begin{bmatrix} 1 & 1 & 1 & 1 & 2 & 1 \\ 1 & 1 & 1 & 1 & 1 & 2 \end{bmatrix}. \lozenge \quad (30)$$

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POINT OBJECT EXTRACTION FROM SCANNED TOPOGRAPHIC MAPS FOR THE DIGITAL TOPOGRAPHIC MAPS PRODUCTION

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Abstract:

Topographic maps published by the Military Geographical Institute are an important cartographic source in the process of creating a digital topographic map in the scale of 1:25 000. Existing topographic maps are scanned and georeferenced, but vectorization of the required content from these maps is done manually, which requires a lot of time. The homogeneity of cartographic content gives the potential for the application of algorithms for automatic vectorization of geospatial data. This paper presents a tool programmed in the Python programming language that extracts point symbol - well objects (as a hydrographic object) from a georeferenced map, by identifying objects based on assigned samples and generating vector point spatial data. Recognition is performed on a processed input raster containing only shades of blue. The output data are the geographical coordinates of the identified objects and the initial raster with markings at the places where the objects are recognized. 1074 wells on 24 map sheets in the wider area of Novi Sad and Zrenjanin were generated. Proposed Points from Corner method showed satisfactory positional accuracy results.

Keywords:

Object Detection, Automatic Vectorization, Template Matching, Scanned Maps Processing, Computer Vision.

INTRODUCTION

Topographic maps are very important and extensive sources of data. Topographic maps from the period of the second half of the 20th century published by the Military Geographical Institute in Belgrade (hereinafter MGI) represent a very recognizable project of this institution. By switching to the digital system of work, all existing maps in the MGI edition were scanned and georeferenced in order to be used as a cartographic source when performing works on the production of digital geotopographic materials. Manual digitization, which is still mostly done in such and similar examples, requires a lot of effort as well as a lot of time. Therefore, the development of tools for automatic recognition of spatial objects, i.e. information and vectorization of cartographic content is very necessary [1]. Processing of rasters obtained by scanning analog

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topographic contents would be very important because the obtained results would be reflected in more optimal and faster production of digital topographic map in the scale of 1:25 000 (hereinafter DTM25) which is currently the main MGI project. In addition, spatial data on older editions of topographic maps could be searched in much more useful ways [2] therefore in the context of map elements that can be related to today's similar elements (political and administrative borders, river flows, etc.) and elements in the same geographical locations. On the other hand, as stated in [3] raster data is "unintelligent" and any information is only pixel-related. Also, according to [3] objects, contours, lines and symbols are heavily fragmented by the raster, the information of geometric and topological features is mainly lost, reduced or summarized to the raster-compatible information, and between the pixels there is no other geometric and topological relation than the neighborhood from one pixel to the other in certain discrete directions of the raster table. In raster data we cannot recognize objects directly, and we must compare pixels which are standing together, and similar information among these pixels provides segments that may be interpreted as one object [3].

The idea of this paper is to present the possibility of automatic recognition and vectorization of wells as a hydrographic object from the second updated edition of the topographic map in the scale of 1:25 000 (hereinafter TM25) which represents condition from the year of 1968. Map sheets from the wider regions of the cities of Novi Sad and Zrenjanin were processed, from which 1074 wells were detected and generated in the vector point data. The *Points from Corner* method for determining the geographical coordinates of identified objects has been proposed, which has shown potential for other different applications, such as e.g. the process of automatic georeferencing of a scanned topographic map. The possibility has been shown that the created tool is additionally autonomously developed and improved in the direction of further needs of the Institution. Existing software for similar purposes was a model for the development of this tool.

2. TM25 AS A SECONDARY CARTOGRAPHIC SOURCE IN THE PROCESS OF MAKING DTM25

The main activity of MGI is the production of digital topographic map in the scale of 1:25 000. After the Second World War, the map has gone through three editions, while the fourth edition is currently in making, which differs from the previous ones in that the new technological environment is designed so that the entire production process takes place in a central database environment.The condition for making each map is the possession of cartographic sources that allow obtaining the necessary geographical data on the territory of mapping [4]. The main source of the data acquisition in the central database are data obtained by the digital technological process for aero photogrammetric imaging in the MGI [5]. In addition, earlier releases of TM25 have found their application as secondary data sources for content creation on DTM25. In the period from 2002 to 2004, the TM25 was digitized by scanning map sheets. After scanning, georeferencing was performed in the national coordinate system within the seventh zone of the Gauss-Krieger projection (creation of * .tif and * .tfw files), and later in the UTM coordinate system [6]. Geographical elements are the most important part of a topographic map. They make up the basic - geographical content of the map. In cartography, hydrography is a collective term for all waters and objects that have water as an integral part. As a very important element of the content of each topographic map, it influences the development of other geographical elements, reliefs, plants, settlements, communications, etc. It is a kind of basis for displaying other elements of content. In the process of making DTM25, it is applied first and the accuracy of application is taken into account [4].

Interpretation and presentation of geographical elements on topographic maps is a required and narrowly specialized procedure. Aerial photogrammetric images are used as the primary data source in the process of making DTM25. Data processing is mainly carried out through the phases of 3D and 2D restitution. Through the 3D restitution phase, content is created and stored in a central database. Thereafter, DTM25 goes through a 2D restitution phase. The 2D restitution introduces the cartographic modeling of the content obtained by 3D restitution method and the additional content which was not treated in the 3D restitution process [5]. At this stage of processing, previous releases of TM25 are often used as a secondary data source. The main reason for this is the dilemmas in the process of interpreting aerial photogrammetric images as a cartographic source. There may be a dilemma as to what an object or phenomenon represents in the field. One of the cases, as practice shows, is that, due to the vegetation cover, certain objects and phenomena on the aerial photo cannot be identified and classified with certainty. These can be rivers that do not have a large width, occasional watercourses that, during the summer months, usually do not

have water, paths and roads through the forest, certain objects, especially lower altitudes, including wells. Also, the large number of facilities and supporting infrastructure in densely populated areas can make it difficult to spot facilities of public importance and other phenomena that have priority on the map. In such cases, and in order to resolve existing dilemmas, the interpretation of content from previous editions of TM25 can be used to solve the problem.

2.1. TOPOGRAPHIC SIGN OF WELLS ON TM25 AND DTM25

Topographic signs are conditioned and most often established graphic signs (symbols) for displaying, recognizing and determining the qualitative and quantitative characteristics of objects, phenomena and other facts on topographic maps and related geographical maps. The shape or some detail of the internal structure of a drawing usually resemblesthe objects it depicts [7]. Due to its relatively small dimensions, the well cannot be represented on the scale of the map. Therefore, it is given a dotted topographic symbol, which does not show the dimensions of objects in nature, but only their position. As the well is a topographic sign in the shape of a circle ( ), the exact position of the displayed object is determined by the main point of the sign which is located in the middle of the respective image. The topographic symbol of the well created for the logical data model for DTM25, remained unchanged compared to the previous version of the topographic key analog TM25 so that when displaying the well on DTM25 the vector center coincides with the center of the well symbol.

2.2. VECTORIZATION OF WELLS

Wells are classified as drinking water facilities. In addition to the general importance, when they are outside the settlement, they are important means of orientation. The well is shown if it is arranged and has visible aboveground features. In places where the population grows vegetables, so there are more wells, only a few signs are displayed to convey the character of the phenomenon [8]. Where the land is rich in water, wells are mostly shown outside the settlement, while on arid land, on a large map, every well is shown. On multicolor maps, they are shown in blue [4]. Due to the size of the well and the fact that they are often surrounded by other objects in the farm or vegetation, their observation on aerial photographs often challenges even the most experienced performers and requires them to greatly enlarge the image when inspecting the terrain, unnecessary for most content. It takes time, because due to the increase in view, a smaller part of the space is viewed. Therefore, in practice, they are first found on TM25, after which, on the aerial photogrammetric image, special attention is paid to the space where the sign is located on TM25. In this way, the executors are directed to expect the appearance of wells in that area. Finding a well on the TM25 can also be a problem, especially on maps that show a part of the terrain that is loaded withcartographic content. The symbol of the well is small, so here again the executor must enlarge the raster map while working in GIS, again seeing less space and spending more time. TM25 sheets can contain hundreds of wells.

3. METHODOLOGY OF WORK

Our method for generating spatial data of interest - well symbols on the map (Well Generator Tool) is implemented in the Python programming language, using the openCV library. The method works by having a scanned and georeferenced topographic map 1:25 000 as input and raster samples of well signs extracted from the map, and as output the initial raster of the scanned map is generated which contains markers where wells are located and a file in * .csv format in the form of a table with the geographical coordinates of the located wells which are later used to create vector data (Figure 1).

Applications of similar algorithms on historical maps whose appearance varies from drawing style are much more complex because it is much more difficult to apply one type of algorithm for different types of maps [2]. However, the mentioned topographic maps are homogeneous in their structure, and the process of their production is characterized as standardized. This allows the application of the described methodology on numerous map sheets of this edition with very little user effort. As stated in [9], for homogeneous and large cartographic content (which TM25 is) it is possible to achieve excellent results with algorithms for computer vision, but their application is very specific because it is based on detailed knowledge of the content and construction of the map which implies the potential of such a model. The model is assigned raster samples of well symbols, without its wider environment, taken from the map in the original resolution (Figure 2).

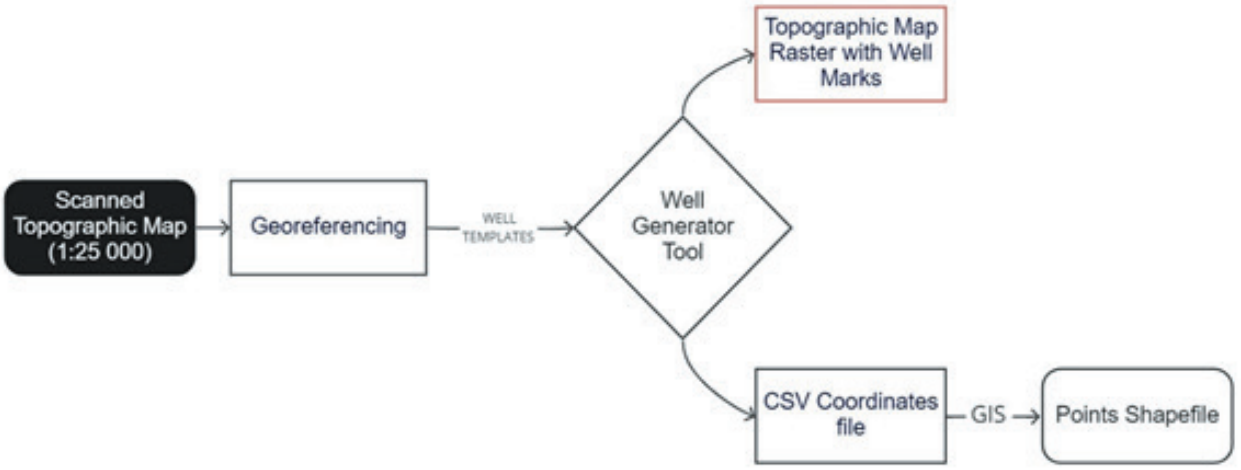

Figure 1 – Workflow.

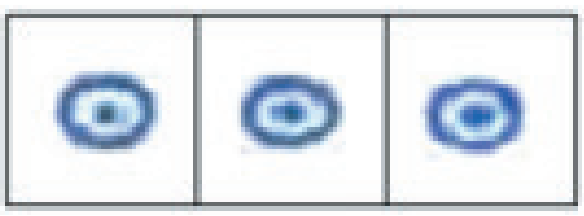

Figure 2 – Well templates.

The output raster represents an existing scanned map with added labels showing the detected object of interest, as shown in Figure 3. Detection of the object of interest is enabled using image processing techniques, the most important of which is the *imageTemplate* function from the openCV library. Detection is performed over a raster version that contains only cartographic content in blue. As the raster of the same resolution is processed, the obtained information on the location of the identified object is only applied to the input raster. The knowledge base of the template matching strategies is the template itself, which is given as pre-information. During the matching process, the template is matched with raster image samples [3]. In its simple form, a given pattern is sought in an image, typically by scanning the image and evaluating a similarity measure between the pattern and every image window [10].

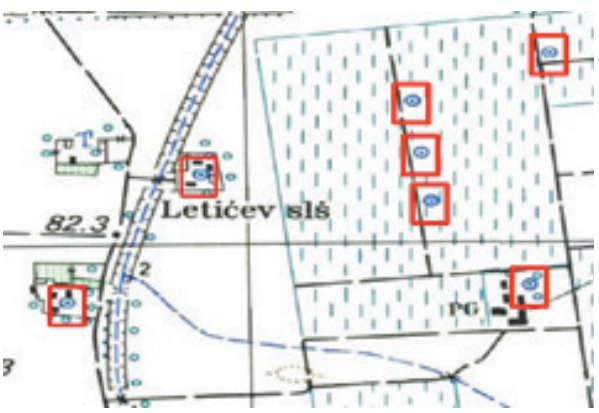

Figure 3 – Raster output with well marks.

A threshold value was introduced as the recognition limit, which defines how much the minimum match of the part of the input raster with the sample is enough for the object to become identified. Unlike the approach in [9] and in accordance with the nature of the input data, the selection of empirically determined unique threshold values with respect to map homogeneity shows good results in practice, but high accuracy results could be achieved by applying techniques to form an adequate individual threshold value.

3.1. CALCULATION OF GEOGRAPHICAL COORDINATES OF IDENTIFIED OBJECTS

The calculation of geographical coordinates was performed according to the cartographic projection of the map that uses Greenwich as the initial meridian on the Bessel ellipsoid.

The generating of geographical coordinates was done by first identifying the top left cartographic content point, i.e. point with known geographical coordinates. By identifying the point, its pictorial coordinates were also obtained. It was identified in relation to the nearest corner of the outer frame of the map, which was sampled in the same way as the symbol of the well (Figure 4, marked with 1), so the empirical approach led to the mentioned point (Figure 4, marked with 2). How the outer frame of the map sheet was created according to the sample from the map program when creating the topographic map 1:25 000 [4], each of the sheets has an external frame created in the same way, so the assumption was that the starting point empirically determined on one map sheet can be applied to all input map sheets, which proved to be relevant. This method *Points from Corner* was also used to calculate other parameters.

Another important component in the mathematical model for calculating the geographical coordinates of wells concerns the determination of the values of longitude and latitude according to the value of one pixel. As the territory is shown on the map in the format of 7°30' latitude difference and 7°30'of longitude difference, the pictorial distances of the map sheet frame were determined, and the mentioned values were obtained based on the proportion. The image distances of the map sheet frame are different for each sheet by longitude, so this component was calculated separately based on the differences between the pixel coordinates of the starting (Figure 3, marked with 3) and ending points of the scale (Figure 3, marked with 4) located by *Points fromCorner*. After that, local pixel coordinates were obtained by subtracting the image coordinates of the top left point from the image coordinates of the identified object (equations 1 and 2). Multiplying local pixel coordinates with a value of one pixel in longitude and latitude yielded local geographical coordinates (equations 3 and 4), which were added together with the geographical coordinates of the starting point of the map content to give the total values of latitude and longitude coordinates (equations 5 and 6). The equations are shown below.

As multiple well samples were used for identification, the total score would represent the union of the results obtained with each sample. This would lead to the well symbol appearing multiple times in the results. Such a phenomenon is neutralized by processing a set of results and throwing out close and the same pairs of values of geographical coordinates.

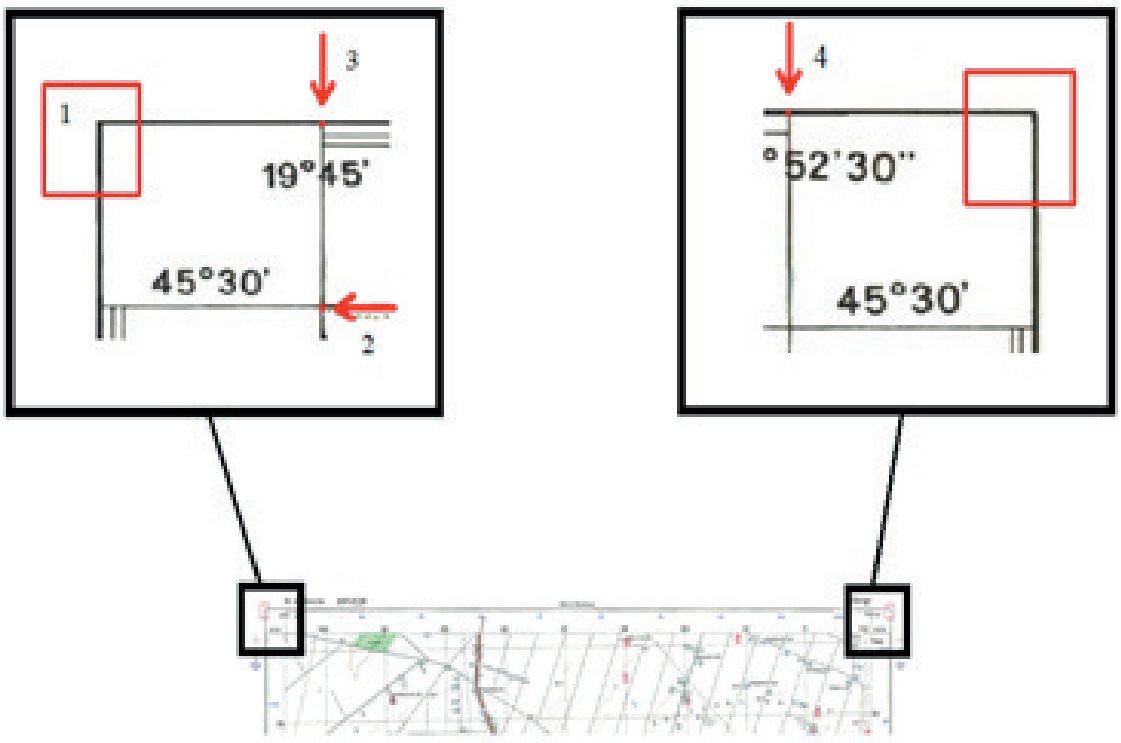

Figure 4 – Map corner with key elements.

$$Object\ pixel\ coordinate_X - Starting\ point\ pixel\ coordinate_X = Local\ object\ pixel\ coordinate_X \quad (1)$$

$$Object\ pixel\ coordinate_Y - Starting\ point\ pixel\ coordinate_Y = Local\ object\ pixel\ coordinate_Y \quad (2)$$

$$Longitude\ pixel\ increment \cdot Local\ object\ pixel\ coordinate_X = \Delta\lambda \quad (3)$$

$$Latitude\ pixel\ increment \cdot Local\ object\ pixel\ coordinate_Y = \Delta\varphi \quad (4)$$

$$\lambda_0 + \Delta\lambda = \lambda \quad (5)$$

$$\varphi_0 + \Delta\varphi = \varphi \quad (6)$$

4. RESULTS AND DISCUSSION

4.1. DATA USED

The demonstrated methodology was applied on a sample of 24 map sheets of topographic map in the scale of 1:25 000. The sheets refer to the territories of South Bačkacounty in the wider region of Novi Sad (8 sheets) and Central Banatcounty in the wider region of Zrenjanin (16 sheets) and together form a whole of 6 neighboring map sheets in 4 rows. The scanned maps image's resolution is about 6700x6600 pixels and 96 dpi.

4.2. SAMPLE RECOGNITION RESULTS

All experiments presented in this paper were performed on a desktop computer. The entire process and data generation takes about 20 seconds per map sheet. The results are shown in Table 1. The results are shown as the percentage of wells detected in relation to the total number of wells on the map, the percentage of false-positive detections representing false results in relation to the number of identified objects and the percentage of undetected wells in the map number of wells. The part of the table above the dashed line represents the map sheets that refer to the wider region of Novi Sad, while the part below the dashed line refers to the wider region of Zrenjanin. The percentage of detected wells varies from sheet to sheet, but when you look at the results shown, you can see that 83.91% of the total number of wells was recognized. Attention should also be paid to the appearance of false positive results, i.e. results that are recognized as a well, and on the map actually represent another phenomenon or object. As color preprocessing resulted in cartographic content that is only blue, objects resembling a well or represented by a symbol having the same geometry, but a different color were not detected as false-positive results.

Some of such examples are a symbol for a lighthouse ( ), leveling point ( ), church as a trigonometer ( ) and sinkholes ( ). However, even after the contents of the blue color were separated, certain symbols remained, which were noticed to appear more often than others as false results. These are symbols for a source of less bounty ( ) and fountain symbol ( ) which, in addition to being the same color as the symbol of the well, geometrically resemble it. The table also shows that the number of false results also varies from sheet to sheet, and that there are sheets on which they do not appear. Such results can be obtained for each sheet individually, but this would mean that before releasing each sheet for processing, the threshold value that would give the best result for a particular sheet should be redefined. However, as the goal here was primarily to speed up DTM25 production by processing many sheets in a short time, a unique value was taken for the recognition limit, which proved to be very good on some map sheets, and excellent on some.

In addition to symbols that are the same or similar to the well symbol, the results are corrupted by cases in which there is an overlap between a symbol and a well symbol. The number of such cases is not small, and those in which wells and isohypses overlap, wells and edges of a polygon, wells and road symbols, wells and fence symbols, etc. can be singled out as frequent. Many of these situations are resolved by color preprocessing. Also, there are other situations in which the well coincides with other hydrographic content, but their number is insignificant.

4.3. POSITIONAL ACCURACY OF GENERATED POINT VECTOR DATA

The ArcGIS software package is the most common software in the process of creating DTM25 on MGI, so the final result was generated as vector data in Shapefile format. The data loaded into the ArcMap software within the mentioned package over the initially georeferenced

Map sheet nomenclature	Map sheet name	Detected wells on the map sheet (%)	False-positive detections (%)	Undetected wells on the map sheet (%)
378-2-1	Sirig	86.02	5.88	13.98
378-2-2	Temerin	94.74	8.47	5.26
378-2-3	Novi Sad - sever	89.66	11.86	10.34
378-2-4	Kać	69.05	3.33	30.95
378-4-1	Novi Sad - jug	58.00	29.27	42.00
378-4-2	Sremski Karlovci	78.87	29.11	21.13
378-4-3	Ruma	97.22	39.66	2.78
378-4-4	Krušedol	76.19	30.43	23.81
379-1-1	Čurug	89.00	1.11	11.00
379-1-2	Taraš	88.51	15.38	11.49
379-1-3	Đurđevo	73.24	0.00	26.76
379-1-4	Mošorin	94.32	9.78	5.68
379-2-1	Elemir	95.65	8.33	4.35
379-2-2	Zrenjanin - sever	73.68	0.00	26.32
379-2-3	Deonica	93.06	10.67	6.94
379-2-4	Zrenjanin - jug	77.78	36.36	22.22
379-3-1	Kovilj	62.50	35.48	35.70
379-3-2	Krčedin	74.19	13.21	25.81
379-3-3	Inđija	83.05	3.92	16.95
379-3-4	Novi Karlovci	98.11	20.00	1.89
379-4-1	Titel	89.23	18.31	10.77
379-4-2	Perlez	89.13	8.89	10.87
379-4-3	Surduk	60.98	13.76	39.02
379-4-4	Opovo	87.50	33.33	12.50
		83. 91	**14.76**	**16.09**

Table 1 – Detection results.

topographic maps show that the positional accuracy of the obtained results is satisfactory. Table 2 shows a coordinates comparison of manually mapped wells with the wells obtained as a result from the same source.

5. CONCLUSION

The paper focuses on the detection of a certain element of cartographic content from a georeferenced raster, and we have introduced a practical approach to solving this problem. This paved the way for mass extraction of data from scanned maps in MGI as a great cultural-historical and information heritage. Progress has been made in understanding the problem of identifying and extracting objects from a map, both on one sheet and on a larger group of mapsheets. The results showed a kind of instability on the whole group of mapsheets, while the method, applied especially for an individual sheet, proved to be very good. The above, but also the experience gained from this project led to the following concluding theses:

- The application of deep learning algorithms would significantly contribute to the improvement of results on the entire sample of input

data, primarily in order to determine the appropriate threshold values for each map sheet individually;

- Preprocessing of the input raster by passing colors of interest significantly contributes to a higher rate of object identification and reducing the occurrence of false-positive results from other thematic units of cartographic content, especially when it comes to symbols similar to the well symbol;
- The *Points from Corner* method proved to be relevant for determining the geographical coordinates of identified objects, which shows the high positional accuracy of the obtained vector data in relation to the georeferenced raster data, but also showed the potential for other different applications and
- Homogeneous cartographic content of input data shows eligibility for usage of automatic vectorization algorithms.

Guidelines for future work would be improving the tools according to the concluding theses, first in order to reduce the number of false-positive results, and then to reduce the number of unidentified objects. Optimizing program code for faster processing is something to look out for in the future. Directly generating geographic coordinates would be one of those steps, although the *Points from Corner* method has shown good results, it is complex. It is necessary to consider the possibility of applying other ways of computer vision to identify objects processed in [11]. Although the proposed method can speed up the vectorization, it is not fully automatic and requires user input, which is reflected in the manual sample selection which may have an impact on the proposed method application.

This would not be practical if we wanted to vectorize all types of point objects [12]. Future work could be focused on the complete automation of the project, as well as on solving the previously mentioned.

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Extracted data (°)		**Manual vectorization** (°)		Δ(°)		Δ(")	
Longitude	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude
19.78221	45.39781	19.78225	45.39782	0.000039	0.000015	0.140	0.054
19.78523	45.40073	19.78525	45.40072	0.000023	-0.000007	0.083	-0.025
19.79002	45.40238	19.79004	45.40239	0.000023	0.000006	0.083	0.022
19.79020	45.40121	19.79024	45.40122	0.000039	0.000010	0.140	0.036
19.79043	45.40013	19.79047	45.40013	0.000039	0.000001	0.140	0.004
19.79269	45.39822	19.79269	45.39824	0.000003	0.000021	0.011	0.076
19.79313	45.40349	19.79314	45.40349	0.000015	0.000001	0.054	0.004

Table 2 – Positional accuracy of extracted point objects (Figure 3 map extent – 7 objects).

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PREDICTION OF GOLD PRICE MOVEMENT CONSIDERING THE NUMBER OF INFECTED WITH THE COVID 19

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Abstract:

The beginning of the health and economic crisis caused by the appearance of the new Covid-19 virus showed us that, in the perception of investors, gold is still highly valued as a guardian of value. This paper aims to test several models and select the best one for predicting the price of gold on the world market for the next day, in five and ten days, taking into account the number of cases and deaths from the Covid-19 virus. We believe that predictions with Covid-19 parameters give more accurate results than predictions that take only historical gold prices as information. These predictions can help decision-makers whether, at what point, and in what amount, it is best to invest in gold and gold-related financial instruments, relative to the projected price of gold from the model. The paper tests models called Decision tree, K-nearest neighbours, Linear regression model, and Support vector machine based on the information on gold prices and the number of cases and deaths from the Covid-19 virus. It will be seen in the paper that even models with only information on the price of gold give quite reliable predictions, but in unstable times like this, models that take into account the instability factor give more accurate predictions. The research is aiming to determine the optimal amount of information on which the models will "learn" to give the most accurate possible result. This work's data processing and models are done in the Python programming language.

Keywords:

Gold price, COVID 19, Decision tree, K-nearest neighbours, Linear regression model, Support vector machine.

INTRODUCTION

Throughout the history and development of economic systems, various goods and materials have played the role of money. At the time of barter, goods were exchanged for goods, later it was possible to exchange goods of greater value for more goods of lesser value. Eventually, a system was established where one type of goods became the general equivalent of payment, accepted by all participants. For a large part of history, the function of money was performed by gold. That gold was in the form of coins of precisely determined quality, shape and weight, and in return, it was assigned a value. Of course, bigger, heavier coins, with higher purity had a higher value and thus in return, they could get larger quantities of goods and services.

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Gold has always been considered a custodian of value and its basic function is to preserve purchasing power in times of great uncertainty. In the last few years, we have been experiencing a period of great uncertainty regarding the health situation, which further leads to uncertainty in the financial, market of goods and services, as well as in all other fields. A new virus called SARS-CoV-2 has appeared in 2019 in China as an infectious disease caused by severe acute respiratory syndrome. The World Health Organization (WHO) has declared the Coronavirus outbreak of 2019/20 a pandemic and public health threat of international importance. Evidence of local disease transmission has been found in several countries, in all six WHO regions.

Although the death rate from the virus was quite low at the very beginning, it is increasing over time, and the number of patients is growing. A pandemic was soon declared and thus began instability in the financial, but also in all other markets. This is best seen through the significant jump in the price of gold. Yousef and Shehadeh [1] explain this situation quite well, where they prove that there is a correlation between the number of patients and the jump in the value of the price of gold. That is why the research problem in this paper is the prediction of the price of gold in conditions of uncertainty, such as the appearance of the COVID-19 virus pandemic. There are many methods in the literature that make predictions of the price of gold based on historical data. These methods, although effective, lose precision when major market disruptions occur. Therefore, the topic of this paper is to prove that such models have less accuracy than models that include historical data on the cause of market disruptions, which in this case is a pandemic of the COVID-19 virus. This paper starts from the assumption that investors need to be able to follow the trend of gold prices, and this paper relatively accurately (over 90% accuracy) follows models that give predictions for tomorrow, five days, and ten days in the future. In this way, investors can determine at what point and in what amount they can invest and thus get the most value. Also, this kind of research helps those who operate in short-term markets like the Forex market where things change quickly. Such analyses can help them make the greatest possible profit in the shortest possible time. Predictions are of great importance for financial decision-makers. The data within the models used in this paper can easily be replaced by data on any other financial instrument in the event of any similar crisis that will almost certainly occur in the future. We believe that this is the greatest contribution of this paper.

2. BACKGROUND AND LITERATURE REVIEW

Concerning the importance of the gold price in the overall economic environment, predicting the price of gold is very significant, and different studies and models have been used for this purpose. In some eminent research, classical econometric methods were used for this prediction [2] [3]. Different techniques for the gold price prediction, were used and although various models give very good results, the ARIMA (autoregressive integrated moving average) model is the most precise of all traditional statistical models [4] [5] and it is good to use a sliding dataset for the prediction [6]. By comparing the models on the same data set for profit prediction it can be concluded that the choice of the dataset is very important and that parameters unrelated to gold can help in a better prediction [7].

In some prominent research, the artificial neural network model has been used for modeling the gold price and compared with the traditional statistical model of ARIMA. The three performance measures, the coefficient of determination (R2), root mean squared error (RMSE), meaand n absolute error (MAE), are utilized to evaluate the performances of different models developed. The results show that the ANN model outperforms the ARIMA model, in terms of different performance criteria during the training and validation phases [8] [9].

Machine learning has often been applied to the prediction of financial variables, but usually with a focus on stock prediction rather than commodities [10]. The application of machine learning in trading with financial instruments has shown very good results [11] as well as predicting gold price direction [12] especially by using a decision tree algorithm and support vector [13].

3. DATA

The time frame of the data set is dictated by the COVID-19 data set frame. Virus data and gold data are merged into one data set. For the models to be able to predict such a union of data, all N / A values have been dropped, and data on the value of gold will start at the beginning of 2020, which is from the first of January. Also, the stock exchanges are closed from Friday from 4 pm to Monday at 8 am, and there is no weekend information.

A set of data containing information about gold was used from the Python library Yahoo! Finance. The following values were taken directly for prediction:

- Close - the value indicates the final price of gold on the stock exchange for a given day.
- High - the highest daily price of gold.
- Low - the lowest daily price of gold.
- Volume - daily turnover, number of transactions for a given day.

Based on the close value, two columns were added, which represent the average price of gold in the previous three and nine days. This way of creating a model is based on the idea of Shah and Pachanekar [14]. This way of processing data is called moving average, it is good for predictions of any period and it is very easy to present graphically. When we take into account 3 days, this method is called simple moving average and is used as a significant indicator among brokers because it gives equal importance to all three prices and thus shows the price trend.

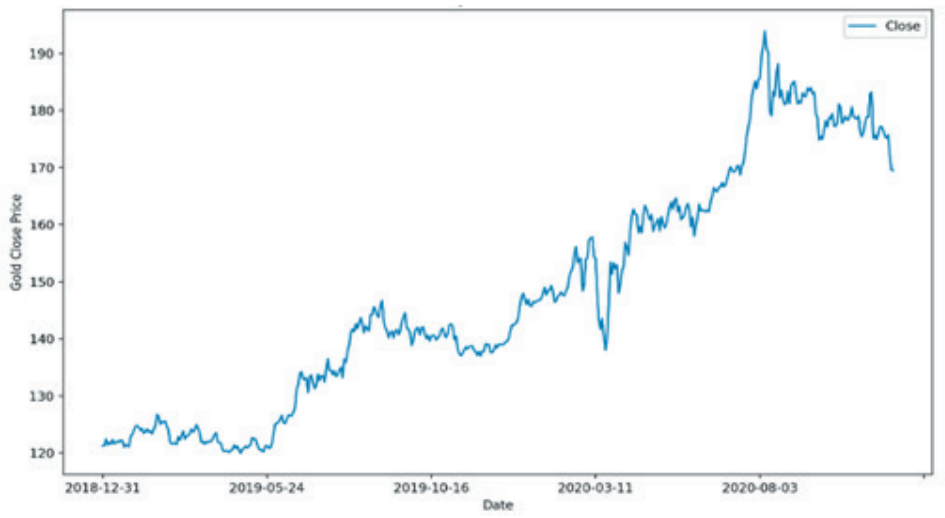

Figure 1 – Gold price from the beginning of 2020

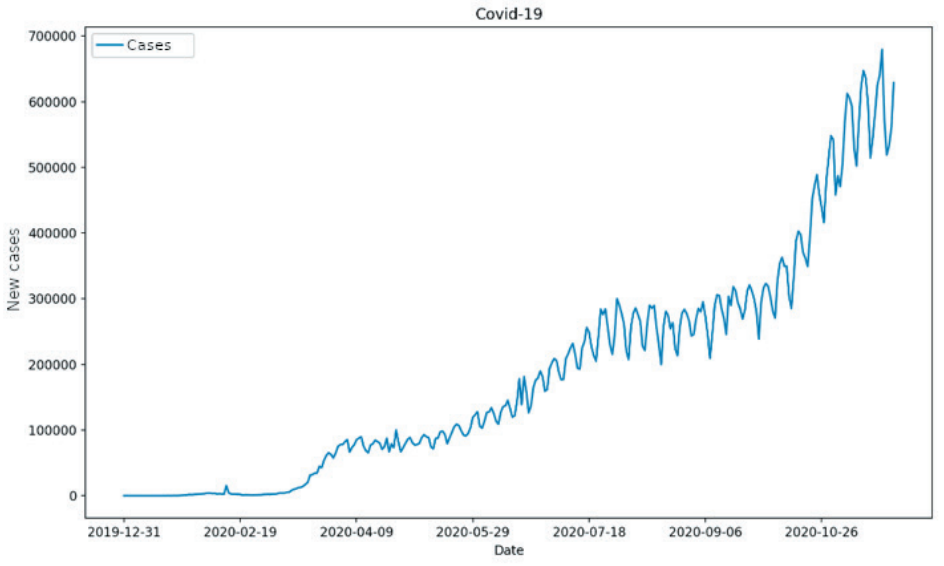

Figure 2 – The number of people infected with the COVID-19 virus in 2020

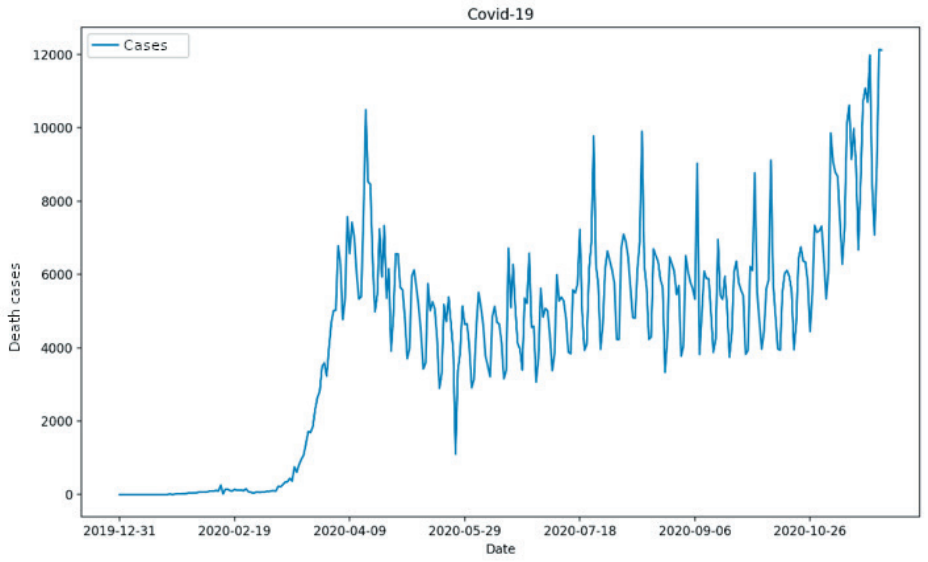

Figure 3 – Number of deaths from Covid-19 virus in 2020

4. MODELS USED FOR THE RESEARCH

The paper uses four popular models of machine learning that apply the following algorithms: linear regression, the decision tree, K-nearest neighbour, A support vector machine.

Linear regression tries to show the values of the dependent variable in the most accurate way possible about the independent variable with a linear function. This is a common way of predicting the value of financial instruments, especially if the values are inert.

The decision tree is one of the best and most commonly used classification algorithms because, in addition to offering high prediction accuracy and clarity, it also easily maps nonlinear relationships. This algorithm easily solves regression and classification problems.

K-nearest neighbour (kNN) can be used for classification and regression problems. It is a model that classifies data points based on the points that are most similar to it. It uses test data to "learn how to guess" what to classify in an unclassified point. More specifically, one might wish to weight the evidence of a neighbor close to an unclassified observation more heavily than the evidence of another neighbor who is at a greater distance from the unclassified observation [15].

A support vector machine (SVM) is a model reminiscent of a more advanced version of linear regression. This model presents data as points in space that it classifies into two categories between which there is a gap. The SVM efficiently constructs linear or nonlinear classification boundaries and is able to yield a sparse solution through the so-called support vectors, that is, through those observations that are either not perfectly classified or are on the classification boundary [16]. For the model not to be a linear regression model, the so-called kernel trick is used, which implies observing individual zones, and not the whole set.

5. RESULTS

This research intends to predict the price of gold for one, five, and ten days in advance by using the models of linear regression, decision tree, K-nearest neighbour, and support vector machine. We attempted to see whether one model gives relatively accurate predictions of these prices and which. The algorithms did not change in the testing itself, but the intention is to get the best result through changes in the variables. To begin with, it was important to find the model that makes the most accurate prediction for the next day, and later on to predict the gold price five and ten days in advance.

Due to the specific nature of machine learning models, testing and result representation are adequately adjusted, with multiple repeating independent runs taking place during testing, and results showing statistical results of multiple iterations. Additionally, various parameter settings were tested in search of optimal performance.

	Linear regression		Decision tree		K-nearest neighbor		Supp. Vector machine	
	Gold	**Gold and Covid-19**	**Gold**	**Gold and Covid-19**	**Gold**	**Gold and Covid-19**	**Gold**	**Gold and Covid-19**
Explained_variance_score	-0.6391	-0.6295	0.9616	0.9627	. 0.9386	0.9387	0.9307	0.9306
Max_error	143.1799	143.1799	10.7200	10.7200	13.4921	13.4722	11.3136	11.3128
Mean_absolute_error	6.6431	6.5635	1.8054	1.8054	2.4035	2.4021	2.5986	2.5994
Mean_squared_error	274.9183	273.2479	6.4203	6.2792	10.7402.	10.7300	12.1284	12.1423
Mean_squared_log_error	0.1156	0.1155	0.0002	0.0002	0.0003	0.0003	0.0004	0.0004
Median_absolute_error	2.8622	2.8233	1.3300	1.2699	1.8060	1.8060	2.0386	2.0307
r2_score	**0.6412**	-0.6313	0.9616	**0.9625**	0.9358	0.9359	0.9275	0.9275

Table 1 - Results of gold price prediction models with the model with the greatest accuracy

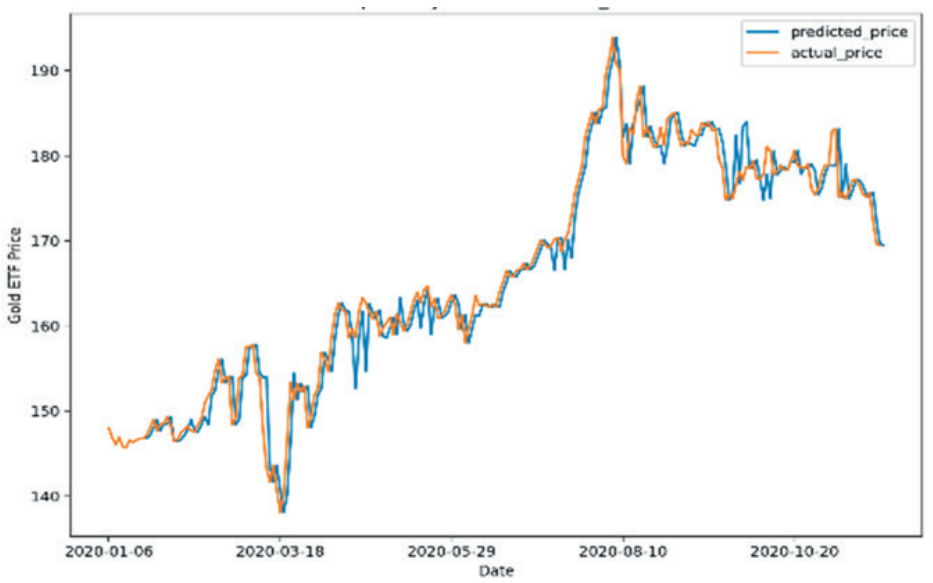

Figure 4 – Graphic view of most accurate model, decision tree with gold and Covid data

The results tell us that the best model for predicting the price of gold for tomorrow is the decision tree model, which, in addition to the historical price of gold, also contains data on the number of cases and deaths from the Covid-19 virus with 96.25% prediction accuracy. The model is trained on seven-day data, taking into account the historical price of gold and the average number of Coronavirus cases and deaths in the last seven days and that is the only model shown in this paper. The second-best model is still the decision tree, which contains only information on historical gold prices. This iteration is the first that, in the case of the support vector machine model, managed to equalize the accuracy of the prediction in the case of data with and without information about Covid.

Additionally, the same model is giving us the most accurate results for predictions five and ten days in advance with an accuracy of more than 95%.

6. CONCLUSION

Linear regression tries to show the values of the dependent variable as accurately as possible in relation to the independent variable with a linear function. Many research papers deal with the prediction of the price of gold with the help of linear regression, which can be explained by the relatively stable price of gold in the past, but due to the instability caused by the Covid 19 virus, this model does not give nearly accurate predictions. In fact, of all the four models tested, this model can be

called the least applicable for this type of prediction. We attribute this to the fact that the data do not follow any linear trend and are too "scattered" for this type of prediction to give meaningful results.

The k-nearest neighbour model shows the highest accuracy of the prediction in the case of predictions for the next five days, and only on the basis of historical data on the price of gold. The maximum error of the model is always quite similar for both the model with historical gold prices and the model with the Covid virus.

The support vector machine model in almost every iteration shows more precise results when the prediction is made only on the basis of the historical price of gold. Similar to the k-nearest neighbour model, the accuracy of this model is almost always over 80%. The maximum error of this model is almost the same regardless of what data we take into account, and very often it is smaller than the model that has higher levels of accuracy.

In each iteration and in almost every case, except one, the accuracy of the decision tree model is the highest compared to other tested models. The highest accuracy, of 96.25%, is given in the model trained on a seven-day data set, with information on the seven-day average number of patients and deaths from the Covid-19 virus where the prediction was made for the next day. It is believed that this level of precision is very successful in conditions of great imbalance.

Based on all the above, it is believed that the hypothesis that information on the number of infected and infected with the Covid-19 virus helps to create models with greater accuracy in determining the price of gold than those with only historical values of gold prices has been proven.

Future research could focus on adjusting the parameters of algorithms for creating models and testing other models. It is also believed that such models can be applied not only to the situation with gold and the Covid-19 virus but also to determine the price of any financial instrument at any time in a crisis if appropriate quantifiers of the crisis situation are inserted. Given that health crises are becoming more frequent in the last few decades, it is believed that this work will have wide applications in the future.

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REGRESSION ANALYSIS APPLIED TO INFLUENCE OF TRAFFIC FLOW PARAMETERS ON EMISSIONS OF COMBUSTION PRODUCTS

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Abstract:

The aim of this paper is to analyze the impact of emissions of combustion products in the area of the street network of cities. During the preparation of the paper, we start from the relations that express the dependence of the emission of characteristic compounds, toxic components: carbon monoxide, nitrogen oxides, and solid particles from various parameters related to the street environment and traffic volume. The main contribution is updating the relations to which these dependencies are expressed. The parameters in the relations are the orientation of the street, the concept of the same, whether the street is of the canyon type or not, as well as those related to the volume of traffic. Dependency relations were obtained by regression analysis. We start from the position that the coefficients along with the parameters should be checked in accordance with the greater participation of modern engines on the one hand, but also the dilapidating of vehicles on the other. In order to establish a new state, a new recording of the emission of the mentioned components is performed, on the basis of which up-to-date dependencies are formed. The contribution is in the formation of new relations through regression analysis, for each component, by applying a software package developed by the author of the work on recording the obtained value of toxic components for Despot Stefan Street in Belgrade.

Keywords:

Environmental protection, Traffic, Regression analysis.

INTRODUCTION

Along with the increase in the intensity of traffic in the city network, the greater share of dilapidated vehicles and the bus type of public city transport, there is a need to check the relations that show the dependence of the emission of characteristic toxic components on meritorious parameters. These parameters refer to the orientation of the street, its width, ventilation and the volume of traffic. The relations obtained by regression analysis, which are already applied for the approximate establishment of the composition of combustion products, need to be checked and harmonized with the specific condition of the vehicle fleet. To that end, the authors of the paper approach by recording the participation of Carbon monoxide, nitrogen oxides and solid particles, on the basis of which up-to-date dependencies are formed.

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2. LOCATION OF THE EXPERIMENT

Despot Stefan Street is a characteristic street in Belgrade from the aspect of high pollution with combustion products in SUS engines, [1] and [2]. The main characteristics of the street are Poor ventilation of the street as it is provided at an angle of approximately 90^0 in relation to the wind direction characteristic of the location. Major wind direction stretches from north-west to south-east. Another unfavorable aspect is a large number of huge buildings on both sides of the street, which, in addition, adversely affects the ventilation of the street and forms it to be of a canyon type. The section of the Street from George Washington Street to Brace Jugovica Street is also characteristic from the aspect of: small road widths and - small width of sidewalks on both sides. It is characteristic that the level of toxic components in the emission of combustion products decreases exponentially with distance from the source of pollution. From that point of view, the small width of the sidewalk is a significant problem, [3]. Bearing in mind the possibility of varying parameters:

- Street width [m], - traffic volume [vehicles/h],
- Wind speed [km/h],
- Average vehicle speed [km/h],
- Air temperature [^{0}C],
- Uniformity of traffic flow.

It is possible to set new dependencies by applying regression analysis.

3. EXPERIMENT CONCEPTION

Characteristic toxic components whose participation in the emission of combustion products is found are:

- Carbon monoxide, CO,
- Carbon dioxide, CO_2,
- Parts of hydrocarbon chains or rings: CH components,
- Nitrogen oxides: NO_x,
- Sulfur compounds: SO_2,
- Solid particles.

For carbon monoxide, it is characteristic that it is measured directly next to the source, near the end of the exhaust system, since it is unstable and, almost instantaneously, binds to oxygen free radicals, forming, stable from the labile compound: carbon dioxide, [4] and [5].

This compound plays a key role in creating the greenhouse effect. It is important to emphasize that Diesel engines are significantly higher pollutants than OTTO engines, given that combustion products are more toxic in terms of carcinogenicity. The reason is the structure of hydrocarbon compounds, the basic components of petroleum distillates. Petrol is light hydrocarbons, [6], consisting of easily dissociable lower hydrocarbon chains. These are paraffin hydrocarbons, as well as isooctane. Unlike these paraffin hydrocarbons, diesel fuel consists of isoparaffin chains, but also difficult-to-separate cyclic hydrocarbons - naphthenes. Due to their more difficult decomposition, naphthenes can also cause more serious consequences for the environment, [7] and [8]. Having in mind the strong and conditionally pleasant, aromatic smell, these hydrocarbons are also called aromatics.

The harmfulness of combustion products can be reduced. This is achieved by more complete combustion by optimizing the participation of oxygen, which affects the mixture in the combustion process, as well as by burning exhaust gases by injecting additional fuel. Also, the process of transformation of nitrogen monoxide into, less harmful to the environment, nitrogen dioxide is being realized. The realization is performed by catalysts, that is, by accelerating chemical reactions in the combustion process in the engine as well as by acting on the combustion products in the process of blowing. This represents the engines: EURO 5 and EURO 6, [8]. One of the results of this process is a significantly lower temperature of the exhaust gases, which achieves their lower inertia and penetration as well as the distance they reach when leaving the exhaust system. This is the reason why the relationships that established the participation of certain components in the emission of exhaust gases are to be checked and changed. Existing relationships may not be valid for modern engines, which are largely represented today. Those relations are defined by the exploration of experts for urban transport andmembersr othe f Serbian Academy of Sciences and Arts, Vukan Vucic. Mentioned relations are presented in [12], part II, chapter 6 and they are the subjects of verification:

- For the participation of carbon monoxide:

$$\mathrm{CO}[ppm] = 2.26 + 0.14 \cdot T_v - 0.394 \cdot V\left(Q / V_{st}\right) \cdot \left(0.048 \cdot V_s + 1.152 / D\right), \quad (1)$$

Where are:

- T_v – Air temperature [^{0}C],
- V – Wind speed [km/h],
- Q – Volume of traffic [vehicles/h],

- V_{sr}. – Average speed of traffic flow [km/h],
- D – driveway width [m],
- V_s – uniformity of traffic flow,

V_s= 0.94 to V_s= 1.13 for: Q=300 to 2000 vehicles/h,

- For the participation of nitrogen oxides:

$$NO_x[\mu g/m^3]=46.9-0.036\cdot Q+40\cdot 10^{-6}\cdot Q^2, \quad (2)$$

- For the participation of solid particles:

$$P[\mu g/m^3]=0.0431+0.000249\cdot Q. \quad (3)$$

3. RESULTS OF RECORDING THE EMISSION OF COMBUSTION PRODUCTS

Recording of the participation of individual toxic components in the emission of combustion products is being realized for the section of Despot Stefan Street in Belgrade from the street: George Washington to Brace Jugovica Street during the day and is presented in Table 1.

Road data are as follows:

- T_v = 10^{0}C to 20^{0}C – Air temperature, as shown in Table 1,
- V = 5 km/h – Wind speed,
- Q – 1508 to 2480 vehicles./h – Total volume of traffic, as shown in Table 1,
- $V_{sr.}$ = 5 to 27 km/h – Average speed of traffic flow, as shown in Table 1,
- D = 7m – driveway width,
- V_s =1 – uniformity of traffic flow.

4. MATHEMATICAL MODEL FOR APPROXIMATION OF EMPIRICALLY OBTAINED DEPENDENCE BY MULTI-PARAMETER REGRESSION ANALYSIS

Analytically, the dependence of the participation of individual components in the emission of combustion products on the parameters follows in the form of functions, [9] and [10]:

- First degree – linear, t=1:

$$y_t = a_0 + a_1x_1 + a_2x_2 + ... + a_nx_n, \quad (4)$$

- Second degree – quadratic, t=2, for n=3 parameters:

$$y_t = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_1^2 + a_5x_2^2 + a_6x_3^2 \text{ and} \quad (5)$$

- High degree, t=3, for three parameters:

$$y_t = a_0\cdot x_1^{a_1}\cdot x_2^{a_2}\cdot x_3^{a_3}. \quad (6)$$

Recording	Tv[^{0}C]	Q [vehicles/h]	V_{sr} [km/h]	participation recorded state / expressions: 1, 2 and 3		
				CO[ppm]	NOx[μg/m^3]	P[μg/m^3]
1	10	2050	16	18/28	135/141	0.50/0.55
2	10	2160	12	21//39	137/156	0.51/0.58
3	11	2305	14	28/36	142/176	0.52/0.62
4	13	2260	16	29/31	140/170	0.52/0.61
5	13	2121	18	24/26	136/150	0.51/0.56
6	13	2045	20	18/23	134/141	0.50/0.55
7	15	1850	26	12/17	110/117	0.46/0.50
8	15	1650	20	11/19	91/96	0.42/0.45
9	17	1780	24	13/18	98/110	0.43/0.48
10	18	2065	19	22/25	135/143	0.50/0.56
11	19	2380	14	26/38	142/188	0.52/0.63
12	19	2480	11	30/50	153/204	0.53/0.66
13	20	2370	18	29/30	143/186	0.52/0.63
14	20	2324	12	28/43	144/179	0.51/0.62
15	20	2450	10	29/54	150/199	0.52/0.65

Table 1 – Results of recording the participation of combustion products.

The correct values of the participation of the parameters found in the recording are presented in the notation: $j = 1, 2 \ldots k$. The deviation of the assumed, analytically obtained value is established: y_j from the recorded one: for all parameters on which the participation of an individual component depends. The total deviation is the sum of the squares of the deviations between the y coordinate of the point corresponding to the selected analytical dependence: y_{tj}, (4) to (6), and the one corresponding to the measured value: $\hat{y}_{tj}$ for that same point in the form, [11]:

$$S_t = \left(\hat{y}_1 - y_{t1}\right)^2 + \left(\hat{y}_2 - y_{t2}\right)^2 + \ldots + \left(\hat{y}_k - y_{tk}\right)^2 = \sum_{j=1}^{k}\left(\hat{y}_j - y_{tj}\right)^2, \quad (7)$$

k – Total number of recordings.

The values of the parameters for which the specific sizes of the components are obtained are in the form of:

$$x_{11}, x_{12}, \ldots\ x_{1k}, x_{21}, x_{22}, \ldots, x_{2k}, x_{31}, x_{32}, \ldots x_{3k}.$$

The first index refers to the first, second, and third parameter in the expression: (1); these parameters are wind speed, traffic volume and air temperature, while the other index refers to recordings: 1, 2,..... k. The minimum function required is: S, (7), the sum of the squares of the deviations: $y_{t,j}$ of, by

$$\frac{\partial \sum_{j=1}^{k}\left(\hat{y}_j - y_{tj}\right)^2}{\partial a_i} = 0, \quad t = 1,2,3. \quad (8)$$

Where are:

$i = 0, 1...3$ for relation according to (4) and (6), t=1 and 3,

$i = 0, 1...6$ for relation according to (5), t=2.

The coefficients: ai are to be found by equalizing the first partial derivative by the coefficients: ai expressions with the sum of the squares of the deviations of the recorded values and the values obtained analytically, for each recording, with zero, according to (5). Solving equation (5) yields a system of 4 algebraic equations with four unknowns for dependence: (4) and (6), i.e., of 7 equations for approximation, by expression (5). In this way, the coefficients are obtained with the parameters, expressions (4) and (6) as well as the exponents: ai, depending on: (5). Based on that, the authoritative dependence is established, as the one where the total deviation, as well as the relative deviations of the analytically obtained values from those measured for all parameters and for all pairs of points, are the smallest. Expression (1) is followed by a multi-parameter correlation since it is a multi-parameter dependence.

5. APPLICATION OF "INTER5" SOFTWARE TO FIND THE DEPENDENCE OF COMBUSTION PRODUCT EMISSIONS ON INFLUENTIAL PARAMETERS

In order to find out the influence of traffic volume, air temperature and traffic flow speed on the emission of carbon monoxide, nitrogen oxides and solid particles, the authors developed a software package that is based on multi-parameter regression analysis for carbon monoxide emission analysis and polynomial dependence for other two components of combustion products, which is obtained by the minimum squares method. Relations that have got by multi-parameter regression analysis are presented in listing 1.

A comparison of the results has got by regression analysis described above with the recorded value for carbon monoxide in the function of T_{air} [^{0}C] is given in Table 2, of Q[vehicles/h] in Table 3 and in the function of V [km/h] in Table 4.

Results presented in Tables 3, 4 and 5 have got from the recording realized by the Academy of Applied Technical Studies Belgrade College for Polytechnic. Measuring was performed by exhaust gas analyzer, produced by IMR Environmental Equipment, Inc. Method for analysis is performed by infrared gas analyzing, thermo-

APPROXIMATION BY SQUARE DEGREE FUNCTION:
CO = 8.979797E-03+ (0.6545994)*T_{air} + (-3.047681E-02) * Qv+ (2.097633)*V+(-0.022809)*T_{air}^2+ (1.405257E-05)*Qv^2+ (-0.0571197)*V^2,
APPROXIMATION BY HIGH DEGREE FUNCTION, BY SAMPLES VARIABLES:
CO = 1.001688 * (0.0869) ^ T_{air} * (0.6342716) ^ Qv *(-0.7328007) ^ V,
APPROXIMATION BY SINGLE DEGREE FUNCTION:
CO = 0.1021261 + (0.1018782)* T_{air} + (1.402836E-02)* Qv + (-0.5542434)* V,
APPROXIMATION BY HIGH DEGREE FUNCTION, BY PARAMETRES:
CO = 0.9997994 *T_{air}^ (0.9940598)*Qv^ (1.001433)*V^ (1.004146).
VALUE OF CARBON OXIDE PARTISIPATION DEPENDING TO: T_{air} EQUEL TO 21^{0}C, Qv EQUEL TO 2500 vehicles/h, and V EQUEL TO 11km/h IS, ACCORDING TO SQUARE DEGREE FUNCTION IS 31.49ppm.

Listing 1 – Relations that have got by multi-parameter regression analysis.

conducting and thermo-magnetic analyzing devices, all incorporated into a unit, Fig. 1. Traffic flow density, as well as average vehicles speed, were measured by test cars. Air temperature and wind speed were obtained by Meteorological Institute.

Relative deviations for carbon monoxide participation depending on regression function type are presented in Table 5.

Total declination for square regression: 19.48787

Total declination for linear regression: 32.14518

Total declination for high degree regression by samples: 48.76285

Total declination for high degree regression by parameters: 28.25685

T_{air}	Square Regression	Linear Regression	High degree per parameters regression	High degree per samples regression	Recorded
10	19.79	21.01	20.22	18.95	18
10	20.95	24.77	25.81	21.82	21
11	27.03	25.80	24.22	26.92	28
13	26.50	24.26	22.00	25.15	29
13	22.49	21.20	19.39	20.78	24
13	20.21	19.03	17.54	18.79	18
15	12.33	13.17	13.75	14.40	12
15	11.77	13.50	14.38	12.77	13
17	12.26	13.50	14.38	12.76	13
18	20.63	20.37	18.85	18.69	22
19	29.45	27.67	25.92	28.58	26
19	31.22	30.73	31.75	32.57	30
20	28.51	24.85	21.37	26.89	29
20	25.99	28.09	28.71	26.00	28
20	28.92	30.97	33.93	30.89	29

Table 2 – Regression relations: carbon monoxide in the function of T_{air} [^{0}C].

Q	Square Regression	Linear Regression	High degree per parameters regression	High degree per samples regression	Recorded
1650	11.77	13.69	15.50	10.55	11
1780	12.26	13.50	14.38	12.77	13
1850	12.33	13.17	13.75	14.40	12
2045	20.21	19.03	17.54	18.79	18
2050	19.79	21.01	20.22	18.95	18
2065	20.62	20.37	18.85	18.69	22
2121	22.49	21.20	19.39	20.78	24
2160	20.95	24.77	25.81	21.82	21
2260	26.50	24.26	22.01	25.15	29
2305	27.03	25.80	24.22	26.92	28
2324	25.99	28.09	28.71	26.00	28
2330	28.51	24.85	21.37	26.89	29
2380	29.45	27.66	25.92	28.58	26
2450	28.92	30.97	33.93	30.89	29
2480	31.22	30.73	31.75	32.57	30

Table 3 – Regression relations: carbon monoxide in the function of Q [vehicles/h].

V	Square Regression	Linear Regression	High degree per parameters regression	High degree per samples regression	Recorded
10	28.92	30.97	33.93	30.89	29
11	31.22	30.73	31.75	32.57	30
12	20.95	24.77	25.81	21.82	21
12	25.99	28.09	28.71	26.00	28
14	27.03	25.80	24.22	26.92	28
14	29.45	27.67	25.92	28.58	26
16	26.50	24.26	22.00	25.14	29
16	19.79	21.01	20.22	18.95	18
18	28.51	24.85	21.37	26.89	29
18	22.49	21.20	19.39	20.78	24
19	20.63	20.37	18.85	18.69	22
20	20.21	19.03	17.54	18.79	18
20	11.77	13.69	15.50	10.55	11
24	12.26	13.50	14.38	12.77	13
26	12.33	13.17	13.75	14.40	12

Table 4 – Regression relations: carbon monoxide in the function of *V* [km/h].

Figure 1 – Exhaust gas analyzer IMR 2800P.

Recording	Square Regression	Linear Regression	Upper grade regression by parameters	Upper grade regression by samples
1	1.8	3.02	0.96	2.23
2	0.04	3.78	0.83	4.81
3	0.096	2.20	1.07	3.77
4	2.49	4.73	3.85	6.99
5	1.5	2.79	3.21	4.60
6	2.22	1.03	0.80	0.46
7	0.34	1.18	2.40	1.76
8	0.78	2.70	0.45	4.50
9	0.73	0.51	0.23	1.39
10	1.37	1.62	3.30	3.15
11	3.45	1.67	2.58	0.07
12	1.23	0.74	2.58	1.75
13	0.49	4.15	2.11	7.63
14	2.00	0.1	1.99	0.72
15	0.07	1.97	1.89	4.94

Table 5 – Relative declinations for carbon monoxide participation depending to regression function type.

Relations that have got for polynomial dependence of nitrogen oxides to *Q* [vehicles/h] are given in listing 2

Function value for arbitrary value for Q=1500km/h, depending on the degree of the polynomial is given in Table 6.

Degree of polynomial	NO_x[$\mu g/m^3$]
2	80.34
3	60.73
4	65.22
5	63.51

Table 6 – Function value for arbitrary value for *Q*=1500km/h, depending on the degree of the polynomial

```
-Polynomial of second degree: (-110.7766)*x^ 0 + (0.1585238)*x^ 1 + (-2.074109E-
05)*x^ 2,
Value of function approximated by polynomial of second degree for Q= 1500[vehicles/h]
is: 80.34μg/m³.
-Polynomial of third degree: (-556.6325)*x^0+ (0.6797687)*x^1+ (-2.08401E-04)*x^2+
(1.973757E-08)*x^ 3,
Value of function approximated by polynomial of third degree for Q=1500[vehicles/h]
is: 60.73252μg/m³.
-Polynomial of forth degree:
(-346.192)*x^0+ (0.3647974)*x^1+ (-3.967294E-05)*x^2+ (-1.830413E-08)*x^ 3 +(3.013003E-
12)*x^ 4,
Value of function approximated by polynomial of forth degree for Q= 1500[vehicles/h]
is 65.2168μg/m³.
-Polynomial of fifth degree:
(-389.7654)*x^ 0 +( 0.4084071 )*x^ 1 +(-4.240591E-05 )*x^ 2 +(-2.768787E-08 )*x^ 3 +
( 6.298993E-12 )*x^ 4 +(-3.114152E-16 )*x^ 5, Value of function approximated by poly-
nomial of fifth degree for Q= 1500[vehicles/h] is: 63.50912μg/m³.
```

Listing 2 – Relations that have got for polynomial dependence of nitrogen oxides to *Q* [vehicles/h].

```
- Polynomial of second degree:  (-0.5429083)*x^ 0 + (8.749957E-04)*x^ 1 + (-1.795907E-07)*x^ 2,
Value of function approximated by polynomial of second degree for Q= 1800[vehicles/h] is:
0.4502101μg/m³.
- Polynomial of third degree:
(-6.774442E-02)*x^ 0 + (1.713299E-04)*x^ 1 + (1.642255E-07)*x^ 2 + (-5.546015E-11)*x^ 3,
Value of function approximated by polynomial of third degree for Q= 1800[vehicles/h] is:
0.4492966μg/m³.
- Polynomial of forth degree:
(-0.1832796)*x^ 0+( 9.235148E-04 )*x^ 1+(-7.699401E-07 )*x^ 2 +( 3.689458E-10 )*x^
3+(-6.556882E-14)*x^ 4,
Value of function approximated by polynomial of forth degree for Q= 1800[vehicles/h] is:
0.4478176μg/m³.
- Polynomial of fifth degree:
(0.0853321)*x^ 0 +(-1.7632E-04 )*x^ 1 +( 3.89889E-07 )*x^ 2 +(-6.731721E-11 )*x^ 3 +(-
3.084162E-14 )*x^ 4+ +(7.13882E-18 )*x^ 5,
Value of function approximated by polynomial of fifth degree for Q=1800[vehicles/h] is:
0.4497324μg/m³.
```

Listing 3 – Approximation of emission of solid particles depending on *Q* [vehicles/h] by polynomial dependence.

Degree of polynomial NO_x[$\mu g/m^3$]

A Polynomial approximation of NO_x of *Q* [$\mu g/m^3$] is presented in Table 7.

Q[vehicles/h]	NO_x
1500	63.51
1600	79.73
1700	94.13
1800	106.74
1900	117.59
2000	126.74
2100	134.25
2200	140.17
2300	144.59
2400	147.58
2500	149.23

Table 7 – Polynomial approximation NO_x of *Q*

Function value for arbitrary value for *Q*=1500km/h, depending to the degree of the polynomial is given in Table 8.

Degree of polynomial	NO_x[$\mu g/m^3$]
2	80.34
3	60.73
4	65.22
5	63.51

Table 8 – Function value for arbitrary value for *Q*=1500km/h, depending to the degree of the polynomial

The degree of the polynomial is to be accepted is 5.

A Polynomial approximation of solid particles of *Q* [$\mu g/m^3$] is presented in Table 9.

Q[vehicles/h]	Solid Particles [$\mu g/m^3$]
1500	0.369
1600	0.398
1700	0.425
1800	0.450
Q[vehicles/h]	Solid Particles [$\mu g/m^3$]
1900	0.471
2000	0.489
2100	0.503
2200	0.513
2300	0.520
2400	0.522
2500	0.522

Table 9 – A Polynomial approximation of solid particles of *Q* [$\mu g/m^3$]

Results which are presented in the tables, express a lower rate of exhaust gas emission. Particularly, participation of components: carbon monoxide, Carbon monoxide, nitrogen oxides and solid particles is lower than before due to the fact that more efficient engines are embedded in vehicles. In the paper presented, relations have got by regression analyzes are applicable to a great range of similar calculations.

6. CONCLUSION

The analysis given in this paper establishes new dependences of the participation of carbon monoxide components, nitrogen oxides and solid particles in the emission of combustion products. The dependence is expressed as a function of traffic volume, air temperature and vehicle speed. The dependence function was formed on the basis of measuring the obtained quantities in a characteristic street in Belgrade and with the help of software developed on the basis of a mathematical model based on correlation analysis with multi-parameter regression functions and polynomial dependencies. A different dependence than the one used so far has been established. The share of the considered combustion products is significantly lower as a result of more modern engines and a lower share of older vehicles. The contribution of the paper is the presentation of the application of the software "INTER5" as well as the preparation of the analysis and presentation of the results. The paper's approach is applicable as a useful tool for analyzing such and similar recording results.

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CFD ANALYSIS APPLIED TO SMOKE EXTRACTION IN CAR PARK CAUSED BY SINGLE FIRE SOURCE

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Abstract:

The aim of this paper is to present the application of CFD software to the calculation and to show the image of fluid flow during garage ventilation in an emergency situation. On that way, JET fans, arranged on the ceiling of the parking lot, blow smoke at high speed, transmitting complete energy to the surrounding air. Proper arrangement of JET fans ensures that the entire air mass of the parking space gets controlled movement in the desired speed range. This reduces the pressure required by the main fans to expel and inject outside air from and into the garage space, and thus the required power of these fans. Thanks to the application of CFD analysis, a graphical representation of the flow was obtained, based on when the JET fan can be selected. In this way, the selected fans and the designed ventilation system have significant advantages over the conventional duct flue system.

Keywords:

CFD analyzes, smoke extraction, JET fans, cark parks.

INTRODUCTION

The purpose of this paper is to present the findings of a Computational Fluid Dynamics (CFD) study of the Jet Thrust Fan system for car park project, which consists of three identical buildings.

Computational Fluid Dynamics (CFD) is a design tool used to aid the detailed design of Jet Thrust systems. The software allows the designer to model complex airflows within the car park, visually inspect and analyse the airflow patterns in order to make decisions as to how the final layout of the system will need to be configured.

Governing equations (the Navier-Stokes equations) are important in any fluid flow problems. Equations are either in two forms compressible and incompressible. With compressible fluids density changes significantly in response to a change in pressure (i.e. shock waves) whereas for incompressible fluids the density remains constant as a function of pressure (i.e. density is a property of the flow and not the fluid). When incompressible flow is used with an appropriate sub model for buoyancy, density variations due to changes in temperature can be computed.

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2. PREVIOUS RESEARCHES

The contribution of this paper is the presentation of solving specific requirements by applying the CFD method to the design of smoke systems. CFD analysis is widely used in the design of ventilation systems. During the preparation of this paper, numerous applications of this method were analyzed. The increasing application of the CFD method in the analysis of fluid flow is noted, primarily in JET ventilation systems. In paper [1], it is presented Proper Mesh Transitions between different parts and velocity analysis, where the currents are clearly defined. Paper [2] is very useful by the reason that reduced-scale modelling is applied to tunnels equipped with axial jet fans. By the analysis flow fields in tunnels and current images of temperature profile depending on tunnel sections and time are presented, Fig. 1.

In paper [3], the application of CFD analysis to the fumigation of underground garages in the event of an initial fire on a vehicle is given. The analysis shows the spread of smoke along the height of the object as a function of time. The same paper gives the application of the finite volume method to the analysis of smoke propagation.

3. THEORETICAL BASES

Leading Navier-Stokes equations are important in any fluid flow analysis Equations are either for compressible and incompressible fluid. With compressible fluids density changes significantly in response to a change in pressure, i.e. for shock waves, whereas for incompressible fluids the density remains constant as a function of pressure because density is a property of the flow and not of the fluid. When incompressible fluid is analysed with an appropriate sub model for buoyancy analyzing, density variations due to changes of temperature can be computed. It is very practically, CFD - Solid Works Flow Simulation to be used for mathematical presentation of the car park fluid flow, by which numerically solving of 3- D Navier-Stokes equations is possible. Mesh generation is realized on the bases of the finite volume method, [4].

The law can be formulated mathematically in the fields of fluid mechanics and continuum mechanics, where the conservation of mass is usually expressed by the continuity equation, given in differential form as (1):

$$\frac{\partial \rho}{\partial t} + \nabla \rho u = 0 \tag{1}$$

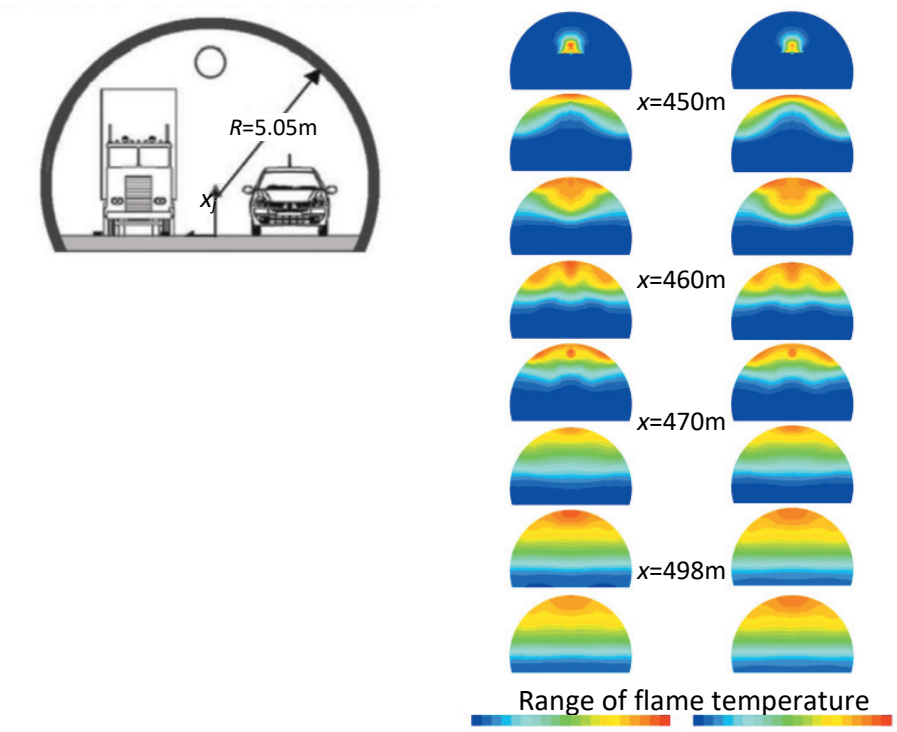

Figure 1 – Images of air flows field in tunnels and temperature profiles depending on tunnel sections and time

The first term describes the density changes with time and the second term defines the mass convection where u represents velocity vector.

Momentum equation: The equation for the conservation of momentum is derived from Newton's second law of motion, which states that the rate of momentum of a fluid element is equal to the sum of the forces acting on it. The equation is written in the form presented by (2):

$$\rho\left(\frac{\partial \rho}{\partial t}+(u\nabla)u\right) = \nabla\rho + \nabla\tau + \rho g + f \qquad (2)$$

The left hand side represents the increase in momentum and inertia forces, while the right hand side comprises forces acting on it. These forces include pressure p, gravity acceleration: g, and external force per unit mass vector f which represents a measure of the viscous stress tensor τ acting on the fluid within the control volume. The full buoyancy model will be used to calculate buoyancy effects from the fire.

Equation for conversation energy law [5] and [6], is defined by equation(3):

$$\left(\frac{\partial}{\partial t}(\rho E)+\nabla\cdot\left(\vec{v}(\rho E+\rho)u\right)\right) = \nabla\left(k_{eff}\nabla T-\sum_{j}h_j\vec{J}+\left(\overline{\overline{\tau}}_{eff}\cdot\vec{v}\right)\right)+S_h \qquad (3)$$

The term is the heat conduction coefficient and is the diffusion flux of species 'J'. The first three terms on the right-hand side of above equation represent energy transfer due to conduction, species diffusion and viscous dissipation respectively. The S_h term represents any other defined heat source.

4. POLLUTION VENTILATION BY CFD SIMULATION METHODOLOGY

The initial point for the construction of the geometric model is a sketch realized by AutoCAD of the car park's geometry, Fig. 2, extruded and hollowed to create the car park. The internal geometry of pillars, walls, service rooms and other reserved spaces are then extruded from inside the model using the same method. Where appropriate the geometry of the car park has been simplified to speed up the calculation and analysis time.

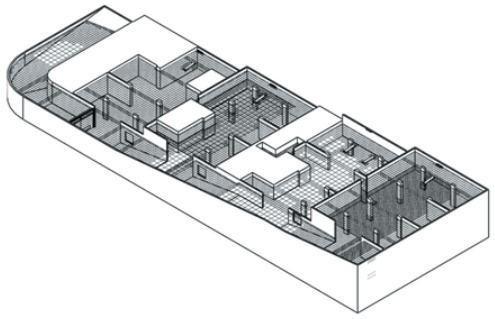

Figure 2 – Computational mesh generation

The mesh specifies the computational domain in which the simulation takes place by splitting the model into individual cells. The equations of state are applied to the individual cells using partial differential equations. The equations are solved on an iterative basis to calculate the air movement and dilution of passive scalar quantities such as Carbon Monoxide or fire smoke in order to [7] and [8].

The mesh size density is crucial to the desired accuracy of the simulation result. If the mesh is too coarse the airflow will not be correctly modelled leading to a misrepresentation of the system. Conversely a mesh which is too fine will exponentially increase the calculation time. Initial location of the fire source is presented on the sketch, realized by CAD software, Fig. 3.

The ventilation system is operating in high pollution mode at the start of the simulation, according to the ventilation mode set-points defined in Table 1. Post processing of CFD results characteristics of ventilation in mode 1, when main fan operation is on the rate of 60% speed. Decreasing of carbon monoxide pollution depending on time on that mode is presented by diagram, Fig. 4. Such analysis is equivalent to analyses realised and presented in [9], [10] and [11]. The main contribution of analysis presented in this paper and illustrated below is shift from channel conception of car parks which was designed by conventional approach to JET fans concept on which CFD method has been applied.

	Thrust fans reference	Thrust fan operation	Main fan reference	Main fan operation	Extract duty [m³/h]
Mode 1 CO>30ppm	JT-01,JT-02, JT-03, JT-04,JT-05	ON at 50% speed	Extract	On at 60% speed	32500

Table 1 – Ventilation mode set – points for the speed on the rate of 60%

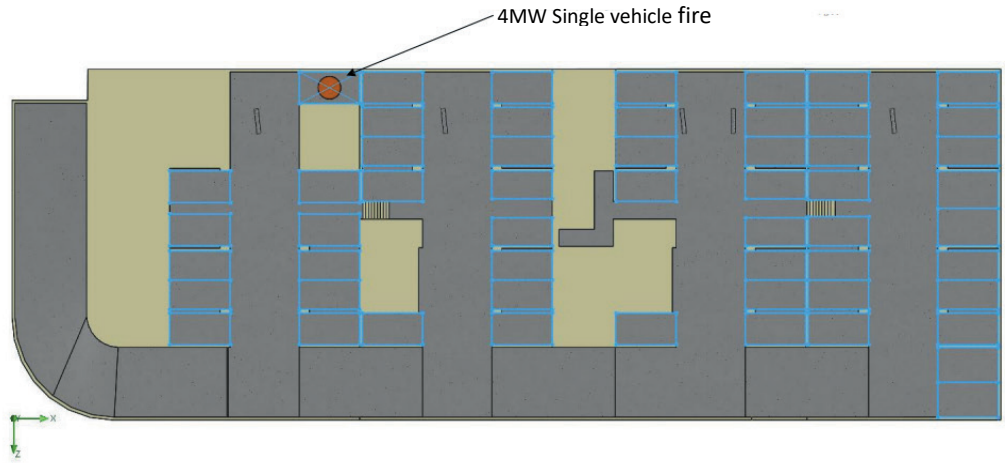

Figure 3 – Single vehicle fire source

The car park is filled with Carbon Monoxide [CO] to create a blanket condition of 50ppm throughout the entire car park (as a worst case scenario).

The ventilation system is activated at the start of the simulation. The equations of state are calculated as a transient/time dependant simulation. The gradient of the decay of CO can then be plotted against time.

The ventilation system is operating in emergency ventilation mode at the start of the simulation according, to the ventilation mode set-points defined in Table 2. Post processing of CFD results characteristics of ventilation in mode 2, when main fan operation is on the level of 100% speed.

The power of 4MW fire is started in the car park in a worst case location. The rate of growth of fire development is set to very fast so that the maximum heat release is reached quickly.

The quantity of smoke produced by the fire is also at its maximum value assuming a constant soot yield of 10%. The heat of combustion of the fire is assumed to be 26MJ/kg.

The time-step used for transient simulations of this type is typically in the range of 0.1 - 0.25s. The time-step is evaluated on a case by case basis according to:

- The rate of convergence of partial differential equations describing the motion and thermal properties of the fluid,
- The characteristic mesh length scale, aspect ratio and skew ness,
- The rate of change of goal dependant and non-goal dependant transport variables.

	Thrust fans reference	Thrust fan operation	Main fan reference	Main fan operation	Extract duty [m³/h]
Mode 2 Fire detected	JT-01,JT-02,JT-03 JT-04,JT-05	ON at 100% speed	Extract	On at 100% speed	54000

Table 2 – Ventilation mode set – points for the worst case location and speed rate of 100%

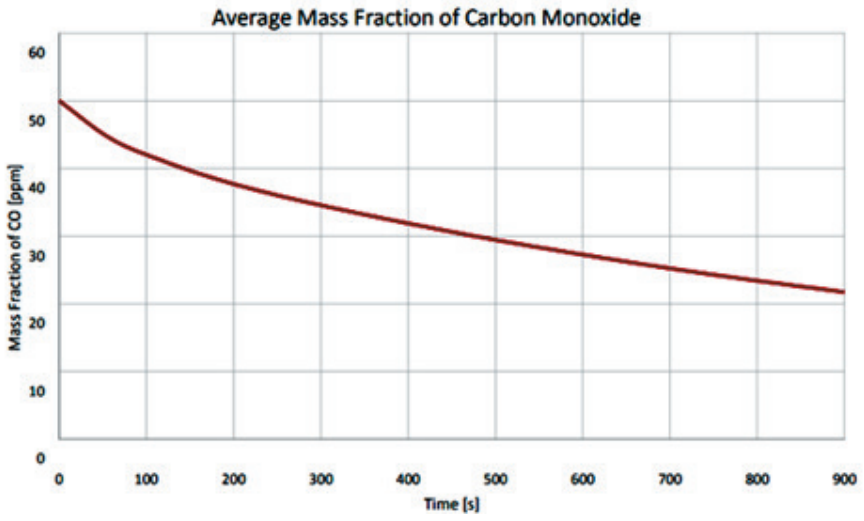

Figure 4 – Carbon monoxide pollution depending on time

Equations: (4) to (7) represent time dependent carbon monoxide rate:

$$VdC = -Q'Cdt\,, \tag{4}$$

$$\int_{C_1}^{C_2}\left(\frac{1}{C}\right)dC = \int_{t_1}^{t_2}\left(\frac{-Q'}{V}\right)dt\,, \tag{5}$$

$$ln\frac{C_2}{C_1} = \frac{-Q'}{V\left(t_2 - t_1\right)}, \tag{6}$$

$$t_2 - t_1 = \frac{V}{-Q'}ln\frac{C_2}{C_1}\,. \tag{7}$$

If initial time t_1 is equal to zero, then follow equations: (8) to (11) in the form:

$$t_2 = \frac{V}{-Q'}ln\frac{C_2}{C_1}\,, \tag{8}$$

$$Q' = \frac{Q}{K}\,, \tag{9}$$

$$t_2 = \left(\frac{K \times V}{-Q'}\right) \times ln\frac{C_2}{C_1}, \tag{10}$$

$$K = \frac{t_2 - Q' \times ln\dfrac{C_2}{C_1}}{V}\,. \tag{11}$$

By integrating time from t_1 to t_2 and concentration from C_1 to C_2, it is to be got:

$$K = \frac{720 \times \left(-9.03\right) \times ln\left(\dfrac{25}{50}\right)}{5333.27} = 0.84. \tag{12}$$

In equation (12) variables represent:

K - Ventilation performance factor for incomplete mixing,

t_1=0 [s] - initial time

t_2=720[s] - time necessary for carbon monoxide to be reduced half,

V =5333.27[m^3] - Air volume of the car park,

C_2[ppm] - Carbon monoxide concentration at time t_1, ppm represent flow of particles per minute,

C_1[ppm] - Carbon monoxide concentration at time t_2, ppm represent flow of particles per minute.

According to results presented above and CFD analysis illustration of the visibility in car park in is achieved as given on Fig. 5 .

5. CONCLUSION

The paper presents the CFD method used for the analysis of behaviour in the field. The application of this method is present both in the field of mechanical engineering and in the field of electrical engineering. This paper presents the application of this method for the calculation and visualization of fluids in ventilation systems.

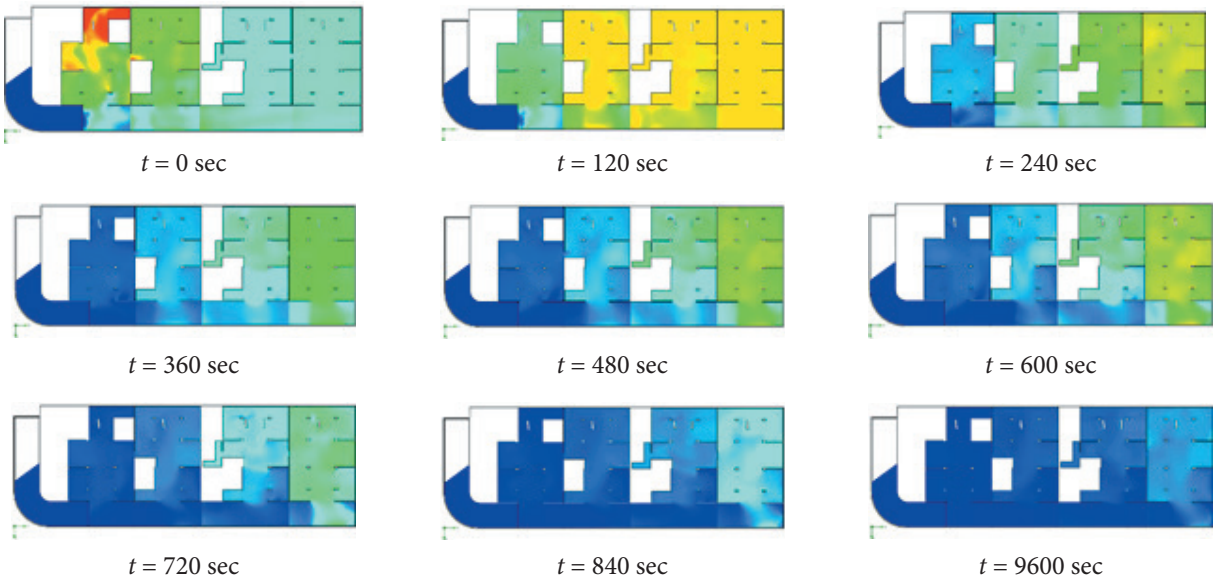

Figure 5 – CFD analysis of visibility progressing depending on time

The paper presents the application of this method to smoking a parking garage in case of fire. The aim was to give a graphical representation of the spread and removal of smoke as a function of time. In addition to the graphical representation, the method also performs the calculation of fluid flow. In the specifically processed example of parking garage smoking, this method was found to reduce the time of smoke emission, reduce the amount of smoke, increase the space for evacuation and allow easier access to the source of the fire to the fire brigade. Fluid flow behaviour is difficult and complicated to predict. The accuracy of the calculation is the most important for choosing the most efficient way of ventilation. CFD simulation checks whether there is enough air movement in all parts of the parking lot, whether a sufficient number of air changes is provided.

In order to perform CFD analysis, it is necessary to have a 3D model of the object that includes all openings, beams, ceiling surfaces as well as all other necessary details for CFD simulation. CFD simulation is used for the purpose of simulating air flow and to ensure good air distribution for efficient operation in normal and emergency situations. The program includes solutions for several relevant maintenance equations (mass, momentum and concentration). The software solves these problems until an accuracy is achieved that allows for accurate system design.

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THE PROCESS OF TRAINING A GENERAL-PURPOSE AUDIO CLASSIFICATION MODEL

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Abstract:
Branches of machine learning such as image classification, object detection and speech recognition are more commonly used in modern devices today than ever before. Most smartphones released in the last five years have at least one function that depends on one of the aforementioned fields. Google allows users to make a query based on a speech input which is converted into text, cameras on both iOS and Android devices have built-in object and face detection, and gallery apps can automatically sort photographs based on their content. Speech recognition falls under the category of audio classification, which also contains subfields like music genre classification, song identification, automatic audio equalization, voice-based identification, etc. This paper describes the basic steps of training a general audio classification model which can predict a limited number of distinct sounds, and it outlines the techniques that are employed during the process of training any sound classification model, regardless of its intended usage.

Keywords:
Sound classification, TensorFlow, Raspberry, Neural networks, Python.

INTRODUCTION

Sound classification is an area in which principles and techniques are applied in the field of signal processing, statistics, psychoacoustics [1]. In machine learning, the term "sound classification" can describe problems such as speech recognition, speech transcription (speech-to-text), voice recognition, music genre classification, etc., and these problems can differ in their implementations and applications. Depending on their objective and eventual outcome, these issues can be classified in a variety of ways. For example, models for music genre classification usually use convolutional neural networks (CNNs) in their architecture [2], [3], while models for speech recognition use recurrent neural networks (RNNs) [4]. The initial steps during model development of any sound classification model are almost always the same in all sound classification techniques, and they represent solutions to a few key problems that arise during the development of these models.

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2. DIGITAL REPRESENTATION OF SOUND

Sound is a mechanical wave produced by a source's periodic oscillation which affects the pressure of its surroundings or medium, and the information that they carry can be represented as an analog signal [5]. Classifications models take tensors which contain numbers which represent information regarding sound as input. As sound waves are represented as analog signals, we must first convert them to their equivalent digital representation which can be read by the model.

Signal sampling is the process where a continuous, analog signal is translated into a discrete, digital representation by recording the signal amplitudes at fixed intervals and assigning a value to the recorded amplitudes from finite range of numbers that suit their intensity [6]. The number of samples per second represents the sampling frequency, while the number of possible values for the amplitude represents the bit depth or resolution [7]. As an example, the sampling rate and bit depth of CD-quality audio files is 44100 Hz and 16 bits, respectively [8]. In other words, the audio signal is sampled 44100 times per second, and each sample might have up to 16 different values. In general, in the case of an audio file the higher these numbers are, the digital representation is more accurate and high-quality (Figure 1).

3. AUDIO FEATURE EXTRACTION

When a digital form of sound exists, it is necessary to find out how to extract its characteristics which contain information that can be used to classify it into a predefined category. In other words, we need to find out what makes an audio signal unique, which of its features give it its "identity" and how to use those features to classify it.

According to Fourier analysis, any physical signal can be decomposed into a finite number of discrete frequencies, that is the sum of these frequencies represents the original, complex signal [9]. This collection of frequencies represents the spectrum of a function and it shows the amplitude of each frequency present in the signal. In Figure 1, which shows the sampling process of an audio signal, the signal is shown in the time domain, which shows how its amplitude changes over time. Similarly, we can view the amplitudes of all the component frequencies of a signal at a specific point in time (Figure 2), and this represents frequency domain or the spectrum [10].

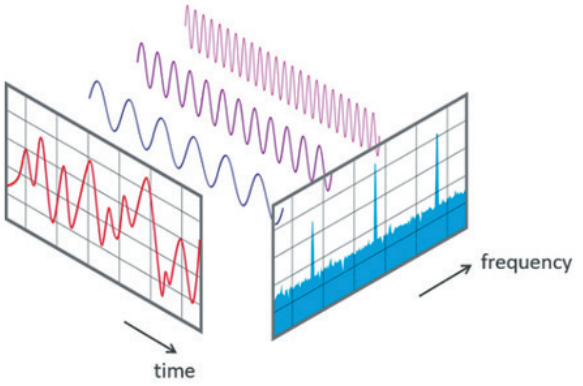

Figure 2 – The time and frequency domains of a signal.

Because a signal can produce different sounds over time, its component frequencies and, therefore, its spectrum can also change over time.

The visual representation of how the spectrum of a signal changes over time is called a spectrogram (Figure 3).

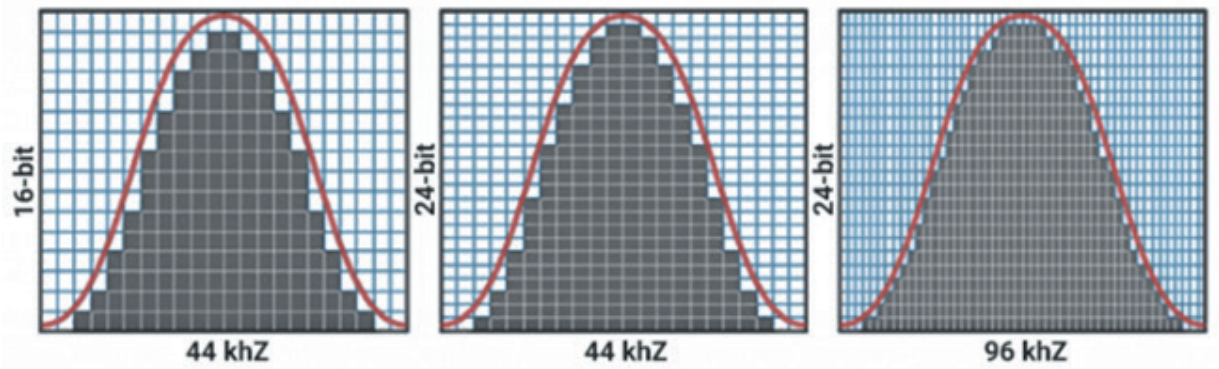

Figure 1 – Comparison of different sampling rates and bit depths.

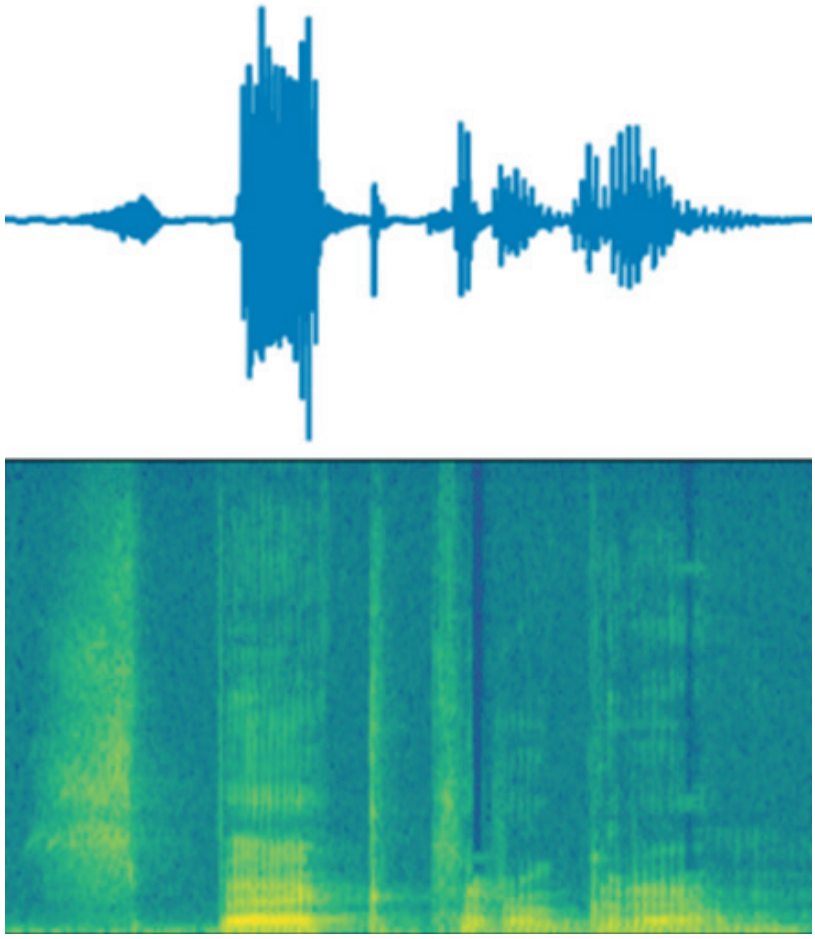

Figure 3 – The waveform and spectrogram of a signal.

The brightness of a color on a spectrogram indicates the amplitude or intensity of a frequency in a given moment in time, and every segment of the graph is a representation of the frequency domain and energy distribution of the signal in that point in time. Each segment of the graph shows the state of the spectrum, i.e. frequency domain and signal energy distribution at that time. A spectrogram can be considered of as an "image" of an audio signal. The spectrogram shows characteristics and features that are unique to this complex signal, allowing the model to classify the signal into the appropriate category.

4. TRAINING CLASSIFICATION MODEL

This section describes the process of creating a general audio classifier, a model which has the ability to differentiate a finite number of sound classes (Figure 4):

1. Loading the audio files in the correct format;
2. Creating spectrograms based on the audio files;
3. Audio or spectrogram augmentation;
4. Creating a feature map for a given spectrogram in a convolutional network;
5. Predicting the score for all supported classes in the model for the given signal based on the extracted feature map.

Firstly, we need to load the audio data from a file and convert it to the appropriate format. This is usually a single-channel audio file (mono) with a sampling frequency of 16kHz and a bit depth of 16 bits, encoded by pulse code modulation (PCM), or in other words, an uncompressed bitstream format file. A sampling frequency higher than 16kHz is not necessary due to the fact that features can easily be discerned and extracted from the spectrograms of lower frequency samples. Comparing two spectrograms of 16 and 48 kHz, we can conclude that the brighter sections of the spectrograms (the ones that often represent features) remain unchanged regardless of the sample rate (Figure 5).

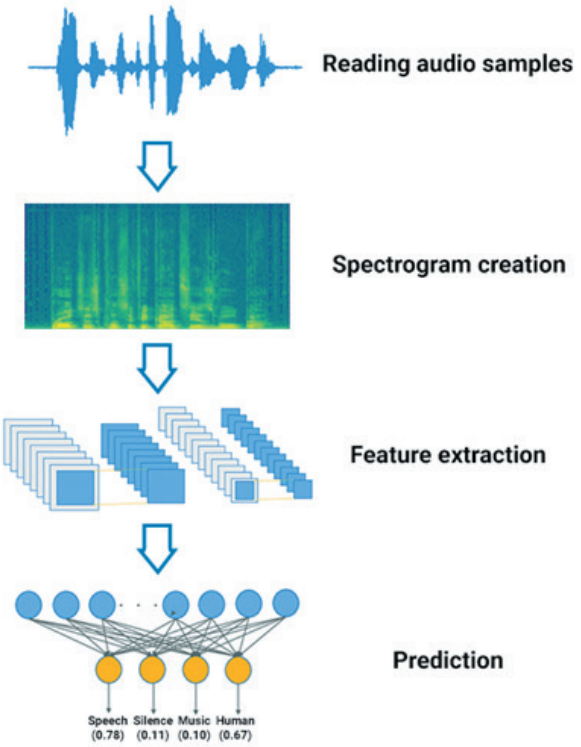

Figure 4 – Steps of model training.

To ensure the resulting classification model is accurate in its predictions, the training dataset must be large and diverse. Differences in the length of pauses, silence or noise can have a significant and often negative impact on the classification accuracy. As a result, training data are usually processed to represent the unique characteristics of the sound signal they contain better, using techniques like noise reduction, silence trimming, etc [11]. This is done to present the key sound features as accurately as possible to the neural network and to define them as clearly as possible for each category (class) that the model supports. This step can be performed before or after the conversion of the samples into spectrograms. Although it is not necessary, doing this step is recommended as excess noise or silence can easily hinder the accuracy of the classification model.

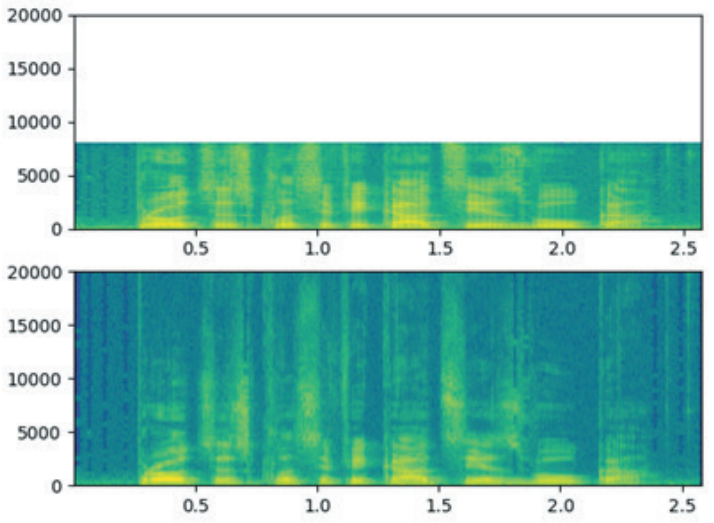

Figure 5 – Comparison of spectrograms of audio signals with a sample rate of 16kHz (upper) and 48kHz (lower).

After converting and loading the training data, a spectrogram is constructed usually by using Fourier transforms which can be performed automatically by mathematical libraries [12]. As the model classifies sound based on its spectrogram, the classification process is very similar to image classification. As previously mentioned, spectrograms can represent the "image" of an audio signal, and in the same way specific arrangements of pixels contain information unique to a particular object in a photograph, a collection of pixels in the image of a spectrogram can also represent features of an audio signal, and because of this, very similar methods are employed when implementing image and sound classification models. The most used neural network architecture for image classification is the convolutional neural network [2], [3], [13]. Therefore, this architecture has also been used in sound classification models.

The underlying methods of training these neural networks differ from library to library, but the core principles remain the same regardless of implementation. The neural network takes a tensor of a specific rank and dimension with the data that comprises the spectrogram of the audio signal, and these tensors are passed through the convolutional layers of the network, by which another tensor, which contains the activation or feature map of the given signal, is created. The information contained within this tensor is processed by specific neurons depending on the contents of the feature map and the receptive fields of the given neurons [14]. One of the last layers in the neural network is a fully-connected layer or linear classifier, and this is where classification actually happens [15]. In other words, this is the layer that outputs the prediction scores for each supported category of the model for the input audio. After which, optionally, the prediction scores can be passed through a loss function such as softmax [16], which is similar to the sigmoid function, and it indicates the “cost” of wrong predictions – this information is used for improving the accuracy of the model. Finally, the model outputs an array of prediction scores for all classes for the given input signal.

5. A PRACTICAL EXAMPLE

The example application has the ability to classify seven different classes of sound, and it was made using the TensorFlow library for Python. When creating a classification model, the first step is to collect training data. The dataset should, ideally, be large and diverse, and the training samples should represent the ideal version of the sound in question, e.g. a small amount of noise, adequate length, etc. The samples for our model have been compiled from YouTube and Kaggle, which are sites where users can download many predefined datasets for training purposes, besides other available functions.

The model that this application uses is able to differentiate the following sounds sources: car, truck, cat, dog, human speech, crowd speech (conversation, multiple people speaking) and silence. The dataset used is quite small, and its contents are the following:

- Car - 104 samples
- Cat - 164 samples
- Crowd - 105 samples
- Dog - 113 samples
- Human - 206 samples
- Silence - 71 samples
- Truck - 107 samples

The total number of samples for this model is 870, which means that the model will not be the most accurate. Typically, when training a classification model, thousands of unique samples are used as training data. For example, Google’s YAMNet model for sound classification is trained on well over 2 million individual audio samples, so our model is somewhat modest in regards to the number of samples, but it is enough for demonstration purposes. These samples must be converted into the correct format: a .wav file with a sample rate of 16kHz and a bit depth of 16 bits. Datasets from Kaggle usually come in this format, but in the case that some data needs to be converted anyway, tools like ffmpeg can be used to easily batch convert multiple files at once.

The model training follows the procedure described in the previous section. During the model training, it is important to distinguish three different types of datasets: training dataset, validation dataset and testing dataset. The training dataset is the dataset which is used exclusively for training the neural network – the model’s weights and biases are adjusted based on the contents of this dataset [17]. The validation dataset is used for recognizing and correcting mistakes in predictions during training, and it typically consists of randomly extracted samples from the training dataset – these samples are not used for training the model [17], [18].

The number of borrowed samples may vary depending on the size of the training dataset, but the validation dataset usually takes a 20% of the samples from the training datase.

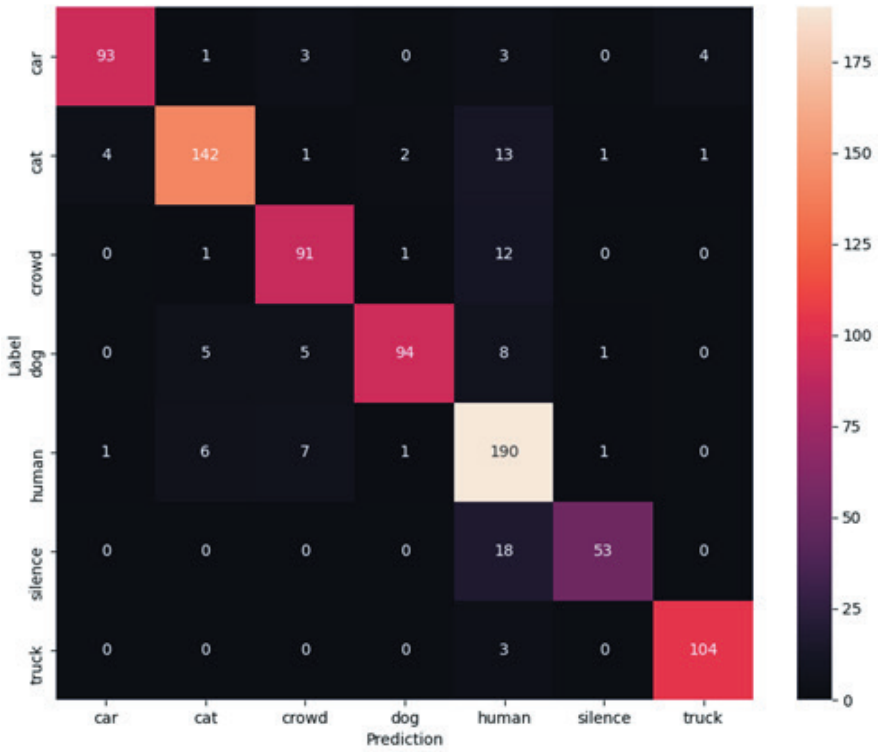

Figure 6 – The confusion matrix for the predictions made during training.

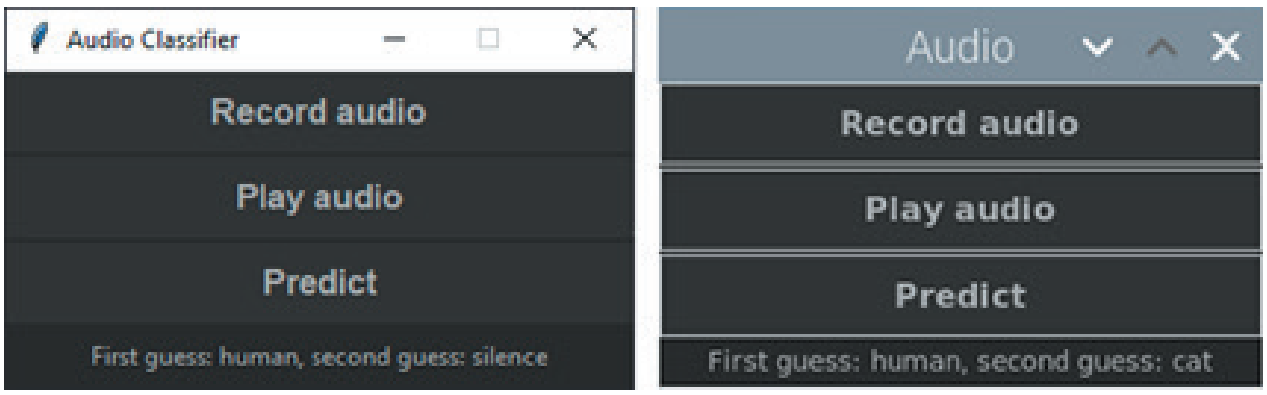

Figure 7 – The GUI applications on Windows 10 (left) and Raspberry Pi OS (right).

Finally, the test dataset is usually a completely separate dataset which is used for the evaluation of the final model after training ends, and it does not contain samples from either of the two previously mentioned datasets [17].

After training the model, we can display a confusion matrix which indicates the model's accuracy when predicting samples from the validation dataset (Figure 6):

The user interface of the application was made using the cross-platform Tkinter library for Python. In the application, the user can record audio from their microphone, play the recorded sound and call the model to output predictions for the recorded audio (Figure 7).

After recording some audio, clicking on the "Predict" button the model is called, and the classification of the recorded clip is performed and the first two classes with the highest prediction scores will be displayed. The application is designed to run on a Raspberry Pi OS, and has been tested on a Raspberry Pi 4 device, where, on average, it uses between 150 and 200 MB of RAM, though with extended use, that number sometimes increases up to 300 MB.

6. CONCLUSION

Sound classification models are currently most often used for speech and music recognition, but they could also be used in, for example, IP cameras. Many IP cameras today can automatically detect human figures or silhouettes and execute specific functions depending on what they "see", e.g., activating alarm or lighting systems, and this is powered by image classification models. Similarly, sound classification models may be used for activating specific functions depending on what the microphone "hears" but the camera can't immediately "see" or detect glass breaking or a loud noise above a certain threshold. Sound classification also has the potential to be employed in natural environments, such as detecting illegal deforestation operations [17] or tracking the activity of difficult-to-see wildlife like insects in their natural habitats [18].

The basic steps outlined in this paper can be used to implement a sound classification model using most of the popular machine learning libraries such as PyTorch and TensorFlow. They are easily configurable and the models can be adapted for a relatively wide range of applications. Options such as the number and order of layers in the neural network, tensor rank and dimensions, loss functions and the datasets themselves all have an effect on the prediction accuracy and quality of the final model. The process described in this paper, however, is mostly used for training a general-purpose audio classification model which can classify a few different types of audio. When implementing a model for a different use case, such as speech recognition, the architecture of the neural network may be different, but the core principles of digital audio representation and discerning the inherent attributes of an audio signal through feature extraction rarely ever change when implementing a sound classification model.

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SOFTWARE FOR RELIABILITY TESTING OF THERMOMECHANICAL INSTALLATIONS

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Abstract:

The aim of this paper is to present the application of Auto Desk software: Revit on Heating, Ventilation and Air condition building installation systems. Determining the reliability of a number of components that are installed also plays an important role in the design of such systems. In this context, the authors developed software for determining the probability of rendering system components using probability theory. An overview of the application of this software as well as the Revit program is given in the paper. The software package was applied to establish the failure of individual components of the thermo technical installation in a larger complex of buildings. Characteristic of this analysis is that the probability of failure of each component weighs zero, while the number of components weighs infinity. The software package was developed for various probability analyzes that are accessed through several different probability distributions. This analysis can be applied to different industries. The need for failure analysis in thermo technical has arisen within the theory of system reliability and is useful for companies engaged in the maintenance of thermo technical installations and fire protection systems of larger residential and business complexes. The paper presents the specifics of the installation on the one hand, as well as the software package that was applied to solve specific tasks, where the Poisson probability distribution is established as appropriate.

Keywords:

HVAC systems, Revit, Poisson distribution, Reliability, Probability analyses.

INTRODUCTION

The analysis considered in the paper is applied to Heating, Ventilation and Air condition (HVAC) systems in residential and business complexes. However, the HVAC system's pipe network in buildings is highly branched and contains pipes of different diameters. This means that the water and therefore the heat are distributed unevenly, and some consumers get more heat than others. The consumers farthest from the pump are supplied with too little heat, and those nearest the pump get too much. As soon as one room occupant turns on the heat, another area of the building will inevitably get less heat. It means that the water is distributed in the optimal way. With hydraulic balancing, all components in the hydraulic system are matched and balanced, ensuring that energy is distributed evenly throughout the system.

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Some of the components exposed to a higher risk of failure and necessary for reliable operation of the system are: Valves, filters and thermostats. To create a balanced hydraulic system with standard control valves, you first need to determine the design flow rates and calculate the pressure losses across the whole hydraulic network. Then you'll determine the valve type, size, and proper flow coefficient. HVAC valves are such components without which we cannot control flow in pipes. Valves are needed for every media whether it is water, gas, air or any other liquid. The thermostat is the control for the entire HVAC system in your home or office. Most people are familiar with this part of their HVAC system as they've used it before. This small appliance is situated on a wall at the most used level of your home or office. You can use it to set the desired temperature for the room. Many people have upgraded to what are known as smart thermostats. These allow you to control the thermostat from anywhere you have an internet connection and they're fully programmable. An HVAC filter is a filter that is used in a heating, ventilation and air conditioning system. The filter increases the efficiency and longevity of the HVAC system by protecting it from dust and airborne particles. It is therefore an integral, yet often overlooked part of the system. In addition to protecting the HVAC system from damage, some HVAC filters are designed to improve the quality of the interior air. In order to check the reliability of each key component of the system Poisson distribution was to be applied and establish the most probable number of them being malfunctioned.

2. RELATED WORK

Description of the aim explored in the paper is based on the references based on the HVAC itself as well as on the optimisation process represented by the distribution of probability of reliability of the system components. In the papers [1] and [2] authors have made focus on design layout in order to improve the reliability of each HVAC system component. The goal of such analysis is minimizing the repetitive process of system. In these papers graphical visualization of the reached progress in the Building Information Modelling (BIM) model is presented. Authors have presented optimizing the construction process by which they allow an immediate and intuitive understanding of the status of a construction project. In the paper [3], the primary purpose of the authors is to present the way of data collection in order to increase the effectiveness of the database by increasing the quantity and quality of the information through facility reliability/availability assessments. However, only forming of databases is presented without probability analyzes and without mathematical methodologies in order the process will be optimized. On such way production failure could be minimized and estimation of the reduction of the time associated with various systems or subsystems could be realized. In paper [4] authors present all the technical information related to an efficient design proving the benefits and necessity of the requirement. This paper presents a complete design of a Heating Ventilation Air Conditioning (HVAC) system for battery rooms using modern components and techniques to achieve a cost effective design. In paper [5] authors give practical example of BIM which assumes total amount of components to be installed by a certain task on-site in order to estimate reliable way for duration of the task itself.

3. AIM OF RESEARCH

In this paper the HVAC building system is analyzed. Graphic representation of the mechanical installation model system was done in the Auto Desk software package: Revit program, Fig.1. Complet duct system with all its components could be designed and locate the main critical points, as well as major conflikt points caused by ducts intersection. Great number of fiting parts have dominant role in HVAC building instalation. Among them, three considered elements were selected as representative having in mind their mass application in the HVAC building system. These selected elements are: valves, filters and thermostats.

In order to create a balanced hydronic system with standard control valves, it is neccessery to determine the design of flow rates and calculate the pressure losses across the whole hydronic network. Then it is to be determined the valve type and size, proper flow coefficient, to define type of filters as well as of thermostats.

Statistical analysis is applied to each of the key components listed above. By such analysis it was possible to establish the mathematical expectation of each component failure. Based on this data, it is calculated the probability that more components, than allowed number of them, will be malfunctioned in relation to the total number of each of them. In the paper is presented the methodology, as well as application of software based on it and realized by authors of the paper in order to calculate the reliability of population consisted of 1500 valves, 1000 filters and 500 thermostats.

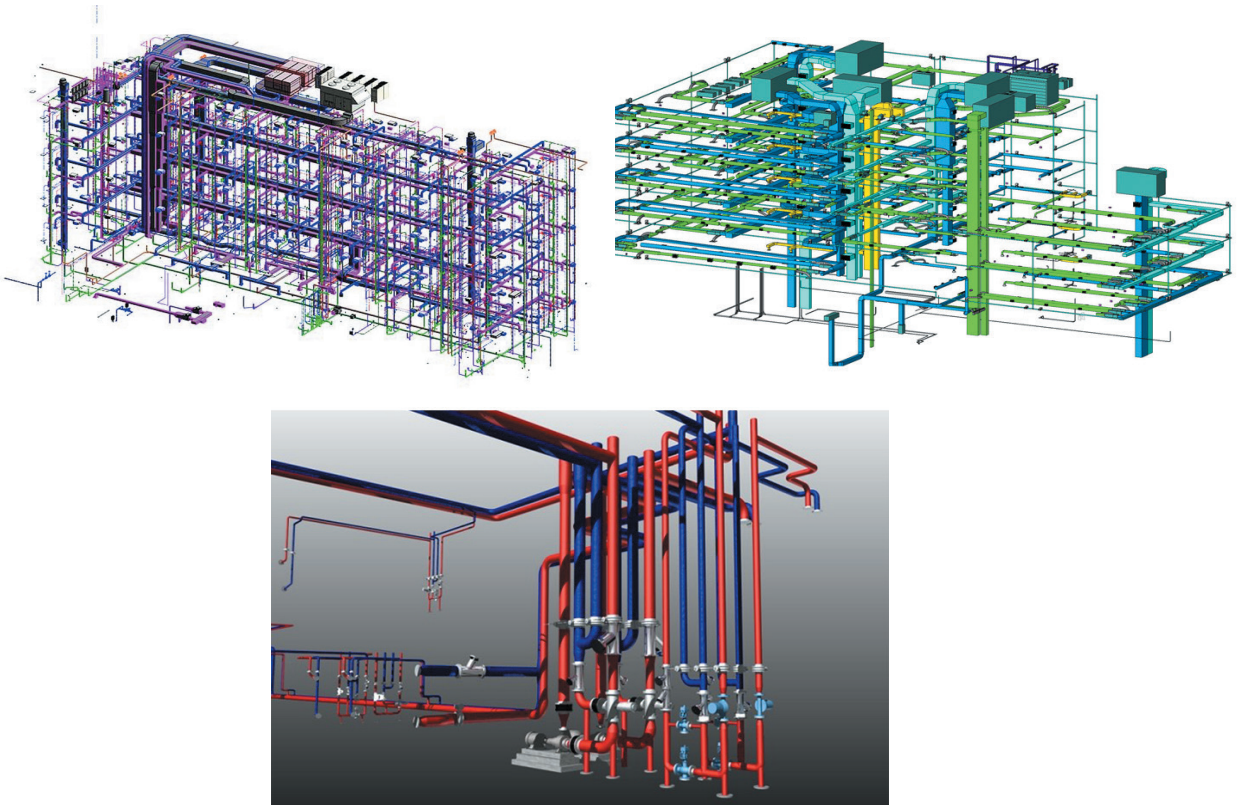

Figure 1 – Overview of Mechanical and plumbing installations in Revit

The probability of arbitrarily selected valve sample is 0.1%. The probability of arbitrarily selected filter sample is 0.5%, and the probability of an arbitrarily selected thermostat sample is 0.1%. The assessment of mathematical expectation of the number of the malfunctioned parts of each component individually is established.

Main goal of research is application of Revit software on HVAC thermo - technical installation, globally, and realize high level of reliability all its components.

The methodology and software for the inspection of reliability, presented in this paper, are applicable to a different number of considered samples and different probability of failure of each of them in different branch of industry.

4. MATHEMATICAL MODEL FOR EXPLORING OD RELIABILITY OF HVAC KEY COMPONENTS

The mathematical model for process optimization is based on the application of the event probability distribution. In that sense, the establishment of the probability of failure of system components is realized with the support of probability distribution models and statistics as well as with software support. The appropriate distribution for the analysis is Poisson's, and the basic settings of the method are given below. The basic premise for the application of this distribution is a very large number of samples and a very small probability of events, malfunctions, concrete components. For that reason, we start from the binomial distribution, which is based on combinations of realization: k times and non-realizations: $(n\text{-}k)$ times in n attempts. The probability of occurrence of the event is: p and non-realization: q. Probability that the event will be realized in n attempts is:

This binomial distribution, (1), tends to exponential:

$$P_{binomna} = \binom{n}{k} p^k q^{n-k} \Big/_{k=1, n\to\infty, p\to 0} \to P_{\boldsymbol{eksponencijalna}} = \boldsymbol{e}^{-\lambda} \frac{\boldsymbol{\lambda}^{\boldsymbol{k}}}{\boldsymbol{k!}} \Big/_{k=1} = e^{-\lambda} \cdot \lambda, \text{fig.2.} \quad (2)$$

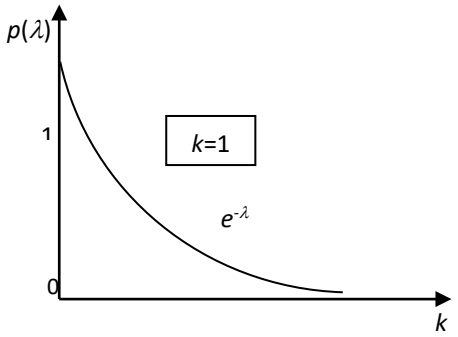

Figure 2 – Exponential distribution of probability

$$B(n,p) = P\{S_n = k\} = \binom{n}{k} p^k q^{n-k}; k = 0....n, \text{ where} \quad (1)$$

$$\binom{n}{k} = \frac{n \cdot (n-1) \cdot .... \cdot (n-k+1)}{k!}$$ - represents number of combinations.

It is valid:

$$n \to \infty, p \to 0, q \to 1, \lambda = n \cdot p, k = 1. \quad (3)$$

However, when: $k > 1$ in (3), the exponential distribution shifts to Poisson distribution, fig. 3, (Siméon Denis Poisson, 1781 - 1840), on which the papers: [6] and [7] are based on. This distribution is in the form of:

$$P\{A_k\} = e^{-\lambda} \frac{\lambda^k}{k!} \quad (4)$$

Distribution (4), [8] and [9], is characterized by: n and k, $0 < k < 20$. Here λ refers to the mathematically expected number of samples in which the failure occurred.

In this case, k, fig. 3, refers to the characteristic number of samples. This number is the limit and great amount of probability is expected to be that the sum of malfunctions of particular part will not be greater than imposed. The aim is to establish the probability that the number of samples, in particular, of defective components will be higher than the limit. Two conditions are imposed:

- the probability that the number of samples is greater than the limit must not be significant, greater than allowed,
- if the limit number of samples is greater than 20, a number significantly less than the total number of samples, the premise of adopting the Poisson distribution as valid is not applicable.

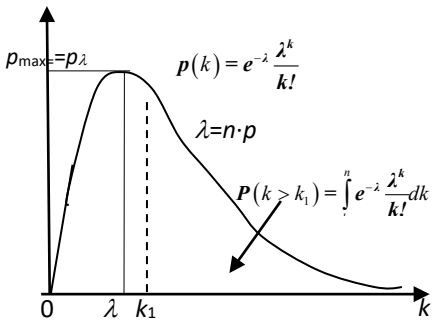

Figure 3 – Poisson distribution of probability

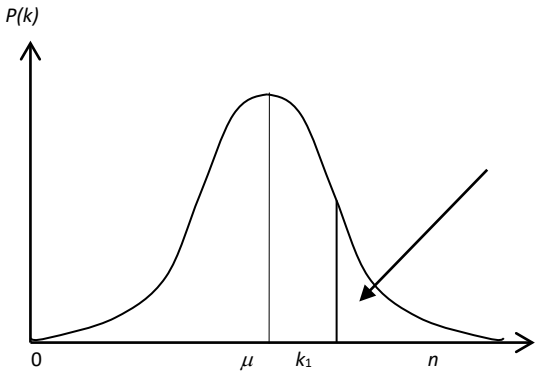

Figure 4 – Gaussian distribution of probability

In that case, another distribution from the family of Γ distributions, [10], is adopted, most often Gaussian, [11], fig. 4, in the form of:

$$P\{S_n = k\} = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{(k-\mu)^2}{2\times\sigma^2}}. \quad (5)$$

Characteristics of this distribution are:

$$n \to \infty,\ \mu \approx n \cdot p, \mathrm{k}>20 \quad (6)$$

but not the imposed condition from previous: $p \to 0$. Here, μ represents assessment of mathematical expectation for the limit number of realizations: k in n attempts. Parameter σ represents deviation of the distribution.

In any probabilistic analysis, the premise is that it is appropriate that the risk of accepting the assumed distribution be up to 5%. Testing of the premise is realized by Pearson x^2 test, [7], by x^2 distribution, fig. 5.

Expression for x^2 is in the form:

$$\chi^2 = \begin{cases} \dfrac{x^{\frac{k}{2}-1} \times e^{\frac{x}{2}}}{2^{\frac{k}{2}} \times \Gamma\left(\frac{k}{2}\right)}, x \geq 0 \\ 0, \quad x < 0 \end{cases},$$

$$\Gamma\left(\frac{k}{2}\right) = \int_{x=0}^{x\to\infty} x^{\frac{k}{2}} \cdot e^{-x} dx = \left(\frac{k}{2}-1\right)! k \in \{C\}. \quad (7)$$

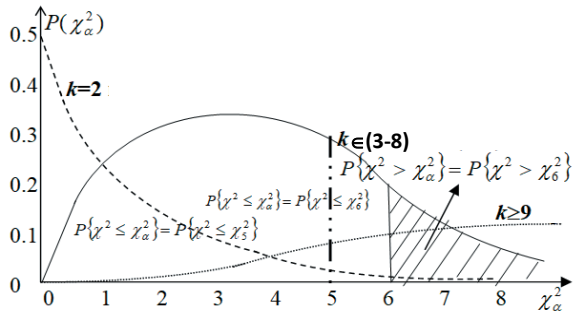

Figure 5 - x^2 distribution

5. RESULTS HAVING ACHIEVED BY SOFTWARE: "POISSON" APPLIED TO MATHEMATICAL MODEL FOR EXPLORATION OF RELIABILITY OF KEY COMPONENTS OF HVAC INSTALLATION

In order to explore the reliability of mechanical and plumbing installations authors of this paper have developed the software: "POISSON" for establishing the percentage of malfunctions of the key components of the system. Software used for analysis is based on Poisson's, fig. 3, Gaussian, fig. 4, and x^2 distribution, fig. 5, as key ones as well as on the others but which are not applied to this analysis. x^2 distribution, (7), is applied to testing the premise that adopted distribution is appropriate for analysis. Software is realized in QBASIC program language, while graphic presentation is realized in Harvard graphics. Results of analyzes are presented by diagrams which represents distributions and cumulative curves of the number of sum of defective key components of the system depending to malfunction of the particular part, fig. 6.

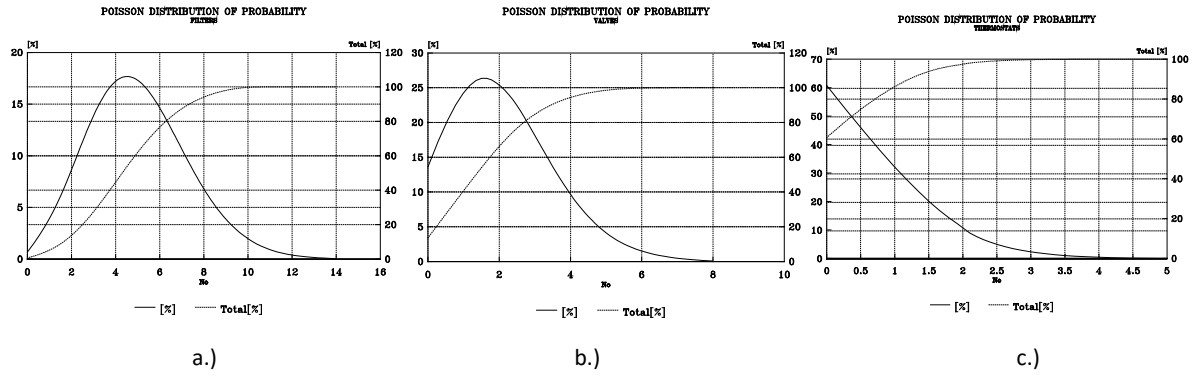

Figure 6 – Distributions and cumulative curves of the number of sum of defective valves, filters and thermostats depending to malfunction of the particular part

On fig. 6 is clearly visible that graphic of probability distribution character moves from the shape similarly appropriate to Gaussian distribution, (5), fig. 6 a, over Poisson distribution character, (4), fig. 6 b, to exponential, (2), fig. 6 c. Such shifting from symmetrical graphic shape to exponential one is depending on parameters: n, p and λ, according to (3) and (6). It is to be established the percentage that the number of malfunctioned samples of each component being tested greater then the number of malfunctioned samples that has imposed to be minimal. Such percentage depending to malfunction of each component as well to the imposed number of failed number of samples allowed to be minimal is presented by diagrams, fig. 7. Total number of samples per component, taken in research, is equal to 1500, 1000 and 500 unites, referring to each components.

Results of the analysis realized by software are given below.

Poisson distribution of Probability
VALVES

Probability of particular valve malfunction: 0.2 [%]

Probability that number of malfunction parts is greater then 4 is 38[%]

Poisson distribution of Probability
FILTERS

Probability of particular filter malfunction is 0.4 [%]

Probability that number of malfunction parts is greater then 5 is 22 [%]

Poisson distribution of Probability
THERMOSTATS

Probability of particular valve malfunction is 1[%]

Probability that number of malfunction parts is greater then 4 is 55 [%]

6. CONCLUSION

The paper presents a model of installation in buildings realised in the Revit program and gives a concrete example of the analysis of the HVAC system components. Primary role of this software is design of installations as well as defining and locating conflict points on them. The other contribution is presentation of the results have got by applying software: "POISSON" realised by authors.

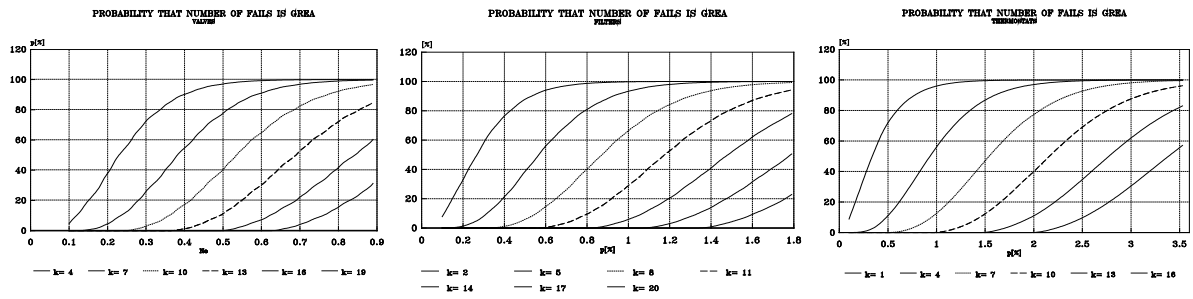

Figure 7 – Percentage of failed valves, filters and thermostats depending to the limit number of the parts allowed to be malfunctioned and to the dysfunction of the particular key component

Last mentioned software is yoked with software for graphic presentation: Harvard Graphics what integrally result the analysis of reliability of the whole installation. Building Information Modelling assumes complete design with calculation of the reliability each crucial component.

Graphics presented on the figures above demonstrate the specifics of the software "POISSON" which is convenient to calculate the probability of wide range different populations. What more, it is considered for each premise for probability analysis to be tested by Pearson x^2 test. On such way it is possible to consider the results of probability analysis has been applied, as adequate and to accept them for calculations that follow. Software: "POISSON" is proved by a lot of analysis, firstly Gaussian, Poisson, and on family of Erlang distributions on the field of Queuing theory, [12]. The specific of the paper is integration of Revit software, POISSON software and Harvard Graphics as complete unit giving relevant results for Building Information Modelling and reliability calculation.

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IT APPLICATIONS IN EDUCATION SESSION

AUTONOMOUS GRADER – A NEW DIGITAL SUMMATIVE ASSESSMENT TOOL

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Abstract:

Assessment is an essential part of both traditional and online education. Regardless of the learning environment, assessment can be formative and summative, each with advantages and disadvantages in the digital era. In order to harness its possibilities in an online environment, educators must overcome certain challenges that technology-based assessment imposes. This paper includes an overview of the literature that covers tools that can be used as digital alternatives to traditional pen and paper tests. In order to maintain the positive learning environment in online education, assessment tools had to be adapted to the new learning environment in order to be accessible remotely to a large number of students. The paper discusses several advantages of digital assessment tools in light of their credibility, validity, and reliability, especially in case of summative digital tools, which includes the solution presented in this paper, the Autonomous grader. This tool, created with the purpose of promoting the use of technology in teaching, improves the testing system by offering effective, precise and unbiased grading of each individual assignment, reducing the time spent on grading. The proposed solution is a test environment utilizing Selenium tests. The solution includes a language for defining tasks and evaluation criteria used to generate individual Selenium tests. The result of the automatic evaluation process is a human-readable report containing the results of individual assignments. We conclude that this type of tool can be used effectively and can be a valuable asset to assessment in the digital age.

Keywords:

Summative assessment, online education, automated grading.

INTRODUCTION

Due to the abrupt change in the education system caused by the pandemic of COVID-19, the traditional forms of evaluation ceased to be used. Digital alternatives had to be found for both formative and summative assessment, which are considered to be two most occurring forms of assessment in any learning environment [1]. While formative assessment focuses on observing students' learning process, alternation, modification and improvement of their learning [1], summative assessment does the opposite. Summative assessment tools are standardized tests typically given upon completion of a course and are often seen as a quantitative appraisal of specific learning outcomes [1, 2].

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With the full change of focus from traditional pen and paper tests and in-person observations, both summative and formative assessments suffered great changes. Seeing students on devices, teachers started combining technology with assessment forms because they noticed the advantages of adapting it to the new learning environment. Using digital forms of formative and summative assessment has proven to provide faster and almost immediate feedback, allowing teachers more time for rapport with students. In the light of capabilities of learning in an online environment this paper will present the process of creation of a new summative assessment tool – Autonomous grader. This tool was created with the purpose to evaluate any structured document. The validation process is demonstrated on an end of the course summative assessment for undergraduate students at Singidunum University. Their final exam in the course focused on the utilization of modern technologies in language learning. It was based on the creation of an online summative assessment tool using already existing online learning platforms such as Google Classroom, Microsoft Teams, and ClassDojo.

2. THEORETICAL BACKGROUND

In recent times, there has been a widespread use of online tests in assessing students' knowledge. The increased need for new forms of assessment was derived out of a need to prepare students to be "work ready", competent and capable to meet the digital age [3]. Though many might have had doubts about the use of digital assessment tools, numerous benefits can be pointed out, not only concerning their efficiency, but pedagogical reasons as well. Digital tests are highly efficient due to automated grading and the possibility for immediate feedback, especially with large groups of students or in the case of different topics that need to be covered in one test of limited duration [4, 5]. When it comes to pedagogical reasons, digital assessment tools still struggle with traditionally oriented teachers, who doubt their validity, reliability and fairness [1, 6], which are the commonest reasons why they hesitate to implement these forms of testing in regular online or blended learning. However, the effectiveness of online tests should not be doubted if they are implemented in the context of an overall learning experience, and additionally supported by other forms of assessment [6]. Moreover, one should not forget the impact of individual and immediate feedback they provide [7, 8], which is likely to help students learning [9].

Digital assessment tools have been increasingly used in an online learning environment caused by the emergence of the world pandemic, in both formative and summative forms of assessment. Multiple choice questions, fill in exercises, online forms and quizzes are frequently used tools for summative assessment while discussion boards, reflections and small group discussions, digital portfolios are used for formative assessment [1, 10]. Since this paper focuses on the development of a new summative assessment tool, only forms focused on summative digital assessment and their characteristics shall be addressed in the following text.

One of the major benefits of summative digital assessment tools is their ability to provide automated answers and immediate scoring of evaluated data, which reduces the possibility for mistakes due to human factor. Digital scoring is effective and precise and the time invested in grading each individual paper is significantly reduced [2]. With the transition to online learning, many teachers decided to transform paper-based multiple-choice tests to digital format. It wasn't long before they realised the benefits of this format, because it allowed them to enrich their testing system with different media such as video, audio and other multimedia content.

Another advantage of digital assessment tools is the ease of their use. Once mastered, they are easily administrated to large groups, and the automated scoring process speeds up the administration of grades and its distribution to students [11]. Due to the minimization of human-made mistakes, there is an increase in efficiency which leads to their standardization. Another benefit refers to administration of digital tests and teacher's dialect, which is a significant feature concerning phonological awareness and listening comprehension [2]. One should not forget that technology-based assessment tools support educators in case of instructional modifications on an individual level which is necessary when dealing with students of different achievement profiles [12].

Digital assessment systems are surely the future that will cleverly encompass needs and perceptions of both teachers and students [13]. Teachers now have the task to make an effort to successfully integrate new technologies in their classrooms. Further advantages of technology based summative assessment tools are yet to be discovered, because with their increased use in an everyday classroom situation the potential for their advancement is inevitable.

Digital assessment systems are surely the future that will unavoidably encompass needs and perceptions of both teachers and students.

3. IMPLEMENTATION

The solution proposed in this paper is implemented as a sequence of Selenium tests, mimicking the usual workflow employed by teachers during the manual evaluation of students' assignments. The assignments are supplied by the teachers in the form of a structured document containing tasks. Each task is described using natural language, as to be delivered to students, a series of steps necessary to extract students' answers for a given task, and conditions that dictate when a task is considered successfully solved. Each condition corresponds to a single task and contains a template of an expected answer, as well as the score attained for successfully satisfying a condition. The template allows for a more flexible validation as opposed to the validation using strict equality with a specific value.

An example of a possible teacher-submitted task description is shown in Listing 1. Each variable defined in a GET clause can be used in the following get clauses and conditions. Variables defined in the GET clauses must be unique. Each variable can be assigned a set of values by using FROM SUCH THAT expressions. The FROM expression extracts values either from previously defined variables, constants, or implicitly defined variables such as the webpage variable. The SUCH THAT part of the FROM expression is optional and can be used to acquire a subset of values that match a specific criterion. Conditions are given as [VERBS] variable COMPARATOR [VERBS] value|variable SCORES score_value expressions where VERBS is an optional part of the expression consisting of a sequence of verbs acting on values or variables to extract additional data. The SCORES part of the expression is used to express the score a student is given if a condition is satisfied. The steps and conditions, given in a previously defined manner, of a task description, are translated into concrete Selenium tests. An example of the generated Selenium test for the task description shown in Listing 1 is shown in Listing 2.

```
Task: Create at least one mandatory multiple-choice question worth at least 5 points
   Steps:
      Get quiz by URL url
      GET questions FROM quiz SUCH THAT type=multiple-choice AND required=true AND value>=5
   conditions:
      Count questions > 0 SCORES 1
```

Listing 1 – An example of a simple task description.

```
@task("Create at least one mandatory multiple-choice question worth at least 5 points")
def task_1():
   score = 0
   Driver.get("url")
   questions = driver.find_elements(By.XPATH, "//question[@type='multiple-choice' and @
   required='true' and @value>=5"]
   if(len(questions) > 0):
      score += 1
   return score
```

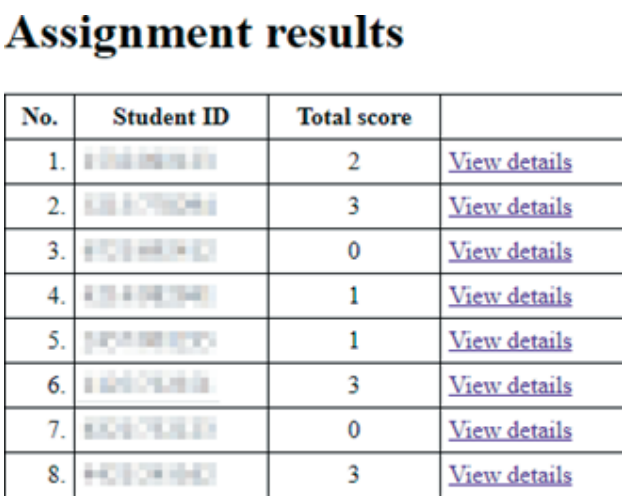
Listing 2 – An example of a generated Selenium test.

Once a teacher collects all the students' works, they can initiate the automatic evaluation process. During the evaluation, an evaluation model is created for each submitted work. This model contains the total score per student, as well as triplets, one for each task, consisting of the student's extracted answer, the conditions the answer was required to meet, and the evaluated score. An example of a generated model is shown in Listing 3.

A human-readable report is also generated based on the models acquired by evaluating the students' work. The report is presented as an HTML page, shown in Figure 1, containing a table listing all the students and their scores, as well as links to individual models, with examples shown in Figure 2.

```
{
   "total_score":69,
   "Create at least one mandatory multiple-choice question worth at least 5 points" :
{"expected": ["count questions > 0"] , "submitted": ["count questions = 3"], "score": 1},
   ...
}
```

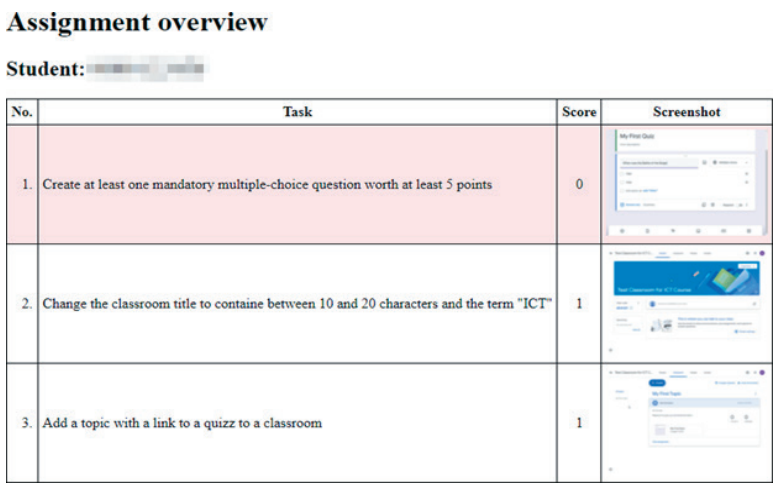
Listing 3 – An example of a resulting report model.



Assignment results

No.	Student ID	Total score	
1.	[redacted]	2	View details
2.	[redacted]	3	View details
3.	[redacted]	0	View details
4.	[redacted]	1	View details
5.	[redacted]	1	View details
6.	[redacted]	3	View details
7.	[redacted]	0	View details
8.	[redacted]	3	View details

Figure 1 – A table showing students' IDs and their scores for a given assignment.



Assignment overview

Student: [redacted]

No.	Task	Score	Screenshot
1.	Create at least one mandatory multiple-choice question worth at least 5 points	0	
2.	Change the classroom title to containe between 10 and 20 characters and the term "ICT"	1	
3.	Add a topic with a link to a quizz to a classroom	1	

Figure 2 – An overview of a single submitted assignment. Pink rows indicate incorrectly completed tasks.

4. CONCLUSION

Making technology-based summative assessment tools part of regular educational practice has the potential to enhance the assessment process by increasing its credibility, validity, and reliability. However, numerous challenges and issues are commonly encountered when introducing innovative technologies in education. Those challenges include cheating as one of many practices students engage in when exposed to online or digital testing tools [14, 15]. In case of being assessed remotely, as it was the case during pandemics, students often took digital test as open-book tests, using numerous techniques such as multiple computers, online search engines, communication platforms and even helpful and knowledgeable friends [15] logging in from different devices under same name to help their classmates. However, many authors claim that the problem of cheating in using digital tools in not a big concern, since the same problem often occurs in face-to-face testing as well [16]. As in the case of taking regular pen-to-paper tests in the traditional classroom environment, teachers always have the opportunity to involve additional methods of testing their students' knowledge, such as an oral confirmation of the acquired material. Another drawback of the transition to digital assessment tools is the lack of technology requirements. Although it is a common occurrence today that every household has a computer and Internet connection, one must not forget multiple-children families where two or more children must share the same device. Even if a device is available to each student, not all students are experienced computer users and many will need further help or training in order to familiarise themselves with this type of assessment [17, 18, 19].

However, the benefits of using digital assessment tools outweigh the challenges, since they are proven to be extremely accurate and fast method of students' evaluation in comparison to traditional paper-based tests. The benefits of using these forms of assessments are numerous and present in different domains; these benefits are utilized by teachers and students in educational institutions to achieve educational aims [20].

Benefits for students are seen in friendly interfaces and gamification of assessment materials, and the possibility for numerous simulations of testing environment through repetition of the material that needed to be worked on [21]. Digital assessment tools, especially summative ones, offer immediate feedback that can further enhance students' learning, especially if students are located in remote areas or are employed.

Benefits for teachers are numerous, starting from the fact that digital assessment tools are less time consuming, unbiased, precise and accurate, with immediate feedback for each assignment. It also enables teachers to monitor students' progress analysing their performance across many assignments [22].

Digital assessment tools support educational goals of an institution showing that the institution is willing to adapt to the challenges of the new educational environment in order to support learning and teaching in the digital era.

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HIGH SCHOOL STUDENTS` COMMON ERRORS IN PROGRAMMING

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Abstract:

Identifying and classifying the commonness of errors made by novices learning to write computer programs has long been of interest to both: researchers and educators. Teachers understand the nature of these errors and how students act to correct them, hence more efficient teaching can be performed. Some errors are more frequent than others.

In this paper, we examine the most common errors in novice programming of first-year gifted mathematicians in Mathematical Grammar School. Regardless of extensive coverage of these types of errors during the lectures and in learning material, we have noticed that these still persevere when students write programs. Our findings imply that students who usually make all common mistakes have lower marks, but excellent students also make logical errors in conditions for loops. Therefore, we advise more practice in logical thinking with novice programmers and an introduction to formal semantics.

Keywords:

Computer Science Education, C# Language, Errors, Novice Programmers, Programming.

INTRODUCTION

In today's world, computer science education has an important part of the STEM curriculum. Students who are early exposed to STEM content commonly extend their interest in STEM subjects through elementary and high school up to the faculty level [1] [2]. Computer science education provides an abundance of new learning concepts and opportunities crosswise domains. Computational thinking in education prepares today`s school-aged students to live and work in an entirely digitized world [3].

Learning programming is sometimes very difficult for first-year high school students. Therefore, students produce significant errors in their code when they confront difficulties in learning programming [4] [5]. Analysis of frequent student errors is necessary for computer science professors to understand students' problems in learning programming. Accordingly, a computer science professor needs to obtain expertise in the subject matter and pedagogical knowledge of teaching the subject`s content.

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Due to the global COVID-19 pandemic, in the last two years, education has been implemented mainly in the home environment. Face-to-face teaching in schools was substituted with teaching online, using online platforms as new virtual classrooms. This pandemic brought remarkable disruption to education, as well as to High School Education, locally and all over the world [6] [7] [8] [9] [10] [11].

In this paper, the data collected during an introductory C# programming course in the first year was used to identify which errors are often made by Mathematical Grammar School scholars in two generations. One generation attended classes before the COVID-19 pandemic and the second generation attended classes during the COVID-19 pandemic. We have considered all different kinds of errors that were conducted to an incorrect solution. Further, we investigated connections between scholars' error-related behaviors and their achievements in C# introductory programming course.

Our work is innovative in several criteria. First, the population for the course is first-year Mathematical Grammar School gifted mathematicians scholars. Second, there was an inconsistency between the errors identified in papers by the researchers and those errors experienced by the high school scholars.

The paper is organized as follows: The next section gives an overview of related work. Common programming errors with methodology and results are shown in Section 3. The last section concludes the paper.

2. RELATED WORK

Ko and Myers in [12] gave the categorizations of programming errors linking the causes of errors. Identifying and helping to correct Java programming errors for Introductory Computer Science students using the education tool, Expresso, made for Java programming, is presented in [13]. This interactive tool generates error messages and additionally provides instructions on how to fix the code. The main purpose is to be used all along the beginning process of learning programming and for students to become more skilled with Java and gain a better comprehension of the essential programming concepts.

In 2005, [14] presents an integrated semantic and syntax error pre-processing system to benefit new programmers unravel the otherwise cryptic compiler error messages for them to concentrate more on design issues than implementation issues used in the United States Military Academy taken for an introductory programming course.

In [15], the authors investigated the types of errors most frequently accomplished by students practicing writing short fragments of Java code using the CodeWrite practice tool. Further, it was examined how long students spent resolving the most common syntax errors and discovered that certain types of errors are not solved any more quickly by the higher ability students. Furthermore, it was noticed that these errors waste a large amount of student time, advancing that targeted teaching interference may yield a significant outcome in terms of increasing student productivity.

The diagnostic message frequencies in [5] show a relatively high occurrence of "cannot find symbol", "';' expected", "')' expected" and "illegal start of expression" diagnostics. The results are similar to the study [14].

One recent study [4] implemented a data-driven approach to identify Chinese high school students' common errors in a Java-based introductory programming course using the data that was collected in an automated assessment tool "Mulberry". Students' error related behaviours were further analyzed, and their relationships to success in introductory programming were explored. The study suggests that students' competence in improving code is important to their accomplishment in introductory programming.

Ettles, Luxton-Reilly and Denny analysed 15000 code fragments [16], created by novice programming students that contain logic errors. They classify the errors as algorithmic errors, misinterpretations of the problem, and fundamental misconceptions. Additionally, they identified that misunderstanding is the most frequent source of logic errors and leads to the most complicated errors for students to fix.

In [17] proposed, a method for the categorization of frequent errors in solution codes. The authors used paired source codes (incorrect - accepted) for these experiments. The longest common subsequence (LCS) algorithm is influenced to find the differences between wrong and accepted codes.

Due to the COVID-19 pandemic, many studies confirm the learning loss caused by schools closures and online learning [6] [7] [10] [18] [19] [20]. Besides this confirmation, studies also propose solutions to make up for the missed knowledge: consolidation of the curriculum, extending instructional time or improving the competencies of learning by supporting teachers to apply structured pedagogy and targeted instruction.

3. METHODOLOGY AND RESULTS

In this section, we describe the design of our study aimed to identify which errors are often made by first-year Mathematical Grammar School students compared with two generations, pre- and in- COVID-19 pandemic. At the end of this section, we focus on the obtained results and observations.

3.1. CONTEXT

We analyse the data that was collected during a first-year programming course for gifted mathematicians in Mathematical Grammar School "Jovan Jovanović Zmaj", Novi Sad, Serbia. The introductory C# programming classes were held five school hours per week. The major topics examined in this course are program structure, input/output, variables and operators, conditionals, and loops.

Two separate collections were performed. One started before the COVID-19 pandemic in the school year 2019/2020 and another entire during the pandemic in 2020/2021. The first group had 17 students, and the second had 19 students. Some students finished seventh and eighth grade in the Mathematical Grammar School. So, they had prior knowledge of programming.

Both sets of data collection are collected from students' written exams. Thus, students solved their tasks by writing on the paper without possibility to compile the program. Thus, students did not have the help of the compiler to warn them about mistakes, as is usually done in other studies [5] [12] [13] [15] [21]. Moreover, all solutions were inspected manually.

We analyzed the solutions obtained from the first three written exams.

3.2. CATEGORIES OF PROGRAMMING ERRORS

Our review of the literature demonstrated that researchers used a diversity of methods to identify common errors. Commonly accepted categorizations of errors are lexical, syntactic, semantic, and logic errors. Besides, these errors can be either static (compile-time) or dynamic (run-time) in nature. Nevertheless, the types of errors highly depend on the exercise [13].

Logical errors are the hardest of all error types to detect. Occasionally, referred to as semantic errors, there are situations where the programmer's code compiles successfully and executes but does not generate the proposed output for all possible inputs [16].

3.3. LIST OF COMMON HIGH STUDENT ERRORS

The following errors were identified in our research made by both groups of students:

- The comparison operator (==) vs the assignment operator (=);
- Unbalanced:
- parentheses ('(', ')');
- square brackets ('[', ']'),
- curly brackets ('{', '}'); and
- quotation marks;
- Inserting a semi-colon after the parentheses defining *if, for, foreach*, or *while* conditions;
- Separating the *for* loops with commas (',') instead of semi-colons (';');
- The equal sign in front of :
- the greater-than sign (or) ('=>') for a greater than or equal; and
- the (or less than or equal) ('=<'), instead of following them.
- Improper casting, i.e. missing of the cast; and
- Logical errors in loop conditions.

Also, we have noticed that students who write their code neat mostly do not have unbalanced errors. Another common error (up to 10%) was in conditions in the if-else statement are wrong due to the substitution of the comparison operator with the assignment operator. More, inserting a semi-colon before *if, for, foreach*, or *while* the block was common among 10% of students.

Surprisingly, the most common mistakes were logical errors in loop conditions with 30% of students` exams in first evaluations, notwithstanding the pervasive coverage of these types of errors during the lectures.

No significant difference was noticed between students' error making and obtained marks between face-to-face lecturers and online, unlike the reports given in [18] [19] which observed that in core subjects, like math and reading, there are alarming signs that in some grades students might be falling even further behind pre-pandemic expectations. Also, the average learning loss graded by the length of the school closure during the pandemic was presented in [20]. We could consider the main reasons for having the same students` accomplishments before and during the pandemic. Teaching was conducted without interruption online as face-to-face, with the same hours; and the groups are rather small, up to 19 students.

3.4. STUDENT ERRORS AND MARKS IN THE COURSE

Introductory programming is usually difficult for high school students. However, our students are gifted and have academic performance in math and science as one of the most important predictors of their achievement in introductory programming courses [4]. Although the observed groups of students have passed an additional exam for entering the course for gifted mathematicians, some students in high school discontinued their excellent mastering of subjects. Consequently, students with many errors in their exams had pure marks.

On the other hand, it is noticed that up to 20% of students with very good and excellent marks make logical errors in loop conditions. Hence, logical thinking should be more practiced during the lessons.

4. CONCLUSION AND FUTURE WORK

This paper has analysed high school students' solutions to programming exercises in an introductory C# course. We have identified the most common errors high school students made and given their categorization.

We can agree with [22], that the deficiencies in students' strategic knowledge are one of the main reasons programming is a challenge for students.

Students in the second group were followed in their second year, and only students with pure marks still made logical errors in loop conditions. Given the current state of affairs, our recommendation for expanding programming tuition would be to introduce a theoretical introduction to formal semantics. Students would thus become acquainted with the theoretical features of languages, which would help them realize the important features at the level of syntax and its connection to the resulting semantics and thus avoid several mistakes in writing programs [23] [24].

For future work, we could additionally consider code and "algorithmic" smells to instruct students not only to write correct but also adequate and proper programs. The result of our research is significant for teachers and researchers wishing to advance programming pedagogy.

5. ACKNOWLEDGEMENTS

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IMPORTANCE OF STUDYING COMPUTER GRAPHICS AT FACULTIES FOR COMPUTER AND INFORMATICS ENGINEERS

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Abstract:

The modern way of life and work tasks of computer and informatics engineers also require knowledge of working with computer graphics. This segment is mostly neglected or very little applied, so engineers during their education at the faculties acquire minimal or almost no knowledge about this area. This field has been widely applied in recent decades in various software and experts of that profile and knowledge are in great demand on the market. In this paper, we deal with the basic knowledge that we believe that every engineer dealing with digital products should possess. We have proposed subjects that could be studied so that future experts from the faculty would be more competent in the field of computer graphics. The primary goal of this paper is to encourage experts and creators of new programs at colleges to consider the application of these programs to acquire defined skills that would give users greater opportunities in choosing the final occupation and specialization.

Keywords:

computer graphics, vector graphics, raster graphics, user experience and user interface.

INTRODUCTION

In their work, computer and computer engineers often come across computer graphics. Or to be more precise, it is difficult to do anything in the digital world without computer graphics. [1] This imposes on us the need for every future engineer to encounter the subjects they are studying during their schooling. [2] This is very often the case, but mostly in one subject that deals with this topic in general, which is only possible given the small number of classes during one semester.

If we take into account that subjects such as Internet programming and mobile programming are studied at faculties, then there is a need for knowledge that would be acquired in a block of subjects that would cover a wider range of knowledge in the field of computer graphics. [3] Both the web and mobile applications abound with a lot of computer graphics, so it is necessary to have basic knowledge. [4] Developers need this knowledge as much as knowledge from subjects such as: operating systems, computer networks, computer architecture, etc. [5]

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Most programmers deal only with programming languages, but they need to have general technical knowledge in these areas in order to adapt their software to the given criteria and better synchronize with experts whose specializations in these areas.

Most of the programs at the faculties are dedicated mainly to programmers with general knowledge from other fields. This is probably dictated by the labor market itself, which has high demands on developers. This is quite legitimate, but when you take into account that engineers choose their specializations themselves, they need to be able to master all the necessary skills that will help them in their further life and development. [6]

When we look at all this, it is clear that computer graphics skills are very necessary [7] or at least desirable. [8] Knowing 5 or 6 programming languages for every engineer is an excellent basis, but one programming language is enough for learning programming. We are always guided by the slogan that the basics are mastered at the faculty and one slowly enters the world that is being studied, and that in his independent work a person improves himself for further challenges he encounters. All of the above shows how important it is for all knowledge to develop evenly.

2. COMPUTER GRAPHICS

This area is very broad and requires basic specific knowledge. This knowledge should be acquired from a block of subjects that can be divided into three to four subjects in order to acquire only the basics that would be studied from those subjects. Some of the subjects that deal with specific graphic knowledge deal with:

a. vector graphics,
b. raster graphics,
c. user interface - UI,
d. user experience - UX.

In addition to these subjects, I have many others who can deal with 2d and 3d graphics [9] and similar specific knowledge, but this is an area that should be left for specific areas such as graphics engineers. [10] The above subjects only serve to provide computer and computer engineers with a foundation that can help them in their further work or direct them to new areas of computer graphics that they want to deal with.

2.1. VECTOR GRAPHICS

Vector graphics in its work relies on mathematical support to draw various shapes using dots, straight and curved lines. An example of the work is the drawing of a square of size 300 dpi, which is drawn using four points that are mathematically connected and filled, making the shape of a square. Some of the vector graphics that we often come across are fonts or logos.

The characteristics of vector graphics are: the possibility of infinite magnification, small file size, the possibility of modification, etc. In addition to the listed features that are among the advantages, there are some limitations, such as: limited possibilities for details and effects.

The most common programs used and used in practice are: Adobe Illustrator, Inscape and Corel Draw.

2.2. RASTER GRAPHICS

Unlike vector graphics, a raster is made up of many (hundreds, thousands or millions) of small squares (dots) that make up one complete image. These squares are also called points that contain information that makes up a given image. This kind of graphics has a lot more details and effects, but also flaws in terms of file size and image magnification. Such a graph contains the same number of points in one square of size 300 dpi, which makes it much more complex than the square drawn in vector graphics. The most common type of raster graphic that we encounter every day is photography.

The most common programs for working with raster graphics are: Adobe Photoshop and Gimp.

2.3. USER INTERFACE (UI)

UI is a software environment that allows the user to adequately communicate with the computer [11] using predefined functions. [12] UI users are also defined as GUI (Graphical User Interface). Apple Macintosh and Microsoft Windows operating systems are most responsible for its development. While learning how to make it easier for the user to work on their operating systems, they developed GUIs that are still used today and are constantly being developed and improved. [13] The graphical user interface replaced the impractical and difficult text interfaces of earlier computers (e.g., MS-DOS) with a relatively intuitive system, which not only simplified computer handling but made it much

more natural and enjoyable. In addition to computers, the GUI is used in many mobile devices, gaming devices, smartphones, and home and office control devices.

2.4. USER EXPERIENCE (UX)

A relatively new concept in the IT world, but very important and a large number of companies are increasingly paying attention to this segment when creating new digital products. This term is defined as emphasized by the International Organization for Standardization, as "the perception and reaction of a person that results from the use or expected use of a product, system or service". [14] Or simply put, this is what you feel when you interact with a product while using it.

Manufacturers have realized how important customer experience is to their existing and future customers, and that this is the way to build the trust and loyalty of those customers. [15] Precisely because of the manufacturer's awareness of UX [16], there have been greater demands from customers who have become less and less tolerant of bad experiences. [17] This means that this field has a future and will be increasingly sought after, and thus create new jobs for UX designers or researchers. When we talk about UX we mean all kinds of products, not just digital products and if it all started with them.

3. MARKET NEEDS

Market analysis is done through online job search platforms such as :

a. Upwork,
b. Fiverr,
c. Freelancer.com,
d. PeoplePerHour.com or
e. Guru.com.

These are global platforms for freelancers with a large number of job offers, mainly from technical fields. The Upwork platform also includes specific jobs such as those in the field of computer graphics. It is interesting that on this platform, jobs in the field of vector and raster graphics are divided into separate units, and the same is the case with UI and UX jobs. The Design & Creative sector includes jobs from vector and raster graphics, while the UI / UX sector is located in Development & IT.

On other platforms that are much less popular and used, they are mostly in similar categories. Somewhere it is web design in another place Graphics & Design, Graphic Design, Web Development & Design, Programming & Development. From these divisions, it can be seen that experts connect them with design as well as with development and programming. This is exactly what says that this is a difficult segment to separate in the daily work of an engineer and that it is very necessary.

On all these platforms, there is a very large number of business offers for jobs that we have defined in this paper as computer graphics. On these platforms, there are a large number of divisions by jobs and by names of positions, which are quite branched in relation to our basic division.

Some of the jobs are divided as :

a. UX/UI Designer,
b. Product designer UX/UI,
c. UI Designer,
d. UI researchers,
e. UX Designer,
f. UX researchers,
g. UX Architect,
h. UX Writer,
i. UX Analyst,
j. UX Strategist or
k. UX Consultant.

All of these jobs are in demand and require a basic set of computer graphics skills that we wrote about in this paper. This shows the justification for the introduction of this group of subjects in the basic study of computer engineers and informatics. Some of these jobs listed above have their application in the field of electronic marketing. For this set of occupations and jobs in which they can participate, it is safe to say that they are multidisciplinary, combining established knowledge of design, programming, analysis, research, design and strategy. Unfortunately, due to the exceptional similarity in the mentioned jobs, it is difficult to make precise statistics on how many jobs from which area were requested on the mentioned platforms. Users who post jobs very often define jobs with multiple position tags as mentioned above, so there is a big overlap of results.

4. DISCUSSION

The paper lists the basic segments of computer graphics that we believe that every computer and computer engineer should encounter during their schooling. Observing these divisions, we can see that raster and vector graphics complement each other, so they need to be studied individually. On the other hand, UI and UX are often assumed to go together [18], which is normal when one affects the other and vice versa. [19]

In the entire educational process at the faculty, the student encounters 30-40 subjects and it makes sense that three subjects are dedicated to such an important segment as computer graphics. It is similar with the blocks dealing with programming languages, computer administration, databases, information systems and general education subjects. Despite the fact that most faculties strive to educate programmers, in reality a large number of engineers resort to other mentioned segments.

Regardless of whether students want to deal with this segment of computing, we believe that this would facilitate work with experts in this field who have become an integral part of every development team. This approach avoids only a superficial acquaintance with the important segments of computing that every faculty strives for. On the other hand, students are given the opportunity to choose and specialize within the sciences for which they are studying.

5. CONCLUSION

Computing and informatics is a broad term and requires a large number of specific knowledge from future engineers. One of those specific knowledge is computer graphics. Therefore, it is desirable that future engineers have knowledge that can change in further work or in interaction with other associates who work in this field within a development team. Despite the belief that all engineers will be programmers, experts in other fields often meet in practice. Some of these areas are network or server administration, databases or UI / UX designers, etc. Precisely because of this, it is necessary to innovate study programs and give greater emphasis to the basics of computer graphics.

The intention of the author was to encourage the professional public to pay more attention to computer graphics and thus enable future engineers for the greater demands of future labor markets. When you look at the fact that Microsoft and Apple pay a lot of attention to this, it can be expected that others will follow this example, and therefore this knowledge and skills will be desirable for any new expert.

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M-LEARNING IN SERBIAN SECONDARY EDUCATION – A COVID-19 SIDE EFFECT

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Abstract:

Learning represents a relatively permanent and progressive character of an individual's personality and behaviour change, and it arises as a product, i.e., the result of a specific experience. Modern digital technologies have further contributed to the improvement of learning. Some of these technologies have been developed specifically for educational purposes, but most had to be adapted to be suitable for teaching and/or learning. These communication and mobile technologies became crucial during the Covid-19 pandemic. The goal of this paper is to determine how current mobile technologies and devices can further be applied in secondary education and to analyse student habits and attitudes towards using mobile devices in secondary education in the light of returning Serbian secondary schools to traditional classes after a two-year-long state of a medical emergency.

Keywords:

Educational Technology, M-Learning, Secondary Education.

INTRODUCTION

Even though mobile devices permeated every pore of contemporary society during the last two decades, mobile learning (e.g., m-learning) was a novel approach to most of the teaching practitioners in secondary education who became painfully fast aware of its potential during the Covid-19 pandemic. The emergence of m-learning originated from e-learning as a way for learning on the go by taking advantage of every free moment in ever more saturated everyday routines of students. The concept of m-learning is still not clearly defined. There are several definitions of m-learning, one of which is that it represents any type of learning that takes place when the student is not in a predetermined place or that it is learning that takes place when the student uses mobile technology/device. However, m-learning can be broadly defined as the use of ubiquitous technology (devices) in combination with online access, to facilitate, support, enhance and expand the scope of teaching and learning.

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The possibilities of using mobile devices in education are diverse. Providing online access via 3G/4G/5G network has created very good conditions for the implementation of teaching and made it easier for individuals to access all the necessary information and services [1].

Due to its rapid development and accessibility, m-learning can be one of the key factors for the future development of educational technology and the improvement of learning/teaching processes. Of course, teachers play a primary role in the process of introducing and implementing any new educational technology. Their task is to observe and analyse the potential needs and possibilities of applying some new technology in the teaching process, primarily in their class. If they play it the right way, teachers will often make their work easier and (more important) they will enable students to learn experientially and gain new functional knowledge and skills. This research aims to analyse the current potentials of using mobile devices in secondary education, what students most often use them for and how, whether teachers already use them in their practice and what is their opinion on mobile technology's future potentials and development after experiencing teaching during the Covid-19 medical emergency.

2. RELATED RESEARCH

[2] [3] [4] observed that while most of the developed countries keep up with introducing new technologies and the applications of m-learning, Western Balkan countries still "drag their feet" when we think about the possibilities of using smartphones in secondary education. Researchers conducted a survey that included 9 municipalities, with 455 students and 49 teachers. Smartphones were most often used as a tool for gathering information but also for taking notes. Of the total number of respondents, 47% were male and 53% female. The age of the respondents ranged from 11 to 18. According to results, 72% of students owned a smartphone and 88% used it primarily for entertainment. Students generally used their smartphones to maintain communication (92%), but 63% stated that they benefited when tried using their smartphones for learning. However, this also had its downsides, namely 73% of examinees stated that they sometimes used their mobile device for cheating on tests. [5] also pointed out the need to use mobile devices for learning. Researchers believed that traditional learning has become very boring for today's students and that this boredom could be at least reduced by introducing the model of mobile learning. In their work, [6] presented some advantages and disadvantages that accompany mobile technology. The research was conducted on a sample of 148 teachers, out of which 101 were in secondary schools. The survey was conducted through a paper survey. The age of the respondents ranged from 25 to 50. As for smartphones, 98% of teachers owned at least one, and 65% owned also a tablet. Most of the schools had the infrastructure necessary to use the Internet in classrooms. About 60% of teachers stated that they use smartphones in their classes. Paradoxically, 53% of teachers do not allow students to use their mobile devices during class. Male respondents were much more confident in themselves and their knowledge of using mobile technology than their female colleagues. [7] researched which mobile phones, applications and social networks students use, as well as the frequency of that use. As many as 92% of students always carried their mobile devices with them to school. However, 43% of respondents said that their mobile is always on but that they only look at it occasionally. It was recognized that the largest percentage of students used their mobile device for up to 3 hours a day, but there were 15% of respondents who used it for more than 5 hours a day. In most cases, students perceived m-learning as sending pictures of processed lessons to friends via their smartphones or finding information related to the lecture as well as reading books/files online. There are four applications that students used the most, namely YouTube (97%), Messenger (94%), Instagram (88%) and Facebook (80%). 94% of students used their smartphones to correspond with friends about class-related information outside of class. An example of an m-learning classroom based on the use of tablets was presented by [8]. Researchers reported that their approach was suitable for conducting tests and screen sharing, i.e., teachers used their own tablets to share the images they would traditionally share via projector or TV. [9] experimented by making a mobile game about the process of the circular movement of water. Namely, they divided the students into two groups of 19 students and gave one group a mobile device with a game that initially had a video about the movement of water in nature, and then the questions had to be answered. Another group of students attended traditional classes where they acquired knowledge about the same phenomenon using traditional methods. Later, they switched groups and compared how much the students learned using the mobile game, and how much the control group learned the traditional way. The results did not significantly differ, but a lot of time was saved when using mobile devices and students who used them were able to get

instant feedback. In one of the previous researches, there was talk about how it is possible to implement tablet technology in the teaching process so that it is of the greatest benefit to the teacher. In the research of the implementation of mobile learning in foreign language teaching on the example of German conducted by [10], it was found that the use of mobile devices had a positive effect on the quality of teaching and student achievements. The research involved 120 participants and it was found that over half of the respondents owned a tablet and used it once a week or less to find some information or for communication. According to researchers, the use of tablets had a positive effect on the quality of teaching by stimulating a creative atmosphere and the most significant advantage was fast feedback. [11] examined how much time students spend using their mobile devices and their favourite apps. It was found out that students used their mobile devices for approx. 4,5 hours a day on average. Based on this, they concluded that all previous tests on the ubiquity of smartphones were correct and that it has been confirmed that mobile technology will increasingly occupy young people. As for the applications that students used, it was mostly Instagram (42%), YouTube (26%) and Viber (5%). [12] stated that it was necessary to develop reliable tools and methods to properly implement m-learning. M-learning needs to form the conceptual basis that would give it certain credibility and authority in professional circles and that would be the good starting point for its evaluation [13]. [14] discussed the phenomenon of m-libraries and their social mission (which operate largely also as school libraries) attempting a correlation between the function of the welfare state and its obligations to citizens. [15] studied parents' preferences and beliefs towards using mobile technologies. Their study was conducted with 293 families in Greece which show that most of the parents had a positive attitude towards the use of these technologies. Parents wanted to support their children's learning and seek to provide a stimulating home learning environment for them. However, older and less-educated parents seemed unable to adapt appropriately to rapid technological progress and thus could not effectively exploit the advantages that m-learning have to offer to children. However, the positive attitudes of parents about m-learning are hampered by the lack of knowledge about the choice of apps with 'substantial educational value' as well as their use, particularly in the domestic environment.

3. METHODOLOGY

This research aims to present the current situation regarding using mobile devices and technology in secondary education and analyse future potentials. The research should determine whether and how students use their mobile devices, at what time of day, whether they think that mobile devices should be introduced in the teaching process, whether schools should allow and encourage the use of mobile devices, whether online hazard training should be introduced in the schools, etc.

The survey questionnaire used for the research consisted of 14 questions and 10 statements. The initial part of the survey and the first two questions referred to personal demographic data about the respondent and the rest of the questions and statements were related to the research topic itself. Questions were composed in such a way as to objectively represent the views and opinions of the respondent. The first part of the research was realized in the fall of 2019 (just before the Covid-19 pandemic) and the second part in the first quarter of 2022 after the Serbian secondary schools returned to traditional classes. The total number of respondents was 155 secondary school students from Serbia, all of which correctly completed the questionnaires. The largest number of respondents were third-grade students (N = 96), of which 62 were female and 34 were males. There were 30 first grade students, 14 males and 16 females, while 29 respondents were second-graders, out of which 13 males and 16 females. Of the total number of respondents, 20 lived in rural areas while 135 lived in urban areas.

In total, five hypotheses were stated: (General H0) Students usually don't use their phones for school purposes; (H1) Students most often use their mobile devices to reduce boredom; (H2) Students who live in the rural areas use their mobile devices less during the day; (H3) Male students were more likely to use mobile phones to cheat on tests; (H4) Female students most often used their mobile devices for accessing social networks.

4. RESULTS AND DISCUSSION

The questionnaire was validly completed by N = 155 respondents. N = 61 (39%) of the examinees were male respondents, and N = 94 (61%) of the examinees were females. Of the total number of respondents, N = 20 (13%) lived in rural areas (5 males and 15 females), while N = 135 (87%) respondents lived in urban areas (56 males and 79 females). In total, N = 128 (83%) students reported having a brother or a sister, and N = 27 (17%) had no siblings.

When asked "How many mobile devices have you owned so far?", one respondent answered that he has not owned any devices so far, three responded that they owned only one device, 12 responded that they owned two mobile devices and 139 students answered that they owned more than two mobile devices. When asked "How many mobile devices do you currently own?", one respondent said that he does not currently have any, 124 responded that they currently own one device, 15 responded that they currently own two devices and 15 responded that they currently own more than two devices. In total, 102 respondents stated that their smartphone runs the Android operating system, and 52 students stated that their smartphones were running the iOS. If we ignore the respondents that stated that they do not own a device, and we consider all others who use Android and iOS systems on their smartphones, we concluded that all students use modern smartphone devices.

Based on the results obtained from the t-test, there was no significant difference between respondents living in rural areas (N = 20; M = 2.65) and respondents living in urban areas (N = 134; M = 2.75). Based on the obtained results t (152) = - 0.530; p = 0.597, it was concluded that hypothesis H2 has not been confirmed. One student that was living in the rural area and two living in urban areas stated that they used their smartphones less than one hour per day, N = 9 students that were living in the rural areas stated that they used their mobile devices between one and three hours per day, while the number of such respondents living in the urban areas was N = 58. By analysing the results in two time-frames (before and after the Covid-19 pandemic), we concluded that most of the students used their smartphones for up to 3 hours per day in both periods (67%). However, in the 2019 survey, 15% of respondents used their mobile devices over 5 hours per day, while this number has significantly risen in 2022 to more than 21%. Out of the total number of respondents, N = 10 respondents stated that they used their mobile devices mostly in the morning, N = 32 respondents stated that they used their mobile devices mostly in the afternoon, and the largest group of respondents (N = 96) stated that they used their mobile devices mostly in the evening. N = 13 respondents used their mobile phones primarily during the night.

When asked if they used their mobile phones to do homework, N = 132 (85%) students responded positively. When we observed students by gender, N = 47 were male and N = 85 were female. In total, N = 16 males and N = 7 females said that they did not use mobile devices to do homework.

When it comes to teachers and whether they use their mobile devices in classes, N = 72 (47%) answered that they were. A slightly larger number of respondents said that they did not use their mobiles in class, N = 81 (53%). When teachers were asked how often they generally used their mobile devices, most answered that they rarely used it N = 87 (56%). A smaller group of teachers did not use a mobile device whatsoever N = 32 (21%) and a slightly larger group used it occasionally N = 34 (22%). When we compared this issue with the previous one, we see that there is a contradiction. When answering the question, 32 students answered that their teachers did not use their mobile devices. Suppose that the students did not pay attention when they answered, it is possible that the students did not think that teacher used a mobile device if he/she used it to check what time it is, etc.

When students were asked what did they most often used the Internet for, N = 146 (94%) stated that it was for entertainment, while only N = 9 (6%) responded that they used it for school. If we take into account the gender of the respondents and the way of using the Internet, we could conclude that regardless of gender, the largest number of respondents used the Internet for entertainment, N = 54 males and N = 92 females.

When asked what students most often used their mobile phones for at school, most responded that they used mobiles for social networks, i.e., N = 57 (37%). The number of respondents who did not use their mobile devices in class at all was N = 46 (30%). N = 29 (19%) respondents said that they most often used their mobile devices at school for communication/correspondence, while the number of respondents who used their mobile for mobile games was N = 19 (12%). As expected, just N = 3 (2%) of respondents most often used their mobiles in school to acquire new knowledge. When we compared the gender distribution, N = 43 female respondents most often used their mobile devices for social networking, while the number of male respondents was N = 14. The largest number of male students (N = 18) did not use a mobile phone at all. N = 28 was the number of female respondents who did not use a smartphone in class. In total, 11 male and 18 female students used their mobile phones for correspondence at school. It was also significant that only N = 5 female respondents used their mobile phones for mobile games at school contrary to N = 14 male respondents. Based on the results, it can be concluded that students often used their mobile devices at school, although the school's policy forbids them. An increasing number of students were actively using

phones at school and in class. The percentage of such students was about 53% in 2019 while in 2022 it rose to a staggering 70%. Based on the t-test results, there was a significant difference between male students (N = 60; M = 3.05) and female students (N = 94; M = 2.97). Based on the obtained results t (152) = 0.342; p = 0.733, the hypothesis H4 that female students most often used their mobile devices at school for accessing social networks was confirmed.

When we questioned using mobile devices at home, the largest number of respondents said that they used their mobiles mostly for social networks N = 91 (59%). The number of respondents who used their mobile phones for correspondence was N = 43 (28%), and N = 15 (10%) students stated that they used their mobile devices at home for playing mobile games. As expected, we recorded the lowest number of those who used mobile phones to acquire new knowledge N = 4 (3%) while N = 2 (1%) students stated that they did not use their smartphones at home. We observed that both male (N = 30) and female (N = 61) respondents used their mobile phones mostly for social networking. The situation was similar with communication/correspondence, N = 18 males and N = 25 females. When it comes to playing mobile games, we observed that it was more prevalent among male respondents, about twice often. The result of the t-test shown a significant difference between male (N = 61; M = 3.75) and female (N = 94; M = 3.71) population. Based on the obtained results t (153) = 0.346; p = 0.729, it was concluded that the hypothesis H4 that female respondents most often used their mobile at home for social networking was confirmed.

One of the characteristic questions was "Have you ever used a mobile phone to cheat on a test?". The results should not be observed with complete certainty because students probably gave socially desirable answers. However, a positive answer to this question was given by N = 46 (30%) respondents, while N = 108 (70%) stated that they had never used their mobile phone for cheating at school. When we observed this result by gender, we concluded that N = 22 males have already used their mobiles to cheat on the tests, similar to the number among female respondents (N = 24). However, there were significantly more students who said that they did not use their mobiles for those purposes (N = 69 female and N = 39 male). According to the results obtained by the t-test analysis, there was a significant difference between male (N = 61; M = 1.64) and female students (N = 93; M = 1.74). Based on the obtained results t (119,689) = -1,333; p = 0,185, it was concluded that hypothesis H3 was confirmed - male students used their mobile phones to cheat on tests more often.

When asked if they think that using mobile devices could improve the quality of teaching, N = 26 respondents fully agreed so, N = 43 respondents generally agreed, N = 34 was undecided, N = 22 partially agreed and N = 28 strongly disagreed. If we analyse the gender distribution, we can see that the largest number of respondents mostly agreed with this statement, both male (N = 18) and female (N = 25). However, when it comes to respondents who disagreed, a difference was noticed, N = 21 females versus N = 7 males.

Regarding the use of mobile devices for teaching, students generally agreed with the statement, namely N = 40 of them. A similar number of students partially agreed (N = 39) and were undecided (N = 38). The smallest percentage did not agree at all (N = 14). When we observe it by gender, we detected one very important feature. The largest number of male respondents (N = 18) stated that they mostly agree with the statement, while females stated that they only partially agree with the statement. Based on these results, we concluded that male respondents believed more in this claim. In total, 24% of students agreed that mobile devices can improve the teaching process. Most students generally agreed with this statement N = 50 (33%). However, there were 22% (N = 33) of respondents who only partially agreed. However, when students' gender was analysed, N = 33 female respondents stated that they mostly agreed with this statement, while the majority of male respondents (N = 20) agreed with it. Although it was very important to pay attention, N = 25 students only partially agreed with this statement. Of course, the smallest number were those who disagreed with the statement.

Perhaps the most interesting claim was that access to the wireless network should be available in each classroom. As many as 60% (N = 91) of students agreed with it. There were significantly lower percentages of those who mostly agreed (20%), those who were undecided (8%), those who only partially agreed (7%) and those who disagreed (5%). The results show that the largest number of male (N = 35) and female (N = 56) students agreed with this statement. Based on these results, we concluded that the Internet has become something that young people living in modern society think that they cannot function without.

The next claim examined the support for the use of mobile devices by the school staff. We observed that the largest number of respondents N = 47 (30%) declared indecisive, 23% (N = 35) generally agreed with

the statement, and 20% (N = 31) strongly agreed. N = 47 respondents who were undecided in most cases were females. This is also the largest number of females who opted for this answer. On the other hand, the largest number of males (N = 18) generally agreed with the statement. N = 54 (35%) of respondents agreed that mobile devices should be used in computer science classes, N = 33 respondents were undecided while N = 28 respondents mostly agreed with the statement. There was the smallest number of those who disagreed with the statement N = 18 (12%). As with wireless internet, respondents agreed that mobile devices should be used in computer science classes. The largest number of males (N = 21) and females (N = 33) absolutely agreed with this statement. However, the next largest number of male respondents (N = 17) generally agreed, while the next largest number of females (N = 25) was undecided. When it comes to using mobile devices in other classes, the situation is a little different. The students were almost proportionally distributed, but still, 24% of them only partially agreed with this statement, 22% of the respondents mostly agreed with this statement and 20% were undecided. Based on these results, we concluded that the respondents were divided into two groups - those who were more inclined to use mobile devices in other classes and those who were not.

Of the total number of respondents, 40% agreed with the statement that training should be introduced in schools to learn about the dangers of the Internet and social networks. In addition, 28% of students generally agreed with this statement. This told us that almost 70% of respondents were aware that there were dangers on the Internet and social networks that should be learned in schools. It was interesting that the same number of male respondents (N = 19) stated that they absolutely agreed with this statement and that they mostly agreed with it. It was also interesting that the largest number of females (N = 43) agreed with this statement, while N = 24 said that they mostly agreed with this statement. Based on these results, it was clear that both male and female respondents were very aware that the Internet and social networks were not harmless.

It is known that a new practice emerged in modern times - when there is something that we do not know or we are not sure about we most often "consult" with Google search engine. This was indeed the case with sampled high school students, N = 122 responded that they agree with the statement that with the help of mobile devices and the Internet the answer to a certain question is faster and much easier. Significantly fewer respondents (N = 20) said they mostly agreed with the statement, and only N = 6 reported they partially agreed. However, as expected, the smallest number of students did not agree at all. When we observed the gender distribution, we saw that males and females mostly agreed with this statement. Based on these results, we concluded that respondents were already widely using their mobile phones to find answers. When we added that students were aware that there were dangers on the Internet, we concluded that students were ready to learn how to protect themselves, but also how to find the right and relevant sources.

The last statement mostly referred to the use of a mobile device to reduce boredom. Out of the total number of respondents, N = 71 (46%) stated that they agreed with this statement, N = 40 (26%) respondents generally agreed that mobile benefits reduce boredom and N = 19 (12%) were undecided. When we took into account the gender, we saw that in this case, the largest number of respondents of both genders (N = 25 male and N = 46 female) agreed with the statement. In addition, there was a large number of respondents who mostly agreed with the statement (N = 19 females and N = 21 males). The t-test analysis returned values of (N = 61; M = 4.00) and (N = 94; M = 3.95) for male and female students, respectively. Based on the obtained results t (153) = 0.267; p = 0.790, it was concluded that hypothesis H1 was confirmed - students most often used their mobile devices to reduce boredom.

Based on the results and confirmed hypotheses, we concluded that the general hypothesis H0 was confirmed - students usually don't use their phones for school purposes.

5. CONCLUSION

Even though the digitalization of modern society is a process that began several decades ago, we are still witnessing the accelerated development of information and communication technologies. Today, life and education became impossible to imagine without the possibility of long-distance communication at any time, especially during emergencies, such as the Covid-19 pandemic. Young children are already well acquainted with mobile technologies and devices and handle them very well. Our research confirmed that most high school students have smartphones or some mobile digital device. This represents a challenge for the school system itself, which definitely needs to find more ways to apply and use all this alternate power. Most high schools still completely

forbid using mobile devices in class, but there are more and more examples where teachers start encouraging students to use their smartphones if they see that they can be used in the right way. However, this research has proven that students often abuse the technology, for instance when cheating on tests, and that is why the beforementioned school restrictions can be, in a way, justified. In addition to that, students found a way to apply mobile technologies in the process of acquiring knowledge by using them to do homework. It is clear that generations born in the 21st century grew up with social networks and most often they are not completely aware of their dangers. The integration of mobile technologies in schools is a necessity and an inevitability. It is an innovative technology that should already be in use. Due to the growing possibilities of free online access, the following question arises: "Is it really necessary for students to know every detail of every lesson by heart when they can access it all in just a few seconds using their smartphones?". This can be a problem with this technology paradigm. Hardware resources are also becoming problematic because it is becoming necessary to procure all the equipment for the classes to be carried out according to the desired plan. However, these costs will surely be reduced because as proven by this research, students in most cases already have newer generation smartphones that surely can be used for these purposes.

Creating a subject curriculum that includes the use of mobile learning and technologies is very difficult because of the constraints of the traditionally framed educational system. Modern schooling and education are facing great difficulties. Even if we could ignore the mobile learning model, there are more and more new technologies that also allow students to get instant information. Additionally, a significant number of teachers are not sufficiently familiar with the possibilities nor trained to implement mobile devices/technologies in their teaching practice and were mostly left to improvise during the covid-19 state of emergency. Therefore, if we want to ensure, advance and further integrate technology into secondary education, the first step should surely be to train and employ digitally literate, skilled and competent teachers who have the power, desire and will to take the next step into the digital future.

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IT APPLICATIONS IN EDUCATION SESSION

TEACHING TRIGONOMETRY ONLINE USING GEOGEBRA DYNAMICAL MATERIALS

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Abstract:

In this paper, we present our experience in teaching mathematics online using GeoGebra as a software tool. The GeoGebra teaching materials developed and used for the online trigonometry course for Gymnasium students are shown and described in detail.

The experiences of teachers and students are presented and discussed. Also, in the paper are presented the research results related to the achievements of students during the online and classroom teaching and learning process.

The research results indicated that the application of GeoGebra materials during the online teaching process had a positive impact on maintaining the admissible level of students' achievements.

Keywords:

Trigonometry, GeoGebra, dynamical materials.

INTRODUCTION

Education worldwide is currently facing major challenges, considering the conditions imposed by the pandemic. Both teachers and students are faced with new ways of teaching and learning. With the help of technology, we have managed to sustain the educational process, but we encountered many obstacles. In the spring of 2020, when new conditions and restrictions emerged, it was necessary to establish, as soon as possible, an online teaching process. At the time, we did not have at our disposal the technical equipment needed for real-time online teaching (such as pen tables). The mathematics teaching process was particularly vulnerable because, to be able to give our students the maximum, it was necessary to provide them with learning conditions that would correspond to the direct contact we had in the classroom.

Trigonometry is one of the main subjects in the high school mathematics curriculum. Understanding trigonometry is very demanding for students even in normal conditions because they need to adopt the three representations at the time: algebraic, geometric, and graphic [1].

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In an online classroom and without the possibility for real-time contact, we had to find a way to show our students all three representations. We have chosen to use GeoGebra software as a tool for an easier understanding of basic trigonometric concepts and functions. The GeoGebra software was chosen because it provides the possibility of multiple representations, and also for its dynamic nature suitable for making simulations and animations.

2. GEOGEBRA SOFTWARE

GeoGebra is open-source dynamic mathematical software that can be used to implement various mathematical theories. It is designed both, for scientific and educational purposes. One of the main GeoGebra's features is the possibility for multiple representations of concepts: algebraic, geometric, and graphic. In this way, objects can be displayed in multiple representations at the same time and it is possible to manipulate them. All representations are related and the change of parameters in one representation automatically implies changes in other representations. In that way, GeoGebra allows us to manipulate the objects and variables, that is, to make simulations and animations.

GeoGebra supports multiple platforms and can be installed on computers, tablets, and mobile phones. When installed, the user can create materials, but there is also the possibility of using ready-made materials available on the official GeoGebra site [2]. In that way, the materials can be used or shared at any time.

When it comes to its application for educational purposes, the main feature of GeoGebra is its ease of use and low requirements regarding the training of teachers and students for its application in teaching and learning practice. However, this is very powerful software, with the ability to meet the requirements of all users. The dynamic nature of GeoGebra is one of the main reasons for its use in STEM education [3]. Due to its visual and dynamic properties, GeoGebra is very often mentioned in research in education and teaching [4]. Today, GeoGebra is a software that is constantly present at all levels and in many fields of education, especially in the teaching of mathematics and sciences [5], [6].

For all its features, we have chosen GeoGebra as a supporting tool for teaching trigonometry. There were reported positive experiences in teaching trigonometry using GeoGebra [7], [8]. Those positive experiences were related to student achievements, understanding of basic trigonometric concepts, and also to the motivation of students for learning.

3. GEOGEBRA ASSISTED TRIGONOMETRY LEARNING

In the spring of 2020, we started with the online teaching process. In Gymnasium Zrenjanin was organized using the Google Classroom platform. The existing teaching schedule was realized in such a way that the teachers sent students written materials that contained lessons that were processed according to the curriculum. The materials for mathematics contained all the concepts and explanations related to the topic being covered, tasks and detailed solving procedures, as well as practice tasks. Students studied these materials and were able to ask the teacher a question using the Google Classroom option for comments. But, this kind of communication was slow and the lack of direct communication was more than obvious. However, the students were able to follow the materials at the beginning while topics started at school were still being addressed. When trigonometry had to be started, there were some concerns present about how will students learn and understand some completely new concepts to them using only written materials.

For that purpose, we decided to use technology to enrich the written materials with the GeoGebra dynamic elements which could help students to see and to better understand the connections between trigonometry concepts by giving them the possibility to manipulate the objects within those dynamic materials. For teaching trigonometry online, we used GeoGebra materials that we previously have made and designed. We uploaded those materials as resources on the official GeoGebra site. We made five GeoGebra materials, considering all the topics covered by the trigonometry course. Those topics were as follows:

1. Unit circle;
2. Reduction to the first quadrant;
3. Graphs of trigonometric functions;
4. Trigonometric functions with parameters;
5. Trigonometric equations.

For each of these topics, the link toward the matching GeoGebra material was included in the written material. The link provided students with access to the GeoGebra material which they could use for learning and practice.

3.1. UNIT CIRCLE

The unit circle is the basic concept with which students first get acquainted when learning trigonometry. They have to master and understand the representation of four trigonometric functions (*sinx, cosx, tgx* and *ctgx*). For that purpose, we created GeoGebra material as presented in Figure 1.

In the left window, there is a graphic representation of the unit circle. All four trigonometric functions are labeled and marked in different colors. On the circle, there is a point *M* that can be "dragged" on the circle thus changing the angle α. In that way, students can observe how a change in angle affects the change of the values and signs of trigonometric functions. The values and signs of the trigonometric functions are displayed in the right window, and the change of position of the point *M* on the unit circle corresponds to the change of values in the right window.

3.2. REDUCTION TO THE FIRST QUADRANT

With the reduction to the first quadrant students usually have a lot of problems, mostly due to misconceptions about unit circle and signs of trigonometric functions. To avoid that, we created GeoGebra material, which also consists of two windows, Figure 2. The window on the left is used for geometric representation. The students can move the point *M* on the circle, changing the angle φ that is, the quadrant in which the angle φ is located. At the same time, on the circle are represented the angle φ (marked yellow), and the two other angles used for reduction to the first quadrant, angle α (marked blue, used when reduction is realized as, $\varphi = a \pm k\pi, k \in Z$ and angle β (marked red, used when reduction is realized as $\varphi = a \pm k\frac{\pi}{2}, k \in Z$. In the window on the right, there is an algebraic representation of reduction to the first quadrant, using both angles, α and β.

In this material, the three representations (graphic, algebraic and dynamic) provided students with a deeper understanding of the problem of reduction to the first quadrant because they could experiment with angles in all four quadrants and at the same time observe the connections between the angles involved in reduction.

3.3. GRAPHS OF TRIGONOMETRIC FUNCTIONS

The GeoGebra material for trigonometric functions is presented in Figure 3.

In the left window, there are four checkboxes, one for each trigonometric function and the unit circle. By checking one function in the left window students can observe its graph in the right window. Both windows are dynamically connected, meaning, when students move the point *M* on the circle in the left window, the function is plotted in the right window.

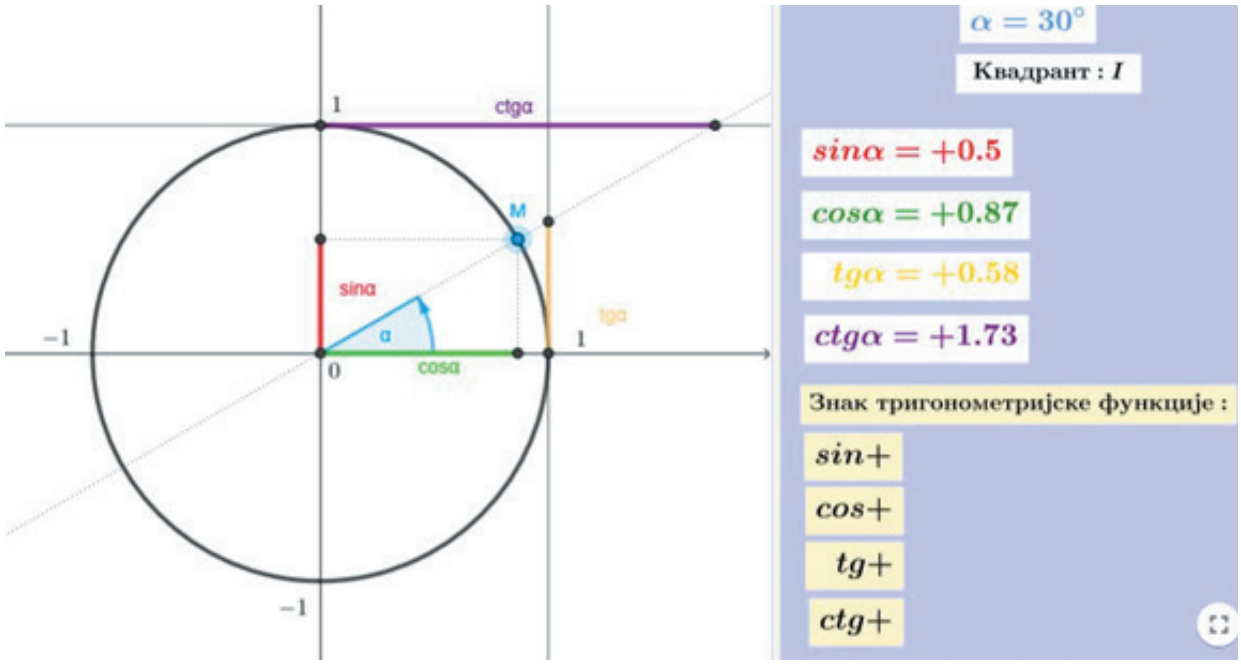

Figure 1 – Unit circle.

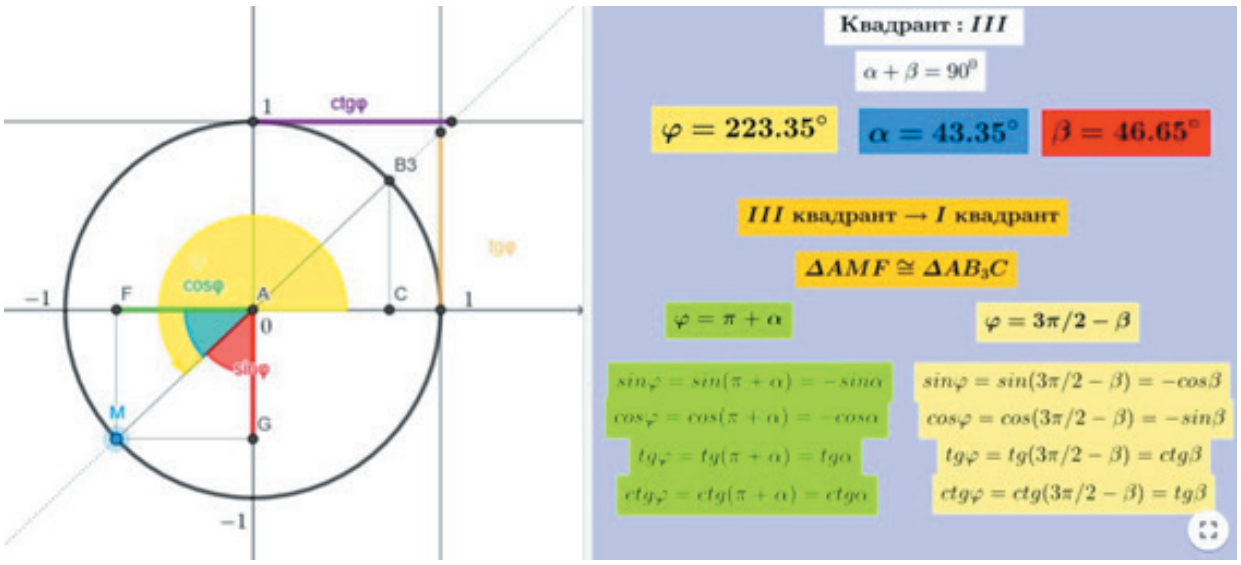

Figure 2 – Reduction to the first quadrant.

Also, the functions periods are highlighted in different colors. It is also possible to check more than one checkbox in the left window so that it can be observed more functions' graphs at the same time. We have included this possibility in the GeoGebra material so that students can see the similarities and differences between the graphs of trigonometric functions.

3.4. TRIGONOMETRIC FUNCTIONS WITH PARAMETERS

One GeoGebra material was made for trigonometric function with parameters, Figure 4. It is also designed with two windows. In the left windows, there are four checkboxes, for each trigonometric function shown in the form of three parameters: *y=a f(bx+c)*. Below checkboxes, there are three sliders, one for each parameter: *a, b, c.*

Students could change the parameters' values by moving the sliders and at the same time observe in the right window how the graph of a trigonometric function is changed (the graph is marked red) and also they could compare it to the graph of the basic trigonometric function without parameters (graph is marked black).

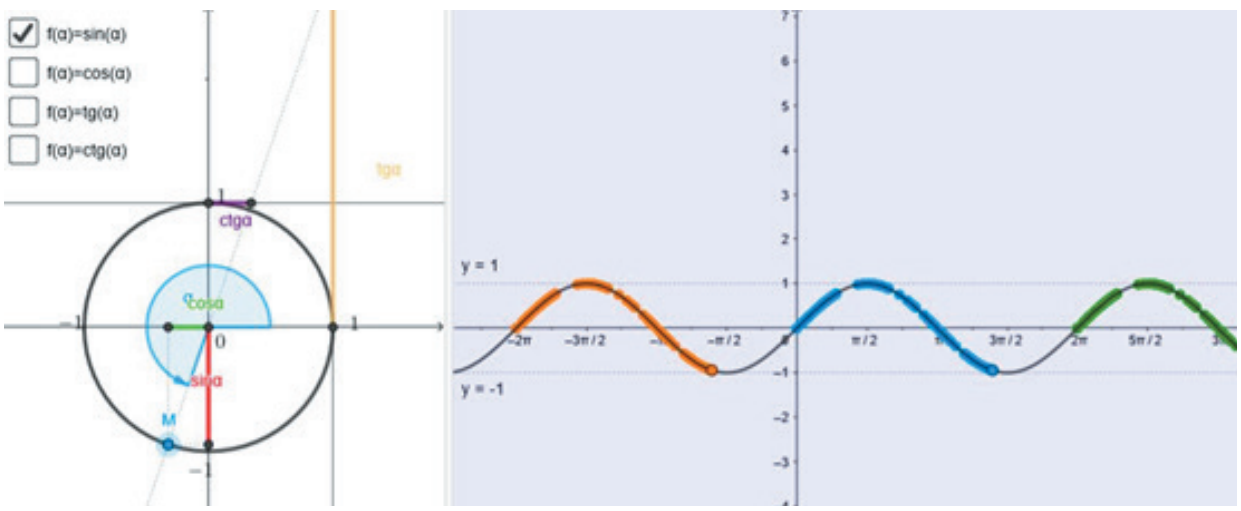

Figure 3 – Graphs of trigonometric functions.

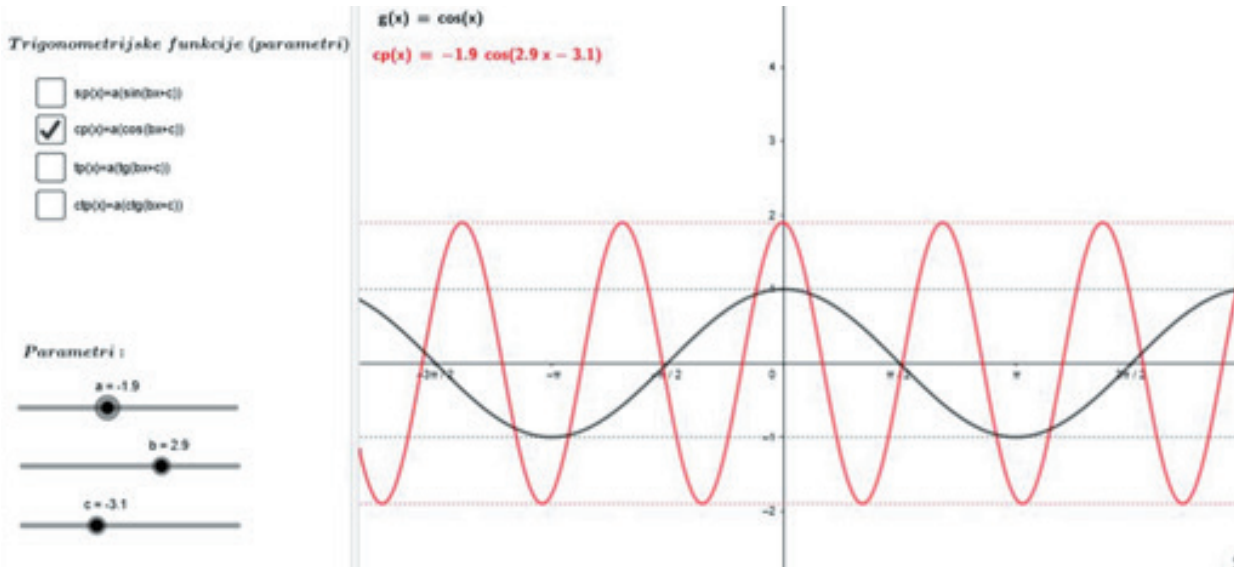

Figure 4 – Trigonometric functions with parameters.

3.5. TRIGONOMETRIC EQUATIONS

The GeoGebra material for trigonometric equations has checkboxes in the right window, one for each trigonometric function. The form of the trigonometric equation is f(x)=a (where f(x) can be sinx, cosx, tgx or ctgx). The unit circle in the left window is used for choosing the value a in the equation, e.g. for selecting the type of equation by moving the point M on the circle. Also, by including the unit circle in this material we intended to show a graphical representation of all solutions for each kind of equation, Figure 5.

By setting the desired equation form using a unit circle, the students can see its solution in the right window. The solutions are given in two ways, as values of angles on interval $[0,2\pi]$ and also in the general form below.

The most important goal of this material is for students to see how the solutions of trigonometric equations are connected and that they are periodically repeated.

4. RESULTS AND DISCUSSION

First, it is important to emphasize that the presented materials were available to all students and that they were already familiar with GeoGebra because they have used it before for learning mathematics as a supporting software tool.

During the online teaching process using written materials together with the links to the GeoGebra materials, we monitored students' reactions and their achievements in learning. Especially, the homework of each student was carefully examined, to detect eventual weak spots which needed further explanations.

The students' reactions to the GeoGebra materials were positive, they commented that these materials helped them to understand the concepts of trigonometry. They emphasized that the dynamical nature of GeoGebra, i.e. the possibility to manipulate the materials and create different angles, choose parameters' values and compare trigonometric functions was what they needed to be able to better understand trigonometry. The students also suggested to the teacher that they wish to use GeoGebra materials in the future, for learning other courses of mathematics.

The students from generation 2020 had the trigonometry course realized completely online, using only written and GeoGebra materials. We wanted to compare the achievements of students from this generation to the achievements of students from previous generations who traditionally learned trigonometry, in the classroom in the school.

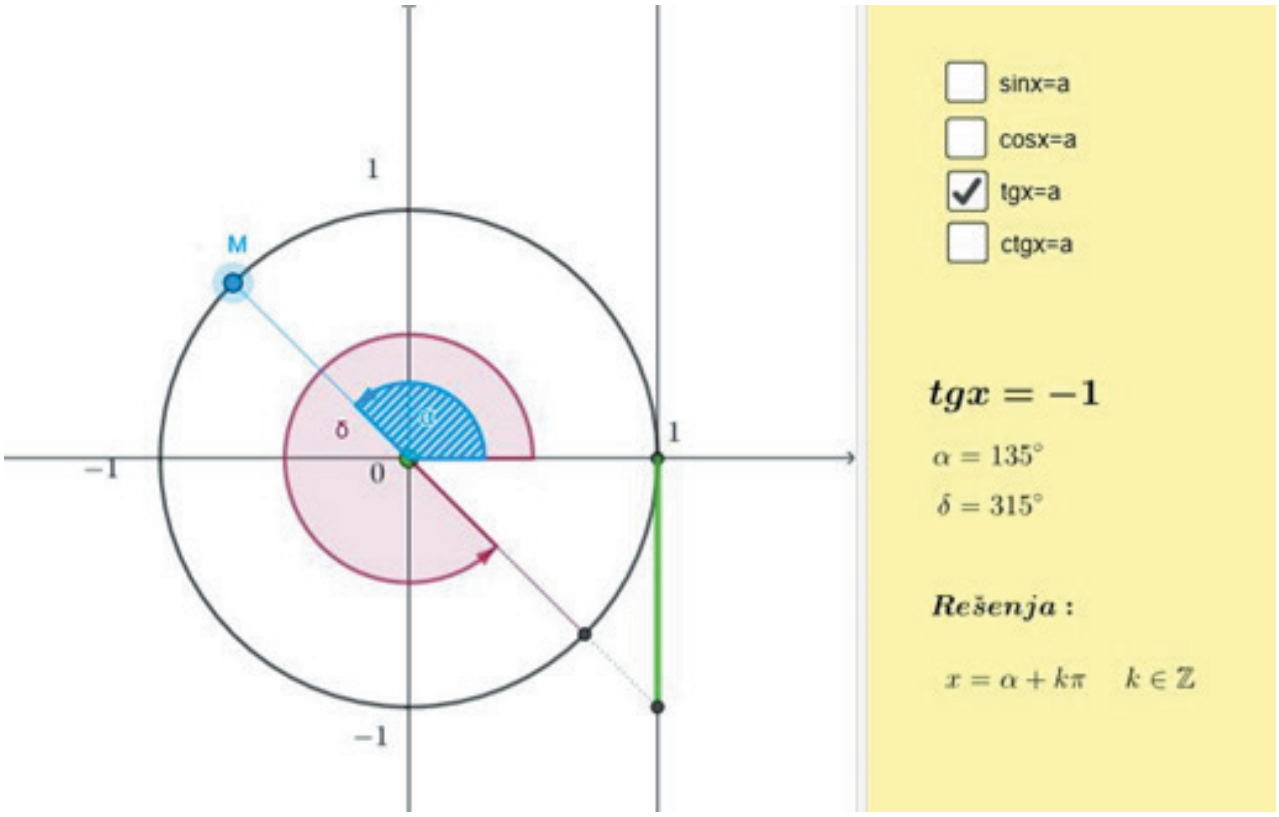

Figure 5 – Trigonometric equations.

We had the data on the results of the trigonometry test for generations of students from 2016 to 2020. All generations of students had similar tasks on the trigonometry test and all generations had the same mathematics teacher. The only difference was that the teaching process with generation 2020 was realized online and with the other generations in the classroom. We compared the percentage of the students' grades (from 5 to 1) on the trigonometry test, Figure 6.

Observing the grades of the 2020 generation, it can be noticed that (except for the generations 2018 and 2017 where exists a large disproportion of the highest grades among all other generations) the achievements of this generation is not particularly different compared to 2019 and 2016, or the average achievements of generations 2016 - 2019 in total (marked on the graph with 2016 – 2019 AVG), Figure 6. It implies that online teaching and using GeoGebra materials can contribute to teaching and learning trigonometry.

We also compared the average grade of all generations on the test. The average grade for generation 2020 was 3.40, while the average grade for generations 2016 – 2019 in total, was 3.58 which implies that students' achievements during the online teaching process did not fall behind the achievements of students who were taught in the classroom.

Although we have returned to the classroom after 2020, due to the positive experiences of both, students and teachers, we still use the GeoGebra materials presented in this paper as supporting materials for teaching trigonometry.

5. CONCLUSION

Teaching trigonometry courses in high school can be very challenging even in normal conditions, not to mention the online teaching process. However, in both cases, it is of great importance to find the best possible approach to present and explain trigonometry to the students.

Modern software tools allow teachers and students to explore various aspects of learning mathematics. GeoGebra software has proven to be particularly useful for teaching and learning mathematics because of its dynamic nature and the possibility for multiple representations of concepts.

We have presented and described the GeoGebra materials that we have created and used for teaching trigonometry courses in high school.

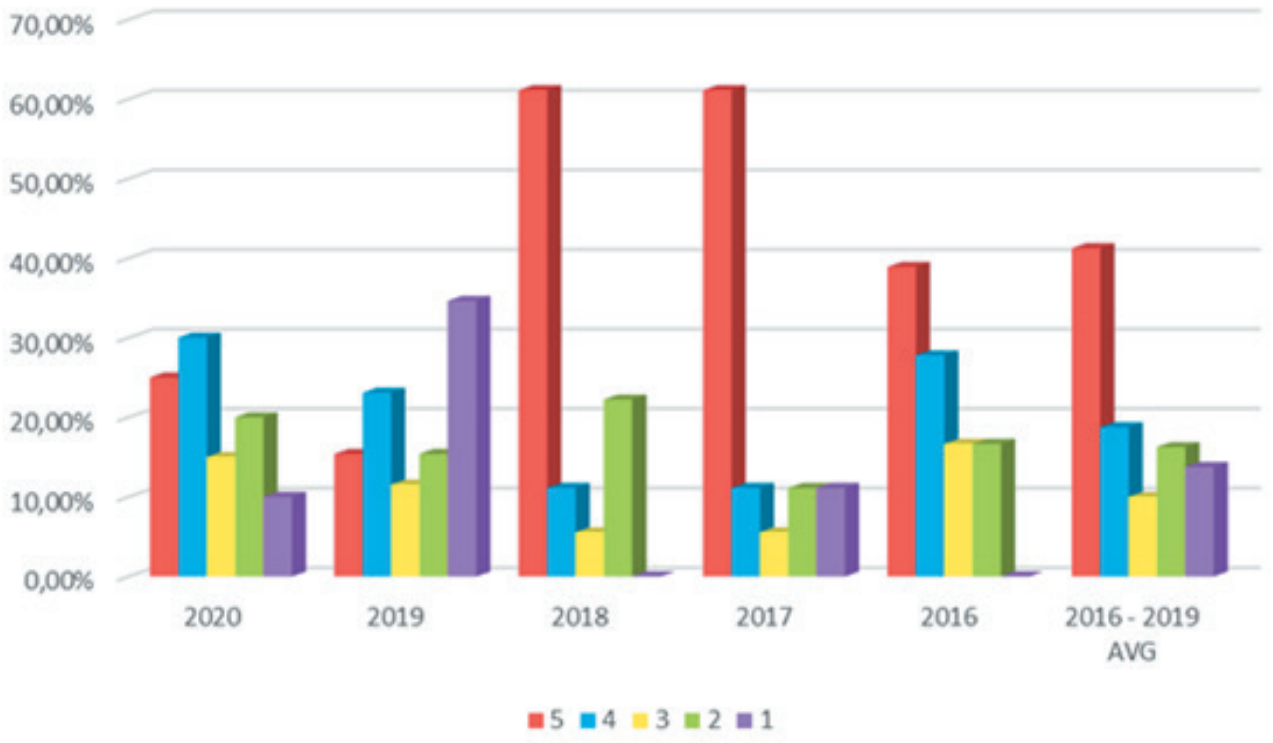

Figure 6 – The percentage of the grades on trigonometry tests for generations 2016 – 2020.

The teachers and the students had positive experiences using GeoGebra materials. The students' impressions about these materials were that they helped them to better understand trigonometric concepts, and most important of all, that they get the opportunity to experiment on their own using these dynamical materials.

The research results indicated that the online teaching process supported with GeoGebra materials managed to keep the level of students' achievements close to the level of the classroom teaching process.

Taking into account all the above-mentioned results and experiences of students and teachers, we can conclude that GeoGebra can be used to support both, the online and classroom teaching process and therefore, we continue to develop and improve GeoGebra materials for teaching mathematics at all levels of education.

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IT APPLICATIONS IN EDUCATION SESSION

THE IMPORTANCE OF INTRODUCING INNOVATIONS IN THE TEACHING OF INFORMATICS AND COMPUTER SCIENCE IN PRIMARY SCHOOL

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Abstract:

The paper presents the importance of introducing innovations in the teaching of informatics and computer science, which is studied in primary schools.

Given the rapid development of science and technology and the availability of these new technologies to today's new generations, there is a need to change the way we approach the students' upbringing and education. The introduction of innovations in the teaching process, primarily computers and computer technologies, encourages greater motivation and interest of students to acquire new knowledge and to study teaching materials, as well as check previously acquired knowledge.

The justification for introducing innovative methods in teaching the subject of informatics and computer science has been proven on a concrete example through the usage of the application "InfoZNANJE". This application was created with the aim of enriching and improving the teaching of the subject in which it is applied, and its functionality is reflected in solving pre-prepared interactive tests in a digital form adapted to the age of students and the class they attend.

Keywords:

Student, computer, informatics, information and communication technologies.

INTRODUCTION

At a time when real preconditions for the successful application of ICT in teaching are being created in our educational system, it is up to the school as an institution and up to a teacher as an individual to decide whether to continue working according to the traditional model or improve their work and education in general by enhancing the achievements of their students through applying innovative teaching methods [1].

In recent years, computers have begun to be widely used in schools and conditions have been created for better innovation of educational technology. And just as the goal of a modern school is to prepare students for life, one should strive for the student who leaves the educational institution to have enviable skills and abilities related to the use of computers [2].

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Using the possibilities and advantages of modern digital teaching aids, technical devices, and educational software, the teacher achieves the best effects in transferring and acquiring knowledge, making the teaching process more dynamic, attractive, and successful [3].

2. INNOVATIONS IN TEACHING

Innovation in teaching means a novelty that is implemented in pedagogical reality. The purpose of every novelty is to improve the activity in which it is introduced.

The organization of education itself must change, especially the contents and methods of work of educators. The school as we know it today, a peaceful and relatively closed oasis of knowledge, must grow into an open research station where young people will acquire and constantly innovate their knowledge. It should be a laboratory in which experiments are continuously conducted, created, discovered, and innovated. Today, innovation is a condition for the school not to lag behind the social and technological changes that occur every day [4].

Most of the work teachers did in the past has now been taken over by modern means of presenting information. Thanks to the progress and development of information and communication technologies, students and teachers can interact with databases rich in various information very far from their classroom or study [5].

2.1. MOTIVES FOR INNOVATION

Intensive development of science, technology, and engineering requires that every educator improve their skills and be up to date with innovations in the world that are of importance for their professional field and that directly affect the quality of teaching. The teacher should aim to help students form certain knowledge, skills, and abilities. School's goal is to develop the personality and individuality of every child.

Modern teaching should enable the creative freedom of students, which is reflected in selected and prepared program units. These units enable students to learn, express their abilities and form positive attitudes toward modern technical and technological creativity [6].

Continuous innovation in the teaching process intends to contribute to a more efficient and better realization of the educational process. A successful educator (teacher) does not expect someone else to demand or impose a novelty (change) on them. They must be the initiators and implementers of innovations in teaching - their preparation, programming, implementation, monitoring of the flow of innovation, and evaluation of the results obtained. Since innovations should become a way of work for teachers in schools, every teacher should be trained to perform innovations and use innovative models of work in the teaching of individual subjects [5].

Today, it is more important for students to learn how and where to find the necessary information, how to check and use it, than how to keep all the information in their heads. "Learning how to learn" has become more important than dry memorization and reproduction of knowledge.

2.2. PROFESSIONAL DEVELOPMENT OF TEACHERS

Continuous professional development and acquisition of new knowledge and skills for employees in education are extremely important because their task is of social interest. The roles and needs of teachers have changed throughout history, supplementing and adapting to the needs of time and society. The traditional approach to the educational process is still present in practice, and teachers themselves must be more open and ready for certain changes in work (active teaching, constant involvement of students in work, use of modern technologies) [7].

Without an educated teacher, their ability to accept and adapt to new developments in science as well as personal skills and motivation, educational institutions cannot be developed, educational processes cannot be improved, and students cannot be sufficiently trained and educated, which is the basic goal of education.

Continuous professional development of teachers includes monitoring, acquiring, and applying modern achievements in science and practice to achieve the goals and objectives of education and improve educational practice. Teachers improve existing knowledge, skills, and abilities and develop openness to continuous learning through individual or group forms of professional development [4].

2.3. COMPUTER AS A TEACHING TOOL

A computer is a teaching tool which can replace many other teaching aids that were represented in traditional teaching with the appropriate software, internet connection, and additional technical devices. It is physically impossible to provide one teacher for one student, but in modern society, we have the opportunity to use computers in teaching, which facilitates and improves the work. With such an approach, each student can progress according to their abilities. The use of computers in teaching aims to make lessons much more attractive to students, which encourages active learning but also greater motivation. Information should be more interesting, lessons tailored to the needs and interests of students, as well as to the pace of student work, which would contribute to better efficiency of the learning process.

Disadvantages of traditional teaching that can be avoided by using computers:

- Students are not passive in the teaching process but learn actively and sometimes independently at their own pace. The student is the subject of teaching.
- Students immediately get feedback on what is right in their answers and what is wrong and thus control themselves, which creates the possibility of learning from their own mistakes.

Computer simulation is a special type of teaching in which there is a possibility of visualizing the process. The essential feature of computer simulation is modeling using a mathematical apparatus and/or formal-logical rules. From the student's point of view, computer simulation provides two-way transmission of information because the student can independently manipulate model variables.

Virtual laboratories, experimental programs created using computers, require the integration of laboratory procedures into software solutions, the formulation of special curricula and the determination of complementary educational outcomes.

Online teaching (or web-based teaching) requires students to be connected to the Internet. This allows access to various data sources, the direct exchange of information, discussion, checking progress, etc. This type of teaching relies on previous ways of using computers in teaching. It can be an independent teaching process, but the possibilities of incorporating it into regular teaching activities are recognizable.

3. "InfoZNANJE" AS AN INNOVATIVE METHOD IN TEACHING INFORMATICS AND COMPUTING

As an innovative method in teaching the subject of informatics and computer science in the elementary school "Žika Popović" in Vladimirci, an application called "InfoZNANJE" was created by the teacher of the mentioned subject.

The project "InfoZNANJE" was designed and created to enable the students of the aforementioned school to become better acquainted with the materials of informatics and computer science in digital form and to enable them to master the most important points from each teaching unit more easily, as well as to solve tests.

The project was conducted using databases, HTML code, PHP, and CSS.

Due to technical limitations in the institution where the application was created and used, the installation of the application "InfoZNANJE" was carried out on a local server and used in the local network. The application diagram showing the key parts of the system is shown in the figure that follows (Fig.1).

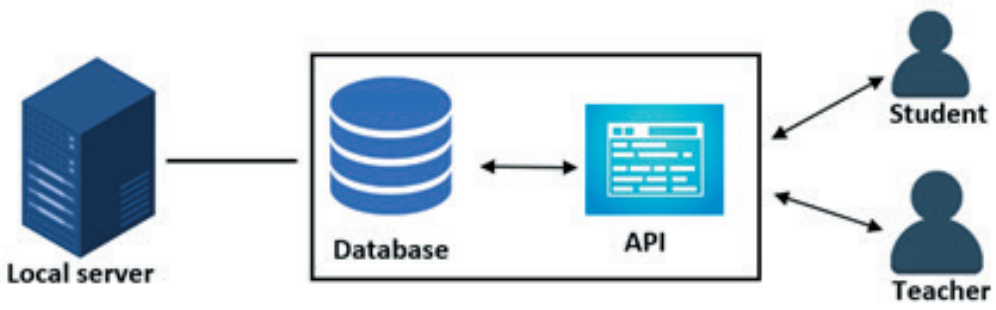

Figure 1 - Application diagram showing key parts of the system

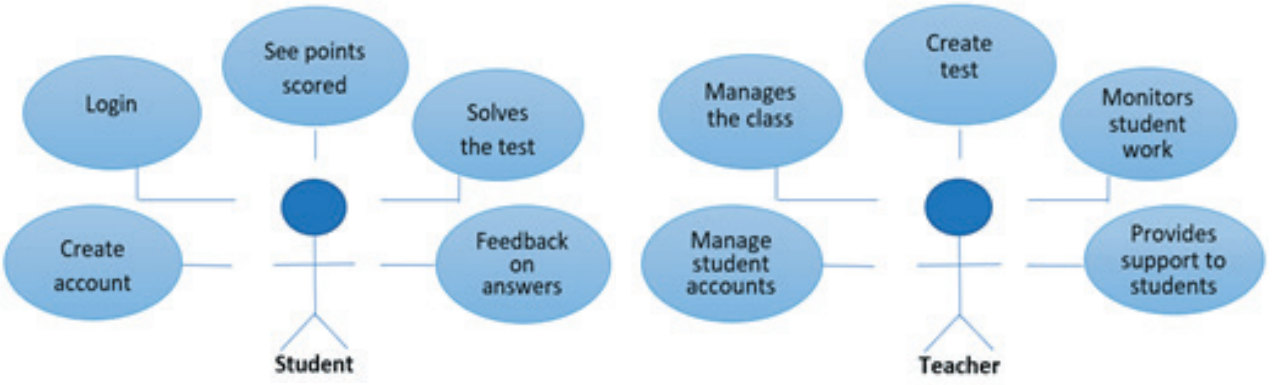

Figure 2 - Use-Case diagrams for student and teacher

This application consists of a user (student) part and an administrator (teacher) part. Each user in the application has their own role and certain privileges that are shown in the Use-Case diagram (Fig.2).

3.1. APPEARANCE AND FUNCTIONALITY OF THE APPLICATION

When accessing the application (Fig. 3) there is a home page that contains basic information about the project, an e-mail that students can contact if they have questions or suggestions, a special section for login students who already have an account or if they use the application for the first time, they will be redirected to a page to create their own account.

When creating a new student account, they need to enter their unique ID and password, which they will use every time they log in to the application. Students will also be required to enter other information such as name, surname, e-mail address, and the grade they are attending. Based on the ID data, the application monitors the work of that student, their activities, and the results they record in the database.

After login, students have the opportunity to review their previous results or choose a new test (Figure 4) with pre-defined knowledge test questions.

Figure 3 - Appearance of the "InfoZNANJE" application page.

Figure 4 - The appearance of the test question.

Depending on the class they attend, students can choose the unit from which they want to solve tasks or to master the previous material and achieve better results; they are allowed the option of retaking already completed tasks, where the application will record the number of attempts to fill test and record each result. Each test consists of several questions that are selected as the most important for a given teaching unit and which are in accordance with the curriculum of the class the student belongs to.

The administrative (teaching) part (Fig. 5) allows teachers to log in to their account and to add tests and questions after the topic, which students will be able to solve later. There is also the possibility of adding new teaching units and new classes. The teacher in the application can check the success of individual students, their interests, and activities in the application.

3.2. SUBJECT OF RESEARCH

The main research question of this paper refers to the positive impact of the innovative applied method in teaching informatics and computer science in the elementary school "Zika Popovic" in Vladimirci through the active usage of the application "InfoZNANJE" by students and teachers of this subject.

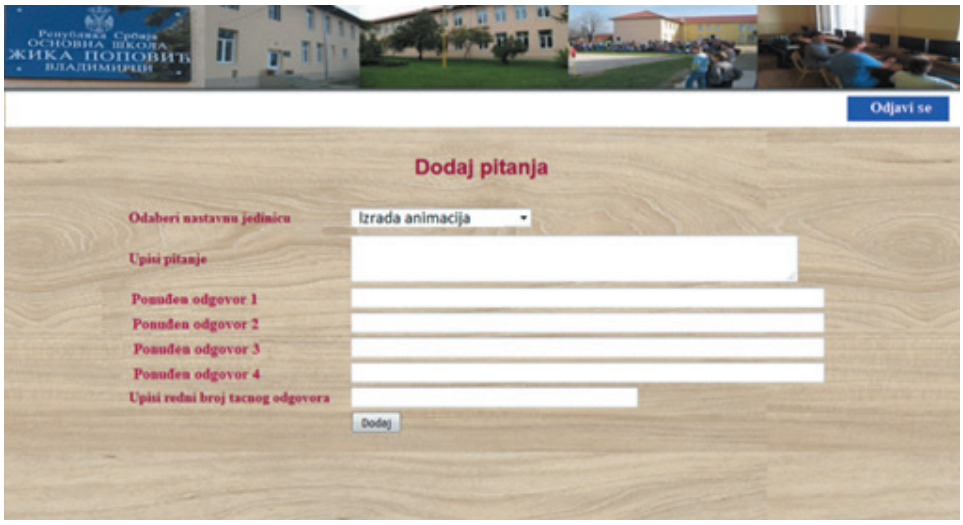

Figure 5 - Administrator account..

The research starts from the general hypothesis, which reads:

The application of innovative methods in teaching the subject of informatics and computing has a positive impact on the increase in the efficiency of teaching in primary school.

3.3. THE GOAL AND TASKS OF THE RESEARCH

The research aims to form a picture of the application of innovative methods in the teaching process of the subject of informatics and computer science, as well as the attitudes and opinions of students about it. The aim is to point out the statistically significant possibility of raising the overall level and quality of the educational process by using information and communication technologies in teaching, based on the use of innovative methods in the education of primary school students. Students are expected to express a desire to make greater use of modern teaching aids.

Research tasks:

- To determine whether students use an innovative method in teaching the subject of technique and technology presented through the program "InfoZNANJE"
- To determine whether the mentioned innovative method has contributed to easier mastering of teaching materials;
- Review their interest in continuing this form of teaching and processing new material through the subject;
- Examine their desire to introduce innovative methods like this into other subjects

3.4. RESEARCH METHODS, TECHNIQUES, AND INSTRUMENTS

In the research process, the method of anonymous type survey was used, i.e. the survey questionnaire instrument. The questionnaire is designed to contain five questions and an explanation of how to answer the questions. They are set in writing, and answers are also given in writing. Each question is answered, and students should mark one of the offered. The survey was used only for statistical purposes for this paper.

The questions are designed to provide an overview of students' opinions and attitudes on the application of innovative methods in teaching, and specifically on the usage of the application "InfoZNANJE" in the teaching of informatics and computer science.

3.5. SAMPLE AND PLACE OF RESEARCH

A deliberate sample was taken for research purposes. The examined group consists of 178 students of the fifth, sixth, seventh, and eighth grades of the elementary school "Zika Popovic" in Vladimirci, who have the subject of informatics and computer science as obligatory during their schooling.

3.6. RESEARCH RESULTS

Based on the research (Fig. 6) in which 178 students of the fifth, sixth, seventh, and eighth grade of the elementary school "Zika Popovic" in Vladimirci participated, very positive results were obtained which speak of the justification of applying innovative methods in teaching computer science.

To the first question (question no.1): "Do you use the InfoZNANJE application regularly?", 81% of students answered YES, 7% NO, and 12% answered OCCASIONALLY.

To the second question (question no.2): "Did the InfoZNANJE application contribute to easier mastering of materials from the subject of informatics and computer science?", 92% of students answered YES, and only 8% NO.

To the third question (question no.3): "If you had the opportunity to choose, would you always choose to work in the application instead of other ways of testing knowledge?" 79% of students answered YES, 6% NO, and 15% of students answered OCCASIONALLY.

To the fourth question (question no.4): "Would you like InfoZNANJE to continue to follow your teaching in informatics and computer science?", 93% of students answered YES, 2% NO, and 5% of students answered OCCASIONALLY. This speaks to the desire of students to learn through play.

To the fifth and last question (question no.5): "Would you like to have similar applications for other subjects" 96% of students answered YES, and 4% NO. This information should influence the motivation of teachers to introduce innovative and modern methods in their organization of classes.

The results of statistical data analysis presented in Table 1 and obtained by comparing the responses of students of all grades confirm the hypothesis and the expectation of positive results. Statistical analysis was performed in the SPSS program.

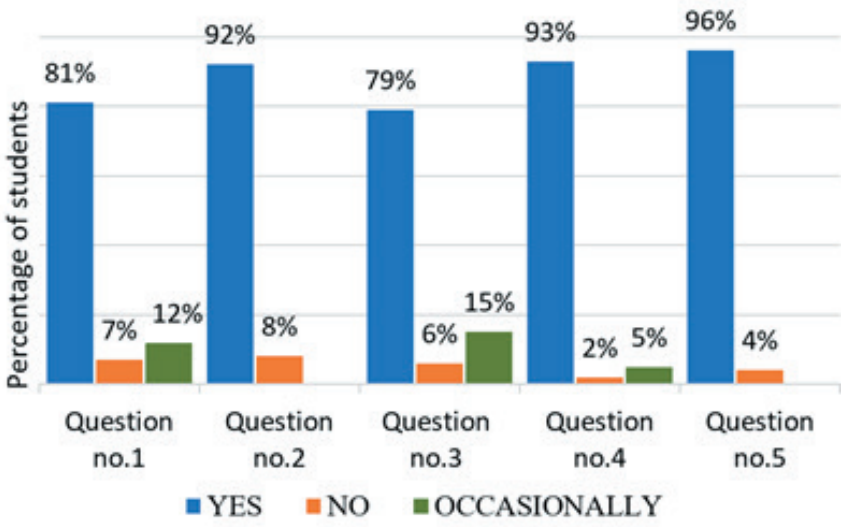

Figure 6 - Graphic presentation of research results.

4. CONCLUSION

The research in this paper has shown and proved that there is a great justification and need for the introduction of innovative methods in the teaching process in school because that is what today's generations need for the successful acquisition of teaching materials.

Science and technology are evolving at a rapid pace, and the school itself, teachers, and students are in a significantly different environment than a few years ago and perhaps a decade ago.

In such circumstances, the school cannot remain in the traditional way of working, where the teacher, textbook, and accompanying teaching literature are the only source of information and the students themselves are passive receptors of the material.

Much of the work that was once done only by teachers is now being taken over by modern teaching aids, and the approach to students is becoming different.

Due to all of the above, it is necessary for teachers to embark on modern teaching trends and apply innovative forms of work in the classroom without waiting for the changes to come of their own accord or for someone else to impose those changes on them.

Question	Correlation	Sum of Squares	df	Mean Square	F	Sig.
Question no.1	Between grade	,110	3	,037	,192	,902
	Within grade	33,328	174	,192		
	Total	33,438	177			
Question no.2	Between grade	,124	3	,041	,564	,640
	Within grade	12,775	174	,073		
	Total	12,899	177			
Question no.3	Between grade	,341	3	,114	,558	,643
	Within grade	35,395	174	,203		
	Total	35,736	177			
Question no.4	Between grade	,021	3	,007	,095	,963
	Within grade	12,838	174	,074		
	Total	12,860	177			
Question no.5	Between grade	,075	3	,025	,655	,581
	Within grade	6,650	174	,038		
	Total	6,725	177	,037	,192	,902

Table 1 - Statistical analysis results.

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IT APPLICATIONS IN EDUCATION SESSION

UNIVERSITY STUDENTS' EXPERIENCES AND ATTITUDES TOWARD ONLINE LEARNING DURING THE PANDEMIC COVID-19

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Abstract:

The COVID-19 pandemic had a significant influence on university education and organization of lecturing. Most universities throughout the world had not been prepared for the new circumstances, and this ultimately affected both the organization and the quality of lectures. Universities were obliged to follow trends and implement new strategies in lecturing in order to support their students where help was most required, and furthermore, in order to maintain the quality of their experiences and education. The objective of this research was to gain insight into how students reacted to the new pandemic situation and whether they are satisfied with online teaching so that universities could use the results to adapt and conduct online teaching in the future. The research found that students considered online learning had affected their efficiency, productivity, and level of motivation in the process of learning. Apart from these adversities regarding online teaching and learning, the survey found that the students' attitude toward the implementation of technology in university education would improve the process of online lecturing and examination and enhance the present situation.

Keywords:

COVID-19, online learning, information technology, ICT.

INTRODUCTION

For a short period of time, the COVID-19 pandemic had a great impact on the entire economy, on every field and branch of society, and on university education, too. As indicated by UNESCO, it influenced the education of over 220 million university students in the world. [1] University education in the world had to undergo major changes, which required all its participants to adapt to the situation. One of the first and most prominent changes that occurred in the process of university education was in the lecturing process. The general face-to-face lecturing within the university premises was replaced by learning from one's home by following the online lecturing platforms. [2] Within a few days the traditional form of lecturing in the university premises, to which all employees, professors, and students had been used to, was transformed to online lecturing. The students, who had been accustomed to learning within university premises, were unprepared for these changes.

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In the past, online learning had been considered to be a method applicable for nonformal education. However, this method of lecturing turned out to be the solution to replace the traditional lecturing process. [3] Apart from the positive effect regarding online lecturing, this method of learning influenced the productivity and motivation of students in the process of learning. On the other hand, the initial response of many universities to the new situation applied ad-hock solutions in order to provide a swift and efficient solution. Recent studies indicate that many universities were forced to modify their lecturing process and apply online learning.

The purpose of this paper is to give an insight on how universities had transferred to new methods in the education process and to establish the positive and negative effects that online education had on students. Research had been undertaken to provide a better insight into the experience and opinions of the university students and to establish the effect online learning had on them.

This paper consists of three sections. The first section covers the adaptation of universities in the world to the altered circumstances. The second deals with the students' adjusting process, and the third is an analysis of the attitudes and challenges regarding online education and learning among university students in Serbia.

2. HOW DID UNIVERSITIES ADAPT TO THE COVID-19 SITUATION?

Apart from the persisting crisis that COVID-19 had brought to the healthcare system, it had been followed by a socio-economic crisis, which influenced all aspects of life – its common functioning, businesses, and university education, too. [4] Adaptability of the business, changes in its organization, and an agile approach were required. Since the duration of the crisis could not be defined, this made it difficult to plan and create a strategy. Optimal measures undertaken to resolve a short crisis and provide a swift recovery might prove inefficient if the crisis lasts longer than planned. [5] Some universities had a straightforward response and reacted swiftly to the imposed changes and challenges, while others had a poor response in adopting online education, which presented a significant obstacle in adopting online learning methods and tools. One of the reasons is that online education requires more effort and different methods, in comparison to face-to-face education that had been previously applied. [6] Karalis and Raikou stated that hasty solutions resulted in conflicting opinions and two diverging approaches. It was found in the former case that online education had been efficient and that one should focus on all its benefits. [7] Singidunum University is an example of such a hasty reaction. When the State of Emergency was declared in Serbia on 13th March 2020, by which movements of its citizens had been restricted, within only 3 days the online education process was established through the Google Meet software. Thanks to the immediate response of both the management and employees, the students lost no lecture, exercise, or consultation. [8] The students of University of California and University of Colorado complained of fatigue during their Zoom lectures. They solved this problem with the Otter for Education software [9], which offers online transcription and notes thus relieving students. The lecturers found this intelligent software to be extremely useful to the students with difficulties in learning and other difficulties previous to and during the online environment. In the online environment, remote testing posed a challenge for the lecturers. This was solved in over 500 institutions by applying the Examity validation system in the examination process. Here the examination process is based on biometric analysis of a push button, the predictive analytics, and video review, by which identity of the student is established and the content of the examination preserved. [10] The Ocean County College had an e-mail communication problem and an engagement rate of only 10%. Then the college joined AdmitHub and initiated a chat box in 2017 named Reggie. In the second year of its implementation, the engagement soared for 26% and it was capable to answer 98% of the questions without requiring any human support. [11]

In different case, Karalis and Raikou [7] stated that the introduction of information and communication technologies in university education might generally affect the quality of education, human relations, productivity, motivation, mental health, and other factors that are induced by the pandemic and by online learning. Apart from the mentioned successful adjusting to the online environment and implementation, certain universities noticed its negative consequences, too. Zhang and Gao [12] wrote that professors at the Chinese universities noticed that the transfer to online education had been a challenge and presented an evolutionary environment for both lecturing and learning. When organizing online education one must consider the differences of education in a virtual environment, communication difficulties, the lack of concentration, and the interaction with professors. Research made by the Organization for Economic Cooperation and Development found that less than 40% of lecturers considered themselves ready

to use digital technologies for lecturing. [13] High-performance digital education and improvement of digital skills and competence in online education must be considered a priority in online education. The universities have to make changes in their organization and consider the differences and level gaps regarding digital skills in their professors, the improvement of their capacities, the better financial support of education and the following of the achieved results. [14] Besides, the COVID-19 pandemic affected the financial situation of universities. High expenses for buying new equipment, software and other elements required for online lecturing brought serious financial consequences on the universities and dropped their income compared to the previous year. There was also a weaker financial situation among the students, so many were forced to skip their studies or postpone their exams. This further dropped the income of universities. Low income requires a reduction in expenses, hence in the reduction in the number of lecturers and other personnel. [15] Burki found that Covid-19 pandemic cost Universities in Great Britain about 790 million pounds. Facing these challenges some institutions were forced to completely cancel lecturing. The report of the International Association of Universities [4] stated that 43% of universities in Africa had to make a pause in lecturing during the period of their seeking solutions by the institution, while in 24% universities the lecturing had been completely terminated.

3. ADAPTATION OF STUDENTS TO THE SITUATION CAUSED BY COVID-19

After the universities had transferred to the new forms of lecturing the students were forced to follow lectures and exercises via certain online platforms. In comparison to certain professors, the students had less problems in adapting to new solutions. Nowadays students grew up using technologies. Prenski [16] stated that they are "digital native" because their comprehension, learning and everyday behavior is different compared to the elder generations, including lecturers with few digital skills. It is obvious that the lecturers are more and more aware of these differences and strive to learn and adopt required skills to be able to participate in an interactive and efficient online environment. However, many students had limited access to the lectures, either because of possessing inappropriate devices or had poor internet links. There is also a "digital disbalance" in society, therefore not all students had an appropriate communication environment outside the university for them to be able to transfer to online education. [2] The influence of professors on students was limited, thus the students' achievements in learning generally depended on their own efforts, i.e., their motivation, productivity, discipline, and proactivity. [12] In an online environment students have to control their time, be attentive and learn. Students must be devoted, persistent and have self-control. Authors from the town of Novi Sad concluded that their students were not very satisfied with online education and that had higher expectations. Maybe they generally expected more from online education, and their expectations were not fulfilled. The research found that their average opinion regarding online education was below average. [17] Although previous surveys found that children and youngsters had mild forms of COVID-19 compared to adults, the surveys from the School of Medicine in Belgrade found that they are more prone to develop mental consequences. Among the mental consequences in youngsters, anxiety was the greatest problem because of the lack of contact with their colleagues, and a diminished control of stress. [18] Two surveys found that the lack of presence in university premises had a bad impact on students. This was not the case only in Serbia but elsewhere, too. Social relations may have a significant influence and motivate one to study, which has an effect on academic success. The multiple obligations, continuous struggle to have good merits, lack of free time, the introduction of online education, new experimental methods applied in education put stress on the students, which might develop into more severe mental health issues. [19] In the second study on this subject, Tull and his partners found that staying at home, online education and the stress that it brought resulted in an increased level of anxiety, financial worries and loneliness. The lack of relations with people belonging to the same age group and their interactions and complete change in everyday habits may affect the mental health of students, their mood, motivation and academic success. [20]

4. METHODOLOGY

The research in Serbia was undertaken in December 2021 with 454 participants. They were students from several universities, colleges, modules and branches of online education. The ratio of participants was 73,6% female and 26,4% male students. They were classified according to their year of study, though most of them were in the first year of studies (26,4%). There were 19,6% from the second year, from the third 22,2%, and from the fourth year 19,8 participants. The least incorporated were those on master studies (11%) and PhD studies (0,9%).

The instrument applied was a created Google questionary, which the students would have to fill in online, for the purpose of this empiric research. It was distributed to the participants by mail and social networks. All participants that took part in the research were guaranteed anonymity and had been told that their answers would solely be used for research. The main research technique was the questionary, which was to establish the attitude of the participating students on the challenges they met when learning and acquiring knowledge in an online environment. The questionary consisted of 6 questions, of which the first two focused on one's general opinion regarding online education and its efficiency.

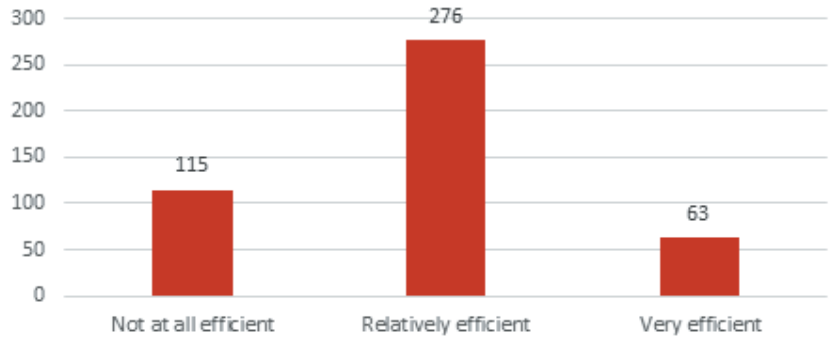
The next two questions focused on the motivation and productivity of online education. The last two questions were about the participants' opinions on implementing technology in education and the online environment. The questions were closed type and the research had an empirical character. After completing the questionnaire online, the results were summed and an analysis based on the results had been made. The analysis of the results applied was in the descriptive method.

5. TABLES RESULTS AND DISCUSSION

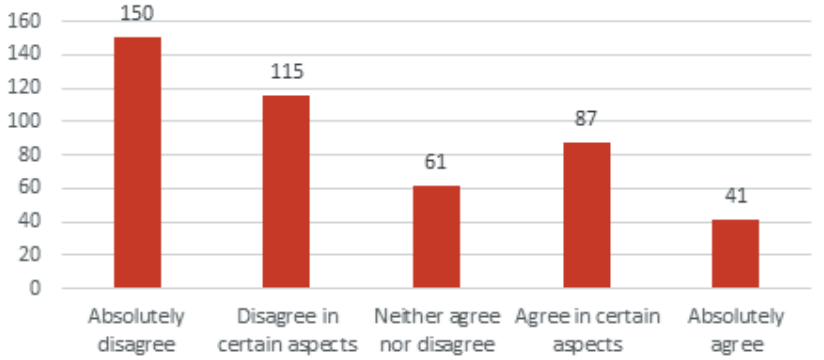
The first question was about the attitude of the participants regarding online learning. The students' answers were based on their experience after many months of learning in an online environment and their opinion regarding its efficiency.

Graph 1 indicates that as much as 60,8% of the participants consider online learning relatively efficient. However, one should consider the number of participants that found it not at all efficient was 25,3%. Only 13,9% considered online learning very efficient. This co-insides with the previous research [17] which found a decline regarding online learning efficiency. These results clearly indicate that online education should be accustomed to students and should undergo further adjustment.

Graph 2 shows us to which extent do the students consider that online learning manages one to acquire knowledge and skills in online learning compared to standard (direct) learning. As much as 33% of the participants consider that they did not achieve equal skills and



Graph 1 - Students' opinion on the effectiveness of online teaching



Graph 2 - Online teaching equally helps in the acquisition of knowledge in relation to classical teaching

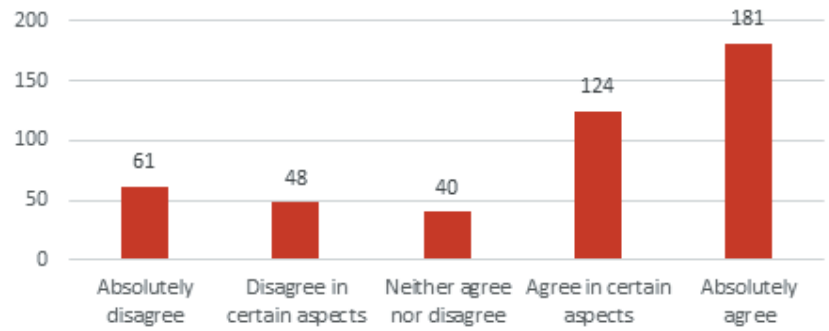
knowledge through online learning. If considering those that disagreed in certain aspects, this number reached 58,35% of participants. Only 8% of the participants absolutely agree that they had acquired the amount of knowledge and skills as if by standard learning.

Graph 3 indicates that online learning reduced productivity in learning. 39,9 % of participants considered that online learning had affected their productivity, and if we include those who considered that it affected their learning to a certain degree, the percentage of those whose opinion was that online learning had a negative influence on their learning reaches 67,2%. Only 8% of the students were of a neutral opinion. When compared to the statements of Karalis and Raikou [7], who stated that the introduction of technology in university education might affect one's productivity, our results confirm their standpoint.

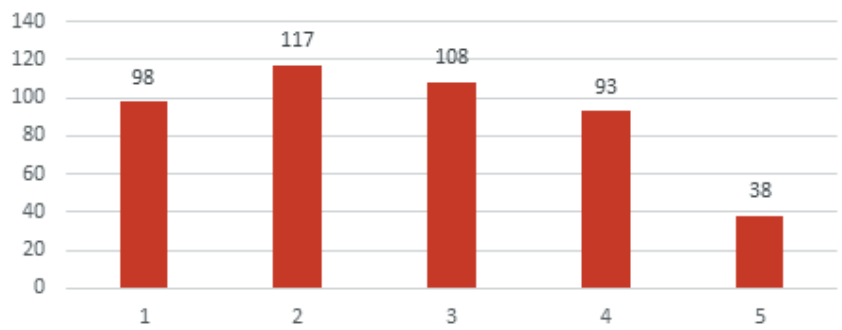
Graph 4 presents the average motivation level in students regarding online learning. Merit 1 indicates a very low level of motivation while merit 5 indicates a very high level of motivation. The average merit is 2,68. Only 8,4% of students were motivated by online learning, while approximately half of the participants (47,4%) said that their motivation was low. The results and the answers of the participants comply with the opinions of the authors of existing research. [17] [19] [20]

Graph 5 presents the opinion of students when technology and smart tools had been applied in online learning, whereby 64,7% of students said that the application of technology absolutely helped them and also improved their learning, while 34,1% agree it helped in certain aspects. The implementation of technology and smart tools in university education might have been completely strange to some students, and this is indicated by the 22,5% of students with a neutral opinion. Modern technologies have infiltrated not only the entire industry and business branches, but the highest levels of education, too. This development of technologies force universities all over the world to keep step with the trends and use all the benefits that technologies provide.

Finally, the students were asked to analyze their attitudes regarding the implementation of technology in lecturing and examinations. Out of 454 participants in the research, 68,5% considered that technology solutions



Graph 3 - Students' opinion on whether online teaching has affected the decline in productivity



Graph 4 - The level of motivation of students while attending online classes

adapted to online learning would eliminate the existing disadvantages of online learning. [18] [19] [20] Although the students generally had an adverse opinion regarding online learning, according to their opinions we think that something could be done for it to be improved. Useful new solutions applicable for online learning and improvement of the reduced productivity and motivation in learning would bring them more free time. The number of students that do not believe in the potential and positive effect on online education present 7,5% of the participants.

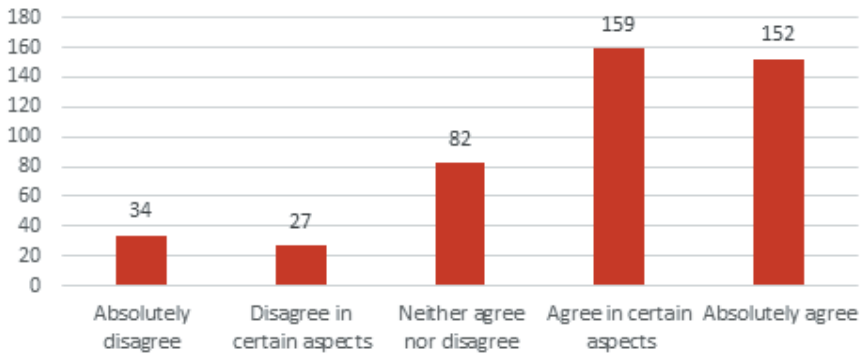
6. CONCLUSION

The entire world population had been affected by the COVID-19 pandemic and many universities, likewise. The university education had undergone sudden changes, which required adjustment of the lecturers, of other staff members and of students. One of the first and most important changes was the change in the form of lecturing. The traditional lecturing within the university premises had to be transferred into online platform lecturing.

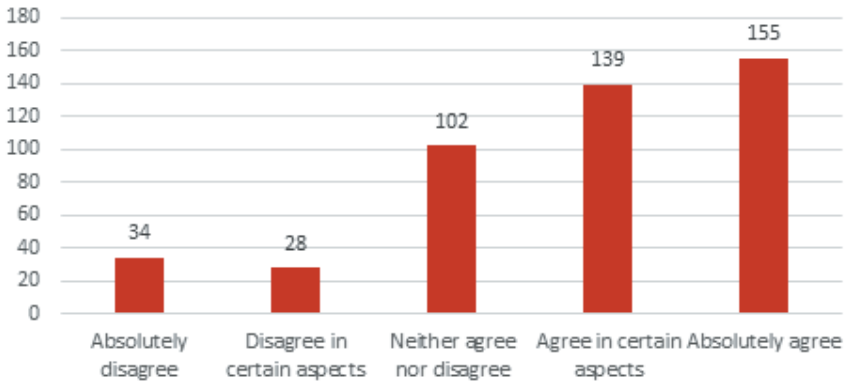
The universities and their management were forced to hastily adapt and implement certain changes in the organization of their business. Certain universities had done this without any difficulty and swiftly, while others significantly lacked flexibility and capacity to adapt to the online lecturing process.

Young university students had no problem in adopting new solutions, compared to the elder students and lecturers lacking digital skills. The duration of the COVID-19 pandemic throughout several semesters of online learning, had a negative influence on the productivity, motivation and general satisfaction of the students regarding acquired knowledge. The lack of free time, the new form of lecturing, the experimental forms applied in them, as well as the social distance had brought serious consequences on the mental health of students.

Based on the collected and analyzed data, we found that the sudden change in the lecturing process had an adverse effect on the satisfaction of university students' in Serbia. In online learning the efficiency, productivity and motivation in students were low when compared to the traditional form of lecturing. The present experience of the



Graph 5 - Technological solutions in online teaching would increase productivity and motivation to learn



Graph 6 - The use of technology and smart tools would enhance online learning

students confirms the assumption that the implementation of technology in the lecturing and examination activities would significantly improve these parameters. Since we are living in a digital era in which the high educated population are daily exposed to challenges and changes, in future researches will apply longitudinal methods, i.e., repeat the research regarding online learning to establish whether after a lapse of time there have been significant improvements. The plan is to create and distribute a questionnaire each year in order to analyze situation and the attitude of students regarding online learning.

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MULTIMEDIA STORYTELLING ON THE WEB

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Abstract:

This paper seeks to provide different forms of media on the web, such as those already used for digital storytelling. Several practical examples from the real web are described. Furthermore, the advantages but also the limitations of each individual medium used for digital storytelling on the web, are presented. The contemplation finally expands focus on the use of combined media in the context of digital storytelling and presents the concept of multimedia storytelling. The emphasis is on the description on specific forms of multimedia storytelling compared to more common content on the web.

Keywords:

Multimedia, Storytelling, Animation, Image, Video.

INTRODUCTION

Multimedia storytelling is the artwork of conveying a story through more than one kind of media along with text, such as image, animation, audio and video [1,2]. This method affords new possibilities for telling stories, however additionally increases new challenges. Different media have special strengths — and they need to be used with intention. When executed well, multimedia stories are capable of leverage the ones strengths to carry emotions and construct empathy in approaches that single-medium stories cannot.

Multimedia stories are interactive in a manner that single-medium stories are not [3]. By incorporating numerous forms of media, a variety of stories that we cannot imagine can be created. This interactivity is a vital function that allows us to be engaged with our environment and to seek their feedback. Inserting clickable quizzes, remarks, and animation affords an interesting way to get the audience to take part within the story experience.

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Moreover, multimedia storytelling is versatile. Multimedia stories can have different forms, and they can be adapted to discover what model fits fine in a chosen story. This versatility can also assist in construction potential to an organization which seeks to be presented on web. For example, developing short videos to encompass in a multimedia story can assist for creating longer video stories withinside the future.

Viewers are drawn more intensively into the stories and topics through the use of multimedia options. This form of digital storytelling is particularly interesting from a cognitive-psychological point of view. It was found that the human brain far more processes and remembers if multiple, different senses are addressed in parallel. In addition, the term storytelling also describes the way how history is consumed - by scrolling [4]. The user does not have to himself navigate through the site using menus or links. However, this doesn't mean that the user only has to scroll through long texts. Rather the scrolling due to the various multimedia elements becomes an experience through mouse commands, or swiping on smartphones as well tablets. Even the user can individually control the speed of information absorption.

With the advent of the World Wide Web (WWW) at the beginning of the 90s, the PCs changed their function to a media presenter [5]. In this way, what is now the primary platform for multimedia storytelling as we know today was created. Initially, only the display of text and images was possible in rather poor quality. The rapid improvement in technology, the increased performance of the special image formats, such as computer animation or moving images (videos) for the web was possible for the first time. As a consequence, these media required new formats. The prerequisite for use animation was that the users installed the appropriate plug-ins such as Flash, Java, QuickTime and Silverlight [6]. At the same time, however, the new technologies also brought security gaps.

With the introduction of the iPad and iPhone, the technical replacement of these plug-ins was carried out, because Apple's smart devices did not support Flash or other plugins. As a result, the compatibility problem still exists, because the variety of screen formats has increased enormously with smartphones and tablets. Moreover, there is also a problem of various image resolutions on a plethora of multimedia devices, shown in Figure 1.

Current increasing the possibility of animations to be distributed natively on a vector basis, i.e. without to convert first to (pixel-based) videos, established very late in the development of the web. With this step at the latest, today's interactive multimedia web has become an almost ideal platform for the distribution and use of content based on the concept of digital storytelling. One example of different multimedia content on a smart phone is shown in Figure 2.

It can be expected in the near future that next to web other cloud platforms could establish multimedia storytelling. For example, interactive games based on Virtual Reality (VR) and hologram technology can become common [7].

Figure 1 - Multimedia devices with responsive web design
(https://medium.com/altcampus/making-a-responsive-web-design-3ee34b3ee63a).

Figure 2 – Scrolling on different multimedia content
(https://newsroom.unsw.edu.au/news/general/instagram-can-make-teens-feel-bad-about-their-body-parents-can-help-heres-how).

As with the older forms, the web offers extensive potential for storytelling. The uniqueness lies in the technical possibilities that allow different types of media skilfully combined into a multimedia experience. In the following, individual media available on the web for digital storytelling are presented. Storytelling with only text is described in the Section 2. The other kinds of storytelling with images and text, as well as with header images, are presented in the following sections. Before conclusion, storytelling with a video, as the most spectacular medium, is described.

2. STORYTELLING WITH TEXT

One of the simplest and oldest ways of distribution information on the web is text. The Web standard HTML (Hyper Text Markup Language) was originally invented by Tim Berners-Lee and developed exactly for this task. The basic idea was to share information between different scientists worldwide and exchange among research institutions and universities. This content was in the form of pure text pages constructed in HTML and linked via hyperlinks. Due to constant further development, the possibilities in the range of website functions have multiplied. In addition to complex, responsive layouts the support of images, audio and videos was possible. It can be observed that regardless of technical progress on the web, text is still a widely used form of the information presentation. This could be justified because the effort in creation a textual content, such as blog posts, articles or e-books is significantly lower than the production of a video or animation, as a rule.

In addition, it is relatively easy to share text with other media types. The power of written words should not be underestimated. Experienced copywriters can use text tool to create best stories. Even emotions, such as joy or fear, are described by words. Text is also essential part of modern, digital communication. Over 55,000,000,000 text messages are sent daily via various services, such as Viber or WhatsApp. However, observation exclusively text-based websites is no longer widespread. Among other things, this is due to the fact that the users of a website only read 20 - 28% of the words on a page. Rather, the behaviour of the recipients has changed in such a way that the users of digital texts mostly (superficially) scan them. This could be found out with the help of eye tracking studies. Accordingly, the user tends to capture web page by reading the first lines intensive in a horizontal movement. He leaves his gaze with a vertical movement by sliding down a bit on the web page and then captures a content with a second horizontal eye movement. Finally, in another vertical eye movement, he scans the rest of the website. Here it is interesting that the upper left area is considered much more intensively than the rest content below or to the right.

In conclusion, written text is still very present in communication on the web. Nevertheless, it is being consumed differently by users than actually thought, since this is evident increasingly unwilling to read a lot of text on the web. This is particularly important for digital storytelling. Therefore, it seems useful to users to give an incentive to read longer texts anyway. This can be realized in many different ways. A good story, for example, stimulates the user's urge to read. The story should arouse curiosity by the reader by personal, funny, comical or provocative elements. It doesn't matter whether it's about a product, a company, a team, a vision or personal experiences. It is important that the content to be conveyed in a stimulating story, and the user is not only confronted with facts that seem boring to him. Rather, he wants to be entertained.

Based on the described changed reading habits on the web, a clear structure of the text has positive effects in terms of information processing for consumers. Short sections of text with meaningful headings could therefore reflect the changed reading behaviour in digital content and thus lead to a more pleasant reading experience.

3. STORYTELLING WITH IMAGES AND TEXT

The following section will focus on the potential of combination of images and written text for storytelling in more detail. Images have always been a substantial means of human communication - starting with the cave paintings thousands of years ago, up to the billions of photos shared on Facebook, Instagram or flickr, uploaded in recent years. Images can also be used to communicate effectively on the web. The success of the image communication is based on the way how people process information. Heimann and Schütz showed that about 90 percent of information processed by the human brain refers to visual information refers and, on the other hand, images are processed 60,000 times faster than text [8].

With regard to the smartphone, however, it should be considered that the shortened attention span is accompanied by increased information processing. Humans can thus probably identify faster and select what we want to deal with or not. In addition, an image at a glance can tell a whole story, and processing is less tedious than selecting content to read from a text. It is not necessary to read sentence by sentence before each of these fragment merges to form a whole. However, Sammer and Heppel state that in certain cases a picture can be misunderstood or misinterpreted, so that the well-known idiom no longer applies [9]. A meaningful keyword or a short line of text can convey the meaning of an image.

If we take a moment to hold on and to visualize something, without context it remains dull. Accordingly, images can support a story only with an appropriate context. From this it can be concluded that digital storytelling, based exclusively on images, will not work adequately probably due to the lack of context. Here is an example: A loaf of bread being held by a hand with a severed arm is shown in Figure 3. The fingers are dusted with flour, and the background could be a wooden table.

Is this about the offer of a baker, or is this the start of a tutorial on how to bake bread? Maybe there is the bright light behind the bread but hand does something spiritual. As can be noticed, the brain automatically tries to make up a story for ourselves, since the viewer has no other clues other than the depicted subject. Figure 4 shows the added missing text to clarify the context.

For multimedia storytelling on the web, there are mostly four different ways of using images:

1. Header images;
2. Background images;
3. Images in the content area, and
4. Infographics.

Mostly used kind of incorporating images in multimedia storytelling are header images. These images can create a high level of emotionalization and are therefore prominently used in modern Web design. In the past, header images were often only wide images, whereas today fill the whole screen in full size and often go beyond the actual website. These images are only a decorative element, but sometimes they are also part of the content. However, header images often come with a large and important meaning. These images are located in the header area and thus represent an important part of the website, since this area is first accessed by the user. Here the user must both inspect visually and contextually, so that it is sufficient to explore the rest of the site.

Figure 3 – Image of bread without context [4].

Figure 4 – Image of bread with context [4].

There is a skilful combination of image and elementary text. Compared to images in the content area, header images are displayed next to a text, which must therefore be integrated into the image. There are two common variants for the design of static header images. In variant one, an image is just as wide as the actual website content, as illustrated in Figure 5. It thus closes left and right flush with the content.

This creates, especially with big monitors, large unused areas that for example are kept in the background color. The design seems rather calm, since the image dimensions adhere to the grid of the screen design. Because of despite the size, this still has an exciting effect within the layout. In variant two, an image is as wide as the screen, but it has a lower height than the viewport. This will fill the entire screen width used for illustration. As already described, the user is optically drawn into the picture.

In addition to the function as header images, they can also used in multimedia storytelling as background images [4].

They are particularly effective in large format. Background images are technically behind the actual content of the website which is mostly in the form of text. For web designers, the decision is whether the content of the background image should remain recognizable as such, or whether the background image is only used decoratively. It is advisable to give the image its own assign importance. The balance between the meaningful part of the text and the background image is subject to change and must be reconsidered in each individual case.

However, background images that are too remarkable can cause visual conflict with the foreground information and create split-attention effects. Large-format background images are good to represent emotions, feelings, memories and to generate user ideas. To conclude, the meaning of the background image is thus available for multimedia storytelling.

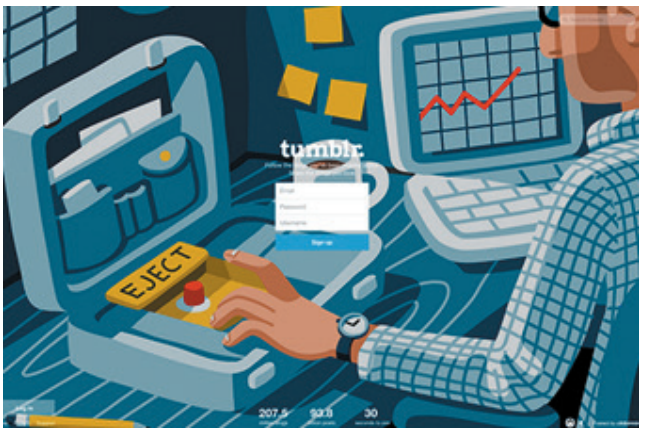

Figure 5 - An example of a header image wide as the web site
(https://www.impactplus.com/blog/6-websites-full-width-image-headers).

Figure 6 – An example of a background image
(https://multiurok.ru/blog/storitelling.html)

Images in the content area often visually clarify the textual sense, but sometimes offer little of their own information content. This is often found predominantly in the texts. Finally, infographics can also tell a story well. They are particularly suitable when it comes to present facts and figures in a visually appealing way. Compared to graphics in print publications digital images are designed in a more complex and multifaceted way, due to a possible interactivity or animation. It is expected that inforgraphics will become a trend in the near future.

4. STORYTELLING WITH VIDEO

Thanks to ever faster data transmission, online videos are currently booming as the most required medium. According to a Cisco analysis, online video made up 73% of all internet traffic in the end of 2021 [10]. Many of these videos have stories behind in some kind. In addition, this medium combines both moving images with audio and thus represents a medium which lends itself to engaging narratives. When people watch videos, it relaxes them while giving them control of both their cognitive area as well as the feelings [11].

Visual stories reinforce this mental attitude because in no other medium can feelings and technique harmonize so expressively. This fascination that the video format radiates could already be proven in a study from the year 2011. The result of the study proves that the visitors of a website, which one video contains, stay twice as long on this one ("100% longer average time-on-site per visitor"). As the web continues to evolve, videos are integrated and disseminated more and more easily.

Videos are now viewed and natively supported by modern browsers such as Chrome, Firefox, Edge, and Safari Opera. This medium can be used in various forms for digital storytelling. For instance, the Scottish whiskey distillery Balvenie informs on their website which artisans for their good whisky are responsible [12]. Within these portraits some videos are also offered, which are sold separately and can be viewed independently. The individual videos are an essential part of the contents and are only replaced by short texts and partly supplemented by a few pictures. The video is integrated as an interactive element. With the help of videos, Balvenie tells the personal story of the distillery and creates an emotional sphere for the user around their products.

In addition to being used as the primary content element, videos can also be used for emotional support. That videos don't tell independent history, but are a part of it. In this case, video is also often used as an integrated background. The goal here is the same as for a wallpaper: create a visual world to evoke and highlight emotions. The video has the advantage in comparison to an image which is usually able to present a situation of just one point of view. Rather, multiple situations and views are reproduced, which trigger a more comprehensive perception experience for the viewer.

Furthermore, through the movement, the website is automatically filled with additional element and should be less static. As can be seen from the website ge.com/digitalvolcano, there is a movement in the form of a recognizable tracking shot in the background video, as can be seen in Figure 6. However, this is very slow and quiet so that the background video is not disturbed by the other informative content elements, such as the headlines and short passages of text.

Figure 7 – The colourful background in the head area (https://www.ge.com/digitalvolcano).

However, this form only became really possible with the expansion of broadband internet. Nothing would in this case affect the user experience more negatively than a background video, which is not played immediately, but only in a certain time would have to be loaded. The user may then see a black background, or even see an animated loading icon which is not displayed acceptably.

Moreover, videos are not present only on websites, but are also increasingly being posted on well-known video platforms like YouTube and Vimeo. As a result, they are detached from the actual site and will be in the website only via a corresponding snippet embedded in the video platform. These platforms offer hence the potential for viral spread. Videos in the various social media are often clicked, commented and shared in a very short time by a very large number of users. Particular stories are often told that are very emotional and personal. In addition, there is a clear trend towards everyday stories. This form is the personal identification of the viewer through the same or similar ones experience, as a key factor.

5. CONCLUSION

In the past few years, the web has evolved from a rather static visual medium increasingly towards a dynamic, multimedia environment, thanks primarily to the higher bandwidth. While primarily text-heavy websites with rather small images were dominant, the further development of technology today allows the use of far more emotional and expressive visual elements, such as large-scale images, videos and animations, as well as much more interactivity. Therefore, the web from today represents an almost ideal place for multimedia storytelling. However, it should be noted that the available multimedia and increased interactivity in the context of multimedia storytelling typically not only provide variety for the user, but involve them directly and actively in the action. Finally, multimedia storytelling on the web is no more location-based, but can be used from anywhere in the world and can be consumed at any time.

6. ACKNOWLEDGEMENTS

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ADVANCED ENGINEERING SYSTEMS AND SOFTWARE DEVELOPMENT SESSION

ADVANCED ENGINEERING SYSTEMS AND SOFTWARE DEVELOPMENT SESSION
INVITED PAPER

AN APPROACH FOR SOFTWARE DESIGN AND DEVELOPMENT

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Abstract:

One of the important challenges in software design and development is gathering of user requirements and its successful translation into engineering specification of a software product. This paper presents an approach for software design and development that enables gradually gathering of user requirements by using purposefully developed AFD language that enables a top-down functional decomposition. AFD is a text-based language with a simple 14 rules grammar and easy to understand semantics that are developed with computational thinking in mind. The computational thinking methodology is incorporated in multiple levels of decomposition in AFD. The lower levels are predominantly intended for users for expressing the requirements while the upper levels are intended for engineers for deciding upon implementation details. The proposed approach suggests using the first four levels for a software design and using the fifth level for mapping the design to selected software development paradigm. In case of object-oriented development paradigm, AFD provides automatic generation of appropriate UML sequence diagrams.

Keywords:

AFD, Functional Decomposition, UML, Software Design, Software Development.

INTRODUCTION

The first step in developing a software product is the requirements gathering process [1]. The functional requirements are those that relate to intended purpose of the product and its capabilities. The functional requirements serve as a main input for making a design specification, and moreover as a sound point of reference for checks and balances throughout production and quality assurance [2]. The main problem in requirements gathering is absence of a proper way of representing the functional requirements. Currently, the requirements are represented either in textual format that is easy for clients to understand but usually lacks sufficient information for engineers, or in graphical format that is preferred by engineers but usually has complex semantics that clients hardly understand. In both cases, the result is jeopardized expectations between clients and engineers, that leaves plenty of room for errors and ambiguities.

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This paper sheds some light on a solution named Annotated Functional Decomposition (AFD) as an alternative for software design and development. AFD is a text-based language that is easy for clients to use and understand, while at the same time enables engineers to use it for a design and development as it provides extendable semantics with annotations for keeping track of all pieces of required information. Even though it could be used as a stand-alone solution, AFD could also be used to complement existing approaches such as UML (Unified Modelling Language).

The remainder of the paper is organized as follows. The second section presents AFD and explains its underlying methodology. The third section provides an example on how AFD could be used for a design of functionalities of an information system. The fourth section describes an approach for software design and development that connects AFD and UML and repeats some findings regarding the usage of AFD. The fifth section concludes the paper.

2. ANNOTATED FUNCTIONAL DECOMPOSITION

Annotated Functional Decomposition (AFD) is a new language that resembles natural languages (so it is easy to use by clients) and supports some semantics of computer languages (so it is adequate for use by engineers). AFD provides solutions for two main problems that exist during initial steps of software design and development. The first one is that functional requirements usually do not adequately recognize all functionalities needed for fulfilling intended purpose of the software product. The second one is that design specification does not meet all functional requirements. AFD solves those two problems by introducing extendable set of annotations for enabling stepwise refinement of functional requirements and linking to the resources that will implement those requirements.

In the essence, AFD is based on the existing design paradigm named Structured design that performs a top-down functional decomposition [3]. However, in order to provide support for recognizing all needed functionalities during the requirement gathering process AFD builds upon methodological concepts introduced by computational thinking (CT). CT is defined as a mental activity for the formulation of a problem and expressing the solution effectively, in such a way that a machine or a person can perform [4] [5]. To achieve the main goal, CT utilizes four techniques, also known as pillars. All four pillars have great relevance and are independent during the process of formulation of solutions computationally viable. The CT involves identify a complex problem and break it down in sub-problems that are easier to manage (decomposition pillar). Each one of these sub-problems can be analysed individually with greater depth, identifying similar problems which were previously solved (pattern recognition pillar), focusing only on the details that are important, whilst irrelevant information is ignored (abstraction pillar). At last, steps or simple rules can be created to solve each one of the sub-problems found (algorithms pillar). AFD implements all four pillars trough annotations divided into groups, that form different levels of the decomposition.

The first level of the decomposition in AFD is mandatory as it describes decomposition of a problem while all other levels are optional as they describe independent and orthogonal aspects of the problem. The second level describes control flow, the third describes data flow, the fourth describes reusage of decomposition parts, and the fifth describes resources regarding implementation. AFD language is formally defined by its context-free grammar that consists of 14 rules, as given in Table 1, which define different levels of decomposition [6]. The flexibility of the AFD is reflected in the fact that the rules are constructed so that the levels of decomposition are made orthogonal. Further extensions of AFD in terms of new levels of decomposition could be easily introduced by adding appropriate rules.

3. EXAMPLE OF AFD USAGE

Usage of AFD language could be demonstrated on an example of designing an information system. Designing process consists of stepwise refinement of functional requirements that starts with abstract description and goes gradually into details that at the end gives sufficient details for development. The steps actually represent different levels of decomposition as defined in AFD, where the first level of decomposition represents the most abstract one easily understanded by client and that is progressively updated by higher decomposition levels leading to the final design specification easily understanded by engineers.

The example resembles a ticket purchasing system. A user can purchase tickets for multiple seats on an event with an optional reservations previously done by the user. For each seat system finds a ticket, and then checks whether the ticket is still available and optionally reserved by the particular user.

No	Rule
1	Function ::= FunctionDef FunctionDecompEntry FunctionList FunctionDecompExit | FunctionDef;
2	FunctionDecompEntry ::= INDENT;
3	FunctionDecompExit ::= DEDENT;
4	FunctionList ::= FunctionList Function | Function;
5	FunctionDef ::= FunctionPrefix FunctionName DataFlows ResourceFlows Condition NEWLINE;
6	FunctionPrefix ::= ID SPACE | FTYPE SPACE | ID FTYPE SPACE | ;
7	FunctionName ::= NAME | NAME HASH | HASH NAME;
8	Condition ::= SPACE CONDITION | ;
9	DataFlows ::= LBRACE DataFlowList RBRACE | ;
10	ResourceFlows ::= LSBRACE ResourceFlowList RSBRACE | ;
11	DataFlowList ::= DataFlowList COMMA DataFlow | DataFlow;
12	DataFlow ::= DIRECTION NAME;
13	ResourceFlowList ::= ResourceFlowList COMMA ResourceFlow | ResourceFlow;
14	ResourceFlow ::= RESOURCETYPE COLON NAME;

Table 1 – AFD grammar

In case of successful checks the found ticket is purchased for the user and reservation, if existed, is removed. Information about all purchased tickets is shown at the end.

The first level of decomposition represents the core for all other decomposition levels. It identifies main function and breaks it down into sub-functions. The process is iteratively done until each function is resolved into sub-functions comprehendible by the user. Each function or sub-function is given in a separate line and is represented by its name that should be meaningful and descriptive in the context of the problem as much as possible. Sub-function is shown indented to the function that it resolves. For the given example, the first level of decomposition is shown in Listing 1.

The second level of decomposition introduces control flow into the result of the first level of decomposition. It identifies the order of the execution, conditional execution, and repetitive execution. The order is represented by numbering each function or sub-function at the particular level of indentation. Conditional execution is represented by a question mark after the number and condition using a forward slash sign and is given after the function name.

Repetitive execution is represented by an asterisk sing after the number and repetition condition using a forward slash sign and is given after the function name. Listing 2 shows both first and second level of decomposition for the given example, while the latter is highlighted in red.

The third level of decomposition introduces data flow into the result of the first level of decomposition. It identifies input and output data of the functions and is given in a pair of brackets after the function name. Multiple data are separated by comma signs, while each of them has name and input/output type. Input and output types are represented with greater then and less then signs respectively. On the higher levels of abstraction in a decomposition, a function could have data represented as streams of data that can be resolved into data for sub-functions following that function. In other words, data streams enable data decomposition in the same manner as functional decomposition enables decomposition of functions. Data streams are represented with an equal sign before the input/output sign while a dot sign is used to represent a-part-of relationship between streams and sub-streams. Listing 3 shows the first three levels of decomposition for the given example, while the third level is highlighted in red. All three levels are shown for the purpose of the completeness of the example, while orthogonality between the second and the third level enables their independent visualisation.

```
PurchaseSeats
	Input
	PurchaseSeat
		FindTicket
		CheckTicketAvailability
			HasTheTicketBeenPurchased
			WhetherTheTicketWasReserved
			WhetherTheTicketWasReservedByTheUser
			ReturnAvailability
		PurchaseTicket
			WhetherTheTicketWasReserved
			RemoveReservation
			Purchase
	GetPurchasedSeatsForUser
	Output
```

Listing 1 - The first level of decomposition in AFD for the ticket purchasing system

The fourth level of decomposition represents marking of the same functions. By identifying the same functions their re-usage becomes possible and therefore designing process eventually becomes more efficient and less error prone. The same functions are marked with a hash sign. Putting a hash sing after a function name represents that the function could be re-used, while putting a hash sign before a function name represents that the function is re-usage of some previously defined function.

Listing 4 shows the first four levels of decomposition for the given example, while the fourth level is highlighted in red. Due to orthogonality between levels of decomposition the fourth level could also be independently visualised.

The fifth level of decomposition introduces implementational details that are unessential for the user, however needed for an engineer. In case of object oriented implementation the details are information about classes that implement particular function. A name of a class that implements a function is given in a pair of square brackets that follows the function name.

```
1 PurchaseSeats
	1 Input
	2* PurchaseSeat /seat in seats
		1 FindTicket
		2 CheckTicketAvailability
			1 HasTheTicketBeenPurchased
			2? WhetherTheTicketWasReserved /purchased == false
			3? WhetherTheTicketWasReservedByTheUser/purchased== alse AND reserved == true
			4 ReturnAvailability
		3? PurchaseTicket /available == true
			1 WhetherTheTicketWasReserved
			2? RemoveReservation /reserved == true
			3 Purchase
	3 GetPurchasedSeatsForUser
	4 Output
```

Listing 2 - The second level of decomposition in AFD for the ticket purchasing system

```
1 PurchaseSeats(=>I.PS,<=O.PS)
      1 Input(=>I.PS,<user,<event,<seats)
      2* PurchaseSeat(>user,>event,>seat) /seat in seats
            1 FindTicket(>event,>seat,<ticket)
            2 CheckTicketAvailability(>user,>ticket,<available)
                  1 HasTheTicketBeenPurchased(>ticket,<purchased)
                  2? WhetherTheTicketWasReserved(>ticket,<reserved)/purchased==false
                  3? WhetherTheTicketWasReservedByTheUser(>user,>ticket,<reservedByUser) ⏎
                        /purchased == false AND reserved == true
                  4 ReturnAvailability(>purchased,>reserved,>reservedByUser,<available)
            3? PurchaseTicket(>user,>ticket) /available == true
                  1 WhetherTheTicketWasReserved(>ticket,<reserved)
                  2? RemoveReservation(>ticket) /reserved == true
                  3 Purchase(>user,>ticket)
      3 GetPurchasedSeatsForUser(>user,<purchasedSeats)
      4 Output(>purchasedSeats,<=O.PS)
```

Listing 3 - The third level of decomposition in AFD for the ticket purchasing system

Character C and a colon are used as a prefix for class name in order to denote that an object oriented implementation is used. Listing 5 shows the complete example with all five levels included, while the fifth level is highlighted in red, and just as for all previous levels of decomposition the orthogonality is maintained.

The design of a system given in AFD language could be verified according to the AFD grammar. For the purpose of verification an appropriate AFD Tool is implemented in Java as the plugin for Eclipse IDE, as one of the most widely used integrated development environment. Moreover, besides verification, AFD Tool enables mapping of AFD to UML. Details regarding relationship between AFD and UML are given in the following section.

4. RELATIONSHIP BETWEEN AFD AND UML

UML represents de-facto standard in domain of software design and development with more than 25 years of proved usability [7]. UML is a graphical language with extendable semantics that is primarily used for supporting object-oriented design and analysis [8]. In comparison with UML, AFD offers more technology agnostic approach that besides supporting object-oriented programming (due to the fifth level of decomposition) also supports traditional procedural based programming. Moreover, that also means that AFD could be more attractive for emerging technologies and novel programming paradigms (e.g. data-flow, functional programming, reactive programming).

AFD could also be seen as a technology complementing other existing ones. For example, using AFD as a text-based language to expedite creation of some UML diagrams, such as sequential or activity diagrams. Current implementation of the AFD Tool enables automatic generation of UML sequential diagrams according to a design of a system given in AFD language when the design includes all five levels of decomposition. Figure 1 shows a corresponding a UML sequence diagram for the ticket purchasing system given in Listing 5, while Figure 2 shows the sequence fragment that is a result of identified re-usage of a function on the fourth level of the decomposition.

Similarly, AFD could be used for use case scenario definition, or could be integrated with existing requirements management tools in order to provide better traceability of the requirements and their implementation in the final product. In that manner, AFD may complement UML during the requirements gathering process or even be considered as general overview of the specification whose details are elaborated on separate UML diagrams. An approach for using AFD in conjunction with UML for the purpose of software design and development is proposed in Figure 3. The approach suggests using the first four levels of decomposition in AFD for software design and using the fifth level of decomposition in AFD for mapping the design to selected software development paradigm. In case of object-oriented programming paradigm initial versions of some UML diagrams could be automatically generated (currently,

```
1 PurchaseSeats(=>I.PS,<=O.PS)
      1 Input(=>I.PS,<user,<event,<seats)
      2* PurchaseSeat(>user,>event,>seat) /seat in seats
            1 FindTicket(>event,>seat,<ticket)
            2 CheckTicketAvailability(>user,>ticket,<available)
                  1 HasTheTicketBeenPurchased(>ticket,<purchased)
                  2? WhetherTheTicketWasReserved#(>ticket,<reserved) /purchased == false
                  3? WhetherTheTicketWasReservedByTheUser(>user,>ticket,<reservedByUser) ⏎
                        /purchased == false AND reserved == true
                  4 ReturnAvailability(>purchased,>reserved,>reservedByUser,<available)
            3? PurchaseTicket(>user,>ticket) /available == true
                  1 #WhetherTheTicketWasReserved(>ticket,<reserved)
                  2? RemoveReservation(>ticket) /reserved == true
                  3 Purchase(>user,>ticket)
      3 GetPurchasedSeatsForUser(>user,<purchasedSeats)
      4 Output(>purchasedSeats,<=O.PS)
```

Listing 4 - The fourth level of decomposition in AFD for the ticket purchasing system

only sequence diagrams are supported). The rest of the software development activities would depend on the selected software development paradigm. Even though the proposed approach resembles the waterfall development methodology the approach could also support iterative or cyclic development methodologies [9] [10].

In order to support the assumptions regarding the benefits of AFD, a preliminary quantitative evaluation was done. The aim of the evaluation was to assess whether using AFD facilitates focusing on required logical checks and constraints while designing software products in comparison to UML. Groups of students who designed the products using AFD were considered during evaluation as experimental groups, while groups who designed the products using UML as control groups. The results showed that experimental groups achieved higher average score than control groups. On three experiments each one involving more than 100 students, average

```
1 PurchaseSeats(=>I.PS,<=O.PS)[C:BoxOffice]
      1 Input(=>I.PS,<user,<event,<seats)
      2* PurchaseSeat(>user,>event,>seat) /seat in seats
            1 FindTicket(>event,>seat,<ticket)[C:Event]
            2 CheckTicketAvailability(>user,>ticket,<available)
                  1 HasTheTicketBeenPurchased(>ticket,<purchased)[C:Ticket]
                  2? WhetherTheTicketWasReserved#(>ticket,<reserved)[C:Ticket] ⏎
                        /purchased == false
                  3? WhetherTheTicketWasReservedByTheUser(>user,>ticket,<reservedByUser) ⏎
                        [C:Ticket] ⏎ /purchased == false AND reserved == true
                    4 ReturnAvailability(>purchased,>reserved,>reservedByUser,<available)
            3? PurchaseTicket(>user,>ticket) /available == true
                  1 #WhetherTheTicketWasReserved(>ticket,<reserved)[C:Ticket]
                  2? RemoveReservation(>ticket)[C:Ticket] /reserved == true
                  3 Purchase(>user,>ticket)
      3 GetPurchasedSeatsForUser(>user,<purchasedSeats)[C:User]
      4 Output(>purchasedSeats,<=O.PS)
```

Listing 5 - The fifth level of decomposition in AFD for the ticket purchasing system

grades for experimental vs. control groups, on a scale 0-10, were as follows: 8.02 vs. 7.60, 7.95 vs. 7.75, 8.49 vs. 7.12. The results of the evaluation suggest that it could be expected that AFD could help communication between users and engineers and to smooth transition from requirements to specification. However, further improvements of AFD would be required in order to integrate it with the existing tools and paradigms.

5. CONCLUSION

Performance of a design and development methodology depends on its ability to provide easy understanding for users and sufficient information for engineers. This paper presents an approach that suggests using AFD language for software design and its automatic mapping to UML for the purpose of software development. AFD is a text-based language based on computational thinking that enables stepwise refinement of a software product design in order to make it more

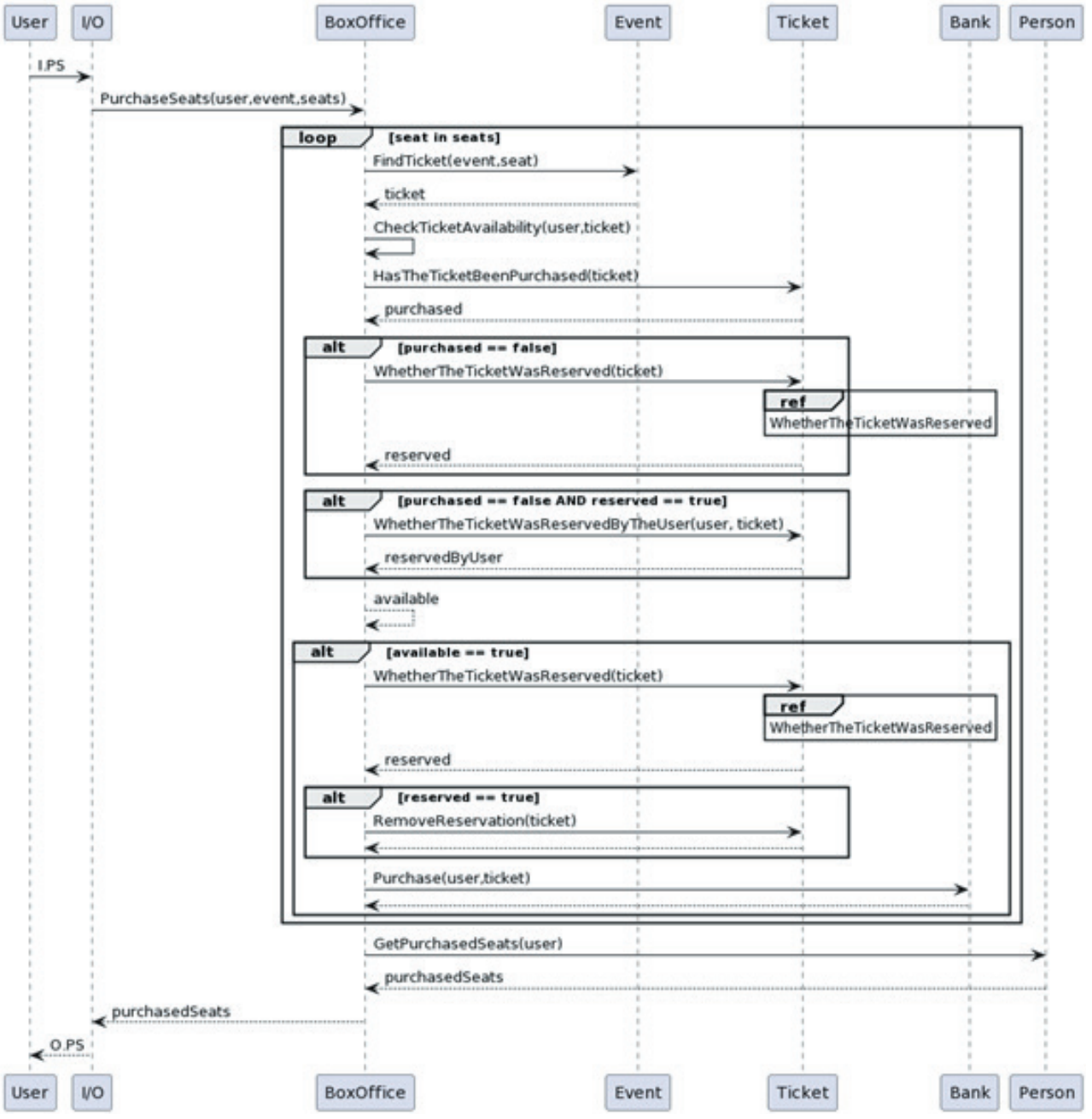

Figure 1 - Example of a corresponding UML for the ticket purchasing system designed in AFD (sequence diagram)

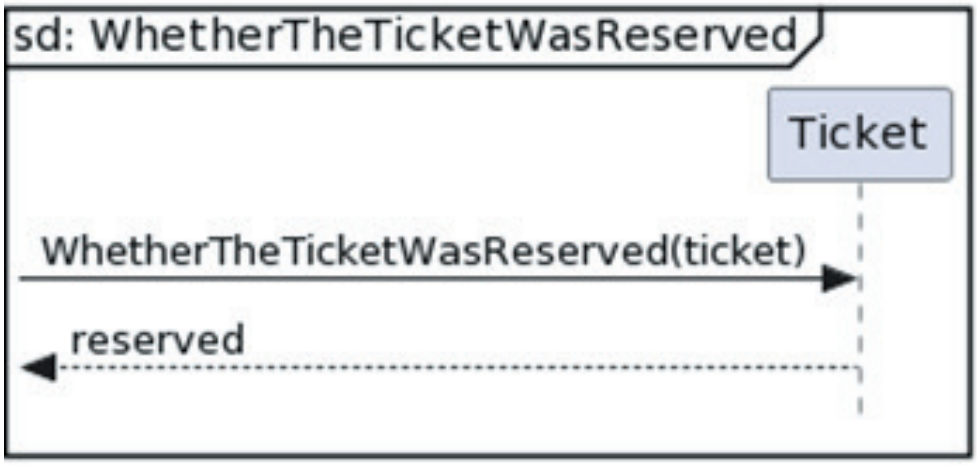

Figure 2 - Example of a corresponding UML for the ticket purchasing system designed in AFD (sequence fragment)

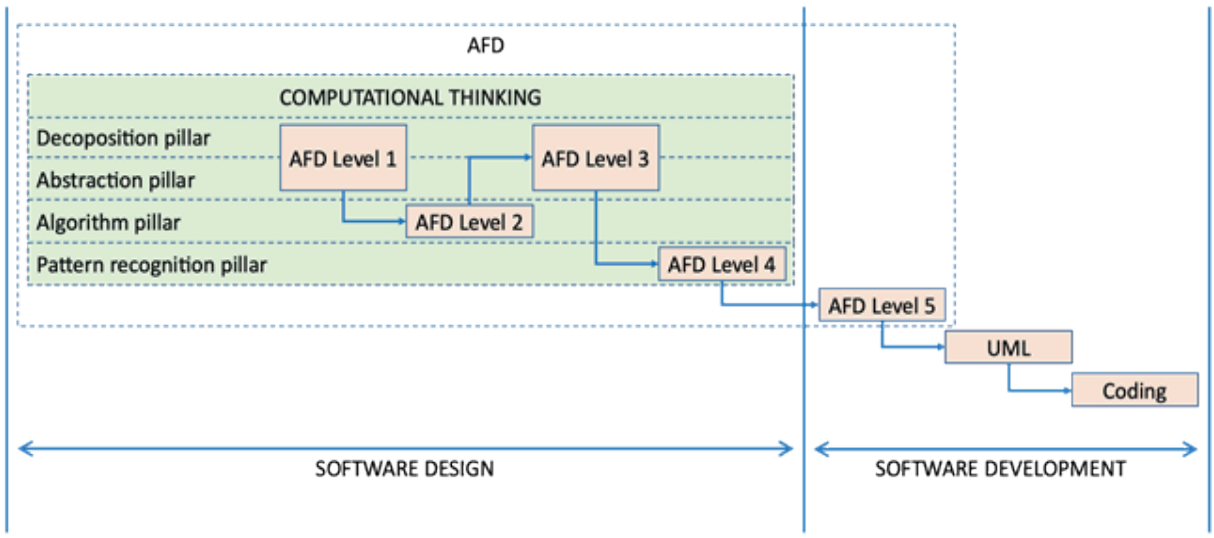

Figure 3 - Approach for software design and development

comprehendible for users and linking it to implementation details required by engineers in order to make software development more consistent with the design. The stepwise refinement is supported with multiple levels of decomposition in AFD. The approach suggests using the first four levels for a software design and using the fifth level for mapping the design to selected software development paradigm. The lower levels are predominantly intended for users for expressing the requirements while the upper levels are intended for engineers for deciding upon implementation details. AFD as a technology that, used alone or in conjunction with other available technologies, tends to help in production of more reliable and robust software products that fulfil end-users expectations. Having in mind influence of software industry on the global economy then each even minor step of improvement may have great value and importance.

6. ACKNOWLEDGEMENTS

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A SUMMARY PROTOCOL ON HOW TO DEVELOP A REMOTE LABORATORY

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Abstract:

Web Laboratories (weblabs) have proven to be a fantastic tool for teaching and learning, especially, as a complement to traditional hands-on labs in technical, engineering and science fields. Unfortunately, designing and implementing a weblab is usually not an easy nor a quick task, making this kind of resources difficult to find in many university courses. Therefore, an effort to educate our educators on how to create weblabs, so they can add them to their courses, is required. The Erasmus+ KA RELAB project is aware of this lack, and so, one of its main objectives is to address this problem. This paper is a result of the work done within the RELAB project. Here, we provide a summary protocol that makes it easier for teachers wanting to develop their weblabs to start doing so.

Keywords:

Remote labs, lab work, online education, engineering education.

INTRODUCTION

Experimentation plays an essential role in engineering and scientific education. Whereas traditional hands-on labs offer students opportunities for experimentation with real systems (they provide "actual experience"), they involve high costs associated with equipment, space, and staff for maintenance [1]. To minimize those costs, remote labs, or weblabs, use real setups which can be used at a distance (see Figure 1). In addition to reducing costs, weblabs the following benefits [2]:

1. Availability: VRLs can be used from anywhere at anytime, thus they support students geographically scattered, who besides are conditioned to different time zones.
2. Accessibility for handicapped people.
3. Observability: lab sessions can be watched by many people or even recorded.
4. Safety: VRLs can be a better alternative to hands-on labs for dangerous experimentation.

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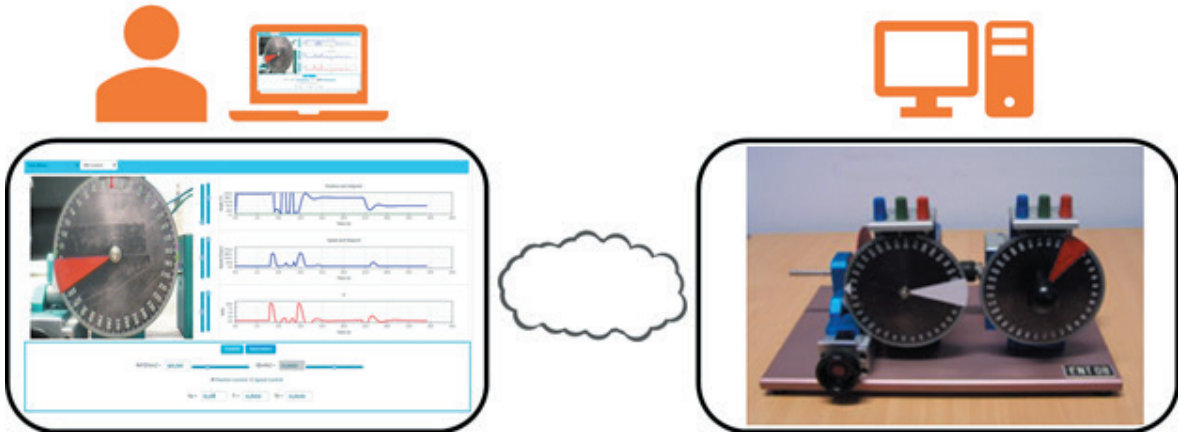

Figure 1 – Basic architecture of a weblab.

Despite their advantages, few teachers and institutions actually use weblabs as a common way to complement their traditional hands-on activities [3]. One of the main reasons for this is that weblabs have been traditionally hard and time consuming to develop. Moreover, they require a mix of skills (programming, communications, hardware setup, etc.) which makes it difficult for single persons or small teams to cover.

Therefore, this paper presents a comprehensive protocol with the steps to follow and the tools to use when facing the challenge of developing a weblab for the first time. This does not pretend to be a full step-by-step guide, nor to cover all the possible architectures, solutions and tools that can be used and applied for the task. For example, desktop-type access for weblabs (which have their own difficulties and risks) is not considered in this work. Instead, it just pretends to give a reasonable starting point for those wanting to develop and deploy their first weblab.

2. SUMMARY PROTOCOL

We can divide the process of designing, developing and using weblabs into four main considerations [4]: 1) security and communication issues, 2) the server-side development, implementation and/or integration, 2) the client-side development and implementation, and 4) the deployment of the weblab app into an online course. The next subsections tackle each of them.

2.1. SECURITY & COMMUNICATIONS

Usually neglected, security and communications issues with weblabs are extremely important, and, sometimes, difficult to address. It is also the first thing that should be considered when developing a weblab, as the decisions made in this phase will likely affect how to develop the other ones.

The following are the most common sources of threats related to webLabs, and the risks associated with them, followed by the basic recommendations to avoid them:

- *Risk*: Equipment (cameras, computers, switches, etc.) use public IPs. When the lab devices use public IPs, they are visible and reachable to anyone. While this is a very handful solution for exposing the lab services and making them accessible, it also carries a huge risk, as any user or bot can try to access such devices. *Recommendation*: Use private IPs within a VLAN/VPN that is protected and allows you to control who may access which resources within the private network.
- *Risk*: WebLab services do not use an authentication system. Sometimes, weblabs are left open, so anyone can access them. This may be done either by design or by mistake, but in both cases, malicious users may take control of the lab and make bad use of it, potentially harming the equipment, monopolizing it and preventing others from using it. Or simply, access to cameras that should not be available to everyone at any time. *Recommendation*: Always use an authentication system at the communications protocol level. Using authentication for accessing a webpage is not

enough, as users may be able to access the webpage at some point, load a web app and keep it open and running if no security is implemented at the communications protocol level. Users may even be able to download the app and keep using it whenever they want, without having to log in and authenticate in the webpage never again.

- *Risk*: Services not running over HTTPS. Even when an authentication mechanism is in place, if such mechanism does not rely on HTTPS, security is at risk due to the use of unencrypted transport of the credentials. *Recommendation*: Always install an SSL certificate to enable the use of HTTPS and encrypted communications.

2.2. SERVER-SIDE DEVELOPMENT, IMPLEMENTATION AND/OR INTEGRATION

The server-side development for a weblab usually has to solve connecting a computer (whether a desktop computer or a single board computer) with real hardware, in the form of actuators, sensors, etc. This can be done through various hardware (Arduino, Raspberry, Data Acquisition Cards, PLCs, etc) and software (LabVIEW, Beckhoff, Matlab, Python, etc.) solutions. This work does not address the hardware part, as this is extremely dependent on the type of experiment to be prepared and the resources that are available or at reach. For the software part, we focus on two well-known solutions (LabVIEW and Python), both equally valid and easy to connect to a web-app in HTML5.

The use of LabVIEW is recommended for those who have a license and can use the software, as there are good chances the lab hardware that needs to be connected for the weblab already has a LabVIEW interface and/or API. Python is recommended for any other situation, as it presents a high degree of interoperability and connectivity, making it ideal for most applications. Two common architecture situations and lab setups supported by these two implementations of RIP are illustrated in Figure 2. Both scenarios can be addressed using a middleware that enables the communication between a client application (see next section) and any software in the lab operating the experimental setup. This middleware is called RIP [5] and can be downloaded for free in both of its implementations: LabVIEW (https://github.com/UNEDLabs/rip-labview-server) and Python (https://github.com/UNEDLabs/rip-python-server). While the installation and configuration to make them work with each particular lab setup and the software used to operate it, differ for these two, instructions can be found when downloading RIP. In any case, once the installation and configuration is completed, both versions would start exposing your lab inputs and outputs as web services, using the exact same protocol. Listing 1 presents a generic JSON example response, provided by RIP, to an HTTP request.

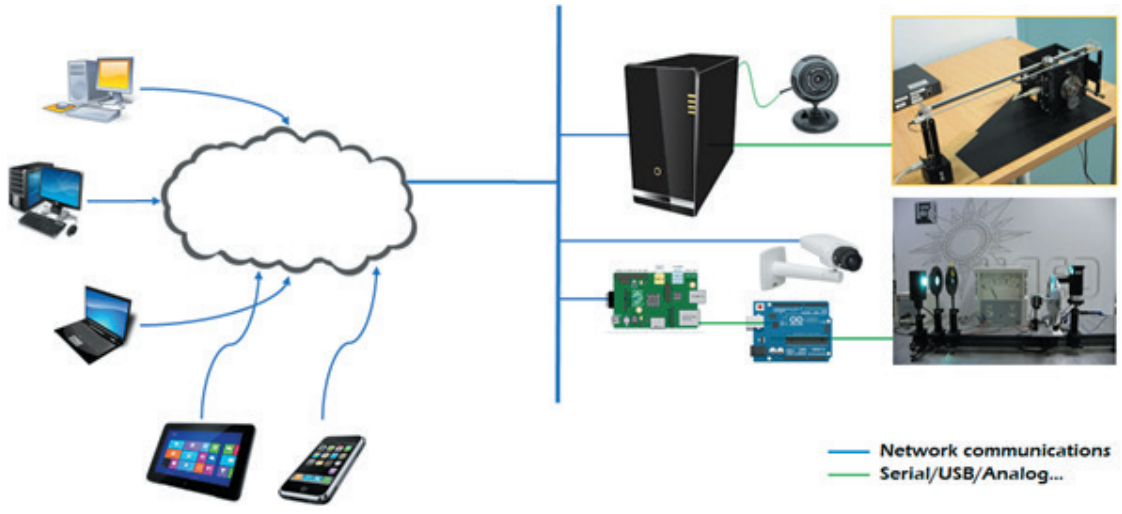

Figure 2 – Two typical weblab implementations supported by RIP.

```
{
  "outputs": {
    "list": [
      {
        "name": "output_1",
        "description": "description_output_1",
        "type": "type_output_1",
        "min": "min_output_1",
        "max": "max_output_1",
        "precision": "precision_output_1"
      },
      // ... ,
      {
        "name": "output_N",
        "description": "description_output_N",
        "type": "type_output_N",
        "min": "min_output_N",
        "max": "max_output_N",
        "precision": "precision_output_N"
      }
    ],
    "methods": [ { //... } ]
  },
  "inputs": {
    "list": [
      {
        "name": "input_1",
        "description": "description_input_1",
        "type": "type_input_1",
        "min": "min_input_1",
        "max": "max_input_1",
        "precision": "precision_input_1"
      },
      //... ,
      {
        "name": "input_M",
        "description": "description_input_M",
        "type": "type_input_M",
        "min": "min_input_M",
        "max": "max_input_M",
         "precision": "precision_input_M"
       }
    ],
    "methods": [ { //... } ]
  }
}
```

Listing 1 - An example of RIP response to an HTTP request.

For the sake of simplicity and briefness, the methods in the outputs and inputs fields are not included. However, they contain all the information a client needs to create REST calls to: 1) subscribe for getting updates on the values of the outputs, and 2) send requests for writing/modifying the inputs. Interested readers can find all the details in [5]. This information, and the available methods, published as webservices by RIP, to write a new value in an input variable and read the value of an output variable, is all a client app needs to actually operate the lab from the web and thus, transform the traditional lab into a weblab.

2.3. CLIENT-SIDE DEVELOPMENT & IMPLEMENTATION

The client-side development tackles with creating the HTML5 web application that would allow students to interact with the remote lab assets. This usually includes buttons, sliders, graphs, input fields and/or a video stream of what is going on in the lab room.

Any HTML + Javascript + CSS programming could give a weblab HTML5 app as a result, but the amount of work to program this from scratch is considerable. Other solutions, such as using Unity or similar web-friendly engines, are also possible, but the same problem remains. Here, we propose the use of EjsS [6] for this task, as it is a tool specially designed to make the task easy and, furthermore, anyone can download it and use it for free.

Web applications developed in EjsS can be either simulations or remote lab interfaces. When the app is a remote lab interface, the communication with the lab hardware/software can be easily implemented using a RIP client, which is already included in EjsS as an EjsS element. Readers needing a tutorial on how to use EjsS can find one at [7].

As a very brief introduction to EjsS elements, it is enough to say that these elements are added to an EjsS app by choosing the Model tab and then dragging one element icon from the palette (in the right part of the EjsS editor) into the model elements list (in the left part of the editor). Then, it is enough to double-click the new element to set its properties. Once created, users can call the element's methods in their app code to operate with the element. In the case of the RIP element, the three main methods to be used are:

- `connect()`: To connect the client web app with the RIP server and enable communication with the lab hardware. It is required to call this method and wait for its response before using the following two. It is important to note that RIP does not provide any authentication mechanism and therefore, this security aspect must be addressed somehow, usually at the VPN level (see section 2.1).
- `[value_i, value_k] = get([output_i, …, output_k])`: To obtain the values of the specified output variables.
- `set([input_l, …, input_m], [value_l, …, value_m])`: To write the specified new values in the specified input variable.

As simple as they are, these three methods provide all the necessary functionalities to communicate with the lab and thus, build a web app that is interactive and allows users to work with the lab equipment remotely. Once the web app is finished, EjsS provides an option to put all the files associated with this HTML5 app (.html, .js and .css files) inside a single .zip file and the only task that remains is to deploy it into an online course so that students can use it.

2.4. DEPLOYMENT

While the work required on the server side is a must in order to setup a weblab, it is the client web application the one that needs to get deployed in an online course to make it accessible to the students and enable them to perform their lab tasks.

As with all the previous tasks, this can be done in several ways. Here, we focus on using a Moodle plugin called EJSApp (which can be downloaded for free from [8]) to enable their easy integration into this Learning Management System (LMS). While this seems to limit its use solely to the case when the institution/teacher uses this LMS, this is not true. First of all, Moodle is open-source software that can be downloaded and used for free. Therefore, anyone could adopt it. Equally important, however, is that any activity embedded into a Moodle course (and this includes weblabs integrated through EJSApp) can be shared with other LMS through the Learning Tools Interoperability (LTI) standard [9], supported by all current major LMS. Therefore, once a weblab is embedded in a Moodle system, it can be shared with virtually any institutional platform and used from their online courses. The process for sharing a weblab from Moodle with another LMS follows the LTI standard for sharing any other learning tool, and instructions about how to do this can be found in the Moodle docs or in the target LMS platform documentation.

Once EJSApp is installed in Moodle (the instructions for this can be found in the plugin's download webpage or in the Moodle docs) embedding a web lab created with EjsS in Moodle becomes extremely easy. Figure 3 shows the web form to add or edit an activity with an EjsS app (EJSApp). The only two fields that need to be filled are the name of the activity and the .zip file that encapsulates the EjsS application.

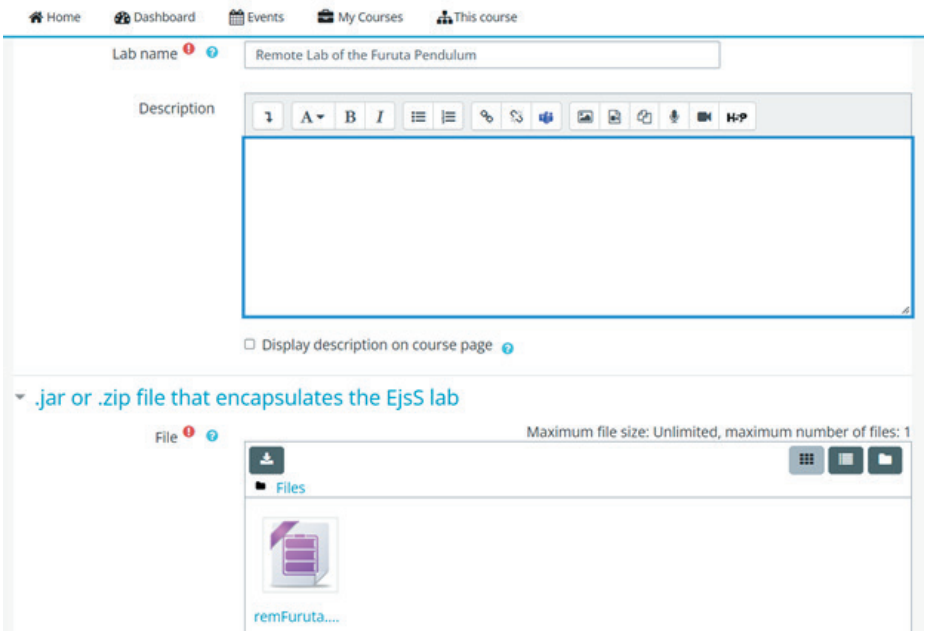

Figure 3 – Weblab deployment into Moodle through EJSApp.

3. CONCLUSION

This work summarizes the protocol and recommendations given in the RELAB's Intellectual Output 6. Following these guidelines, teachers can start getting familiarized with designing, creating and deploying a weblab, as well as with the software tools they can use to do so.

By making the learning curve more accessible and lowering the barriers for the entry point to develop weblabs, we expect to contribute to popularize this type of labs which have already demonstrated their usefulness and effectiveness in science and engineering education.

4. ACKNOWLEDGEMENTS

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AN IMPLEMENTATION OF A WEB LABORATORY CONVERTING OFF-LINE EXPERIMENTS INTO REMOTELY ACCESSIBLE EXPERIMENTS

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Abstract:

The paper presents a procedure for realizing a Web Laboratory, which enables the conversion of offline experiments into experiments available remotely. In this way, the user is provided with the same capacity for experimentation as in the case of conventional laboratory exercises. This paper aims to offer the proposed methodology to anyone who has an interest in organizing remote experiments. The proposed methodology ensures the integrity of remote experiments concerning possible cyber-attacks.

Keywords:

Web-Laboratory implementation, Remote experiments, Conversion of off-line experiments into remote experiments.

INTRODUCTION

Proper insight into experimental phenomena and real laboratory experience (according to the engineering educational principle "mind and hand") allows students to understand educational goals and theoretical concepts, understand the relationship between reality and theory, acquire professional skills, develop analytical skills, and a high level of knowledge absorption during the teaching process correctly and faster. Laboratory work requires the engagement of great resources (equipment maintenance costs, competent human resources, relevant laboratory infrastructure). To reduce the effective costs of an equipped laboratory place per student and provide relevant laboratory support to the teaching process, different universities have integrated their laboratory resources through strategic partnerships in the building of joint or open Web Laboratories (for example, see repository https://www.golabz.eu). A Web Laboratory is a real cyber-physical system that can be accessed through the Internet, where students can remotely operate and control a real system/plant through an experimentation interface. It is possible to access a Web Laboratory from anywhere at any time, but with only one hardware user simultaneously.

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The existing capacities of the Web Laboratories around the globe are not enough for a huge number of students who are oriented to this approach due to the "COVID-19 - crisis".

In the context of the RELAB project, the company CogniPix has designed a technical solution for implementing the Web Laboratory, which will be presented in this paper [1, 2]. Unlike previous approaches [3, 4, 5, 6, 7, 8, 9, 10], the goal is to convert the existing laboratory cyber-physical system into a WEB Laboratory, with the purpose that existing laboratory exercises in engineering schools can be alternatively transformed into online laboratory exercises with the fullest possible capacity and cyber safety standards. The paper also contains an illustrative example that explains the pedagogical side of demonstrating or validating analytical and theoretical concepts. The proposed concept of the WEB Laboratory encourages the development of real-time programming skills to the same extent as the hands-on laboratory. This Web Laboratory performance is an advantage over common solutions for Web Laboratory design.

2. STRUCTURE OF WEB LABORATORY AND MINIMAL HW/SW REQUIREMENTS

Web Laboratory exercises in Figure 1 (three typical experiments or plants for monitoring and control were selected) are connected to a microcontroller Arduino UNO or Arduino DUE, optionally, which is further connected to a PC on the Internet. In this case, the PC contains the installed x2GO client-server (necessary software platform for WEB-Laboratory implementation), and the PC has the following performance: Giga-Byte GB-BACE-3000 BRIX Mini PC, operating system: Linux uBuntu 20.04.3, processor: Intel Celeron N3000, number of processor cores: 2, processor clock speed: 1.04 GHz (2.08 GHz)), RAM: 4 GB. The recommended minimum HW configuration of a PC (for the necessary software installation for WEB Laboratory installation) is a 2 GHz dual-core processor, 2 GB RAM, and 25 GB hard disk space.

WEB Laboratory consists of 4 components:

1. **The experimental laboratory setup** encompasses all the necessary equipment attached for conducting a laboratory exercise (computer equipment such as the Arduino UNO or Arduino DUE in Figure 1, sensors, actuators, physical plant, etc.). This includes the installation of multiple standard Debian packages on top of Ubuntu i20.04LTS.
2. **Lab Server** is a part of the experimental laboratory setup, and it can be Ubuntu/Debian based lightweight computer (x86-based or ARM-based like RPi). Our approach to WEB Laboratory design is based on the assumption that Lab Server does not have (IPv4 or IPv6) public address. In addition, we won't discuss the VPN option as it requires more complex IT setups, which may also create other security concerns.
3. **Weblab Public Server** is a somewhat arbitrary term, but this is typically VPS (Virtual Private Server) available as a Cloud asset, provided by University Campus IT service, or rented from Public Cloud Provider (AWS, Digital Ocean, Azure, Google, or some local cloud provider). It can be used for multiple purposes, like Web server, Chat/Blog Server, File Server, Streaming server, etc. We will limit the scope of discussion in this document to additional (very few) services/configuration modifications required for the proposed solution. This is also typically a Linux-based server.

Figure 1 – An example of experimental setups belonging to the installed WEB Laboratory at the University of Kragujevac

4. **Client/Student workstation** needs very few software modifications. It can be either Windows or Linux-based. Only one or two additional software packages that can be easily installed (<5mins) are required.

3. PROCEDURE FOR WEB LABORATORY INSTALLATION

The primary intention of this approach is to allow migration of existing off-line/on-site Laboratory experiments created with Linux lab server, to online/remotely accessible setup, without additional changes to the original experiment. This is achieved via the enablement of Remote Desktop access. Though this is a very frequent approach today, multiple technologies are involved, typically requiring VPN setup and IT department support. In the follow-up approach, we tried to simplify the enablement of Remote Desktop access suitable for Web Lab experiments. Equally important is attention to a more secure approach since Lab Servers are not using public addresses and are behind the firewall /NAT. Alternative approaches can be used for this purpose, the most notable being the Apache Guacamole project (https://guacamole.apache.org/).

For our approach, detailed procedures with actual commands and configuration parameters are described in [2].

Lab Server configuration (Linux, Ubuntu)

Lab setup servers are affordable mini PCs with 4 GB of RAM, two cores, and 80GB of SSD storage. The same approach can be made using Raspberry PI4, whose Linux distro is also Debian-based. Linux OS used for Lab setups is Ubuntu 20.04.3 LTS. To prepare a mini PC for this role, the following modifications are required (Figure 2):

- **SSH service (open-SSH)**: this allows headless operation and enables reverse-tunnelling.
- **Add Desktop environment lightdm**: This step aims to install a lightweight graphical desktop environment suitable for less demanding remote desktop operation.
- **X2GO-service:** This is an open-source Remote Desktop service based on NXv3 libs, providing quick, low-latency solutions for Linux servers. Clients are available for both Windows and Linux setups.
- **AutoSSH-service:** This service ensures a robust, always-on SSH reverse-tunnel communication link. It needs to be configured to maintain a connection with a specific WebLab (aka bastion) server, using locally generated SSH keys.
- **Restrict X2GO session time**: Special cron triggered script is used to limit X2GO session time to prevent excessive logon time. This is very important if large groups of students need to share the same Lab server platform.
- **Lab server**:
  - » Generate SSH keys
    - › To be added to authorized_keys on the server, for the given weblab user account
  - » Install autoSSH service, logging into servers user account dedicated for the given weblab
  - » Install X2go server and graphical desktop environment (XFCE) to enable desktop experience
  - » As a backup, include a remotely controlled power switch.
- **WebLab Server:**
  - » Add Lab Server client SSH keys to authorized_keys
  - » Add student SSH keys to authorized_keys
  - » Reload SSHd configuration
  - » Automate this procedure via Flask/Nodejs-based dynamic content part of the Web site
  - » Add registration and reservation pages
  - » Allow linking (provide a set of pages) to other services, e.g. Moodle inclusion
- **Student/Client workstation**
  - » Install X2GO Client
    - › Configure for SSH reverse tunnel connection using client keys
  - » Stretch goal: Provide browser only access

Weblab public server configuration

This is typically VPS hosted on a Public or Private Cloud. Also, the same VPS can be used not only for this purpose as a communication node/'proxy-jump' server but also as a Web Server, Mail Server, or similar service provider. We will assume this VPS is Linux/Debian-based.

Bastion server is public-facing (i.e., host with public IP), hardened systems that serve as an entry point to systems behind a firewall or other restricted location. These systems may reside on the same LAN or multiple LANs, even behind different firewalls.

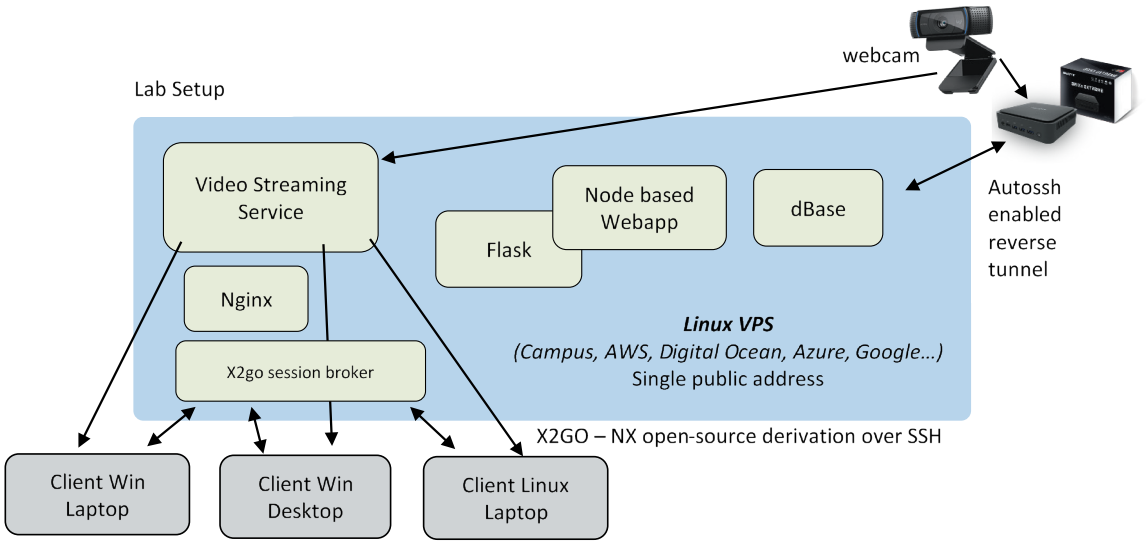

Figure 2 – The proposed concept of WEB Laboratory design and implementation

A single bastion server is sufficient for multiple groups of Lab setups and is limited by available bandwidth and compute power to less extent. Bastion server is the only Linux server accepting public SSH connections. This reduces "surface-of-attack" to a single server only. If a user wants to access a "hidden" (from public Internet) Lab setup machine, they need to connect to the bastion first and make another SSH connection from the bastion to the destination. This process is sometimes called "proxy jump" and can be automated.

In our solution, Lab setups (Figure 3) establish an SSH reverse tunnel (i.e., Lab setup initiates and maintains a connection to the Bastion server) in such a way creating an opportunity for external users (Student/Client machines) to access Lab setups not exposed to the public internet and being behind a firewall/NAT.

Typical VPS server configuration has most of the services included. Still, additional step is needed to create Lab Setup dedicated user accounts just for Lab setup connections, specially created with a limited set of permissions "weblabcpa", "weblabcpa2", ..., "weblabcpa5". This is accomplished using Linux standard 'chroot' commands. In this way, only a subset of commands on the Bastion server can be used by these user accounts.

Further enhancement by addition of custom X2GO session-broker protocol (automatic redirection to available Lab server) and Web app for timeslot reservation will improve usability and resilience of the proposed solution.

Client/Student workstation configuration

Student setup requires installation of two packages only: X2GO client and a specific set of files with custom SSH keys, X2GO session file, and BATCH / SHELL script files.

In this way, a single click or command is sufficient to initiate a connection to remote Lab setup – only a password needs to be entered before a remote desktop connection via the Bastion server is established.

X2GO client installation

- Windows client setup: http://code.x2go.org/releases/X2GoClient_latest_mswin32-setup.exe
- Linux client setup: it is available in standard Ubuntu repositories, so the following command is sufficient: sudo apt-get install x2goclient

  It is important to select XFCE as the session type (since this was selected in the X2GO server type)
- Installation of custom files and login procedure is described in a separate document "Manual for accessing Lab Setups over X2GO server" (in Serbian "UPUTSTVO ZA PRISTUPANJE LABORATORIJSKIM VEŽBAMA PREKO X2GO SERVERA" on https://relab.kg.ac.rs).

  The custom package includes the following files:
  - Predefined X2GO sessions (for all N setups)
  - SSH public keys, different keys for each Lab setup (generated on Lab setup using SSH-keygen)
  - Window/Linux script files for direct access to Lab Setup 1,2, ..., 5.

During operation, we can monitory established connections in "/var/log/auth.log" standard files

```
grep "weblabcpa" /var/log/auth.log
```

and a number of connections successfully created by Lab Setups using the following command:

```
sudo lsof -iTCP -sTCP:LISTEN | grep SSHd | grep "weblabcpa"
```

Connection is initiated from command prompt/terminal: to_cpa.bat/.sh (or to_cpa2.bat/.sh ...)

Only a previously set Lab Setup password needs to be provided at login, and Students can access the Lab setup desktop.

4. PILOT WEB LABORATORY AT UNIVERSITY OF KRAGUJEVAC USED FOR FREQUENCY RESPONSE IDENTIFICATION EXPERIMENT

Students can apply the prepared Arduino program for experiment realization to demonstrate the following learning outcomes in figure 4: real-time programming understanding, setting of sampling time, using DA and AD converters, generation of the control signal, measurement and acquisition of output signal, visualization and analysis of experimental signals, understanding frequency responses, and characteristics, and student knows how to comment on the filter properties of a system. WEB Laboratory allows access to equipment from anywhere at any time, and a much larger number of students can use the equipment 24/7. In the specific illustrative case, the use of the WEB Lab does not negatively affect any aspect of laboratory work.

5. CONCLUSION

An important and innovative performance of the presented WEB Laboratory installation procedure is that the achieved performance of locally prepared experiments is not lost (the experiment is not limited only by changing parameters but enables safe implementation of the arbitrary control-monitoring real-time program).

The solution is created with simplicity criteria in mind for end-users, i.e., students, to allow quick access, easy installation, yet similar experience as being physically present. Another goal is to enable easy conversion of existing Linux box-based lab setups, with attached lab equipment, EVMs or similar – used for offline work, with student physical presence, to remotely accessible/online setups. In addition, we opted for open-source software packages with liberal licenses only. Among various open-source remote desktop solutions, we selected X2GO as a reliable, secure, and low-latency option. All network connections are either SSH or reverse SSH-based, using a single public-facing "proxy jump" server, thus significantly reducing security concerns.

The presented web lab solution was verified over a population of 150 students during the previous semester.

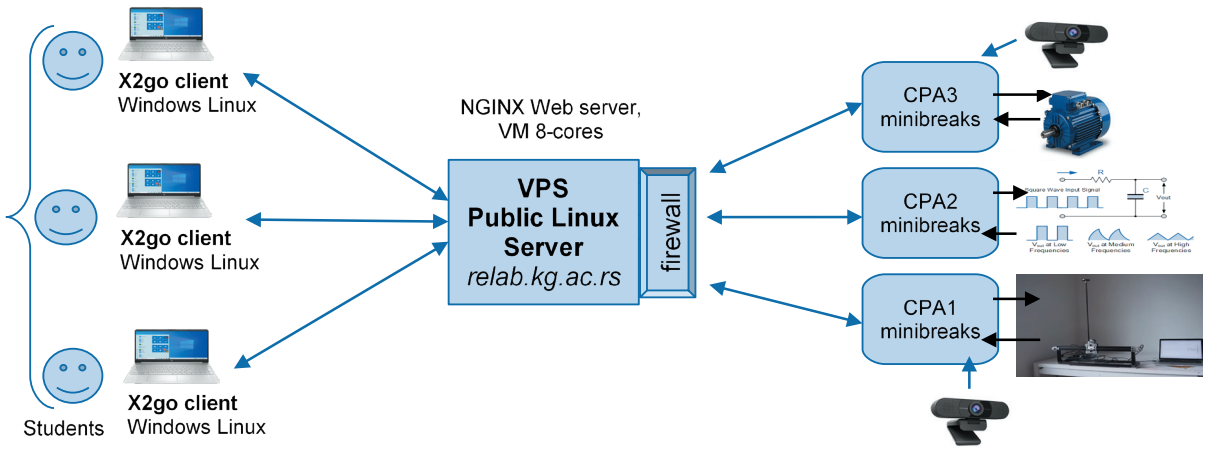

Figure 3 – Configuration pilot installation of WEB Laboratory at University of Kragujevac

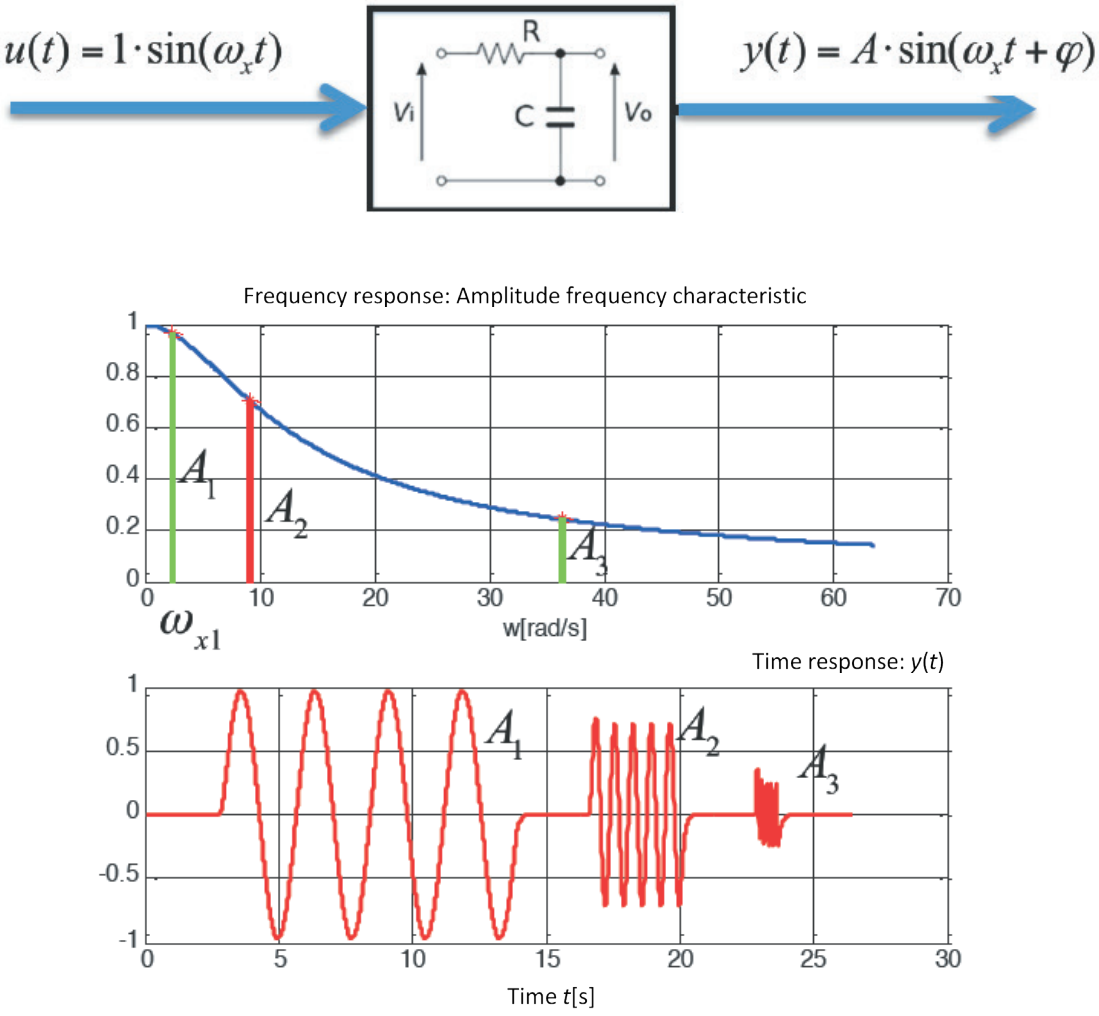

Figure 4 – Experimental laboratory setup consisting of Arduino DUE and RC circuit.
The figure is illustrated experiment for the identification of frequency response

6. ACKNOWLEDGMENTS

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AVAILABILITY OF NGA MARKET POTENTIAL INDICATORS IN THE WESTERN BALKANS

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Abstract:

Broadband residential access to next-generation networks (NGA) with bit-rates greater than 100 Mbps is critical in terms of data volume growth and approach to the gigabit networks implementation. Reliable demand forecasting of the required bandwidth for the residential market is a necessary input for the successful planning of the communication network resources. This paper investigates and compares the availability of the data suitable to be used as market indicators for several Western Balkans countries related to the application categories. This study could be useful for the market potential estimation and development of the NGA demand forecasting model.

Keywords:

NGA, market potential, socio-demographic factors, planning, forecasting.

INTRODUCTION

In the last few years, the world is rapidly transforming towards new technological forms related to the use of intelligent technologies, cloud infrastructure, thus creating a smart environment adapted to modern life demands. Although 5G technologies are widely implemented and 6G solutions are under research and development, the residential market still highly depends on fixed Next Generation Access Networks (NGA). The EU Digital Agenda [1] has practically reached its goal, regarding the facts that overall fixed broadband coverage for the EU27 reached 97.4% at the end of June 2020 (i.e. more than 186.8 million of EU households had access to at least one fixed broadband access technology), the average coverage (availability) of NGA services including VDSL, VDSL2 Vectoring, DOCSIS 3.0, DOCSIS 3.1 and FTTP reached 87.2% of households, while overall FTTP/DOCSIS 3.1 technologies currently capable of supporting gigabit speeds reached the coverage of 59.3% [2].

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It is expected that new user demands will affect the residential market regarding future access speeds up to 300Mbps, 1Gbps or higher until 2030 [3], [4], [5]. At the moment, there are a lot of test programs related to the implementation of 5G technologies to the Fixed Wireless Access (FWA) at the residential market [6]. However, global events in the last few years have affected FWA technology that is not yet ready for widespread implementation [7]. In addition, the new generation of WiFi technology, including WiFi 6 (2.4 GHz and 5 GHz) and WiFi 6E (6 GHz), based on IEEE 802.11ax [8], gives comparable enthusiasm [9], as well. Accordingly, there are several works related to FWA and WiFi 6, which could be considered as more suitable solutions [9], [10].

It is clear that the COVID-19 pandemic affected the global social way of life. The lockdown throughout Europe, as well as in the rest of the world, erased the line between business and residential users and shifted the Internet services closer to the residential part of the market. Accordingly, the general requirements for residential access networks were changed instantly in terms of higher speeds and more symmetrical access networks to provide advanced applications, such as HD and UHD video streaming, video communications, cloud-based applications, as well as Virtual Reality (VR) and Augmented Reality (AR) games. In such conditions, the overall environment of households is becoming of great importance. Accordingly, there is a need to modify the traditional forecasting models depending on the forecasted broadband market potential. Also, it should be identified how the usage of different applications and demographic households structures affect the bandwidth demands.

The broadband NGA technologies (FTTPs and DOCSIS (3.0 and 3.1)) remain the main technologies at the residential market regardless to the traditional WiFi technologies are widely used (ranging from IEEE 802.1n to IEEE 802.1ac).

Although the Western Balkans (WB) countries raising the number of households with broadband access, it will take additional time before percentages corresponding to the EU's Digital Agenda targets will be reached. Reliable forecasting of the required bandwidth for the residential market is highly important for successful network planning of all communication resources. This paper points out the need for development of new market potential models. Therefore, the key parameters necessary for the residential market potential at the WB region are considered.

This paper aims to analyse the residential telecommunication market of the Western Balkan and to investigate the availability of the relevant data for the NGA market potential model. Accordingly, this paper discusses the relevant market indicators related to the applications that would be used by residential users. The relevant sources of data related to these indicators will be considered.

The rest of the paper is structured as follows: a brief review of the relevant literature is given in the Section 2 including two important approaches for assessing the NGA residential market potential. Section 3 considers the availability of relevant market indicators for the WB countries followed by a brief summarized discussion. Finally, the concluding remarks are given in the last section.

2. A BRIEF LITERATURE REVIEW

2.1. MARKET POTENTIAL

The optimal capacity planning of broadband NGA infrastructure should be based on the forecasted traffic demand for the residential telecommunication market. The broadband market potential has to be considered as the main forecasting parameter since it reflects the entire size (i.e. upper limit) of the market for a given set of telecommunication services and applications for a specific time horizon.

The market potential represents all the possible residential users during the longer time horizon. The size of the market potential is probably the most critical element in forecasting matters. It could be considered as a composite parameter, because it includes different indicators, ranging from the number of households, demographic population structure, such as birth rate, gender, education, economic rate of households, up to the presence of competitions at the market, etc. Most of the forecasting models in literature imply the constant market potential, which means that the availability of broadband services remains unchanged throughout the entire life cycle. However, it is not relevant for the telecommunication infrastructure because of its expanding during the time according to the investment planning strategies. Various approaches could be considered in terms of market potential, such as those given below.

From the mathematical point of view, different assumptions are governing the shape of the market potential. In some papers, the market potential is presented as the exponential function of time [11], [12], while a

dynamic market potential is introduced by [13]. Some works introduce a variable structure of the market potential [14], [15], [16], [17]. In some cases, it is exogenously determined as a function of observed variables [14], [15], [16], [18], [19]. Some efforts are necessary for the correct specification of the main drivers (price, number of households with special facilities, number of competitors, number of retailers, threshold probabilities, etc.) and suitable transformation in order to obtain a reasonable correspondence with the adoption process scale. Moreover, there is a model that gives market potential as a function of the external and internal market factors, such as socio-economic factors, changes in population, marketing activities, etc. [14].

2.2. SELECTION OF APPROACHES FOR ASSESSING THE NGA BROADBAND MARKET POTENTIAL INDICATORS

This subsection gives some approaches for assessing the NGA broadband market potential indicators. In order to identify and select target applications and structure of digital services, the socio-economic characteristics of each country should be considered. For example, before launching of new services telecommunication operators should target customers with higher incomes and stronger educational backgrounds in order to minimize time to return on investment. The starting point for demand forecasting is behaviour of the end-users. How much broadband demand depends on the structure of digital services? Looking at the household level as the point of interest regarding the NGA broadband market potential, the approaches applied in UK and Australia attracted the attention [20], [21]. These reports consider the required bandwidths of applications used in fixed locations. The forecasting model for bandwidth demand combines the various applications with user profiles, which are further combined into various household types (Table 1).

Another approach presents the WIK market potential model that encompasses a slightly wider set of applications [22]:

- Basic Internet,
- Home office/VPN,
- Cloud Computing,
- State of the Art Media and Entertainment (4k, 3D, HD)…,
- Progressive Media and Entertainment (8k, …),
- Communication,
- Video Communication (HD),
- Gaming,
- E-Health,
- E-Home/E-Facility and
- Mobile Offloading.

Both approaches recognize certain types of applications as the main indicators of broadband demand increase including cloud-based applications, gaming, VR/AR, video streaming, telemedicine and file management, as well. It is expected that the bandwidth requirements for the most attractive applications will grow at an annual rate of around 30%, including future e-health applications together with telemedicine services [22], which are likely to require more advanced forms of connectivity including additional bandwidth, service quality and reliability.

The WIK model considers the use of mobile technologies to provide broadband connections to households, also. Along with applications, it recognizes the following six user profiles [22]:

- Sceptical outsider,
- Occasional user,
- Professional user,
- Trend user,
- Home office user, and
- Avant-gardist user.

Primary	Secondary	Web	Low bandwidth
Internet TV (SD, HD and 4K) HD video calls YouTube etc. Streamed gaming / HD interactive	Cloud storage Content downloads P2P / BitTorrent Mobile OS downloads Software downloads Non-HD video calls Content uploads	Surfing, excluding the use of video sites such as YouTube	Covers a range of applications not explicitly treated, including e-metering and other machine-to-machine, online radio, online gaming, etc.]

Table 1 - Statistical analysis results.

These profiles are ranging from older persons, who very rarely use the Internet and computers and express negative attitudes towards the use of modern information and communication technologies (thus have minimal bandwidth requirements), up to users with innovative digital equipment having strong abilities and skills to work with software and hardware, including heterogeneous structure of persons, from professionals with a high level of professional education to younger people who spend a significant amount of time in gaming applications, which have extremely high bandwidth requirements [22].

It has to be noted that none of these approaches take into account technical constraints, in terms of the required bandwidth regarding the infrastructure.

The economic constraints related to the explicit willingness of the end-users to pay additional bandwidth were not taken into consideration, as well. Having in mind the abovementioned, as well as the fact that the average GDP of the WB countries is at the level of 35.6% of the EU27 GDP average [23], the authors find out that these constraints could be the main gap to massive NGA adoption. These conclusions are partly aligned with the findings presented in [24], regarding the economic aspect. Therefore, the authors started a broad research in order to develop a new model of the NGA broadband market potential, such as one given in [22], but tailored for the particular economic constraints and user willingness regarding the usage of various applications at the broadband residential market in the countries of the WB region. Among two presented approaches, the authors also find out that the approach for market potential model presented in [22] gives more suitable indicators of various applications needed for broadband demand forecasting in the countries of the WB region.

In order to examine broadband applications by identifying some important factors that influence the decision to adopt broadband services, the first step of this broad research and the aim of this paper is to investigate the availability of the relevant data in different WB countries that could be used as suitable indicators for the new model of the NGA broadband market potential, tailored for the WB region.

3. INDICATORS AVAILABILITY IN THE WESTERN BALKANS COUNTRIES

In order to meet essential requirements for development of NGA broadband market potential model for the WB countries, this paper considers the availability and applicability of the relevant indicators listed in Section 2. Generally, development of the broadband market potential at the national level in each WB country at least could be based on three statistical databases sources: national statistical office, telecommunications national regulatory authority, as well as the European statistical office – Eurostat [25].

In this chapter, an analysis of national data repositories is performed, regarding the possibility to be used as statistical data sources for abovementioned indicators. The analysed results are presented in Table 2 for each country. The Eurostat source is noted along with the corresponding data indicator that exists in the Eurostat database. Datasets marked with *2 sign were published in 2018 only, while datasets marked with *3 sign were published in 2020 for the first time. Datasets and sources marked with the * sign are proposed to be adopted as the data source. Datasets and sources marked with (!) sign are proposed to be revised and enriched with some additional data, while datasets and sources marked with (!!) could be possibly relevant to be used as Digital Economy and Society Index (DESI) indicator. DESI is a composite index that summarises relevant indicators on digital performance and tracks the evolution of EU member states in digital competitiveness. DESI consists of 5 components: Connectivity, Human capital, Use of Internet, Integration of digital technology and Digital public services [26].

All DESI indicator abbreviations are used according Methodological note (2020) [27].

3.1. ALBANIA

Along with the Eurostat, in Albania there are two national data repositories, which are available to be used as data sources:

- The Institute of Statistics (INSTAT) [28] and
- The Electronic and Postal Communications Authority (AKEP) [29].

Results of telecommunications market analysis in Albania (Table 2) show that INSTAT Reports were identified as the primary data source for five indicators.

Reports related to Cloud Computing indicator could be proposed to be used for the DESI 4a1 indicator complement, as well. Also, in the case of two indicators, INSTAT Reports were recognized as complementary data sources. There is a possible lack of data sources related to some indicators.

3.2. BOSNIA AND HERZEGOVINA

Beside the Eurostat, there are two federal data repositories which are available as data sources:

- The Agency for Statistics of Bosnia and Herzegovina (BHAS) [30] and
- Communications Regulatory Agency (RAK) [31].

Results of telecommunications market analysis (Table 2) in Bosnia and Herzegovina show the lack of data that are related to the Basic Internet indicator, although RAK Annual Report contains only implicit data (items 35-40). For other indicators, Table 2 gives the datasets that could be used as available data sources. BHAS Report related to Home office/VPN indicator could be proposed for DESI 3b4 and 3c3 indicators complements, as well. RAK and BHAS repositories are incomplete data sources for some indicators (marked with (!) sign in Table 2). There is a possible lack of data sources related to the Mobile Offloading indicator.

3.3. MONTENEGRO

Beside the Eurostat, there are two national data repositories which are available as data sources:

- The Statistical Office of Montenegro (MONSTAT) [32] and
- Agency for Electronic Communications and Postal Services of Montenegro (EKIP) [33].

The results for telecommunications market analysis in Montenegro (Table 2) are obtained with limited accuracy. Although there is a lack of annual reports, corresponding data could be obtained from January reports. For most indicators EKIP could be proposed as a relevant data source (with limited accuracy). Corresponding data could be obtained from the Research Section of the EKIP repository.

Country / Indicator	Albania	Bosnia and Herzegovina	Montenegro	North Macedonia	Serbia
Basic Internet	AKEP (Annual Reports), INSTAT Reports	RAK (Annual Report, items 35-40) (!)	EKIP	AEK Annual Report, BCO (Connectivity indicators in DESI aligned format), MAKStat	DESI (1b1,1b2)
Home office/VPN	Eurostat: ISOC_IW_HEM (I_WHDAY) (*2), INSTAT Reports	BHAS Report (3b4, 3c3* (!!)), Eurostat: ISOC_IW_HEM (I_WHDAY) (*2) ISOC_EC_IBOS, ISOC_EC_CE_I (*3)	MONSTAT reports (3b4, 3c3, 5a4* (!!)), Eurostat: ISOC_IW_HEM (I_WHDAY) (*2), ISOC_EC_IBOS, ISOC_EC_CE_I (*3)	MAKStat, Eurostat: ISOC_EC_IBOS, ISOC_EC_CE_I (*3)	DESI (3b4, 3c3, 5a4*) Eurostat: ISOC_IW_HEM (I_WHDAY) (*2) ISOC_EC_IBOS, ISOC_EC_CE_I (*3)
Cloud Computing	INSTAT Reports (4a1 equivalent only * (!!)), Eurostat: ISOC_CICCI_USE (2018, 2019)	BHAS Report (!) (4a1,4a4,4b1,4b2,4b3 equivalents (!!)), ISOC_CICCI_USE (2018-2020)	Eurostat: ISOC_CICCI_USE, ISOC_CI_AC_I*	MAKStat, Eurostat: ISOC_CICCI_USE, ISOC_CI_AC_I	DESI (4a1,4a3,4a4,4b1, 4b2,4b3*), Eurostat: ISOC_CICCI_USE, ISOC_CI_AC_I
State of the Art Media and Entertainment (4k, 3D, HD)…	INSTAT Reports	BHAS report (!)	EKIP	MAKStat, AEK Annual Report*	DESI (3b2, 3b3* (!))
Progressive Media and Entertainment (8k, …)	INSTAT Reports	BHAS report (!)	EKIP	MAKStat, AEK Annual Report*	DESI (3b2, 3b3* (!))
Communication	INSTAT Reports	BHAS report (!)	EKIP	MAKStat*	DESI (3b5)
Video Communication (HD)	INSTAT Reports	BHAS report (!)	EKIP	MAKStat*	DESI (3b4)
Gaming	/	BHAS report (!)	EKIP	AEK Annual Report*	DESI (3b2*) (!)
E-Health	ISOC_CI_AC_I (!)	BHAS report (!), ISOC_CI_AC_I (!)	EKIP (!), ISOC_CI_AC_I (!)	MAKStat, ISOC_CI_AC_I (!)	ISOC_CI_AC_I* (!)
E-Home / E-Facility	/	BHAS report (!)	EKIP (!)	AEK Annual Report*	DESI (4a4)
Mobile Offloading	/	/	/	/	/

Table 2 - Data sources for indicators in WB countries.

In the case of Home office/VPN indicator, relevant data could be obtained from MONSTAT and Eurostat as complementary data sources. MONSTAT Report related to Home office/VPN indicator could be proposed for DESI 3b4 and 3c3 indicators complements, as well. Also, Eurostat is proposed as the primary data source for Cloud Computing indicator. MONSTAT and EKIP repositories are incomplete for some indicators (marked with (!) sign in Table 2). Also, there is a possible lack of data sources related to the Mobile Offloading indicator.

3.4. NORTH MACEDONIA

Beside the Eurostat, in North Macedonia there are three national data repositories which are available as data sources:

- The State Statistical Office (MAKSTAT) [34],
- Agency for Electronic Communications (AEK) [35] and
- Broadband Competence Office (BCO) [36].

Results of telecommunications market analysis in North Macedonia (Table 2) were obtained from the national repositories MAKSTAT, AEK and BCO (for the first indicator). AEK could be proposed as the primary data source for two indicators (Gaming and E-Home/E-Facility) and MAKSTAT could be proposed as the single data source for two indicators (Communication and Video Communication). The other five indicators could use two repositories as complementary data sources as well as Eurostat. Also, there is a possible lack of data sources related to the Mobile Offloading indicator.

3.5. SERBIA

Beside the Eurostat, there are two national data repositories which are available as data sources:

- The Statistical Office of the Republic of Serbia (RZS) [37] and
- The Regulatory Agency for Electronic Communications and Postal Services (RATEL) [38].

Serbia fully completed data alignment to DESI and became also a member state of The International Digital Economy and Society Index (I-DESI). Hence, this repository is considered as the primary data source.

Results of telecommunications market analysis in Serbia (Table 2) were obtained mostly from the I-DESI data repositories throughout RATEL annual overviews. Five indicators were proposed to use single DESI indicators as primary data sources, while the other five indicators were proposed to use complementary DESI indicators, along with several Eurostat data sources (aligned with RZS repositories). Datasets related to DESI 3b2 and 3b3 indicators do not clearly distinguish application regarding Gaming (3b2 only), State of the Art Media and Entertainment and Progressive Media and Entertainment indicators, so it is estimated that they need some complementary data in order to improve accuracy. Similar situation is related to the E-health, where lack of data related to the telemedicine service is identified and it should be complemented with an alternative source of data. It is also identified total lack of data sources related to the Mobile Offloading indicator.

3.6. DISCUSSION

The analysis of data availability showed that no WB country has a repositories that fully align to all of the shown indicators. The research confirmed that most relevant data sources in each of the analysed countries are state national statistical offices and telecommunications national regulatory authorities, while North Macedonia has the third data source (BCO), as well. All WB countries collect and publish data in accordance with the adopted local and EUROSTAT methodologies. Additionally, Serbia fully adopted DESI methodology. In some cases, the collection of relevant data was partly hampered by the lack of English versions of the documents. A number of statistical datasets were discovered as possible sources of complementary data to certain indicators. These datasets are proposed to be used either in the purpose of indicators' quality enrichment and/or potentially in the purpose of DESI data alignment (these proposals are marked with a sign (!!)). It should be noted that during this research, the RCC report [39] related to the fulfilment of the criteria of WB countries for the application of DESI methodology was found. The report shows results, which are significantly aligned with the results of our research, regarding availability of DESI datasets by these countries.

The performed analysis of national data repositories found that data sources for few indicators are fully or partially unavailable. Unavailability is mostly related to "newer" indicators, such as Gaming, E-Health and E-Home/E-Facility. It could be caused at the early stage of service adoption by the "invisibility" of certain populations of users (like gamers [40]) who could be described as "innovators" in some forecasting diffusion models [41].

On the other hand, E-Home/E-Facility indicator data could be also deteriorated due to the effect of end-user resistance to the so-called "adoption of the IoT enabled smart-homes" [42]. It was also noticed that E-Health indicator data could vary among countries depending on Telemedicine service involvement [43].

An indicator that suffers the lack of data in all observed countries is the Mobile Offloading indicator that stands for WiFi-Offloading of mobile data [22]. This indicator could be significant since it could produce savings to mobile network operators regarding the CAPEX [44]. Further lookup at given statistics confirmed that there is no useful dataset that could be related to this indicator. In this situation, the model for defining behavioural patterns of smartphone users could be proposed in order to overcome this issue [45].

4. CONCLUSIONS

This paper is a part of the broad research considering the NGA broadband telecommunication market for the WB region. The main outcome is comprehensive review of relevant indicators availability for the WB's national statistic offices and telecom regulatory agencies. These indicators are necessary for market potential estimation and development of reliable NGA demand forecasting model. According to the obtained results, the observed national statistical repositories could provide applicable historical data for corresponding indicators. However, there is a lack of data regarding some "newer" indicators, as well as Mobile Offloading. The identified lack of data should be treated as the significant gap that should be bridged in future works, by discovering alternative data sources and/or ways to create them.

The importance of the broadband residential market especially arose in the COVID-19 pandemic circumstances when all online activities were mostly carried out over residential access infrastructure. Therefore, the reliable network planning activities becomes a priority task in order to meet future demand challenges.

5. ACKNOWLEDGEMENTS

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COMPARATIVE STUDY OF TWO PROPOSED METHODS FOR IMAGE ENHANCEMENT OF ABNORMAL MRI BRAIN IMAGES IN SPATIAL AND FREQUENCY DOMAIN

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Abstract:

Image enhancement is the part of image pre-processing that is used to improve image quality and adjust image information content for further processing and includes techniques such as removing noise or reducing noise levels to a certain extent, adjusting contrast, sharpening the image, etc. In this research, 5 original grayscale images which are abnormal magnetic resonance imaging (MRI) brain images have been processed by using enhancement techniques in two different domains, spatial and frequency. This research described method of enhancement abnormal MRI brain images by using combining spatial domain techniques in MATLAB and method of enhancement abnormal MRI brain images by using combined 2-D stationary wavelet transform for denoising in Wavelet Analyzer technique within MATLAB and filtering in frequency domain technique in MATLAB. Image data used in this research were obtained from Radiopaedia, an educational radiology resource. The best technique to applied on abnormal MRI brain images has been detected by comparing the results of peak signal to noise ratio (PSNR), signal to noise ratio (SNR) and mean square error (MSE). Based on results obtained for PSNR, SNR and MSE measurements, it has been concluded and confirmed that better results for image enhancement of abnormal MRI brain images gives us combining spatial enhancement techniques.

Keywords:

magnetic resonance imaging (MRI), stationary wavelet transforms, spatial domain, frequency domain, Wavelet Analyzer.

INTRODUCTION

Image processing is a method that processes a digital image using an algorithm in MATLAB and thus performs certain operations on image elements to obtain corresponding modified results that are better than the original image or to extract the necessary information from the image. In this paper, techniques for enhancement MRI brain tumours images will be presented. Magnetic Resonance Imaging (MRI) is one of the diagnostic methods in radiology that is used to detect patients' diseases, for example, to detect and analyze some changes in brain soft tissue. Image enhancement is method used for improving image quality, removing or reducing noise, deblurring and sharpening details in an image, adjusting contrast of an image in order so that enhanced images can be utilized by human observer, in case of MRI images, by medical specialists.

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Imaging enhancement techniques play a significant role in MRI image pre-processing, especially in applications for diagnosing and detecting abnormal brain tissue based on human vision. Significant improvements in image quality can help medical specialists to interpret MRI images. In this paper, abnormal original MRI brain image which having low contrast and a certain amount of noise is applied to get some useful information about, for example, size, shape, location of abnormal tissue in the brain. This paper gives comparative study of two proposed techniques of image enhancement of brain tumour MRI images. First technique is combining Stationary Wavelet analysis using Wavelet Analyzer for denoising and combined spatial enhancement methods using MATLAB. Second technique is combining Stationary wavelet analysis using Wavelet Analyzer for denoising and filtering in frequency domain, also using MATLAB. Images data used in this paper are obtained from Radiopaedia, an educational radiology resource.

2. INTERACTIVE 2-D STATIONARY WAVELET TRANSFORM

Wavelet analysis can denoise image without significant degradation of an image just because it provides a different view of a data [1]. In this paper, it is applied 2-D stationary wavelet transform for denoising image using Wavelet Analyzer application.

2.1. OVERVIEW OF A STATIONARY WAVELET TRANSFORM FOR DENOISING IMAGE

In image processing applications, wavelet transform is a technique used to limit the time scale of a window to match the original image and is especially important and useful for non-stationary analysis of signals such as noise. For the purpose of image de-noising, it is suitable to use stationary wavelet transform (SWT) because it makes wavelet decomposition time invariant, it has equal of wavelet coefficients at each level, decomposition is redundant obtained by supressing the down sampling operations and up-sampling procedure is applied before we separate the variables x and y like shown in the following wavelets (vertical, horizontal, diagonal) [2-3]:

$$\begin{aligned}\varphi^{1}(x,y) &= \phi(x)\varphi(y)\\ \varphi^{2}(x,y) &= \phi(x)\varphi(y)\\ \varphi^{3}(x,y) &= \phi(x)\varphi(y)\end{aligned} \quad (1)$$

where φ is a wavelet function and ϕ is a scaling function.

2.2. PROPOSED METHOD

In this paper, it is applied 2-D stationary wavelet transform for denoising image using Wavelet Analyzer application. Image de-noising is used to remove or reduce the additive noise on certain level while retaining as much as possible the important features. The wavelet denoising is achieved via thresholding. Wavelet thresholding procedure removes noise by thresholding only the wavelet coefficient of the details coefficients, by keeping the low resolution coefficients unaltered. There are two thresholding methods frequently used: soft thresholding and hard thresholding. The hard thresholding is chosen over soft thresholding because hard thresholding gives us better PSNR, SNR and MSE results for our research [4].For decomposing original abnormal MRI brain image 800x800 at level 1 to 4, we applied *haar* wavelet through SWT because it gives best results for image quality evaluation [2]. The procedure for denoising image through SWT using Wavelet Analyzer in MATLAB follows next steps:

1. Load original abnormal MRI brain image 800x800 pixels in MATLAB m-file.
2. In the SWT Denoising 2-D tool import image from workspace.
3. Perform SWT decomposition using *haar* wavelet from Wavelet menu, select 4 from Level menu and then use Decomposition button.
4. Apply hard Penalize Low threshold method over detail coefficient obtained by *haar* wavelet (Vertical, Horizontal, Diagonal).
5. After thresholding, new details of the coefficients were obtained on the basis of which we reconstructed the image and obtained a denoised image.
6. Save denoised image and filename in specify folder.

3. SPATIAL DOMAIN METHODS

In the spatial domain, spatial domain techniques are based on direct operations on the pixels of the original image. The advantage of using spatial domain techniques to improve the image is that they are easier to implement and apply to images through an algorithm by improving the image in a uniform way. However, in some cases this can be a flaw depending on the type of image being processed. Two approaches are used to improve images in the spatial domain: point processing operations and spatial filtering operations.

Point processing operations are performed on a single image element where the value of that element depends on the value of the original image element. The following techniques can be used in this approach: negative transformation, log transformation, thresholding transformation, power law transformation [5]. To transform the intensity of the image, spatial filtering operations are used, which are applied to the corresponding pixel and its neighbouring pixels. There are two approaches that can be applied: linear filtering and nonlinear filtering. Linear filtering replaces the value of each pixel in the original image by the average of the gray levels on the corresponding pixel and its neighbouring pixels defined by the filter mask. We need to combine several spatial domain techniques in order to achieve an acceptable result in image enhancement.

3.1. THE SECOND DERIVATIVE FOR IMAGE SHARPENING – LAPLACIAN

In this paper, we use 2D second-order derivative – Laplacian for the sharpening of an image, which we first define with a discrete formulation, and then we construct a filter mask based on that formulation. For a function (image) of two variables *f (k,j)* is defined as:

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \ . \tag{2}$$

To express this equation in discrete form, we use the definition

$$\frac{\partial^2 f}{\partial x^2} = f(x+1) + f(x-1) - 2f(x) \ . \tag{3}$$

In *x*-direction we have

$$\frac{\partial^2 f}{\partial x^2} = f(x+1, y) + f(x-1, y) - 2f(x, y) \ . \tag{4}$$

In *y*-direction we have

$$\frac{\partial^2 f}{\partial y^2} = f(x, y+1) + f(x, y-1) - 2f(x, y) \ . \tag{5}$$

The discrete Laplacian of two variables is

$$\begin{aligned} \nabla^2 f(x, y) = {} & f(x+1, y) + f(x-1, y) \\ & + f(x, y+1) + f(x, y-1) \\ & - 4f(x, y) \ . \end{aligned} \tag{6}$$

The basic way in which we use the Laplacian for image sharpening is:

$$g(x, y) = f(x, y) + [\nabla^2 f(x, y)] \tag{7}$$

where *f(x,y)* and *g(x,y)* are the input and sharpened images respectively.

3.2. AVERAGE FILTER

Average filtering is a method of smoothing the image so that the filter replaces each pixel value of the image with the average pixel value (pixel by pixel) using gray level values and thus reduces the amount of intensity variation between neighbouring pixels. Smoothing the image reduces or eliminates noise.

3.3. SOBEL OPERATOR FOR (NONLINEAR) IMAGE SHARPENING – THE GRADIENT

The Sobel operator is a discrete differentiation operator that calculates the gradient approximation of the image intensity function. In this paper, the Sobel operator is based on the convolution of the original image and two 3x3 filter masks with integer values in the horizontal and vertical directions to calculate the approximation of the derivative - the first filter mask *Gx* for horizontal changes and the second filter mask *Gy* for vertical changes.

$$Gx = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * A, \quad Gy = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} * A \tag{8}$$

The magnitude (length) of the Sobel operator gradient vector *B(x,y)* can be calculated:

$$B(x, y) = \sqrt{G^2 x + G^2 y} \ , \tag{9}$$

where is the value at *(x,y)* of the rate of change in the direction of the gradient vector.

3.4. POWER LOW TRANSFORMATION

Power-law transformations can be calculated as:

$$s = cr^{\gamma} \tag{10}$$

where *c* and *γ* are positive constants.

The exponent in the power-law equation is referred to as gamma. Whether the image will be corrected properly, meaning changing intensity of pixels properly, depends on the gamma parameter. If the properly correction is not applied, the image may be too faded or too dark.

3.5. PROPOSED METHOD

In order to get an acceptable result in image enhancement, we will apply a combination of several spatial domain techniques on abnormal MRI brain image 800x800 pixels [6-10]. The aim of this proposed method is to enhance the image by focusing and highlighting more details of the soft tissue of the brain. We will use Laplace to highlight fine details and Sobel gradient to further emphasize the edges. We can obtain a sharpened image by simply adding the original image and the Laplacian of the original image according to equation (7). As a result, we obtained a noisy sharpened image. In order to reduce noise from sharped image, an alternative approach is to use a mask formed from smoothed version gradient of original image. Sobel gradient is obtained applying equation (9). Components *Gx* and *Gy* are obtained using equation (8). Sobel gradient is chosen over Laplacian gradient because of the gradient of an image with significant edge content has values that are higher in general than in a Laplacian image. A smoothed version gradient of original image is obtained by using average filter 3x3 and Sobel gradient. Next step is obtaining image as the product of Laplacian and smoothed-gradient image for resulting strong edges and reducing visible noise on the image. Adding product image to the original image resulted in sharpening image and obtained image in which can be noticed significant increase in sharpness of detail over the original image [11]. Final step is applying power low transformation over last resulted sharped image by equation (10) where γ=0.3 in order to increase dynamic range intensity of the pixels in image. In the end, PSNR, SNR and MSE is calculated directly in MATLAB using in-build function *psnr* and *immse* and results are obtained showed in Results and Discussion. In-build function psnr automatically calculates SNR measure too. In this paper, we used the built-in functions from the Image Processing Toolbox in MATLAB.

4. FREQUENCY DOMAIN METHODS

In frequency domain, frequency domain techniques are based on operations on the Fourier transform of the original image instead of pixels of the image itself. Image enhancement in frequency domain is a method by which certain operations are performed on transformation coefficients of an image such as Fourier transform, discrete wavelet transform, discrete cosine and sine transform.

4.1. GAUSSIAN HIGH-FREQUENCY EMPHASIS FILTERING FOR IMAGE SHARPENING

Sharpening of the image in the frequency domain is achieved by high-pass filtering because the nature of the edges in image and other sudden changes in the intensity of the image is such that it is closely related to high-frequency components. The transfer function of the Gaussian high pass filter (GHPF) with cut-off frequency is given by:

$$H(u,v) = 1 - e^{-D^2(u,v)/2D_0^2} \tag{11}$$

where D_0 is constant and $D(u,v)$ is given by

$$D(u,v) = \left[(u - \frac{P}{2})^2 + (v + \frac{P}{2})^2\right]^{1/2}. \tag{12}$$

General formulation of high-frequency-emphasis filtering is given by:

$$g(x,y) = I^{-1}\left\{\left[k_1 + k_2 * H_{HP}(u,v)\right]F(u,v)\right\} \tag{13}$$

4.2. HISTOGRAM EQUALIZATION

Histogram equalization is the most commonly used technique for contrast adjusting of an image. The aim is to produce a more uniformly distributed histogram of the image in order to evenly stretch out the gray levels of pixels and obtain a much clearer image.

4.3. PROPOSED METHOD

In this paper, it is used abnormal original MRI brain image 800x800 [6-10] denoised by 2-D SWT using wavelet analyser, following steps in proposed method 2.2, as an input image. A denoised image is first converted into grayscale from RGB. Then using Gaussian high pass filter in combination with high-frequency emphasis

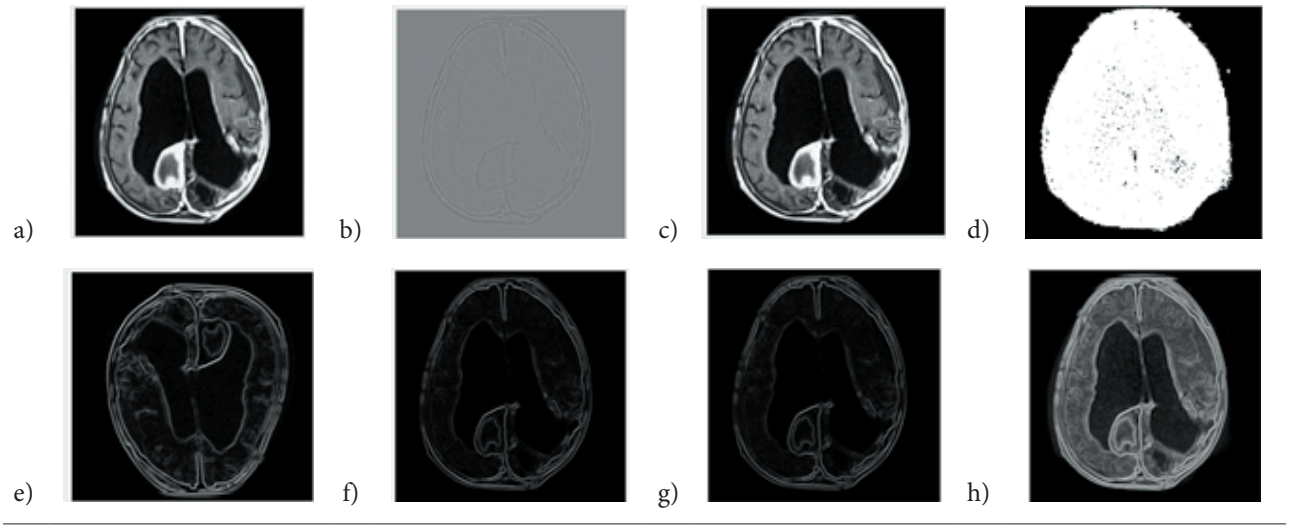

Figure 4 - a) Abnormal original MRI brain image; b) Laplacian with scaling of a); c) Sharped image obtained by adding a) and b); d) Sobel gradient of a); e) Sobel image smoothed by averaging 3x3 filter; f) Mask image formed by the product of c) and e); g) Sharped image obtained by the sum of a) and f);
h) Final result obtained by applying a power-low transformation to g).

filtering implemented by equation (11) and (13) where D_0=3.5, k_1=0.5 and k_2=1.5 high-frequency emphasis filtered image is synthesizes and visualized. MATLAB in-build *fft* function is used for spectral extraction. Final step is histogram equalization applying on an filtered image using MATLAB in-build function histeq. In the end, PSNR, SNR and MSE is calculated directly in MATLAB using in-build function *psnr* and *immse* and results are obtained showed in Results and Discussion. In-build function *psnr* automatically calculates SNR measure too [12].

5. RESULTS AND DISCUSSION

This paper elaborates different methodologies for enhancement a brain tumour MRI providing an insight as to which algorithm should be utilized for more reliable estimate of the original image using PSNR, SNR and MSE evaluation factors [4]. Image data used for this paper are obtained from Radiopaedia, an educational radiology resource. The abnormal original MRI brain images 800x800 pixels [6-10] has been enhanced by various methods.

In proposed method for image enhancement in spatial domain, image has been enhanced by focusing and highlighting more details of the soft tissue of the brain for better features visualization of tumour and the rest of soft tissues of the brain. Combining spatial filtering and intensity transformations of pixels techniques for image enhancement gives us visualized results showed in Figure 4. The effective enhanced images are obtained by using algorithm following proposed spatial enhancement. According to the human vision, the quality of the enhanced images is found to be better than that of the original image because the internal structure of the image becomes clearer meaning image is denoised, deblurred, edges of soft tissues are clearer. For human vision, a disadvantage for MRI brain image enhancement processing using this combination techniques in spatial domain are that dynamic range of pixels intensity is uniform.

There are 5 MRI brain tumour images over which is applied algorithm for combined spatial enhancement method. The higher PSNR indicates the high quality of the MRI brain image results. MSE measure strongly depends on the image intensity scaling. The measurements of the abnormal MRI brain grayscale images using the spatial techniques are described in Table 1. All of the MRI images are processed through the MATLAB code.

MRI images	PSNR	SNR	MSE
I_1[6]	15.7935	6.0805	1712.8970
I_2[7]	15.2719	4.5354	1931.4874
I_3[8]	19.4009	8.6787	746.4243
I_4[9]	14.7724	7.0896	2166.9105
I_5[10]	14.9279	5.6762	2090.6931

Table 1 - Resulted PSNR, SNR, MSE measurements

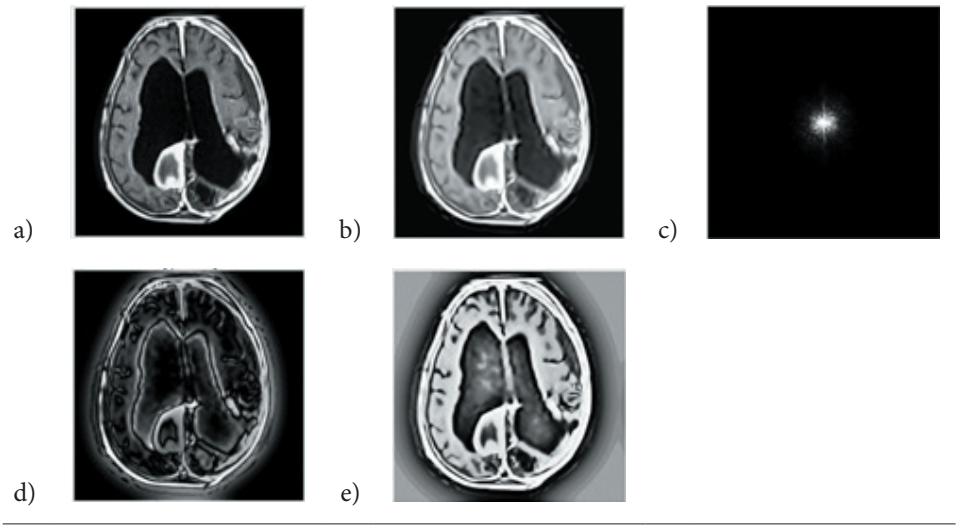

Figure 5 - a) Abnormal original MRI brain image; b) Denoised image through SWT; c) Fourier transform of an image; d) Image obtained by Gaussian high pass filter in combination with high-frequency emphasis filtering applied on image b); e) Resulted image of histogram equalization applied on image d).

In proposed method for image enhancement in frequency domain by combining technique for denoising through SWT using wavelet analyser and filtering technique for sharpening image alongside histogram equalization for contrast adjustment gives also effective results visualized in Figure 5. Denoising image through SWT also has effect of smoothing an image.

The measurements of the abnormal MRI brain gray-scale images using the frequency domain techniques are described in Table 2. All of the MRI images are processed through the MATLAB code.

MRI images	PSNR	SNR	MSE
I_1[6]	11.0792	5.7635	5071.8185
I_2[7]	6.8051	1.1259	13569.7795
I_3[8]	6.0815	1.9607	16030.0327
I_4[9]	5.3789	1.9302	18844.6966
I_5[10]	6.0064	2.0366	16309.5519

Table 2 - Resulted PSNR, SNR, MSE measurements

Based on Table 1 and Table 2, we can conclude that the better results for PSNR, SNR and MSE measurements are obtained by applying algorithm for combining spatial enhancement method on abnormal original MRI brain images than applying algorithm for combining SWT and frequency enhancement method.

6. CONCLUSION

The effective enhanced images are obtained by using algorithm following proposed spatial enhancement. According to the human vision, the quality of the enhanced images is found to be better than that of the original image because the internal structure of the image becomes clearer meaning image is denoised, deblurred, edges of soft tissues are clearer. For human vision, a disadvantage for MRI brain image enhancement processing using this combination techniques in spatial domain are that dynamic range of pixels intensity is uniform. The effective enhanced images are also obtained by using algorithm following proposed method for frequency enhancement techniques in MATLAB and Wavelet Analyzer application within MATLAB. Dynamic range of pixels intensity is extended applying histogram equalization. Based on results obtained for PSNR, SNR, MSE measurements, we can conclude that better results for image enhancement of abnormal MRI brain images provides us combining spatial enhancement techniques.

There is room for further research in the direction of combining some other techniques for image sharpening, image smoothing etc. to enhance MRI images in the frequency domain in order to get better results.

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IMAGE PROCESSING COMING FROM AGRICULTURAL DRONES – IT SOLUTIONS, LEGAL OBSTACLES

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Abstract:

The problem we tried to solve is related to directing agricultural production towards the active use of information and communication technologies. Specific research is based on the use of small drones in order to record agricultural plantations. Observed from the point of view of the application of information and communication technologies in agriculture, drones can serve as a good tool for collecting information on the condition of agricultural areas or the condition of crops in them, all without leaving the traditional tour of the observed areas. This solution brings benefits in reducing costs and benefits in terms of reducing the time required to tour large agricultural areas. When surveying agricultural land, both public buildings and buildings of national importance are often photographed, which can lead to legal problems. The aim of this paper is to focus on two areas of research. The first area refers to methods of processing images and video material obtained from drones, while the second area refers to legal regulations that must be followed and legal regulations that may be a limiting factor in the use of such devices.

Keywords:

Agricultural Drones, Image Processing, Video Processing, Legal acts.

INTRODUCTION

The application of information and communication technologies in agriculture has become increasingly important in recent years and has led to something known as controlled production or precision agriculture. Different definitions for precision agriculture can very often be found in the literature. The basic principles of precision agriculture are reflected in the creation of a set of data that will be used in the later processing process to create examples for predictive models. The application of information and communication technologies in precision agriculture aims to facilitate and make the process of agricultural production more precise [1]. This domain includes systems for collecting data from the field, creation of soil maps, decision making based on data collected from different sources, and at the end the automation of as much as possible agricultural production processes [1].

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Many companies around the world use drones extensively to survey agricultural land in order to gather information on crop status. Footage obtained by flying over agricultural areas can at least be used to obtain general information on the condition of agricultural land or the condition of crops sown or planted in a given area. Such information can be obtained by simply viewing videos by experts in agricultural production. Far more precise information on the condition of crops can be obtained by software processing of videos and digital photos obtained from drones. The process of processing video material and digital photos includes pre-processing and post-processing of the materials obtained in this way.

The ultimate goal is to create a set of data that will be sufficient to train machine learning algorithms in order to create a system capable of prediction and independent decision making. Basing agricultural production on such systems is becoming more common in countries around the world. The first steps in the application of such systems were within the institutes and research systems, while they are further developed towards agricultural producers. The basic application of drones in agricultural production is reflected in the collection of the necessary information from the field.

Depending on the type of drone in use and its equipment, the area it can capture in one flight will differ, and the quality of video material and digital photos. Depending on all the above, the further processing of the obtained materials will depend.

Due to the fact that the survey of production areas is most often performed according to a predefined pattern, it is not uncommon for drones to record more than the area in which the sown agricultural crops are located. In addition, in a significant number of cases, agricultural land is bordered by public or private land and facilities. It is for these reasons only filming or photographing can be considered a violation of privacy. In this regard, filming may be prohibited or even in the event that agricultural areas border the facilities where filming is punishable, persons that operate drones may be punished. In order for the entire process of using drones for the purpose of data collection to be legally legal, a set of legal norms has been defined, which regulates the use of such aircraft.

The goal of this paper is to present the two main tasks of conducted research. The first task is reflected in the possibility of processing the digital materials obtained from drones, all in order to process them and use the information obtained in order to improve agricultural production. The second task was to revise the legal norms that regulate the use of drones in general. In addition, the research also included legal norms related to offenses committed by surveying areas for which a ban on filming is prescribed.

The work is organized as follows. The second chapter provides an overview of relevant literature in the field of drone applications in agriculture, processing of digital video and photographic material, and literature related to legal regulations and legal practice of drone use. The third part of the paper presents the possibilities of using different dehazing algorithms, tools and image processing systems in order to process images obtained from unmanned aerial vehicles. The fourth part of the paper defines the legal norms that regulate the use of drones both in the world and in the Republic of Serbia and neighbouring countries.

2. LITERATURE REVIEW

In one of the researches, the authors set the application of drones and sensor technologies in agriculture as key goals. Namely, they gave an overview of the development of drones that can be used in agriculture. Emphasis is placed on drones that can provide adequate and reliable data that can be used in various applications intended for agriculture. They especially pointed out the advantages and disadvantages of using the observed drones, as well as sensor technologies. As a proposal for overcoming the problem, they mentioned various methods for data pre-processing. [2].

A similar study on a hybrid approach that combines sensor technology and drones is described in [3]. In this research, the authors relied on the definition of potential problems when using remote access sensor technologies and drones. Research has shown that over the years, the performance and capabilities offered by drones in agriculture have increased, while on the other hand, the price of these devices has fallen. The authors also concluded that drones are especially useful when it is necessary to obtain data from bad terrain. The application of sensor technologies in combination with the processing of the image obtained from drones offers a completely new dimension in precision agriculture. The authors cite the legal norms that define the management of unmanned aerial vehicles as a limiting factor for the general use of drones in agriculture.

The key goal of one of the observed studies is to compare different types of agricultural drones. The authors first listed different drones, their characteristics and possibilities of application for the needs of agricultural production monitoring. The advantages and disadvantages of each of these drones are given on the basis of technical specifications. The basic conclusion of the author is that the use of drones in agricultural production should enable easier agricultural production as well as better crop quality [4].

In one of the researches, the authors dealt with the use of drones in the process of collecting data needed in agricultural production. The authors first point out the path of development of drones from the military industry and the use the need for espionage and warfare to today's comprehensive use. In addition, to use in areas such as industry, health care system, use by local governments as well as in the process of transport control, the authors emphasize the special advantages of use in agricultural production. Areas of application of drones in agricultural production highlighted by the authors include soil analysis, monitoring the condition of crops in agricultural fields, monitoring the sowing process, chemical protection, irrigation, drainage, etc. The authors point out that the use of drones in agricultural production is possible from the moment of sowing until the harvest of crops from plantations. Data sets from drones can be very memory-intensive and complex, so special algorithms are used to present them to farmers in an understandable way [5]. As one of the ways of storing high-resolution images obtained from drones as well as data collected by sensors, the authors cite cloud storage, while for the processing process, they cite the use of specialized or other mechanisms by agricultural experts or farmers. These specialized software offer possibilities such as creating terrain maps, as well as displaying places where a specific agro-technical measure needs to be performed. As a special possibility, the authors state that once created, maps can be further inserted into agricultural equipment and machinery in order to, for example, apply a pestle on the part of the surface where it is needed. Connecting drones to satellites using GPS has a special role in this process. As some of the most common areas of application of drones in agriculture, the authors point out field crops such as wheat, legumes, sugar beet, etc. The main advantages of the use of drones in agriculture are reflected in the lack of monitoring and speed of response in the field of application of appropriate measures.

In one of the published researches, the authors presented a proposed approach that would determine the location of soil samples on the basis of high-resolution images obtained from drones. Determining the location is based on creating land maps. Also interesting is the fact that land maps are created based on images obtained from drones. Practically, the drone was used to record agricultural areas immediately after ploughing, which ensured that maps were created based on differences in the structure of the land. The entire research was practically realized in southern Finland. The results of the research show the successful application of drones in the process of creating soil structure maps [6].

Crop recording using drones can provide adequate data that can be used in the process of analyzing the existence of plant diseases and pests on sown crops. One of the researches is based on the use of drones in the process of determining the moment of occurrence of sugar beet disease. The research was practically realized in the fields of Tokat province. The observed disease was sugar beet leaf spot. The authors used different image processing algorithms in the research process. Practically, algorithms have been used to determine if there are changes to the list by comparing images of healthy leaves and images obtained from the field that could potentially be infected. In addition to the application of algorithms, and especially in the training process, the same confirmations were obtained from agricultural experts who performed traditional comparisons. The study included twelve images of different stages in the development of the disease. The mentioned images were obtained by painting the production surfaces at different moments. Also, the effect of natural light was different with almost every shot. Subsequent image processing was performed using MATLAB software. Research has shown that the use of images obtained from drones and their processing provides much more accurate information than is the case with traditional methods. [7].

Drones can be actively used in agricultural production to determine the presence and number of plant species on an area. In one of the studies, the key goal was to determine the presence of weed species within arable land. As in previous research, the results were obtained by combining high-resolution images obtained from drones and algorithms with which the subject images were further processed. Within this research, data processing was used to obtain data that were later used to train machine learning models. The authors gave an overview of the system for precise monitoring and control of weed species.

The processed systems were based on available sensors. The author's conclusion is that serious efforts are needed when it comes to the application of such systems in everyday agricultural production. Their conclusion is based on the great similarity of the weed community with cultivated plants [8].

The use of drones in the world is one of perhaps the most current topics of today, both starting with military use and for much more humane purposes. It is for these reasons that the area of use of drones must be regulated by law. A lot of research exists on this topic. One of the studies provides a review of the relevant literature describing the legal regulations for the use of drones in sub-Saharan Africa. The authors collected the results by conducting interviews with lawmakers. The aim of this research was to properly set the basic frameworks that need to be used in the process of enacting legislation for the use of drones in agriculture. The challenges facing regulators are very great. The research showed that the legal regulations for the use of drones in agriculture largely rely on the already adopted laws of civil aviation, especially in the use of remote-controlled aircraft. Respondents also pointed out that the creation of legal regulations in this region is inherent in the region or country for which it is made, as well as that it requires respect for ethical and other principles [9].

Another study deals with the analysis of legal regulations and legal practice regarding the use of drones. In the research, the authors tried to define the similarities and differences of the legal regulations that regulate the use of drones by applying the method of comparing the legal regulations of the national laws of developed countries. Also, one of the goals of the research is reflected in the proposed solution for the improvement of these legal regulations as well as their harmonization. The legal regulations governing the use of drones differ depending on whether they were created gradually with the advent of drones and the beginnings of their use or were created in a hurry to keep pace with other countries. The authors placed special emphasis on the differences in legal norms for the use of drones in the countries of the European Union. The authors also defined a proposed framework that could be used when creating legislation to regulate the use of drones. The proposed solution defines the diversity of regulations depending on the user, which further results in the advantages and limitations of use [10].

3. DIFFERENT APPROACHES FOR PROCESSING DRONE IMAGES

Image processing in order to collect data is a challenge in relation to the correction of images in order to adjust them. Particularly challenging are images obtained from a great distance and the images from which it is necessary to obtain as precise details as possible. Images obtained by recording the production of agricultural areas with the help of unmanned aerial vehicles require a special degree of processing. Due to weather conditions and atmospheric conditions, it is very often necessary to pre-process images obtained from drones before processing them in order to obtain the necessary information. Some of the methods for removing noise or fog in the figure are described later in this chapter.

3.1. DEHAZING METHODS FOR AGRICULTURE DRONE IMAGES PROCESSING

It is generally known that when photographing the external environment, images of poor quality are very often obtained due to external influences. Images with poor visibility or images that have been discolored or contrasted must be processed to correct the defects. The most common shortcomings that occur under the influence of haze. Dehasing methods have been successfully applied to eliminate the presence of haze. These methods are used in image processing techniques as well as computer vision. The expected results of the applied methods are reflected in the fact that a higher quality image is obtained at the output of the system. This image can be subjected to further processing. The haze model is very often used in order to create an image in the external environment. More precisely, this model can be used if the atmospheric conditions are very bad when creating the image, which includes fog, gloomy weather, light reflections, etc. As particles coming from the atmosphere affect the quality of the image, it is necessary to use methods to eliminate the shortcomings that they carry. Although sizes between 1-10μm, these particles can greatly affect image quality. As the haze model is a linear model, the application of this model changes the position of the pixels [11]. It is known, for example, that fog occurs as a combination of external light and direct attenuation, and thus reduced visibility occurs precisely because of these two phenomena. Depending on the method of application and depending on whether it is applied to one or more images, different dehasing methods may differ. The classification of these methods is shown in Figure 1.

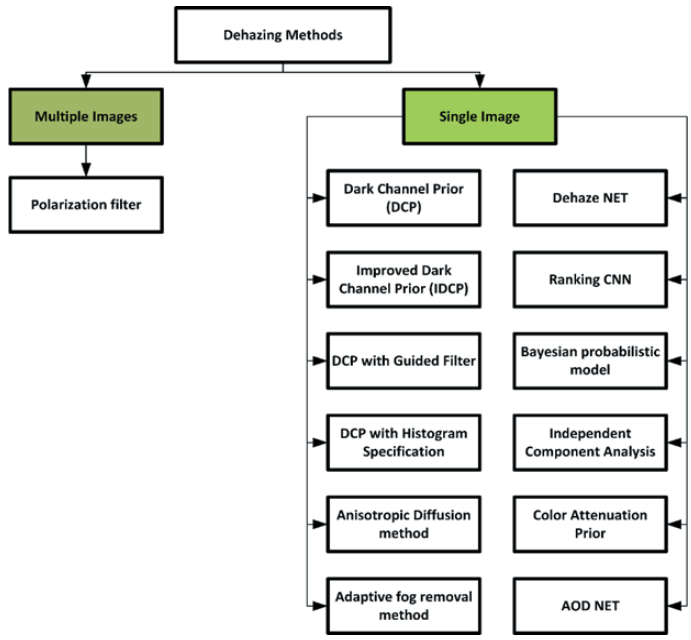

Figure 1 – Classification of dehazing methods

Polarization filter is one of the methods that take multiple input images of the same scene that has been taken during different bad weather conditions. The amount of light scattered due to atmospheric particles in the same direction of direct light arriving in the camera is termed as airlight. In general, the airlight will not be completely polarized. Thus, the polarizing filter, on its own, cannot remove the airlight. The polarization filter alone cannot remove the fog from images. In this method, input image is combination of two unknown components. The first one is the scene radiance in the absence of the fog and the other one is airlight. This method doesn't need the weather conditions to change and it can be applied at any time. The polarization filtering and the orientation of the polarization filter improved the contrast of the single input image. In order to resolve this issue of haziness, polarization filtering is used to determine the haze content of an image and then this haze contents are eliminated from the image to get a clear image.

As can be seen from Figure 1, the single image dehazing method has significantly more than is the case with multiple image dehazing methods. It should be emphasized that the list of methods shown in Figure 1 is not exhaustive. Depending on the quality of the input image and the specific application, each method has some advantages and disadvantages. The following are some of the methods that give the best performance when working with images of agricultural land obtained from drones.

The Dark Channel Prior (DCP) method is based on so-called black pixels. These pixels are characterized by the fact that their presence is very large in at least one color channel. The exception to this rule if you look at an image obtained from the outside environment is the region in the image where the sky is located. The process of image processing using the DCP technique consists of four steps that each of the images must go through. The first step is to estimate the amount of atmospheric light. the second step is transmission map assessment. The third step refers to the refinement of the created transmission map. The last fourth step is the reconstruction of the image, which gives the output. [12].

Starting from the equation of the initial image, the mentioned four steps can be represented as in the following equations:

$$R^{dark} = \min_{c\in(R,G,B)}\left(\min_{y\in\Omega} R^{c}\right) \quad (1)$$

$$\widehat{T} = 1 - \omega \min_{c}\left(\min_{y\in\Omega} I^{c} / L^{c}\right) \quad (2)$$

$$R^{dark} \rightarrow \min_{c\in(R,G,B)}\left(\min_{y\in\Omega} R^{c}(y)\right) \quad (3)$$

$$\widehat{T} = 1 - \omega \min_{c}\left(\min_{y\in\Omega}\left(\frac{I^{c}(y)}{L^{c}}\right)\right) \quad (4)$$

$$R = \frac{I - L}{max(T, t_{0})} \quad (5)$$

R - scene radiance of the image; R^{dark} – dark channel; c- colour channels; T - quantity of light; Ω – patch size; $\widehat{T}$– Transmission map; I – Input image; L^{c} - Channel-wise atmospheric light;

As a prerequisite for applying the DCP method, it is necessary that the image on which this method will be applied does not contain any white and lighter objects. If there are white objects in the picture, the mentioned method can give worse results. The disadvantage in terms of the results obtained by applying the DCP method over such images is that DCP creates artifacts. [13]. It follows that DCP is largely dependent on light in the external environment, and therefore improved prior could give better results. From the point of view of image processing and creating a transmission map, there are two basic parameters that every image must have and which play a key role in this process. One of them is structural and the other is statistical. Artificial intelligence based on neural networks can be used in the process of generating knowledge based on the data obtained from the image. Some of the Convolutional Neural Networks (CNN) have proven successful when it comes to their application in the process of evaluating structural features. On the other hand, when it comes to statistical features within the image, CNN do not show significant results. In order to take into account both features when processing the image using CNN, a method known as ranking layer is very often used. By applying this method, both mentioned features can be used in the process of creating CNN. The principle of application of the Leveling level is reflected in the fact that it takes map features when investing, while maps of a certain size and clarity can be expected at the exposure of this method. In the process of processing input data, this level replaces the order in the input folder. If we compare the calculation of the statistical feature at the level of CNN and Ranking level, we can see that for the calculation using CNN it is necessary to apply more convolutional filters, while with Ranking level it is necessary to apply only one. It is for this reason that the Ranking level has been added to CNN to allow estimates to be made based on each individual pixel. A Random forest generator can be used to increase performance within the rest of the system [13].

4. LEGAL REGULATIONS

Aerial recording of agricultural production areas for data collection that will be used later in the process of assessing crop condition and making decisions on the next agro-technical measures that need to be implemented can often include public and private facilities, and public figures and others. Namely, very often agricultural production areas are bordered by private property, public facilities, acquired facilities, military facilities. During the recording process, and in order to record the entire surface, due to the fact that the recording is very often done on a predefined path, the objects that border the production areas are recorded. Natural persons, public figures, and acquired persons can also be found on the recordings during the filming. Precisely for these reasons, it is necessary to know the legal regulations that regulate the field of shooting and photography. According to Article 144 of the Criminal Code of Serbia, unauthorized photography can be considered if someone makes an unauthorized photographic, film, video or other recording of a person and thus significantly intrudes on his personal life or who hands over or shows such a recording to a third party or otherwise allows him to meet him. The prescribed punishment for such an act may be a fine or imprisonment for a term of one year. It can be seen here that it does not mention or imply photographing public buildings and surfaces, and that it only states and thinks of invading the privacy of a natural person, but not some public performance of that person's business, but only his personal and private life. In addition to this, it can be said that this issue is partly touched upon by the Decree of the Government of the Republic of Serbia on determining security protection of certain persons and facilities ("Official Gazette of RS", No. 72/2010) and it primarily regulates security protection, such as and which services and institutions are responsible for their implementation.

In this regard, it can be said, for example, that a specific service may, in its assessment, under this Regulation, order the application of a measure or action in order to prevent the protection of a protected object, and as far as possible a specific service or in this case (in connection with photography) the competent public utility service for placing signs, puts the sign "prohibited photography" or "recording". Only then does the security officer have the right to warn about this ban and continue to act according to the study, that is. security plan and its powers. The second question of this extremely important topic is what is the envisaged sanction, because we

did not find the threatened sanction for that specific act, and it remains unclear - how to sanction such an "act". This imposes the conclusion that this is not a misdemeanor or a criminal offense, but only a justified basis for the operational processing of the person who is such a recording, i.e. the photograph also provided a sufficient basis for further undertaking certain measures and actions. According to a number of authors, persons who would record and thus record other facilities or persons in addition to production areas could face legal consequences prescribed by Article 143 of the Criminal Code relating to unauthorized wiretapping and recording, and Article 145 of the Criminal Code of the Republic of Serbia. Relating to the unauthorized publication and display of another's file, portrait or recording, due to the fact that the obtained recordings are further processed and may be processed by several persons. Sanctioning of wiretapping and audio recording (143 Kz) is the right of citizens to secrecy, more precisely the protection of that right. Anyone who records or eavesdrops on a conversation without the knowledge or consent of the person whose conversation is being eavesdropped on or recorded commits this offense and may be fined or imprisoned for 3 months to 3 years. Also, paragraph 2 of the same enables the other to get acquainted with a conversation, statement or statement that has been intercepted or audio recorded without authorization. Legal practice shows that it is most practical to process the obtained recordings in order to remove from them the parts in which faces can be seen, or objects due to which the cameraman may bear legal consequences. As the recording of faces and objects is not the primary task, but they can potentially be recorded by mistake, removing parts of the material provides legal protection. On the other hand, if there is a sign that filming is strictly prohibited, for example in the case of military facilities, and if the person in charge of guarding such a facility warns of a recording ban, filming must be stopped. In such cases, a permit for the survey of the productive agricultural area must be sought, with guarantees that the acquired facilities will not be covered by the survey.

5. CONCLUSION

The use of modern information and communication technologies in agriculture improves agricultural production. The main contribution of the use of new technologies in agricultural production is reflected in the monitoring of agricultural areas and crops sown in those areas. The monitoring process begins with the collection of data on the basis of which later in the process of processing them, conclusions will be made about further agro-technical measures that need to be done. One of the ways to collect data is definitely the use of drones. Using these raspberry drones, shots of production areas can be made in order to achieve the required results on the basis of shots in the post-processing phase. Images obtained by shooting outdoors are often blurred due to weather conditions and light reflection, so they must first be processed to obtain images of adequate quality. The proposed methods of image processing have shown good results in application to images obtained by recording agricultural areas from the air. Research has shown that legislation can be a limiting factor in the use of drones in agriculture. This is especially true in the field of surveying areas that border public and acquired facilities. In this regard, the drone operator and the company performing the recording may face legal consequences if objects and people whose recording is prohibited reach the recording. The legislation specifically sanctions the violation of privacy and distribution of recordings to third parties, so in such cases, the processing of recordings must first be aimed at eliminating parts of the recordings where the disputed people or objects appear.

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PROTOTYPE OF AUTONOMOUS WATER MANAGEMENT SYSTEM IN MOUNTAINOUS HOMESTEAD

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Abstract:

Among the basic requirements for a rural household to be suitable for sustainable living is to provide a sufficient amount of water. If the grid is not available, the required quantities of water can be obtained locally on the property. Besides, mountain households often must cope with a water source located below the objects, by pumping the collected water into the reservoir located on the high spot of the system. Traditional manually controlled systems often are not feasible due to required personal engagement, especially if the homestead is not inhabited fulltime, or the water source is not permanent. As currently available water must be preserved for later use, computerized nodes based on the Arduino microcontroller can be of great benefit due to the ability to detect water levels in the reservoirs, communicate and exchange information wirelessly, and autonomously control the water pump without the need for human intervention.

Keywords:

Homestead water system, Homestead automation, Internet of things, Arduino, Automatic watering system.

INTRODUCTION

Until recently, the notion of rural life was closely associated with intensive labour, primitive machines, and poverty [1,2]. However, with the outbreak of the COVID-19 pandemic and the transition of a significant part of the population to working online, an increasing number of middle and upper class people from urban areas are acquiring rural properties for partial or full-time living, the so called trend of exurbanization [3,4]. In most cases, these people are not interested in commercial agriculture, for which they do not have the necessary equipment, know-how, nor can they afford the time for such activities besides their regular jobs. However, they can be interested in limited agricultural production for personal needs, and automation of the activities related to the maintenance of the property, if possible.

Among the basic requirements for a household to be suitable for sustainable living is to provide a sufficient amount of drinking water, as well as technical water that could be used for personal hygiene and watering of animals and plants. If the water supply network is not available, the

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required quantities of water can be provided from natural water springs, watercourses or wells on the property, by collecting rainwater or by fog harvesting. Collected water can be stored in a purpose-built pond or in tanks, from where it gets distributed to the targeted points on the property [5].

2. CONCEPT OF WATER MANAGEMENT IN THE HOMESTEAD

A rural household requires a stable supply of water and electricity, which can be most easily solved by connecting the property to the existing water supply, sewerage and electricity network. However, this is often not an option for various reasons, such as the remote location of the property.

The most energy efficient solution for water distribution is gravity drop, in case of suitable terrain configuration. Otherwise, the use of electric pumps is required, including optional solar panels and batteries for electric power production and storage. Level and quality of water in the reservoirs must be controlled on regular basis, e.g. in case of the algae appearance [6], especially if the water is being stored in IBC totes due to possibility of sunlight leakage. The water system can be divided into smaller, independent subsystems, depending on the layout of the water collection points and reservoirs. Gray water can be filtered and reused for irrigation and in flush toilets, while black water must be stored properly to prevent contamination. The size of reservoirs must be calculated based on the estimated needs of the homestead for daily and seasonal consumption and the regime of seasonal water availability.

Designing a reliable water distribution system for a given terrain configuration and within the required technical parameters requires consideration of various technical solutions. The main components of the water distribution system are one or more pumps, piping and fittings, including valves, reducers and ventilation openings [7]. If the well is equipped with a pump that exceeds its capacity, it can lead to a drop in the capacity of the well [8]. In terms of maintaining of water pressure in the system, the most common solutions are gravity feed or hydrophore.

Mountain households can be observed as a special case scenario where the water spring or well are located below the house and other objects on the property. In this case, the collected water must be pumped into the water reservoir first, located on the high spot of the system, and then distributed by gravity feed to the facilities. The traditional setup usually implies the water pump connected to the power grid and controlled by the manual switch placed in the house, Figure 1. However, manual control of the electric pump, as the simplest solution, often is not feasible due to required personal engagement regardless to the method of implementation, either by the simple mechanical switch, or by remotely controlled electronic switch.

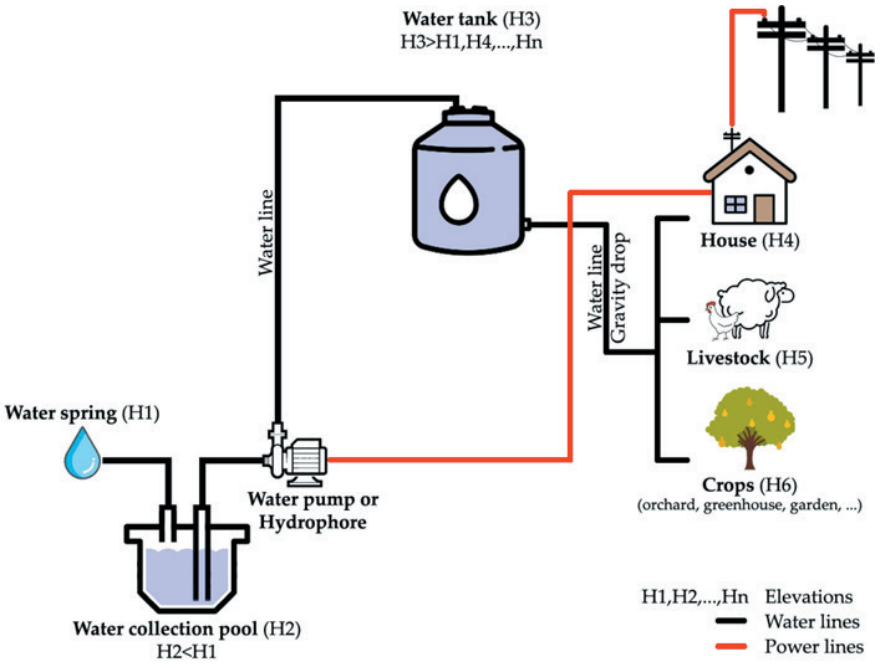

Figure 1 – Manual water management system

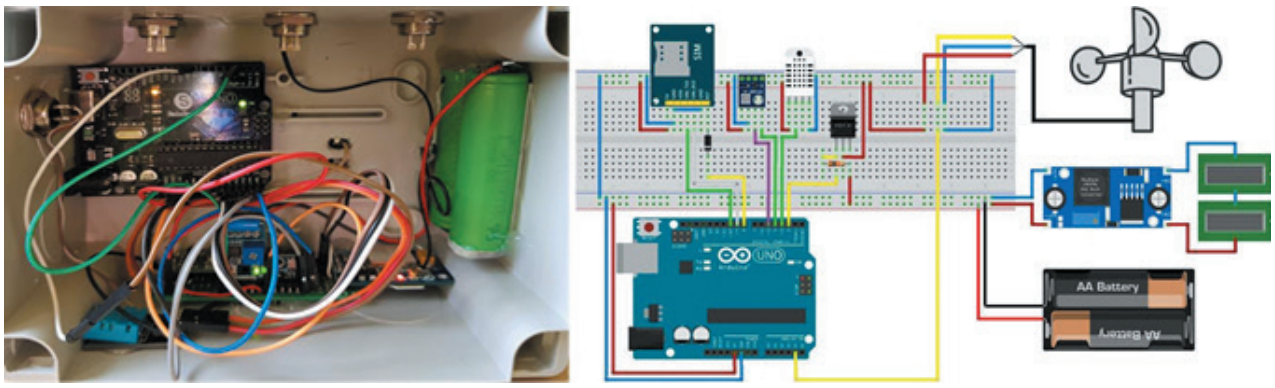

Figure 2 – Arduino AMS, electronic components (left) [9] and breadbord scheme (right) [5]

If the water source on the property is not permanent, or if the available amount of water varies, e.g. in accordance with the season, atmospheric temperature and the amount of local precipitation in the previous period, the currently available water needs to be preserved for later use, which represents a specific problem on properties that are not permanently inhabited.

Providing enough water to the plants requires time and personal commitment. The most popular irrigation systems used to reduce required work hours are the drip system and sprinklers.

The water flow is controlled by manually operated valves, or by a microcontroller via electric valves at preprogrammed time intervals. If the irrigation regime is not in accordance with the current weather conditions, it can lead to insufficient or excessive watering of plants. To prevent this, automated meteorological stations (AMS) based on the Internet of Things (IoT), Figure 2 [9], can be used to monitor current meteorological parameters on the property, and detect potentially extremes that may pose a risk to plants and animals, e.g. highs and lows in temperature, hailstorms, floods. etc.

In general, water distribution can be controlled by a computer, microcontroller, mechanical or digital timer, thus minimizing the man hours required for monitoring and management. The watering process can be carried out in accordance with the weather conditions, soil moisture and current needs of plants. The type and configuration of the system depends upon terrain configuration, soil properties, quantity and quality of the available water, types of plants to be irrigated and the microclimate [10].

Automation of irrigation systems can be classified as follows:

- Irrigation systems that use the basic principles of physics, i.e. gravity drop for water distribution.
- Irrigation systems controlled by electronic timers, which in turn control the water control valves.
- Irrigation systems controlled by computer, the most expensive group, but almost complete automation provides savings in increased yield, number of harvests and reduced need of man power.

3. PROTOTYPE

In case when the water source (water spring, or water well) with elevation H1 on Figure 3 [5], is located below the house (elev. H4) and other facilities (elev. H5-Hn), captated water must be pumped to the tank placed on the highest point of the system (H3=Hmax), and then distributed by the gravity drop. The suggested system prototype has two wireless Arduino automated nodes, Figure 3, capable of mutual communication according to algorithm displayed on Figure 4:

- Node #1, located on the water collection pool, monitors the water inflow from the water spring in liters per second [l/s] and the current water level in the water collection pool.
- Node #2, located in the main water reservoir, monitors the current water level and the water consumption in [l/s], and controls the master valve.

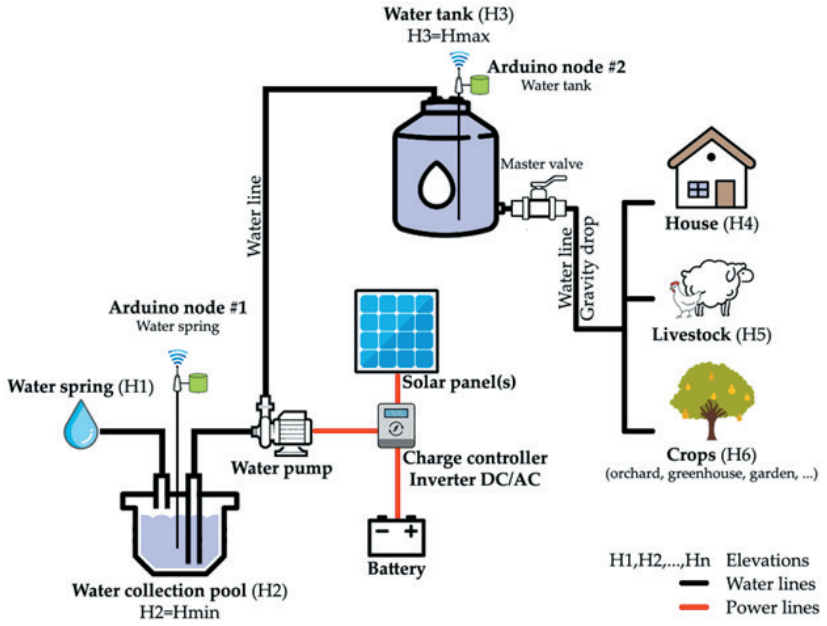

Figure 3 – Autonomous water management system

Both nodes mutually communicate via wireless network in order to pump water to the upper tank, provided that there is water at all, and that the upper tank is not full in order to prevent unnecessary cycles and provide dry run protection on the pump. The goal is to keep the main water reservoir as full as possible, with pump working in optimized cycles in order to reduce the power consumption. Described system working in autonomous mode is especially suitable for periodically inhabited homesteads with water spring that occasionally dries out, because of its capability to store currently available water for future use, without human intervention.

Aggregated data may be logged locally on the nodes, on the microSD card. More efficient approach would be to relay and log data on the local web server, or upload to the cloud for real-time monitoring and analysis.

Data provided by the AMS can be used to control the master water valve by the Arduino Node #2, in order to provide appropriate watering of plants on the property. For precision agriculture, the system can be expanded with additional slave nodes, positioned in various sections of the homestead in order to provide data on soil moisture, soil pH values etc. The same nodes in turn can control various devices based on received instructions,

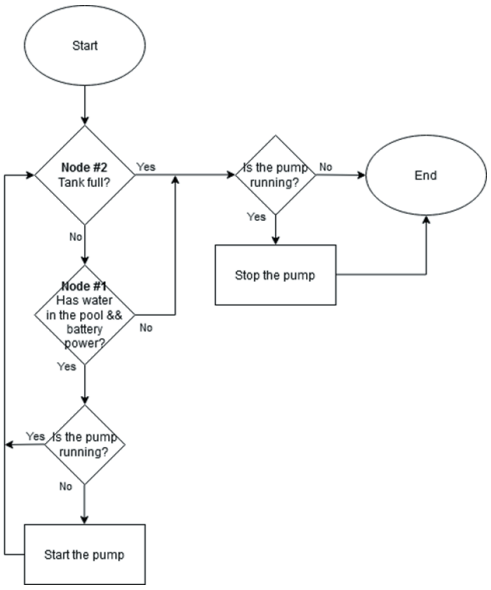

Figure 4 – Simplified communication algorithm between wireless nodes

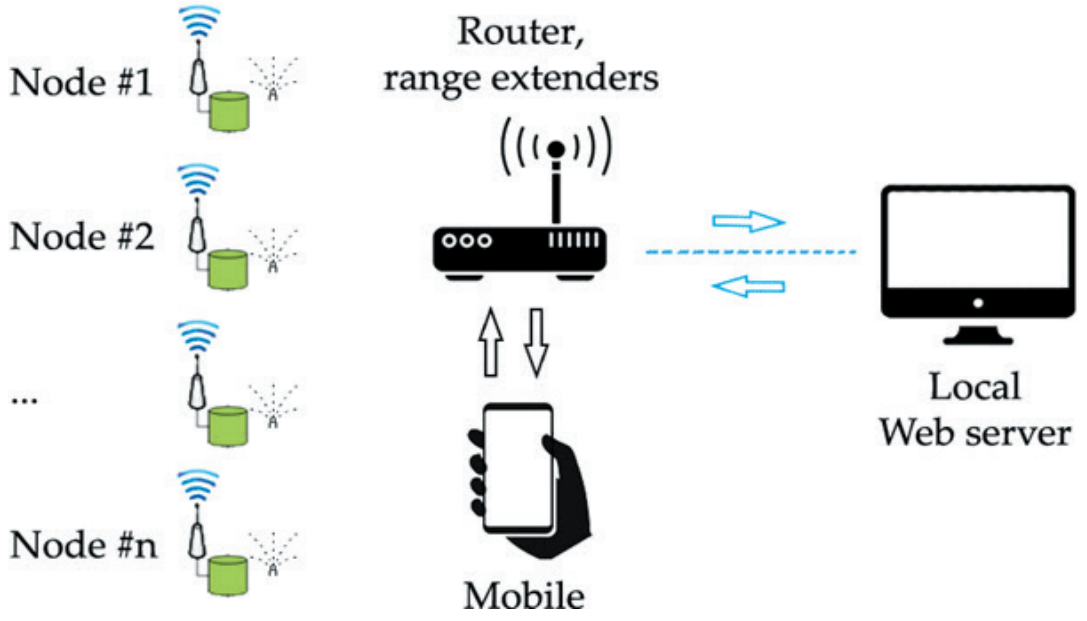

Figure 5 – Simplified communication algorithm between wireless nodes

e.g. secondary water valves. In such scenario, the data would be relayed to the local server, Figure 5, for initial filtration and optional processing by algorithms based on machine learning and artificial intelligence, and then the instructions would be sent back to selected nodes to provoke concrete actions, e.g. activate sprinklers.

4. CONCLUSION

With the outbreak of the COVID-19 pandemic and the shift of a the population to working online, a significant number of people returned to rural properties for at least occasional life in a more peaceful environment. Since they keep their city jobs, usually they are not interested in agriculture besides limited production for their own needs, and thus the need to automate household chores as much as possible in order to have free time for other activities.

One of the most important elements for the functioning of any household is the water supply. As rural households can be located far from the water grid, it is necessary to provide their own water source. In mountainous areas, the water source often may be located under the house and other facilities. This problem can be solved with a reservoir placed at the high spot of the household, from where the water gets distributed to the facilities. Also, due to climate change, it is increasingly common for water sources to dry up at certain intervals, and if the property is inhibited only occasionally, opportunity to provide water reserves for the dry season may be missed.

In such situations, the application of Information Technologies can be useful, which can lead to a better understanding of the current situation in the household, and more efficient decision-making. The described system of application of computerized nodes for monitoring the process of collecting and storing water in the household is self-sufficient and can operate off-grid. Nodes can mutually communicate via a wireless network and exchange information obtained through appropriate sensors, which allows more efficient system operation and reduced power consumption. The described system is especially suitable for households used for part-time living, because of its capability to function autonomously as a whole, or as part of a larger system, without the need for human intervention.

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THE EDUCATION OF DIGITAL GAME TESTERS – PRACTICAL EXPERIENCE

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Abstract:

The paper is aimed at analyzing the importance of digital game testing as one of the key segments for successful game development. As game testers often perform very complex tasks and assignments, this research identified a set of characteristics, competencies, and skills that a professional in this field should possess to be a successful one. To answer the market demand for IT professionals in this specific field, the Faculty of Technical Sciences in Čačak adapted the curriculums of adequate teaching subjects and started continuous assessment of student performance that included additional areas of expertise. The initial survey was performed aimed at identifying some key factors during 2021 and 2022, and these results were presented in the paper.

Keywords:

Game Testing, Education, IT.

INTRODUCTION

Digital game testing represents a process of software testing with the intent to control its quality by detecting and documenting software errors or even conceptual or artwork flaws. In layman's terms, it could sound like an easy process, but actually, it is one of the most demanding and crucial steps in digital game development as it implies extensive competence and skills in programming, game analytics, critical thinking, etc. Game testers must play, observe and identify shortcomings in the game software. The important goal of game testing is also to improve its stability and performance.

Game testing should begin the moment the first code is written and increase in volume and complexity as the game development process progresses towards the end. In the early development stages, a team of game testers is usually very small and focused on daily feedback while analyzing new code. As testing approaches its final stage, more game testers become included in the team and final plans are made.

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Software bugs and even artwork or design flaws must be noticed and reported so that a quality bug report can help developers, designers and programmers successfully fix them. Those unfamiliar with this area of work often think of the game tester profession as fabricated and unnecessary, but various researches and use cases prove the importance and necessity of these team members.

If game testing is neglected, several game production key risks become more probable:

- The game does not create impressive experiences for players;
- Fun factor and/or addictive play are missing;
- The game is not unique, competitive, fast, etc.;
- Gameplay is violated;
- The game fails due to technical problems (broken features, critical errors, poor audio/video, etc.).

The rest of the paper is organized as follows. Section 2 focuses on a brief overview of research related to digital game testing through an educational aspect. In Section 3, the identification and main characteristics of game testing are presented. The last section gives concluding remarks on the topic.

2. RELATED RESEARCH

The literature on digital game tester education is scarce. Digital games are an integral part of the everyday lives of many, and the digital game itself has practically become the source of every modern culture and important economic and social good [1]. It is interesting to observe that with its diverse content and interactive elements, digital games attract children, teenagers, and adults alike. As a combination of visual, acoustic, cognitive, affective, psychomotor, and social stimuli in a simulated space/world, the digital game became a medium through which everyone can test their abilities, interests, and profiles or even present themselves in a completely different way. When analyzing papers published on the topic of digital game testing, one gets the impression that this topic will hardly ever be fully explored as various variable factors continuously change the demand and focus. [2] pointed that digital gaming is an important economic phenomenon, as well as an integral part of media culture in postmodern societies. While hundreds of millions of people spend hours manipulating their digital avatars, digital games have become the subject of a lot of research, showing that this new digital media culture is extremely complex and diverse. As digital games overgrow pure entertainment, they spawned in multiple aspects. Therefore, the serious procedure of digital game testing nowadays requires expertise in multiple fields, not all intuitively connected to the IT industry, which presents a specific problem and complexity of game tester education. [3] observed how the proliferation and influence of digital games increased significantly in recent years and addressed this topic from the perspective of media ethics. They analyzed and evaluated some moral concerns and effects of digital gameplay which game testers should also check when testing digital games. [4] explored the modalities in which digital games can be used in learning English, specifically Never Alone and No Man's Sky. They observed the positive correlation with contemporary educational practice and methods, so in this light, game testers should strengthen their pedagogical competences to recognize and correct possible pedagogical/educational aspects and effects of digital games on the audience. [5] covered referent research in digital game development and design in various genres and disciplines with enough detail and references for professional programmers, so that game tester should use it in their practice. [6] analyzed metaphors that can be used in digital games to encourage various methods in developing new gaming platforms. This approach can be very useful in testing digital games as one can quickly and easily come up with the solution to some identified problem. [7] provided an overview of using creativity in developing digital games and the professional game tester should imply curiosity about the history and future directions of digital games development.

3. EDUCATING GAME TESTERS

As in other occupations, a professional approach to educating game tester is necessary. An inexperienced team leader often assigns a beginner/junior programmer to test the game in a development phase, and this is almost always a sure path to trouble. The game tester must have properly founded knowledge and skills needed to master the work of testing games. They must study a vast amount of reference literature and develop operational and functional skills needed for the job. The surest path to achieve this is through invaluable practical experience in developing games. A game tester can get basic informal education via various game tester courses, which can even provide a certificate of training, but the skills of creative and analytical thinking and an (often required) good knowledge of English are a prerequisite for their future working success. One of the main tasks of a tester is to use the game in as many ways as possible, taking

actions that few users will ever perform. It may seem like a long and monotonous task, but it is a crucial one. The tester is expected to perform all possible actions in the game to identify all possible errors and omissions. An error occurs when a player gets stuck somewhere (e.g., falls into a trap) or when the character animation does not work properly. Many mistakes can appear in the game, but most published games are almost flawless thanks to the game testers. Game testers must continuously work on their development and improvement, and gain as much experience as possible to become reliable team members and earn respect. It should be borne in mind that the ability to look at the system from various angles is necessary so the task of the game tester is to check all possible ways of interacting with the game, even those that the game developer did or could not expect and predict.

So, which characteristics, competencies, and skills should a professional digital game tester possess? First of all, as game testers often work solely or in a very small group, it is self-awareness, organization, flexibility, and responsibility. The tester must fully understand the process of digital game development and design, which includes at least intermediate level skilled programming and artwork design. In order to excel, a game tester should have good problem-solving skills, attention to detail, and patience (while often performing repetitive tasks). While often neglected, a good knowledge of the quality control process provides the tester with a comparative advantage and better team integration.

Having in mind previously stated, the Faculty of Technical Sciences in Čačak integrated a teaching section named "Digital game testing" in curriculums of Digital game development and Digital game design subjects taught in undergraduate and master IT studies.

4. METHODS

The research problem was to examine the current level of competencies and skills of IT students that were identified as important if they found themselves in the role of a digital game tester. To establish the professional competence profile of students as game testers, a series of 13 practical tasks, assignments, and tests in various areas was conducted voluntarily and anonymously by the students. The proficiency levels of technical and digital literacies, (game) project management, creative thinking, and documentation manipulation were assessed via assignments. A series of practical tasks were designed to determine the level of skills in 2D drawing, 3D modeling, computer animation creation, digital video manipulation, and digital design. Two discipline tests were performed. The first one was used to observe and assess the level of student focus while doing repetitive tasks on computers, while the second one observed their precision and persistence in a similar environment. All activities were time-restricted. The research was conducted at the Faculty of Technical Sciences in Čačak.

5. RESULTS AND DISCUSSION

The research was conducted between October 2021 and February 2022, on a sample of 48 students aged 22-26, N = 32 male and N = 16 female, as shown in Table 1. In total, N = 27 (56,3 %) students lived in urban, while N = 21 (43,8 %) lived in rural areas.

Student	Age	N	Percent
Age	22	4	8,3
	23	40	83,3
	24	3	6,3
	26	1	2,1
	Total	**48**	**100**
Gender	Male	32	66,7
	Female	16	33,3
	Total	**48**	**100**

Table 1 – Students' demographic characteristics

When students were asked how often they play games, N = 12 (25 %) answered that they play every day, N = 9 (18,8 %) played 2-3 days a week, N = 3 (6,3 %) played once a week, while the other half of examinees played games rarely, or didn't play games. The t-test revealed a statistically significant difference in gameplay frequency between male and female students (t = 3,50; df = 34,95; p = .001). Male students (M = 3,41; SD = 1,52) played significantly more often weekly than did females (M = 1,94; SD = 1,29). Most of the students played longer than 10 years (N =29; 60,4 %).

Students mostly play games on their laptops (N = 19; 39,6 %), home computers (N = 13; 27,1 %) and smartphones (N = 11; 22,9 %). No statistically significant difference between genders was revealed. When asked about their daily average gameplay time, N = 7 (14,6 %) played more than 4 hours per day on average, N = 12 (25,1 %) played 2-4 hours daily, which makes about 40 % of examinees. The t-test revealed a statistically significant difference in gameplay time between male and female students (t = 3,06; df = 36,16; p = .004). Male students (M = 3,16; SD = 1,63) played significantly more daily than did females (M = 1,81; SD = 1,33).

Students mostly liked playing action, shooting, and platform games (N = 8; 16,7 %), as shown in Table 2. That said, it can be concluded that students were very familiar with digital games and that they often played them.

The highest mean value was achieved in the technical literacy assignment M = 9,07 (SD = 2,41), while the lowest values were recorded in the 1st discipline test that observed examinees focus while doing repetitive tasks M = 3,93 (SD = 3,80), as shown in Table 3.

A series of independent samples t-tests were conducted to examine whether there was a significant gender difference between students concerning their expertise in various areas of interest. The test revealed a statistically significant difference in 2D drawing area between male and female students (t = 2,78; df = 17,42; p < .001). Males (M = 8,47; SD = 1,76) presented significantly higher levels of expertise than did females (M = 5,73; SD = 3,59). The test also revealed a statistically significant difference in 1st discipline test between male and female students (t = 3,33; df = 42,58; p = .002). Males (M = 4,97; SD = 4,04) presented significantly higher levels of focus while doing repetitive tasks than did females (M = 1,87; SD = 2,20). As several factors indicated that male students were performing significantly better than females, it can be presumed that this population of students could be more inclined to excel as game testers. As no other research data was available at the time this paper is written, more extensive research is needed to confirm this presumption.

No statistically significant difference in results between students living in urban and rural environments was observed.

A one-way ANOVA analysis was conducted to explore the impact of current academic success (GPA) on student professional competence profile. Students were divided into four groups according to their GPA (excellent, very good, good, almost good). There was a statistically significant difference at the p < .05 level in Digital video [F (3, 41) = 3,54; p = .023], 1st discipline test [F (3, 41) = 3,75; p = .018], Project management [F (3, 41) = 5,24; p = .004] and Creative thinking [F (3, 39) = 3,96; p = .015] areas.

Genre	N	Percent
Action, shooting, platform	8	16,7
Adventures	3	6,3
Sports, fighting	5	10,4
Driving and flight simulators	1	2,1
Strategy	5	10,4
Logical, puzzle, etc.	6	12,5
Mobile games	5	10,4
RPG	3	6,3
MMO	2	4,2
No favorite genre or didn't play games	10	20,8

Table 2 – Students' favorite game genre

Area of expertise	M	SD
Technical literacy	9,07	2,41
2D drawing	7,56	2,80
3D modeling	8,60	2,47
Computer animation	6,67	1,65
Digital video manipulation	8,33	2,90
1st discipline test	3,93	3,80
Project management	7,93	1,40
Creative thinking	7,88	1,76
Digital literacy	7,95	1,69
Digital design	8,16	1,91
Documentation	7,59	2,17
Game project management	7,95	1,89
2nd discipline test	8,12	2,04

Table 3 – Descriptive results of practical tasks, assignments, and test

Despite reaching statistical significance, the actual difference in mean scores between groups was quite small. Post-hoc comparisons using the Tukey HSD test indicated that:

- the mean score in performing Digital video task for students with excellent GPA (9,01 ÷ 10,00) [M = 10,00; SD = 0,00] was statistically significantly better task than students with almost good GPA (6,01 ÷ 7,00) [M = 5,00; SD = 4,40];
- the mean score in performing 1st discipline test for students with excellent GPA (9,01 ÷ 10,00) [M = 7,14; SD = 3,44] was statistically significantly better task than students with good GPA (7,01 ÷ 8,00) [M = 2,13; SD = 3,22];
- the mean score in performing project management assignment for students with excellent GPA (9,01 ÷ 10,00) [M = 9,00; SD = 1,16] was statistically significantly better task than students with good GPA (7,01 ÷ 8,00) [M = 7,38; SD = 1,15] and almost good GPA (6,01 ÷ 7,00) [M = 6,50; SD = 1,00];
- the mean score in performing creative thinking assignment for students with excellent GPA (9,01 ÷ 10,00) [M = 9,29; SD = 0,756] was statistically significantly better task than students with good GPA (7,01 ÷ 8,00) [M = 6,94; SD = 1,61].

As expected, students with higher grades excelled in the level of competencies and skills needed for proficient digital game testing.

A one-way ANOVA analysis was also conducted to explore the impact of level of English knowledge on student professional competence profile. Students were divided into five groups according to the level (e.g., 1 - Poor; 5 - Excellent). There was a statistically significant difference at the $p < .05$ level in the areas of technical literacy [$F(3, 41) = 3,14$; $p = .035$], computer animation [$F(3, 41) = 2,95$; $p = .044$], digital video manipulation [$F(3, 41) = 3,71$; $p = .019$] and game project management [$F(3, 39) = 3,44$; $p = .026$]. Post-hoc comparisons using the Tukey HSD test indicated that:

- the mean score in computer animation for students with excellent knowledge of English [M = 7,67; SD = 1,86] was significantly better than for students with good level of English [M = 5,55; SD = 1,92];
- the mean score in digital video manipulation for students with very good knowledge of English [M = 9,17; SD = 1,43] was significantly better than for students with sufficient level of English [M = 4,80; SD = 4,55];
- the mean score in game project management for students with very good knowledge of English [M = 8,68; SD = 1,52] was significantly better than for students with sufficient level of English [M = 6,20; SD = 2,17].

Based on previous analysis, it can be concluded that the knowledge of English positively correlated with some key factors for proficient digital game testing.

There was no statistically significant difference in mean scores between other groups.

6. CONCLUSION

Digital game testing is an integral part of every game development cycle, and as this process is repetitive, there may be errors in each new build so testing should be continuous. For some time, game testing was observed as a somewhat less important factor in digital game design, but nowadays it is perceived as one of the key factors for the whole game project to become successful. The gaming industry finances the research in automated game testing (e.g., using AI) for years, and this resulted in a great number of powerful and reliable software systems and agents, but human game testers are still much more versatile and flexible when performing advanced tasks. The key risk of testing digital games by humans is that it does not create a compelling experience for the people that perform it, therefore not everyone who loves playing games can be a good digital game tester, but it can be perceived as a good precondition.

The importance of empowering student competences in the field of game testing was recognized and the first steps in its integration into existing subject curriculums were taken. The results of initial research presented in the paper show that some key factors in identifying adequate students (future IT professionals in this specific field) emerged, but also some problems that future teaching practice can address in order to correct.

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THE PERSPECTIVE OF RADIO BROADCASTING

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Abstract:
Radio broadcasting today has many different types and ways for the end-user. The beginning of digital radio in Serbia was in 2018. Pandemic Covid, slow development DAB+,the rapid development of hybrid radio, further use of FM analogue radio resources and popular streaming radio – they give us one very complicated situation of radio broadcasting. In this paper, we would like to present additional features of any radio. Traffic announcement -TA, traffic and travel information- TTI, virtual voice assistant – we describe what potential solution we expect. Method of realization TA, TTI, comparison of solution. We analyse technologies and the results that drive the radio through the coming years.

Keywords:
DAB+, FM, Hybrid radio, TA, TTI, virtual voice assistant.

INTRODUCTION

Analogue radio together with additional software tool RDS -Radio Data System is to provide the radio listener with useful information, such as traffic reports, program information, the radio re-tune to the nearest transmitter (when the radio goes out of range of a transmitter). The features TA – Traffic Announcement System allows the listener to stay connected only to those radio broadcast information about traffic in the surrounding area[1]. PJ ETV from Belgrade made his system via analogue Radio Belgrade 202. It is dealing with ETV, the Road of Serbia and Traffic Police of Serbia to avoid accidents or at least to avoid even more serious consequences of the road. The radio receiver in the car will be able to have option TA, and this option must be enabled. The idea is to use traditional broadcasting and insert metadata of interest. Today, the radio signal is not enough to satisfy the needs of the user. Many companies invent, develops, and delivers technologies extraordinary experiences, and in this way they improve radio broadcasters hearing. With functionality and features AF- Alternative frequencies, PS – program service name, RT – radio text etc. We will explain in detail how the whole TA features in the project were done and compare it with TTI digital radio solution.

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Radio Data System enabled more attractive analogue radio programs. Digital Radio has a lot of TTI features: Traffic events and news, traffic weather, driver assistance, local hazard warnings, traffic flow and prediction, parking information etc. At this moment Serbia has not implemented yet TTI, but it is a matter of time. Belgrade and the other town in Serbia have very had traffic, make us very nervous and take us very much time. TTI help us to save time and we know exactly which streets with little traffic, which nearest garage is available and has free spaces, where we can find a map of scheduled roadworks, road closures and diversion. The broadcasting system based TTI service architecture seems relatively effective to this kind of one-to-many data delivery job [2]. In this paper, we analyzed which model of TTI requirement is the best choice for us and what we can gain by improving our existing system. We will review the existing TTI system and analysts which one is best for us. The second section described RDS technology analogue radio broadcasting with features TA. Prospective service architecture and the current application are explained in section three. Hybrid radio we analyzed in chapter four. In section five we compare digital and analogue broadcasting features traffic information. Finally, section five give a conclusion, and what is the perspective of further development.

Figure 1 – PI structure

2. FEATURES OF ANALOG RADIO

Traditional analogue FM Radio offers us continued enjoyment of sound. RDS services of Analog radio give us metadata. RDS data is broadcast along with the main signal from the transmitters, and inside every RDS equipped head unit, is a small chip that decodes that information and that is then shown on the display in the car. A lot of kinds of metadata in the RDS service. We will mention some of them and the way in which TA has been implemented in Serbia. The alternative frequencies -AF is a feature that automatically retunes the receiver to another frequency in the network which is broadcasting a stronger signal where there are problems with the reception of the currently tuned station. In the other case, better reception is possible on a different frequency.

This option allows us the highest quality broadcast signal in coverage areas where possible. Programme identification -PI is the most important RDS parameter and represent the unique character hexadecimal code that identifies the station. Figure 1 is showing the structure of PI [3].

Bits 12 to 15 represent country code, Program in terms of area coverage 8 to 11 and finally, 0 to7 bits is program reference number. PS – Programme Service identifies the name of the tuned service. The PS name is an eight-character alphanumeric transmitted by the broadcaster, and the complete PS name requires a minimum of four groups, which at the recommended rate takes just one second to be transmitted [4]. The default function CT – clock time and date, should also be mentioned. PTY – Programme type has 31 coded different type RDS program (4- Sport, 8-Science...). REG- Regional is a very interesting option – lock-dawn the set to their current region or let the radio tune into another region-specific programming as they move into the other region. RT -radio text function allows a radio station to broadcast text messages. Figure 2 represent the structure of the radio text segment -type 2A group [4].

Rt+, radio text plus broadcast additionally some other data: Artist, Title etc. EON – Enhanced other network-connected different radio stations using flags like the TA flag. TMC – traffic message channel, the radio station broadcast digitally-encoded traffic information and for a client need an appropriate decoder. FM Translator Announcements has introduced one type of metadata – identification code for US FM translator. TA IN Serbia was realised with several economic entities. 2019 because of fog on the road, there was a big accident on the highway. Other participants in the traffic did not know that and there was even more confusion and danger for the drivers arriving on the part of the road. That all traffic participants have timely information about unforeseen traffic circumstances and avoid those sections of the highway, public enterprises met Serbian roads, Traffic police, ETV, RTS and REM- Media Sevice Providers Register. The concept of TA implementation was made through a series of meetings of the mentioned stakeholders. The functioning of the whole new system and project is achieved according to Figure 3. The most important creation of traffic information is between the traffic police and the roads of Serbia. The situation on the road is permanently monitored and when the weather conditions change, the information is sent to special part Radio Belgrade in charge of receiving traffic information.

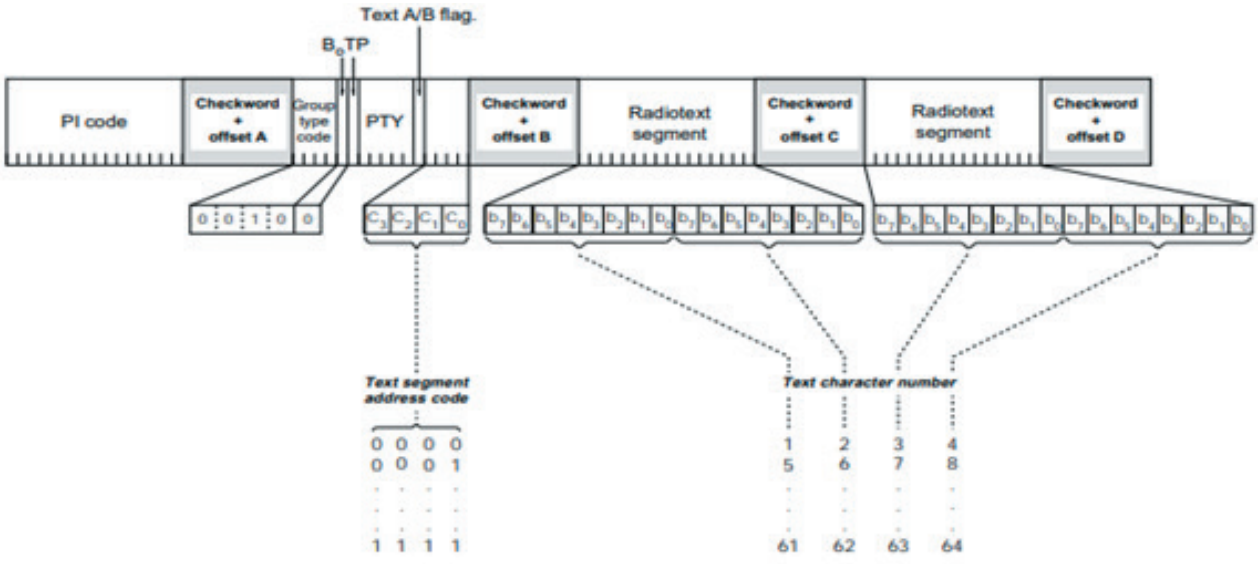

Figure 2 – Radio text format 2A group

Also, Roads of Serbia get information from a possible accident on roads from Traffic Policies, that are provided also Radio Belgrade. Media Service Providers Register regulates the legal framework in which only Radio Belgrade 202 has the exclusive right to activate the TA option. No other radio station may have a TA option for the entire system to function.

REM also reacts if someone does not respect the agreement and sanctions any non-compliance with the rules. The regulatory body has enabled the legal system to function the entire system. Radio Belgrade has a special role in the whole project.

The telecommunication line with roads of Serbia and Police is always on stand by. The special department of Radio Belgrade 202 is in charge of receiving and forwarding information on traffic, accidents and weather conditions on dangerous sections of roads. The speaker in the radio centre must be ready at all times and turn on the option TA if necessary. When important information about the situation on the road section is received, ie when a speaker from the relevant institutions, the radio broadcasting is interrupted and an official statement is sent on a certain section of the road.

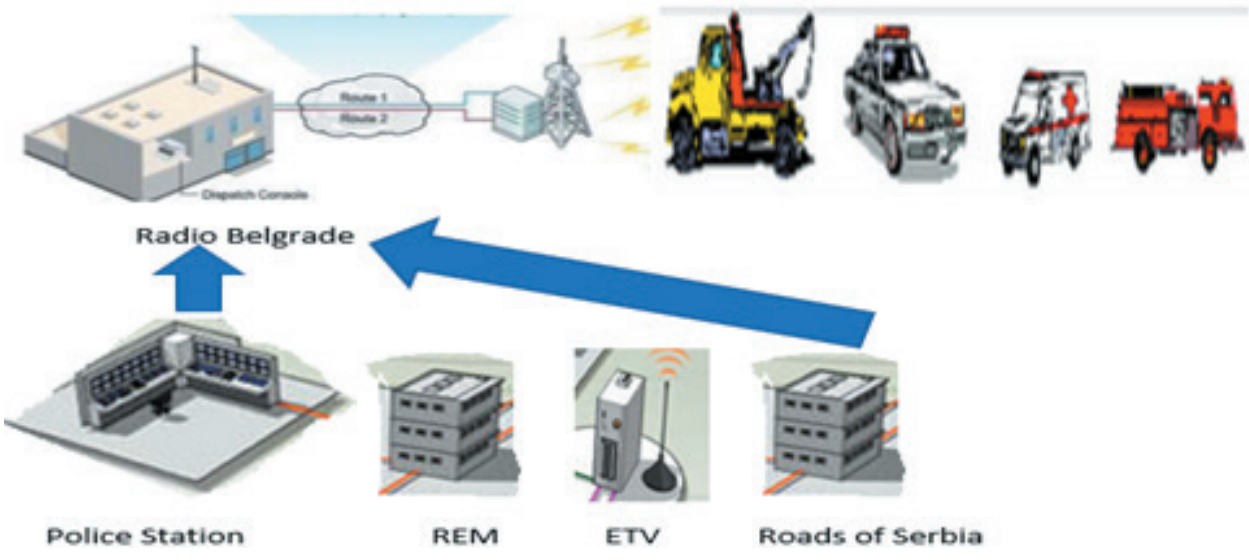

Figure 3 – Concept of TA

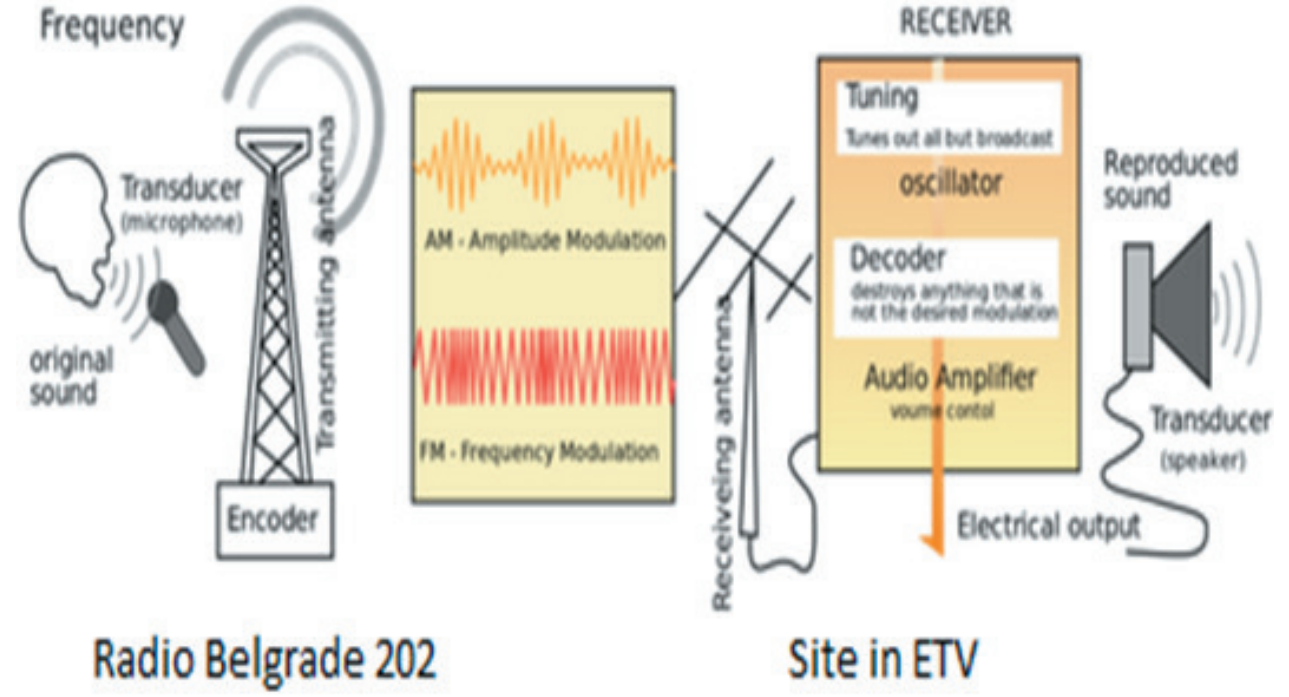

Figure 4 – The principle of forwarding TA metadata

On the way, all cars that have been activated TA option, any radio program to listen – will be interrupted. Receivers automatically switched to the frequency of Radio Belgrade 202. All drivers will hear important traffic information and will be warned in time to be careful of road conditions in that section. If there is a car accident then it should be avoided.

Metadata are inserted via an encoder in-studio Radio Belgrade 202. A certain number of etv locations adjacent to the main highways and highways are received by Radio Belgrade 202 together with TA metadata. On the receiving side must have an encoder and a transmitter that will broadcast the content to the listener. All listeners who have this option in the receiver allow the listener's metadata.

In this way, analogue radio provides its maximum in terms of additional data to the radio signal. Analogue radio gives limited possibilities to send additional data that is used to the maximum.

3. METADATA IN DIGITAL RADIO

In this chapter, we will mention only TPEG – traffic protocol expert group and EWF -Emergency Warning Functionality. Transport meanings as in the context of traffic and travel, and also meaning in the context of moving information from a service provider to an end-user. The content has to be collected and edited according to rigorous standards to ensure it is timely and accurate [5]. At any point in time, only some of the end-user would wish to receive particular information. Any end-user would be deluge with too many messages. Tpeg technology has various filter mechanisms to avoid mentioned situation (accident too far for us, traffic jams in a city where we are not...). So we do not need all the information but only the traffic information that helps us in a particular case. TPEG Technology consists of two main segments: the content segment and the delivery segment[6].

Traffic information and their technology have two demands to satisfy: mobility of access and language independence. The first demand is a complex client device containing a location database. The device must be maintained by the service provider and all client devices. The language independence demand satisfies using table code values.

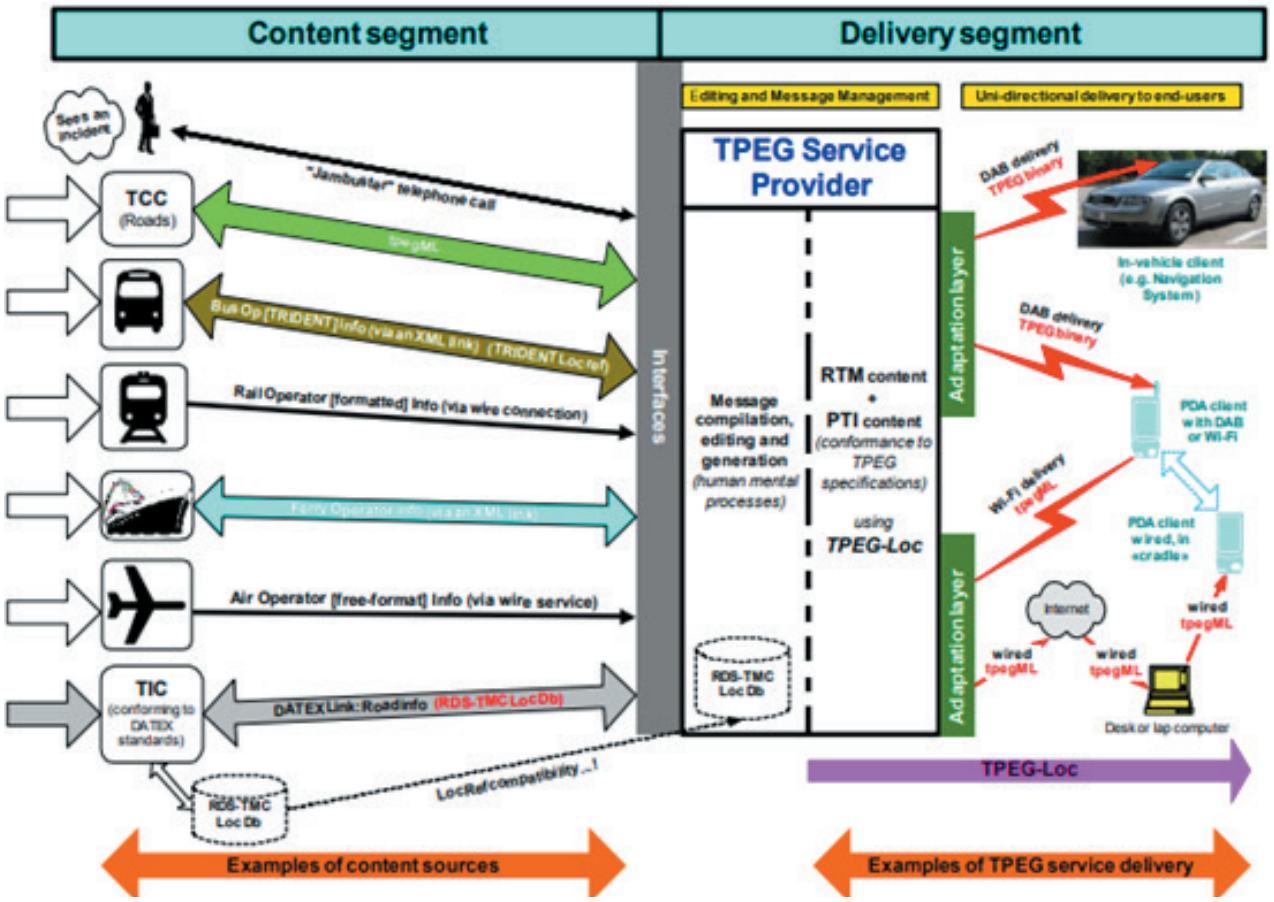

Figure 5 – Content and delivery segment of TPEG

This table contains the generic word for the content. TPEG data consist of three parts: message management, the application Event and Location Referencing. Location information with reference is very important, when is a part of the road closure, bus service cancellation or delay. Service provider or Radio Station can implement very high detailed service lowly detailed and use more or less bandwidth so which require more or less complex client devices. At this moment there is no TPEG implementation in Serbia. Swedish Radio generating some location reference. Intersection point presenting road numbers up to three and the name of the municipality. The segment consists of two intersection points. TPEG table referring can be utilized in any type of location: bridge, fuel station, church, hotel, roundabout, marina, the airport area, etc. Parking information has two messages. First which gives information about the parking facility that is of a general nature, second gives the number of still available spaces. Very usefully can be CTT- Congestion and travel time estimation gives us evidence of congestion and travels time information to allow prediction using computer modelling.

Travel Weather Information – TWI preventing major traffic accidents are caused by rapid changes in local weather conditions, e.g. snowstorms, quickly fog etc. Another feature of digital radio is EIA- Environmental Information Alerts. Environmental details, such as data about localized flooding, local fires can be transmitted.

EWF – Emergency Warning Functionality is another new function, that works through the notification and reporting site figure 6. These include detectors, sensors and high-capacity servers. The main task is a monitoring system device, traffic, applications with sensors and sound alarm, graphic and textual messages in case of large-scale accidents and disasters in the event of an emergency warning. The system can run 24 hours a day, 365 days a year, and can operate very rapidly to change. The information must be consistent and error-free. The Control system handles data from sensors and speakers send signals to the selected group of receivers for whom this information or events are of interest. The most important function of the control system is the administrative separation of information for groups of control listeners who care about disasters information (war,

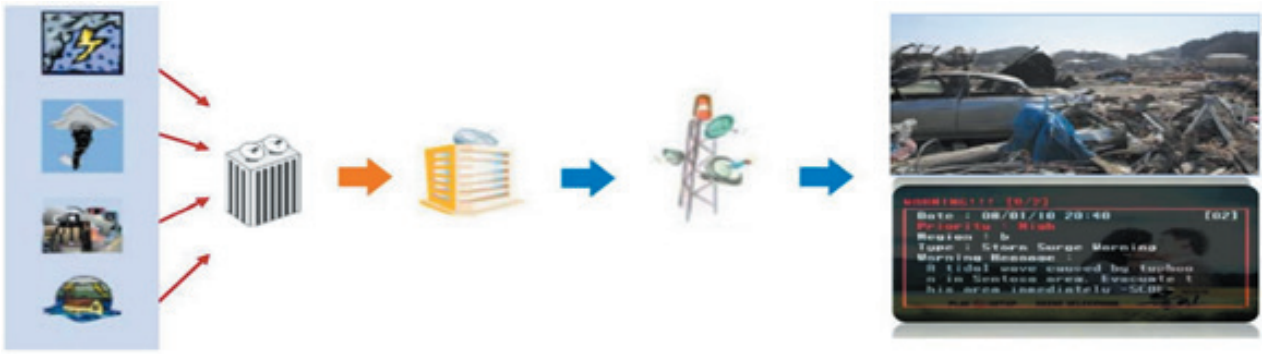

Figure 6 – Emergency Warning Functionality

earthquakes, tornado…) of interest. The world trend is such that the EWF system is constantly being upgraded. Such a system provides a lot of information and prevention in real-time, it still does not work in Serbia. Nowadays, wars, pandemics, great climates changes - floods, fires are unfortunately an integral part of our lives.

4. HYBRID RADIO

Hybrid radio combines broadcasting terrestrial digital and analogue, satellite, online connectivity and streaming content, in this way creating a new kind of platform. Apple Carplay, Android Auto, Alexa integration and Xperi are hybrid radio platforms are capable of integrating FM, DAB+, HD Radio, IP stream and podcast. When hybrid radio sense a week radio signal, it will switch to the online, the channel will switch back from a digital (or analogue) to a radio signal will switch better reception (automatically or by request). The channel will switch back from a digital (or analogue) to a radio signal when it senses better reception. When is noise detected in the FM signal, does the switching technology transition the radio to IP technologies and broadband? RadioDNS (Domain Name System) allows for the seamless transition between the terrestrial radio signals and the mobile broadband connection and will accommodate up to 30 seconds of delay between over-the-air and streaming audio radio reception [7]. Metadata in a terrestrial radio station's signal stream can include song artist and title and streaming URLs, so the hybrid radio receiver knows where to find the streaming audio. But, sometimes the publishing of streaming URLs can create security concerns for radio broadcasters [8] [9]. The solution is that broadcasters need to register with RadioDns and publish the necessary metadata and streaming URL information in a secure and controlled manner to ensure ease of access and consistency for the in-vehicle implementation[9]. Then develop service information (SI), which include all information on finding station logos as well as the broadband stream for the hybrid radio receiver[9]. RadioDNS allows broadcasters to make a button that would request more information about a current radio show, which might be a commercial, might be a song or a talk topic, figure 7. [9].

This implementation enables parallel processing of multiple inputs in real-time, as well as access to the corresponding components via low-and high-level interfaces (C++ and REST-API).

There are two concepts of connectivity in modern vehicles. Radio broadcasters want embedded wireless connectivity in modern vehicles. Second connectivity is through connected smartphones. Vehicles are connected over-their radio reception in addition to internet IP technologies via LTE network connections. Modems in new vehicles support two-way initiatives and it is a very good model and critical for gathering listener data. The car voice assistant is an integral part of hybrid radio that has enabled drivers to have a safe hands-free experience: making phone calls, controlling music, navigation, and used to order takeout, book service, schedule appointments. Voice technology does not provide reliable speech recognition, especially in such noisy environments. Moving vehicles are often in a loud environment. The main task of voice recognition technology is to cut through the background noise effectively.

Differences in accents or slang usage also cause inaccurate speech recognition attention is paid to technology that reduces background noise. It is importantly used to specialized microphones and speaker placement and algorithms which give voice assistants the ability to differentiate between the driver and passengers.

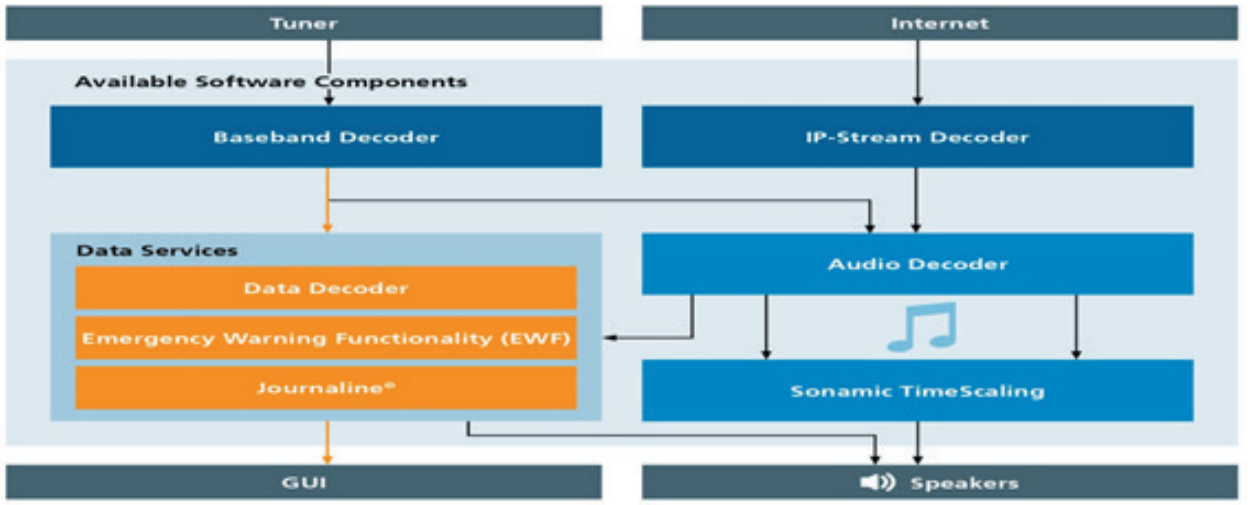

Figure 7 – Hybrid radio solution

The function of hybrid voice assistance is in figure 8. There are many important elements in all system, NLZ -natural language processing – need to answer questions and hold conversation audibly. Also a quality API -Application programming interface is necessary.

You should be avoided the scenario when the voice assistant is not responsive or the response is not accurate. Also, a database from which voice assistant the data retrieved should be able to understand accented language and speech differences [10] [11]. A hybrid model voice assistant has the advantage of being always-on[11]. Meaning that with or without cloud connectivity, or when the internet signal is weak, the driver can still enjoy the hands-free features of a voice assistant[11]. Through context awareness, the voice assistant is able to continue a conversation and remember the information already provided[11]. In this way, users do not need to repeat themselves, and also allow the user to speak naturally and build on the conversation, without having to memorise preset phrases or constantly repeat statements [11]. New features are making voice assistant conversational hinges on a few key elements of the technology: the ability to convert speech to meaning, the availability of a large library of content domains, and the ability to understand the content of the conversation [11]. Yet, many users of voice assistants report concerns around trust, privacy and passive listening. So users still have a little distance from using all the features of voice assistance. New features are the avoidance of such as traffic jams, parking information, traffic weather by simply calling a voice assistant.

Figure 8 – Hybrid voice assistant

5. TRAFFIC INFORMATION OF DIGITAL AND ANALOGUE BROADCASTING

So far we have exhibited various types of metadata through analogue broadcasting, digital and hybrid technology. In this section, we try to describe transmission time when using different techniques. We have already mentioned that digital possibilities of traffic information are not used in Serbia at the moment. We are witnessing a collapse in traffic every day, especially in Belgrade. For this reason, we will prepare an analysis based on the analysis done in other countries to show how much benefit from the introduction of new, technology capabilities that we apply. Bypass around Belgrade – Avala road, repair of roads, closing off part of the highway, traffic jams at the end of working hours, the result is that drivers have no idea, information and solution how to avoid traffic jams. We performed an analysis of what would happen if we had the possibility of traffic information via digital hybrid receiver using digital DAB+ technology. Mention and analyze the important parameters, first of all, the response time and capacity needed to store all relevant information.

Get the right information and they have to be created in real-time. It takes an analysis of the time it takes for traffic information to reach each car. As it would look in Serbia will see in the analysis ahead of DAB+-TTI, FM-TMC, FM–DARC [12]. Time to delivery in FM system is very long up to 2 hours. related information. It is not acceptable for the speed of information that drivers should receive.

Metadata DARC in FM system is located above RDS frequency carrier Figure 9. A system that gives as a solution is a DAB+ system and metadata TTI. Time to delivery up to 3 minutes depending on the bit rate. An important part of TTI implementation is service provider TTI messages. The service provider should have a kind of filtering out functionality for the relatively unnecessary information. Filtering information is important to get application (metadata) parking information and congestion and travel time in real-time.

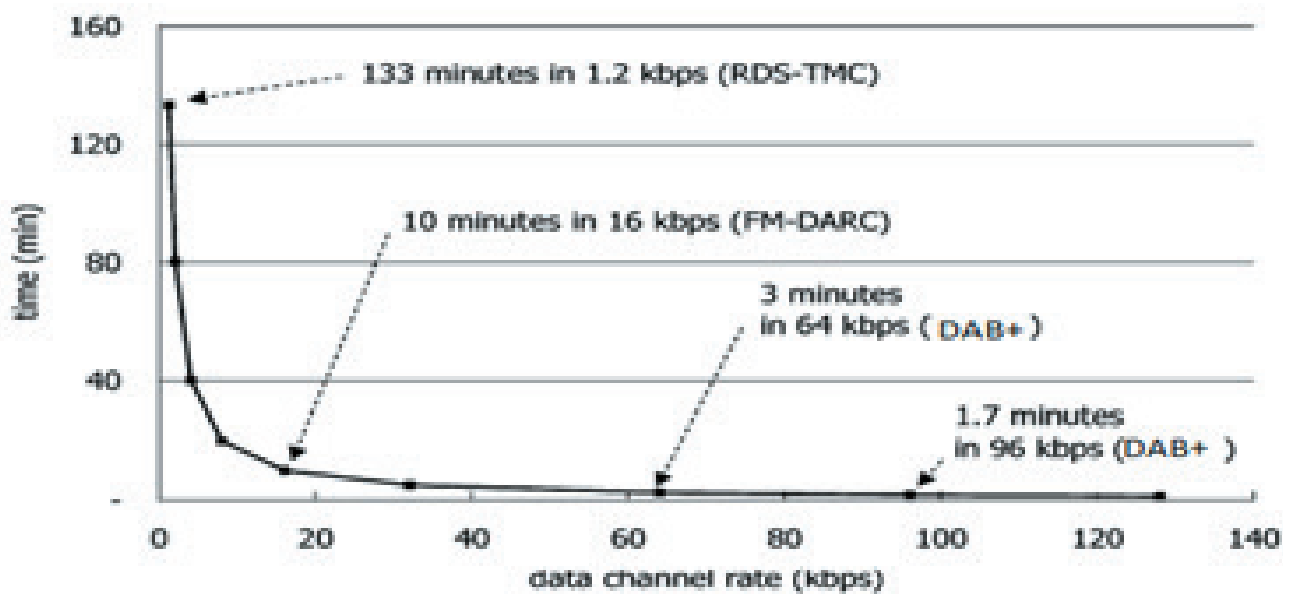

Figure 9 – Comparing transmission system for traffic information

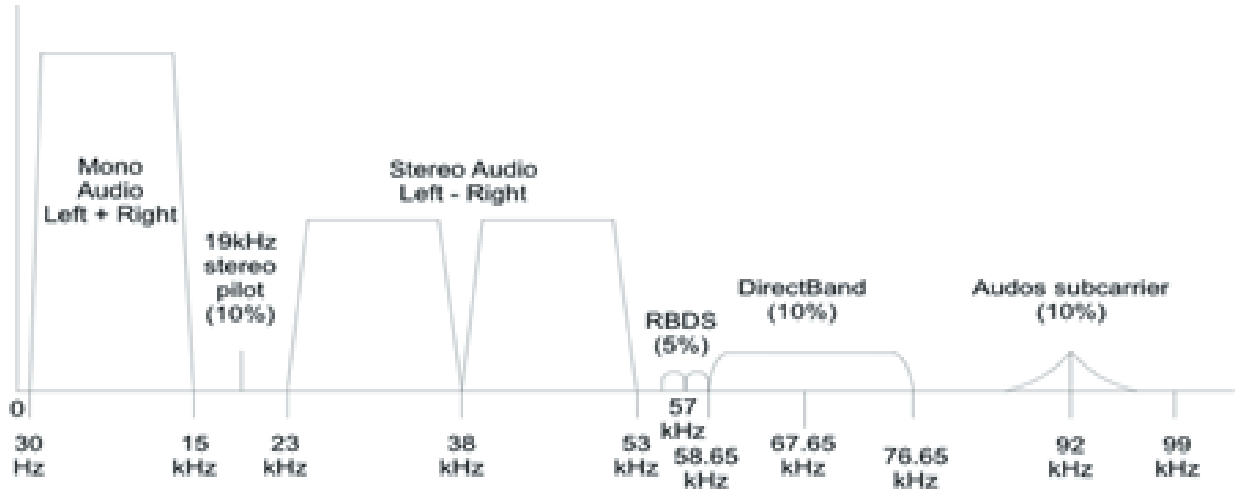

Figure 10 – FM spectrum

6. CONCLUSION

This paper represents implementation metadata in the radio world. We saw the way of implementation metadata about traffic and travel information in analogue, digital and hybrid radio. At this moment hybrid radio is in a trend and uses all sources. In it is a digital radio, analogue radio, internet steaming and all traffic and travel information is availably in every system.

The advantage of an analogue system is that it has an extensive network, listener habits and the simplicity of the metadata system. But the analogue system is slow, has low capacity and has too low a possibility for new features. Digital radio is faster, too high capacity, has great opportunities, low latency. But at present hybrid radio give as best features united with digital radio, analogue radio and IP/wireless technology. Also, a voice assistant who can help avoid traffic jams and find parking spaces to avoid road accidents, unforeseen weather conditions, major disasters. This technology uses traditional technology – FM ST analogue, modern technologies DAB, DAB+, DMB and popular internet streaming. Serbia should build its position through the metadata of traffic information and emergency warning functionality through hybrid radio and voice assistants and applications that support it. By using traditional technologies and adopting new ones, we will make the most of existing resources and get the desired and necessary information.

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INFORMATION SYSTEMS AND SECURITY SESSION

THE APPLICATION OF CONVOLUTIONAL NEURAL NETWORKS FOR FINGERPRINT RECOGNITION: A COMPARATIVE ANALYSIS

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Abstract:

The use of convolutional neural networks (CNNs) in the domain of biometric identification is examined in this paper. On a well-known fingerprint evaluation dataset, the three most widely used networks AlexNet, GoogLeNet, and ResNet were tested in the positive identification scenario. In order to improve interclass discrimination and coherence of input data, image enhancement and region of interest segmentation were used to remove inconsistent regions that are typically present on the image peripheral, generating spurious features that negatively affect the neural network learning rate. The fingerprint database prepared in this technique represents the input data of the identification system entirely based on the capabilities of the CNN, allowing direct comparison of networks performances and selection for further implementation. As a result, trained CNNs can be used as a feature extraction module in biometric cryptosystems or robust authentication systems. However, testing results reveal that the proposed technique outperforms many biometric authentication systems, with 97% accuracy rate.

Keywords:

Biometry, Fingerprint Recognition, Convolutional Neural Networks.

INTRODUCTION

The increasing usage of neural networks for the classification and recognition of objects in images has been influenced by breakthroughs in the development of machine learning in recent years. Convolutional neural networks (CNNs) are a promising field of artificial intelligence development, mainly in the function of categorization of input data, with its output being the determination of a preset class of input data. They were named after convolution, an image processing operator that is commonly used to detect object edges and sharpen or blur images. They are categorized as deep neural networks due to their architecture, and they represent the evolution of artificial neural networks known as Multi-Layer Perceptron (MLP). The neural network consists of layers with learning weighted neurons. Each neuron gets input data multiplied by its weights and uses activation functions to apply nonlinearity.

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Because fingerprint texture is commonly employed in traditional biometric systems for fingerprint categorization, the usage of CNNs has arisen as a novel way that can help improve the process. However, the texture of fingerprints carries enough distinctive information that when decomposed, the essential differentiation for use in authentication can be attained.

2. RELATED WORK

The preliminary findings of using CNNs to compare or extract biometric features show promise. Transfer learning on two convolutional networks, VGG-F and VGG-S achieved 94.4% and 95.05% fingerprint classification accuracy, respectively, to the applied neural network in [1]. With the development of a novel FCTP-Net neural network architecture in [2], fingerprint classification into six classes achieved the accuracy of 94.87%. Using the National Institute of Standards and Technology (NIST) database and classification into four classes, the accuracy of 92.90% was reached. The architecture of a light convolutional network is presented in [3], which uses segregated ROIs containing singular points for classification. Image normalization and enhancement algorithms are used to fingerprint input images, and findings suggest that utilizing fewer neurons while increasing noise resistance can reach 93% accuracy. Res-FingerNet, a deep neural network for fingerprint categorization, was proposed by the authors in [4]. They used the central loss in the network training phase to minimize intraclass variation and raise interclass fingerprint variance, making the learnt features more discriminant, therefore, enhancing classification accuracy by roughly 1.5%. The performance of the approach was evaluated on the NIST-DB4 data set, achieving the classification accuracy of 97.9%. In [5], a comparison was made between the three most common neural networks for fingerprint type classification in systems with four, five, and eight classes on two fingerprint databases. For the NIST fingerprint database, the average accuracy of 95.55%, 92.51%, and 94.88% was achieved using AlexNet, GoogleNet, and ResNet neural networks, respectively, while evaluation on the Hong Kong Polytechnic University (PolyU) fingerprint database resulted in more than 99% precession for all three networks.

The presence of sufficient discriminant information in fingerprint texture for use in biometric identification systems was first verified in [6]. Machine learning and deep neural networks have advanced to the point where it is now interesting to explore if these techniques have improved enough to extract biometric features and therefore replace the appropriate extraction modules in existing biometric cryptosystems. In [7], a biometric verification system based on two CNN modules was presented, which parallelly extracts features from two fingerprints that are compared. The AlexNet neural network [8] was chosen to extract features, and the concatenation of the extracted features forms the input of the last layer, which calculates the score of their matching. This approach does not use pre-processing and image enhancement, yet the entire system relies on the capabilities of CNN. The EER of the reported results is 17.5%. In the field of CNN applications for minutiae extraction, [9] presents the concept of minutiae extraction by categorizing each pixel of an image into one of 36 classes corresponding to minutiae and one class that does not represent a minutia, while preserving data on point location and orientation. In [10] the module for extracting biometric features from the texture of fingerprints was developed by applying transfer learning to the Alexnet neural network, which completely replaced the traditional module based on Gabor filters. The output layer of the neural network is modified to generate fixed length array, which is then converted into binary domains using quantization techniques, enabling the use of Heming's metrics comparison techniques or the formation of a biometric cryptosystem based on a fuzzy commitment scheme with key lengths of 133 and 199 bits and EERs of 1.13% and 1.23%, respectively.

3. COMPARISON OF CONVOLUTIONAL NEURAL NETWORKS

In order to build a CNN and optimize its performance, the neural network must go through a lengthy training process on a significant set of data, which is time-consuming and has a high computational cost. Instead, we can apply transfer learning to networks that have already been created and trained on data sets with thousands of images and hundreds of classification categories. By customizing existing layers and retraining with a much smaller training set, we can set the network for new classification tasks. The main properties of the three CNNs that were experimentally tested and evaluated in this article are summarized in Table 1.

CNN	Input image size	Total number of layers	Year
AlexNet	227 x 227 x 3	25	2012
GoogLeNet	224 x 224 x 3	144	2014
ResNet	224 x 224 x 3	50 / 101 / 152	2015

Table 1 - Properties of the evaluated CNN

CNNs require as many samples as possible in a training set. In case of fingerprints, this cannot be achieved, but it is necessary to enroll one identity with only a few sample images. This negatively affects the accuracy of the neural network and is a challenge for CNN's application in biometrics. By generating multiple instances of one input image, by rotating it in the range of ± 24 ° with a step of 6 °, we achieve a larger training set [10]. This improves the system's accuracy while also making it less sensitive to minor fingerprint rotations during sampling. With fingerprint rotations prepared in this approach, we gain 45 images for each class, which we use to retrain the CNN.

In any traditional biometric system, it is necessary to enhance the input data. In the case of fingerprints, image enhancement is necessary to eliminate background noise that occurs during acquisition and to reduce intensity variability as a result of differences in surface pressure on sensor during sampling. The reference point plays a key role in the segmentation of the region of interest and its precise determination greatly affects the accuracy of the system. The central point of the core print, i.e., the pixel in which one papillary line forms the maximum concavity compared to the others, was chosen as the reference point. The region of interest is selected in accordance with the input parameters of the applied neural network. For the AlexNet neural network, the size of the input image is 227 x 227 px, while GoogleNet and ResNet require a size of 224 x 224 px. The image is cropped to the desired dimensions, with the reference point in the ROI's center. In this approach, the region of the fingerprint that has been proven to have the required discrimination and coherence is retrieved from the image, and inconsistencies in the image that could negatively affect the neural network's learning are discarded.

The original AlexNet neural network [8] has five convolutional layers and three fully connected layers. This network comprises 650 thousand neurons and 60 million parameters. The last fully connected layer is adapted to generate 1024 features that can be used to form a biometric template, i.e., a digital representation of the input fingerprint image. An additional fully connected layer was added to classify 100 fingerprints based on the number of different identities found in the fingerprint databases used. The results presented in the paper were achieved by training the network with an initial learning rate of 0.001 in a series of 96. Figure 1 shows the network performance after the training process in 400 epochs.

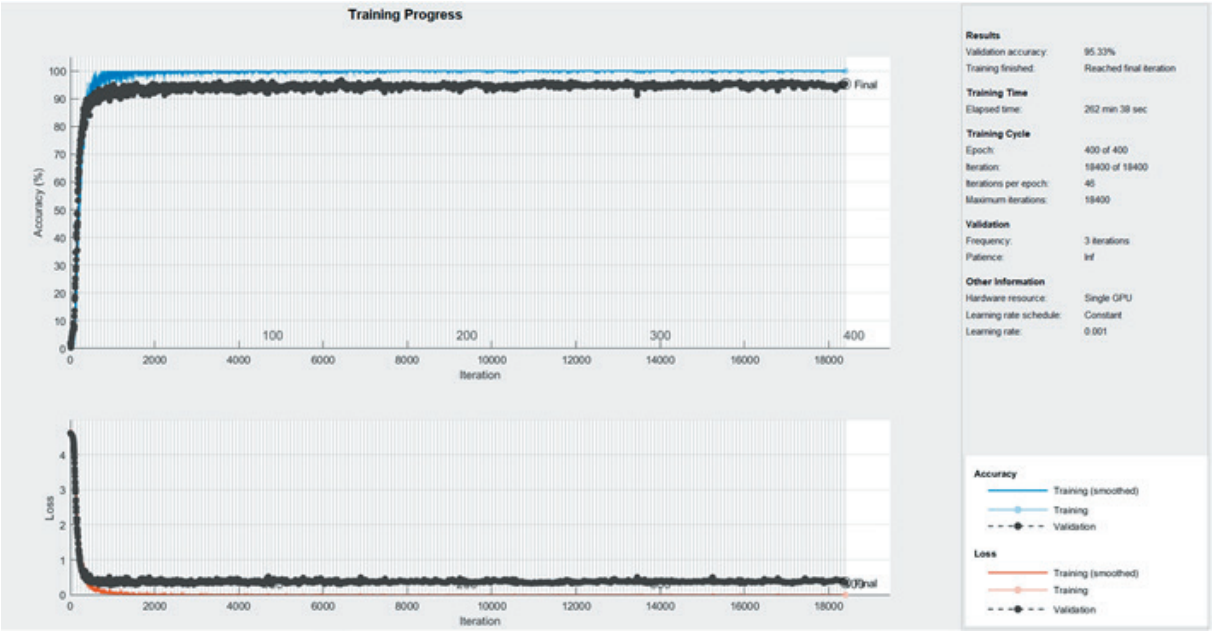

Figure 1 - AlexNet training performance.

GoogLeNet [11] is a convolutional neural network that was constructed in 2014. It has 144 layers, with 22 layers holding function parameters and five layers for compression. GoogLeNet is based on small convolutions, which minimize the number of parameters significantly. This network has only seven million parameters compared to the AlexNet network, which has 60 million. This was accomplished by employing the concept of combining multidimensional convolutions into a single layer. The benefit of applying different dimensions of convolutional filters in parallel is that the global (5x5) and local (3x3) properties may now be distinguished independently. The last fully connected layer is modified to extract 1024 features, and another fully connected layer is added to represent the output for 100 classes, just as it was done in AlexNet. The transfer learning is conducted with an initial learning rate of 0.001 in a series of 48. Figure 2 shows the achieved network performance after the training process in 100 epochs.

ResNet (Residual Network) [12] was developed into three different models, each with a different number of layers. In this research, an experimental version with 101 layers and approximately 43 million parameters was used. In terms of compression, its architecture differs significantly from AlexNet and GoogLeNet networks. The invention of this network was followed by a study into why, rather than improving, the performance of the neural network is degraded when the number of layers is increased. ResNet's fundamental aim was to create a "identity shortcut link" that bypasses one or more layers. The authors proposed the introduction of blocks to overcome this problem, in which the middle layers of each block learn the function of the residual relative to the block's input, as opposed to the traditional network, in which each layer is expected to learn only new and different feature maps. The middle layers can gradually reduce their weights to zero, resulting in a block residual that reflects the function of identity. The classification layer was modified to work with 100 classes based on the specified fingerprint test database, and the last fully connected layer was adjusted to extract 1024 features when customizing this network. The results provided in the research were obtained by training the network in a series of 10 with an initial learning rate of 0.001. Figure 3 depicts the network performance achieved after 15 epochs of training.

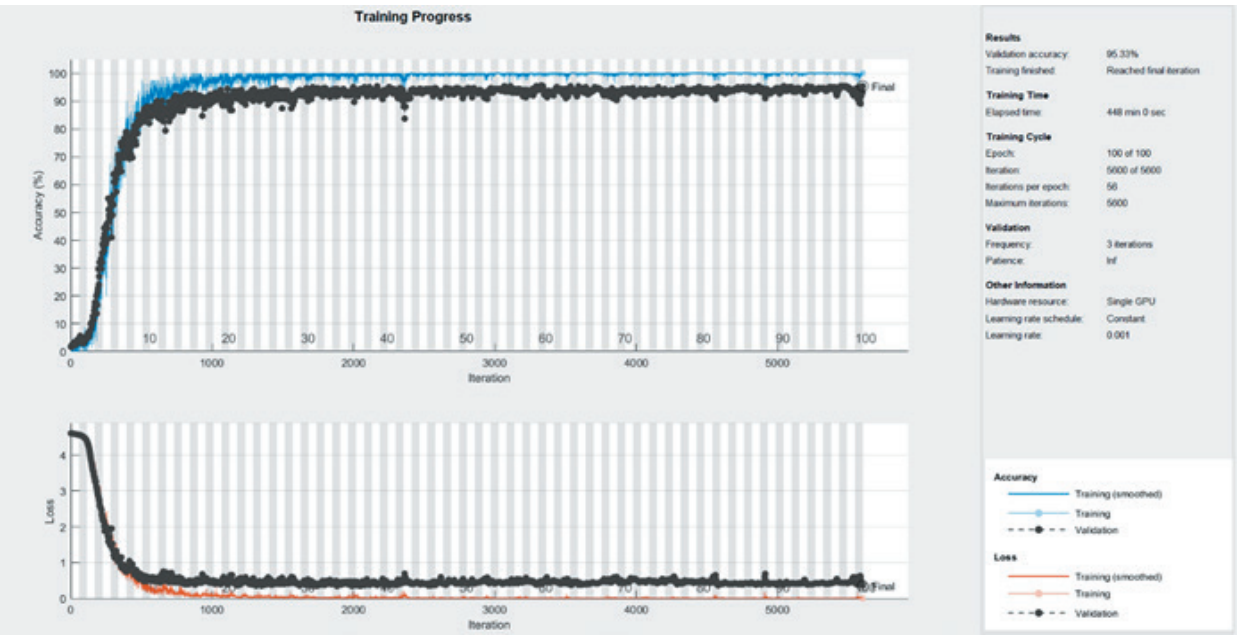

Figure 2 - GoogLeNet training performance.

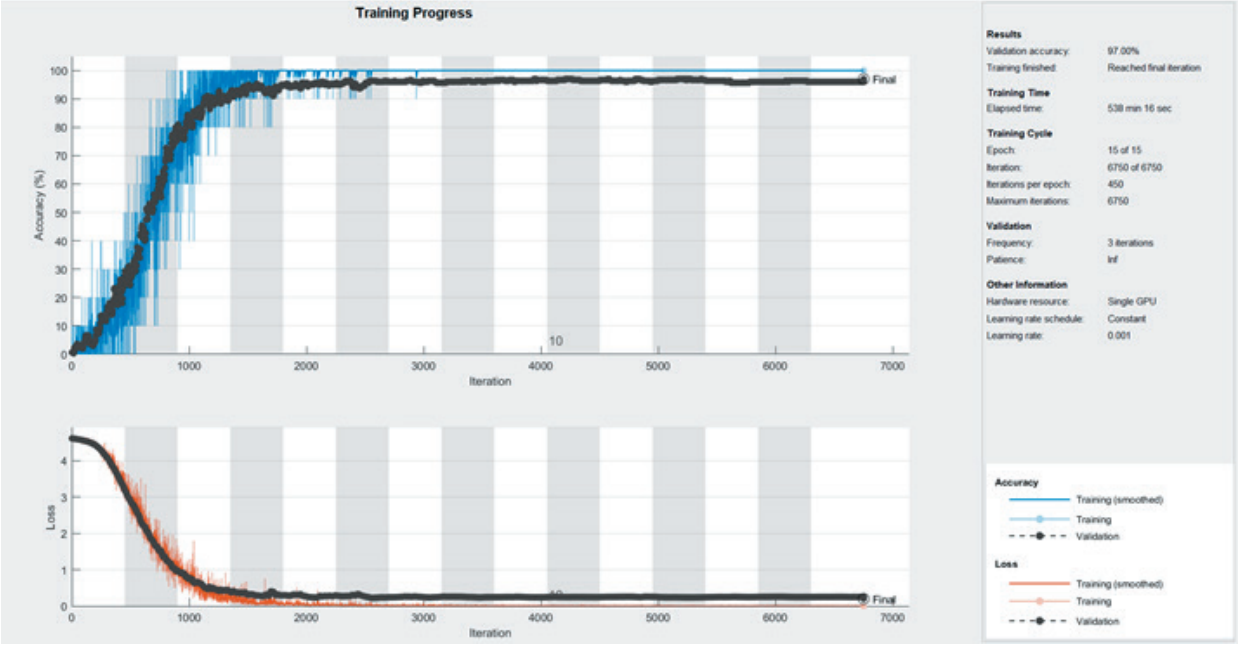

Figure 3 - ResNet training performance.

4. EXPERIMENTAL RESULTS

For effective comparison with other concepts, Fingerprint Vendor Competition database DB2 (FVC2000 DB2) [13] was used for experimental testing of the proposed fingerprint identification system. The database consists of 800 fingerprints collected by a capacitive sensor, and each identity is represented by eight fingerprints. The dimensions of the images are 256 x 364 px in resolution of 500 dpi.

Each class's first five fingerprints were used for network training and identity registration, while the last three were used for system accuracy verification. The experiment was run on a laptop with an Intel i7-8750H processor, 16GB of RAM, and an Nvidia GeForce GTX1050 graphics card, using Matlab 2018a. To examine the accuracy of CNNs, we used the same learning set and a variety of epoch lengths to train all three networks. Table 2 compares the accuracy gained, the amount of time spent on network training, and the number of epochs used.

CNN	Verification accuracy [%]	Training time [min]	Number of epochs
AlexNet	93.67	33	50
AlexNet	94.33	142	200
AlexNet	95.33	263	400
GoogLeNet	94.00	149	40
GoogLeNet	94.67	179	60
GoogLeNet	95.33	448	100
ResNet	96.33	225	6
ResNet	96.67	375	10
ResNet	97.00	538	15

Table 2 - Comparative overview of CNNs performances

5. CONCLUSION

Biometrics has long been used in criminology for positive and negative identification, and it has become increasingly prevalent in the commercial sector for access control, time and attendance, authentication on mobile devices, ATMs, mobile banking, etc. As a result of the foregoing, biometric authentication technique research and development are extremely important. The use of CNNs in biometric identification is analyzed in this research. The experimental results of the three most frequent CNNs in the positive identification scenario support the proposed system's perspective and the application of CNNs in biometric-based authentication systems and cryptosystems. All three networks achieved a high level of accuracy. In terms of accuracy, the ResNet neural network achieved the best verification result of 97%, while the AlexNet neural network reached 100% training accuracy in just 33 minutes, resulting in 93.67% verification accuracy. The comparative analysis and experimental findings reported here are expected to serve as a springboard for further research, improvements to existing solutions, and inspiration for future breakthroughs.

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A MODEL FOR DYNAMIC CYBER SECURITY RISK ASSESSMENT IN THE INDUSTRIAL IOT ENVIRONMENT

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Abstract:

This paper considers cyber security risk assessment, as a vital part of the risk management process, in the industrial Internet of Things (IIoT) systems. A general model for IIoT dynamic risk assessment (DRA) is proposed, starting from the definition of IIoT context. Several risk calculation algorithms are surveyed, with an emphasis on artificial intelligence and machine learning-based methods. The model is illustrated in the example of IIoT-based supervisory control and data acquisition (SCADA) system in a hydropower plant.

Keywords:

Cyber Security, Dynamic Risk Assessment, Industrial Internet of Things, Machine Learning, SCADA.

INTRODUCTION

The Internet of Things (IoT) concept promotes the idea of everyday physical objects (things) being connected to the Internet and being able to identify themselves to other devices. As a subset of IoT, the Industrial IoT (IIoT) refers to machine-to-machine and industrial communication technologies with automation applications, in order to enable more efficient and sustainable production [1]. Since many IIoT systems belong to critical infrastructure, cyber security is one of the key issues that have to be solved to achieve their wide implementation and deployment. Security solutions require equal emphasis upon the system's view, specific mechanisms and their applications, development of the appropriate testbeds, and standardization efforts in the field [2]. Apart from evolving threats, the complexity of the problem increases due to the heterogeneity of physical objects, networking technologies and applications that should be able to communicate and collaboratively provide immutable and verifiable data. The main security risk factors include: real-time and complex interactions; security flaws in certain parts of the system; poor integration of security subsystems; insecure network connections and communication protocols; shared technology issues; multiple points of

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entry and failure; the use of open software platforms together with commercial off-the-shelf hardware and software components; and the lack of protection for legacy systems with long operational life [3].

This paper addresses IIoT cyber security risk assessment (as a core part of the risk management process), which includes risk identification, analysis and evaluation [4]. The need for a dynamic risk assessment (DRA) approach is explained, and a general model is proposed together with a brief survey of suitable risk calculation methods. The proposed approach is illustrated in the example of IIoT-based supervisory control and data acquisition (SCADA) system in a hydropower plant.

The rest of the paper is organized as follows. Section 2 briefly surveys the background and related works. Section 3 proposes the general concept for DRA risk assessment in the IIoT environment and surveys the algorithms for risk assessment with the emphasis on machine learning-based methods. Section 4 illustrates the proposed approach on a hybrid cloud-based SCADA system. Finally, Section 5 concludes the paper.

2. BACKGROUND AND RELATED WORKS

In the context of industrial control systems (ICSs) security, the U.S. National Institute of Standards and Technology (NIST) defines risk assessment as "the process of identifying risks to operations, assets, or individuals by determining the probability of occurrence, the resulting impact, and additional security controls that would mitigate this impact" [5]. Figure 2 illustrates the process of ICS cyber security risk assessment. For general-purpose networks, the objective is to maintain balanced protection of confidentiality, integrity and availability (CIA triad), with data confidentiality as the main concern. Protection of industrial control networks assumes the AIC triad, which means that the availability is given the highest priority. The reversed order of priorities makes difference in terms of security policies and mechanisms, with the main goal to preserve the availability of critical infrastructure systems on a 24/7 basis. Cyber security threats exploit system vulnerabilities and possibly cause incidents, which may further cause damage to assets and have an impact on security infrastructure. Therefore, threats, vulnerabilities, and impacts should be combined together to provide a qualitative or quantitative measure of the risk [6]. Examples of qualitative risk assessment are experts' assessment, rating estimates, checklists of risk sources, method of analogies, etc. According to [7], quantitative risk assessment methods can be classified as follows: (1) analytical methods such as sensitivity analysis, scenario analysis, method of the risk-adjusted discount rate; (2) probabilistic theoretical methods, which include simulation, game theory, tree constructing methods and (3) unconventional methods such as modelling with fuzzy logic and machine learning.

DRA (also known as continuous risk assessment) relies on data that are collected and processed in real time, and encompasses the three basic components: assets management, attack modelling and risk calculation [8]. Assets management refers to material goods (devices, communication links, hardware and software), their performances (including upgrading and updating) and their valuation in terms of impact to AIC triad, criticality,

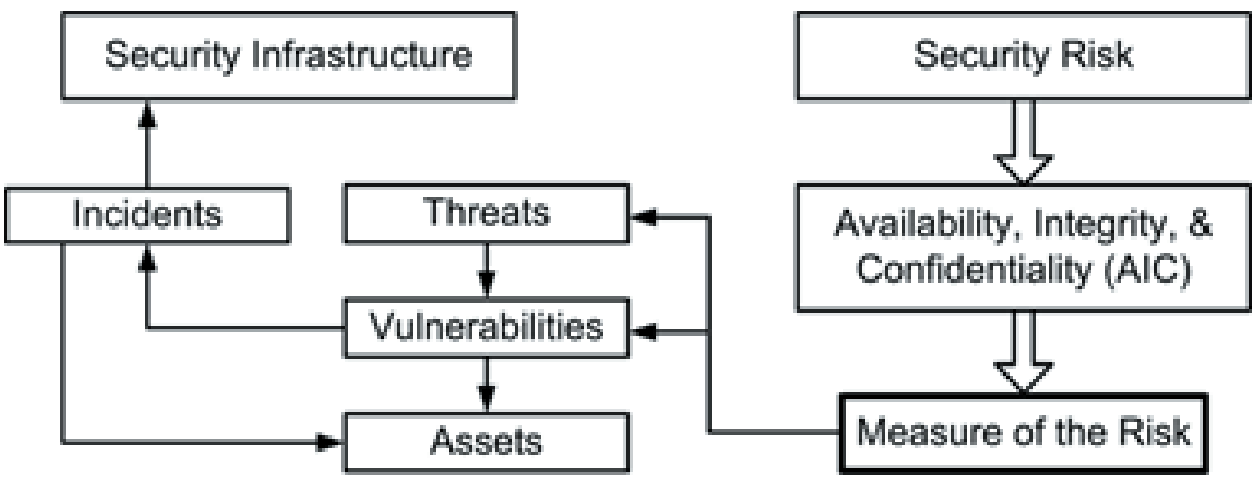

Figure 1 - Security risk assessment process in industrial control systems.

sensitivity and security expenses. Attacks can be modelled by means of different techniques such as: hidden Markov models, graph-based techniques, hierarchical modelling using attack trees, clustering, fuzzy logic, etc. Risk calculation takes into account likelihood (frequency) and the impact of all possible attacks, while the algorithm may depend on attack modelling method.

Measure of the risk can be updated continuously or periodically, and expressed quantitatively or qualitatively. The Industrial Internet Consortium (IIC) implies the need for DRA by considering risk assessment in the context of overall security measures and emphasizing the need to adapt to continually changing threats and attacks, to provide responses that will minimize the impact on the IIoT system, and to enable cooperation of different organizations to ensure the early identification of security threats [9].

Recent trends in DRA techniques have been surveyed in [8] together with a proposal of decision guide to choosing the most suitable technique considering general-purpose networks, IoT environments and ICSs. A general description of a solution that has the potential towards IIoT continuous risk assessment is presented in [10]. The solution makes use of different data sources to analyse cyber risks on a continuous basis, integrating this activity with the operational process. The method is illustrated in the example of environmental control in a data centre. A quantitative DRA approach intended for smart grids is proposed in [11], and relies on attack defence trees and computation of the predefined risk attributes that are being propagated through the tree nodes.

An architectural view of continuous security risk assessment in IIoT is presented in [12], followed by a survey of machine learning-based solutions used for risk calculation. Applicability of deep learning approaches for DRA in IIoT systems is discussed in [13].

3. PROPOSAL OF A MODEL FOR DRA IN IIOT SYSTEMS

The main novelty of this paper is the proposal of a general model for DRA in the heterogeneous IIoT systems. The model relies on identification of the IIoT context for risk assessment, and is completely applicable to different attack models and risk calculation algorithms.

3.1. EXPLANATION OF THE MODEL

Figure 2 shows the proposed model of dynamic cyber security risk assessment in the IIoT environment. It comprises the following steps:

- *Definition of the IIoT context*, depending on risk aspect and involved entities [14]. Risk aspects may differ for sensor/actuator manufacturers; platforms, applications and industrial systems; customers (industry, healthcare, smart cities), or for system integrators, service providers and end users. Examples of entities are humans, hardware, software, communication and cloud infrastructure, and they determine the information flow. Identification of IIoT context is required for two main reasons:
  - Multiplication of cyber-physical attack points is possible in the IIoT system due to the integration of sensors, actuators, platforms, applications and users. This means that the attack performed in a single point may have impact on the whole system; and
  - The same entity can be used in different IIoT contexts, which require different security levels, depending on specific risk factors.
- *Identification of attack points* refers to the recognition of assets that can be targeted by cyber or cyber-physical attacks;
- *Attack modelling* refers to the creation of cyber attack models in order to identify and simulate attacks against security environments, using likely adversary techniques and attack paths. This block is not mandatory, since the risk engine (depending on the applied algorithm) can rely only on monitoring results obtained from security mechanisms;
- *Risk calculation engine* implements a suitable algorithm, taking into account a number of static and dynamic inputs. Static parameters are stored in the knowledge repository; they encompass records such as asset register, asset values, history of incidents, as well as previous risk measures and the risk mitigation plan [12]. Dynamic parameters are obtained from attack modelling (if present) and monitoring tools. The output of risk calculation engine is a qualitative or quantitative risk measure;

- *Risk mitigation plan* specifies techniques and methods to be used to avoid, reduce, and control the probability of risk occurrence, for different risk levels. It also includes selection of security tools such as logs monitoring, antivirus software, firewalls, intrusion detection and prevention systems, malware detection, network traffic monitoring and analysis; and
- *Continuous monitoring of attacks and security mechanisms* provides loopbacks for modification of attack points, revision of attack models and tuning of the risk calculation engine. Security tools capture and process inputs from the IIoT system in a real time and generate notifications about potential threats and suspicious events. The security information and event management (SIEM) software imports information from security tools, performs correlation of the corresponding events and prepares appropriate dynamic inputs for the risk assessment tool.

3.2. RISK CALCULATION ALGORITHMS

Several traditional algorithms that can be used for continuous risk calculation in industrial environments are described in [15], including Bayesian methods, bow-tie analysis and risk barometer. Recent trends show that artificial intelligence (AI) and machine learning (ML) bring substantial benefits for DRA implementation in the IIoT environment due to their suitability for edge computing, big data processing, predictive risk management and efficient decision-making [12], [13], [16].

There are several mainstream machine learning-based approaches, namely supervised and unsupervised learning, deep learning, reinforcement learning and deep reinforcement learning [17]. Table 1 contains a brief summary of these approaches, regarding their suitability for edge computing.

Supervised and unsupervised learning are widely used for data classification and clustering. Supervised learning assumes prior knowledge of the output values for given data samples. The goal is to learn a function that maps an input to an output based on example input-output pairs. Support vector machines (SVMs), decision tree and naive Bayes are typical algorithms that are commonly used for discrete valued classification. Unsupervised learning does not have labelled outputs; its task is to infer a function that describes the structure of unlabeled data. One of the most widely used algorithms is K-means, which splits data whose category is unknown into several disjoint clusters. Certainly, different types of artificial neural networks (ANNs) can be supervised and unsupervised.

Deep learning is a class of ML techniques that is inspired by the structure of a human brain. The algorithms attempt to draw similar conclusions as humans would by using a multi-layered structure of neural networks (e.g., convolutional neural networks, CNNs). The computational model can automatically extract features needed for prediction or classification from massive raw data. Deep learning can be easily integrated into edge computing-based systems and used for traffic and behaviour prediction, as well as for fault and incidents detection.

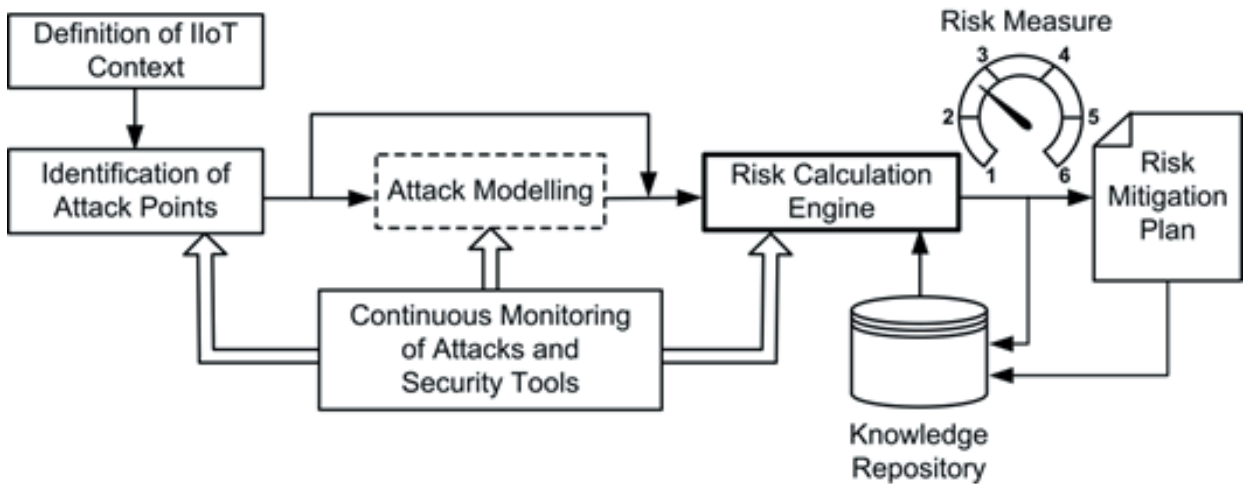

Figure 2 – Proposed model of dynamic cyber security risk assessment in the IIoT system.

Method	Algorithms	Application	Advantages	Limitations
Supervised learning Unsupervised learning	ANN, SVM ANN, K-means	Classification and clustering	Easy and quick to deploy	Sensitive to data, massive data, performance bounds
Deep learning	CNN	Prediction, detection	End-to-end learning features	Long training time, massive data, training tricks, black-box
Reinforcement learning	Markov decision, Q-learning	Decision making	Learning without a priori knowledge	Curse of dimensionality
Deep reinforcement learning	Deep Q-network	Feature extraction and decision making	End-to-end reinforcement learning	Very long training time in large discrete state space

Table 1 - Methods, algorithms and application of machine learning in edge computing

Reinforcement learning, inspired by behavioural psychology, enables an agent to learn in an interactive environment by trial and error using feedback from its own actions and experiences. It assumes rewards and punishments as indicators of positive and negative behaviour. Reinforcement learning is suitable for automatic control and decision making issues in highly dynamic environments. Typical representatives are Markov decision process and Q-learning algorithms.

Deep reinforcement learning (e.g., deep Q-network) combines ANNs with reinforcement learning that are goal-oriented algorithms. In other words, it brings together function approximation and target optimization by mapping state-action pairs to expected rewards. This feature makes deep reinforcement learning suitable for both feature extraction and decision making.

4. CASE STUDY

The case study considers an IIoT SCADA system in the hydropower plant, based on a hybrid cloud infrastructure, as illustrated in Figure 3. Such architecture can easily be extended to support other smart grid applications. Hybrid cloud allows companies to combine their own data centre and/or private cloud setup with public cloud resources such as Software-as-a-Service (SaaS), Data-as-a-Service (DaaS), etc. One of the most common applications of hybrid cloud is to keep sensitive, mission-critical data and applications in the private cloud, and to use public cloud when capacity is needed for less sensitive development or testing activities [18]. The basic idea is to take advantage of cost benefits of public cloud services, while preserving high level of security for critical applications that are executed in the private cloud [19], [20].

In the SCADA system, controllers process signals from field devices and generate appropriate commands for these devices. They encompass remote terminal units (RTUs), programmable logic controllers (PLCs) and intelligent electronic devices (IEDs) that perform local control of actuators and sensor monitoring. Controller network is connected via secure communication links to SCADA application (master terminal unit, MTU) that is executed in the private cloud [18]. SCADA application makes use of the private Platform-as-a-Service (PaaS) model to perform the following functions: (1) Preparing and sending command and control messages to controllers; (2) Collecting and analysing real-time process and historical data obtained from field sites, and generating actions based on detected events; (3) Preparing inputs for hydroinformatics system; (4) Preparing data to be presented on the HMI (human-machine interface) consoles; and (5) Preparing and sending relevant data to be stored on a historian server. Private PaaS allows support of different software platforms that can be tailored to other critical applications in the power utility.

Public SaaS is used for provisioning of publicly available information about the water level of the inflow. Public DaaS can optionally be used for storage of less sensitive data. Hydroinformatics system determines operation of aggregates for optimal consumption of hydropower potential based on the water level, the data obtained from SCADA system and the energy production requirement.

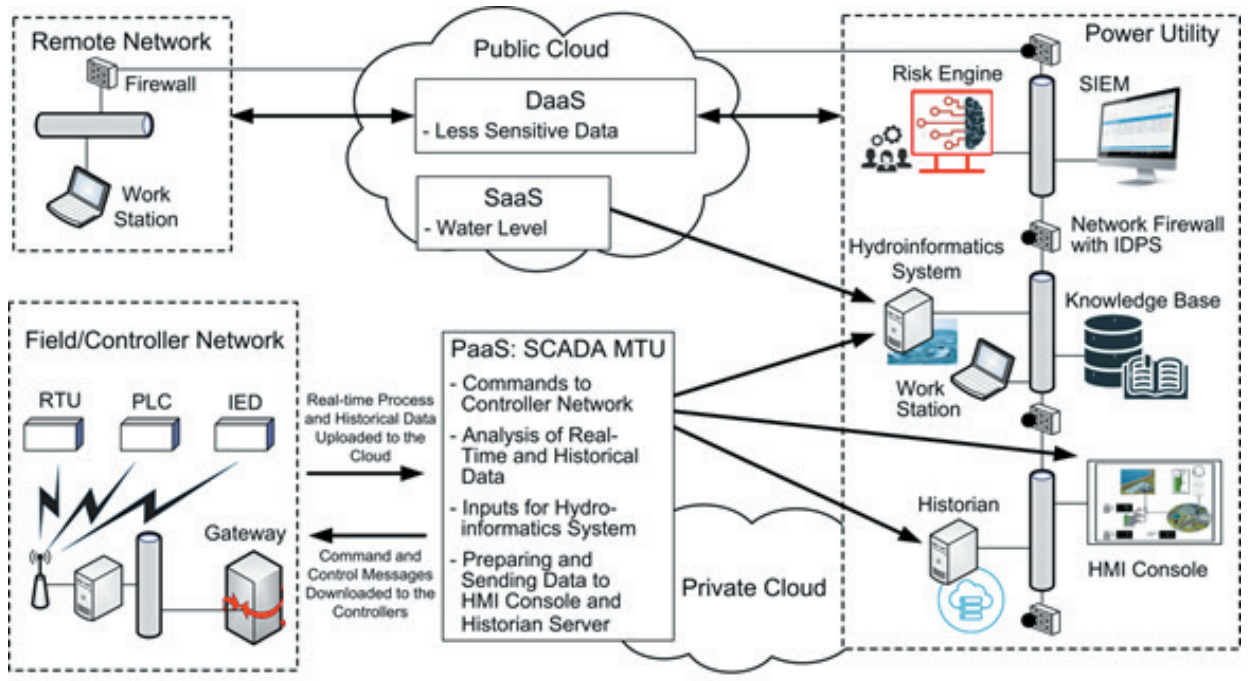

Figure 3 - Architecture of the secured IIoT SCADA system using a hybrid cloud infrastructure.

Based on the previous description, the following IIoT contexts can be identified:

- Real-time communication between the SCADA MTU and field sites;
- Communication between the SCADA MTU and the hydroinformatics systems;
- The use of public cloud services; and
- Communication with the historian server and HMI application.

SCADA control centre performs its actions based on the data received from field sites. Attacks that jeopardize process control focus on modifying control data or blocking the data transfer. Primary threats to SCADA systems are command/response injection, various forms of denial of service (DoS) attacks, including distributed DoS (DDoS), and man-in-the-middle (MITM) attack. Detailed considerations about cyber threats and attacks on SCADA systems can be found in the literature [2], [18], [21].

Achieving high level of security and privacy assumes implementation of complex security measures [2]. Securing the private cloud is complete responsibility of the power company, and it starts from the definition of security objectives and associated policies, followed by implementation of mechanisms that ensure the AIC triad; authentication and access control; intrusion detection and prevention, as well as a set of other preventive measures. Regarding public cloud services, the most important step is the careful choice of cloud service provider with a well defined service level agreement for each service [2].

Following initial risk assessment (in the system design phase), four inline network-based intrusion detection and prevention systems (IDPSs) are installed together with firewalls at network's vulnerability points to cyber attacks, as indicated in Figure 3. IDPSs monitor the traffic in specific network segments and observe the activities of network and application layer protocols to identify and stop suspicious activities and events. They also typically record information about these activities, notify the administrator about important events with warnings and alarms, and generate reports. SIEM software collects and aggregates security-related logs, generated throughout the private cloud infrastructure, performs correlation of the corresponding events, and prepares dynamic inputs to the risk engine.

As mentioned earlier, different algorithms can be applied to perform dynamic risk calculation. However, hybrid approach which takes into account experts' assessment is strongly recommended. The role of experts' opinion is fundamental in the initial phase (system design) as well as for tuning the risk engine and interpretation of the obtained results.

This particularly stands for ML-based algorithms in order to mitigate their shortcomings, primary regarding high error susceptibility and possibly wrong interpretation of results.

Interpretation of results poses questions how to consider risk knowledge, particularly in quantitative risk assessment (e.g., considering two-dimensional or three-dimensional risk matrices), and how these results contribute to system evolution? Calibration and correction based on new evidence would possibly allow risk analysis to consider evolving conditions and improve system knowledge [16].

5. CONCLUSION

Although different qualitative and quantitative approaches, methods and tools for risk assessment in industrial control systems can be found in the literature, only a few of them deal with the models for dynamic cyber security risk assessment in the IIoT environment. The model proposed in this paper starts from identification of the IIoT context, assuming that one entity can be used in different contexts with different security requirements. The model is general enough to allow different attack models and risk calculation algorithms.

Machine learning-based approaches offer a strong potential for DRA, particularly if combined with the experts' opinion. Continuous monitoring of attacks and security tools, followed by a correlation analysis of the observed data, provides feedback for the risk calculation engine. The proposed approach is illustrated in the example of IIoT-based SCADA system that uses a hybrid cloud infrastructure. Finally, our future work is twofold. First, we are planning to develop DRA architectural views for other IIoT applications, particularly smart grids. Second, we are investigating hybrid risk calculation approaches that combine experts' assessment with deep learning based methods.

6. ACKNOWLEDGEMENTS

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SELECTING EFFECTIVE COLLABORATIVE TOOLS FOR CREATING A NEW SOCIAL NETWORK IN THE COMPANY FOR RAISING EMPLOYEE ENGAGEMENT DURING COVID-19 PANDEMIC

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Abstract:

The development of the Covid-19 pandemic brought organisations the necessity to seek new strategies to retain employees' trust, empowerment, collaboration, and sense of loyalty to the company. Adaptive, durable, engaging, yet applicable in a remote environment were narrowly few of the requirements needed for this strategy to help successfully manage co-located teams, their progress, continuous learning, and sustain the motivation and devotion in different personalities within the group. This paper presents how we leveraged collaborative software tools using the shift to virtual work as a unique learning opportunity. Our results exhibit that remote teamwork entails several components to success: a personal and professional sense of belonging, sharing of knowledge and daily life content, and development of social networking at work as the central pillar to staying connected with co-workers. Work after pandemic and how the hybrid model of work will affect all organisations are some of the future research directions raised.

Keywords:

Online Collaborative Tool, Remote Learning, Social Network, Distributed Teams, Work from Home.

INTRODUCTION

With the Covid-19 pandemic acceleration in 2020, societies and organisations have experienced a full-scale effect on all aspects of professional and individual lifecycle. Following complete lockdown in many European counties, we have encountered numerous challenges from March 2020 to June 2020. Most responsible organisations transitioned fully to work from home (WFH). Nevertheless, WFH emerged as challenging on various levels: (a) for companies who had a mission to keep the workforce gathered, as well as for (b) employees who are not able anymore to experience the exact impact of organisational climate at home. Another consequence of pandemic is - lack of stability, which affects employees focus on work and their sense of well-being. Development of pessimistic feelings due to rising cases of COVID-19 in the world, global uncertainty daily makes job security questionable and their income, and other existential factors.

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Due to the listed problems, employee engagement became one of the main topics for discussion, being the primary building block of the modern organisation.

As presented in the paper [1], the digitalization of business processes is very important for every company and various industry sectors. While main goal of the company's business remained unchanged, which is to maximize profits, the use of information and communication technologies in company's business during the Covid-19 pandemic tended to grow.

The most important step for our software engineering company was to define and establish a clear communication and collaboration process within employees, team members, and their superiors and vice versa in times of enforced pandemic measures and absence of physical contact [2]. Lighting the spark with a top-down approach and waiting for other employees to join the board is how this strategy started.

Employees had no hybrid work experience, meaning full-time work from home was a completely new concept. Yet, they already encountered distributed teamwork with clients located in various countries.

Knowing how during pandemic engagement activities started to evolve, family gatherings moved from living rooms to online tools and chat rooms, virtual learning and development became exclusively online events, other educational/professional contents as webinars with industry experts became contactless.

As a response to the online life movement, our organisation pivoted by making daily, weekly and monthly internal events to keep employees connected, based on our previous experiences, expressed in two research papers, [3] and [4], we concluded that the main focuses should be on (1) Team building activities, (2) learning through knowledge sharing, (3) communication and collaboration. Some are online team buildings necessary to keep the work culture alive, sharing a meal over video conferences, short online game sessions, virtual challenges and competitions, online courses, communication exercises, live sessions for new-skill training, online counselling sessions, social interactions in a virtual office, and many more creative learning sessions.

1.1. BACKGROUND OF THE STUDY

Various articles explore work-from-home productivity during the Covid-19 pandemic by studying related literature. Still, there are not many that have a focus on employees collaboration and maintaining loyalty and intense bonds. This paper aims to emphasise the importance of keeping pace and adapting to emerging challenges the Covid-19 pandemic brought in the current state of work and future of work, presenting how we nurtured employee engagement.

In a paper [5], the authors point out that full-time remote work during the pandemic in Microsoft company caused a decrease in synchronous communication and an increase in asynchronous communication. Their results present that for employees, it was harder to acquire and share new information across the collaboration network. Listed are only some of why we choose Slack as one of the leading collaborative tools. The possibility for synchronous and asynchronous communication benefited employees who wanted to be actively involved in touch and passively.

In [6], the authors present that the biggest challenge of information technology companies in moving towards long term remote working is sustaining the organisational culture. This research explores the different corporate cultures adopted by top IT companies in India to understand how to motivate and retain employees in a remote work environment.

The paper [7] highlights the shift to virtual work as a unique learning opportunity, with findings demonstrating that teamwork entails several core activities (task, process, and relationship interactions) that require additional adjustments to enact in the virtual (vs collocated) environment successfully. Authors concluded that transition to an entirely virtual work environment and movement to online collaboration is the central postulate for nurturing close peer relationships that required constant adapting and Agile approaches in all work-related decisions during the pandemic.

1.2. RESEARCH FOCUS

Two main pillars of our research and paper are to present research results on what we learned from the organisational point of view regarding covid19 pandemic and shit to virtual work and how this new way of working impacted employees' performances, learning and overall engagement.

RQ1. A strategic approach to people engaged in a virtual environment, how we did it and lessons learned?

RQ2. How to make an individual approach for creating an intimate, engaging environment and increase personal motivation for attending inclusive activates?

RQ3. How to create a custom social network to engage employees of software engineering companies? How can collaborative tools and virtual mood of work contribute to knowledge sharing mechanisms in remote environments and their benefits?

Based on the experience of using social networks and collaboration tools within the company, we were compelled to react quickly at the beginning of the pandemic. When it was clear that it became a systematic phenomenon, we started to combine the usage of online collaborative tools to retain bonds and motivate people to stay together and connected. Tools used were already known to employees [8], but pandemics brought the need to use them on the advanced level. Optimal mix of their utilisation leads to one new notion - inter company social network has emerged, as the main instrument of communication which produced best results in engagement and keeping loyalty preserved of COVID effects.

A team of 200 engineers working on 15+ different projects with 10+ clients globally spread became the observed sample in this study:

- Over time, the so-called "carrier group" was profiled and was present at all sessions, 15% of which were non-stop active and helped other participants engage even better;
- 55% of employees participated in 60% of new social network activities;
- The remaining 10% were periodically included in online gatherings and virtual discussions; and
- After several months of observation, it was concluded that several people did not participate in the mentioned activities at all, about 20%.

Looking back at the figures mentioned, we can say that our main goal has been met. People collaborated, communicated and shared content and, most importantly, remained connected even though they were separated.

2. APPLIED APPROACH

The goal of our research was to identify a mix of existing collaboration tools in the shortest possible time, a few weeks after the beginning of the pandemic, that would cover the needs of increasing and communicating our engineers to create a natural office environment in cyberspace.

The challenge in front of us is to choose the winning set of communication and collaboration tools that most software engineers would accept. Although, as we know, a typical software engineer is technologically curious, he wants to try as many means of communication as possible. In brief, they are a target group that is not inclined to use one collaboration tool to cover all needs and communication channels.

The main direction of our research is focused on mapping the communication needs and experiences of employees using collaborative platforms that exist in the market. We use some of the collaborations platforms as part of the standard set required by the company (MS Teams, MS Outlook, MS SharePoint, etc.). In contrast, we have through the experience we gained working with our client's project teams (Atlassian Jira, Confluence, Slack, Zoom, etc.).

Our work aims to create an environment that supports the interactions of engineers in the workplace - in the office - in cyberspace. In solving the growing challenge, we wanted to avoid the typical trap set by employees in advanced technology companies, which is to approach synthesis, building a new collaboration-communication platform that would cover all the needs of our employees.

As a starting point, we adopted MS teams for the platform used for the broadest communication because the company required it for standard employee communication. Microsoft Teams is a proprietary business communication platform developed by Microsoft which has been used within our company as the primary communication tool within employees, for quick communications, besides the outlook email.

As email and messaging tools are often used and recognised to be appropriate for long term and external communication, which does not require an instant response and prompt engagement - the need arose to search for an alternative tool that will be a good substitute in the absence of physical contact and office small talks.

A tool that offered synchronous and quicker communication with no restrictions regarding several groups, messages, and had easy access for all employees, was a perfect match. As Slack provides a possibility of having an unlimited number of private and public chat rooms dedicated to project teams or groups of enthusiasts, numerous free add-ins for communication advancement, the opportunity to schedule team meetings for a large number of people and more benefits - made us elect this collaborative tool to be the main point of communication and collaboration during remote work.

Yet tool could be unique to all, but the approach needed to be Individual and tailored. Employee engagement guarantees best results when adapted to individual needs, as different personalities respond differently to various engagement efforts. Within the company, we have developed a platform that helps creating candidate profiles in accordance with clients' requirements [9]. A new approach to attract each group of people to attend engaging sessions are presented in **Figure 1.**

Daily chat/video call sessions were organised via Zoom during the first month, used as Slack add-in. Zoom is a cloud-based peer-to-peer software platform used for teleconferencing, telecommuting, distance education, and social relations. It allows you to set up virtual video and audio conferencing, webinars, live chats, screen-sharing, and other collaborative capabilities.

Sessions lasted around 15 minutes and had the main goal for employees to share positive news, updates, and facts daily from different locations.

Challenge emerged with sessions that mainly contained private information about the employee. The data privacy issue was discussed, as many people have been using their social media accounts to share information from their day to day lives. Before sharing the information, pictures and other contents needed to be reviewed and decided in which form they will be shared. "Passion Sessions" were born.

Conceptually made to be 15 minutes session in which one individual presents their passion whether by adding pictures in ppt or offering it live on a video call- the choice is theirs. As a result, employees got to know each other better personally and started bonding on a friendly and professional basis. These sessions were one of the most visited. Therefore, more than 60 % of invited employees were attending them regularly; furthermore, as time progressed, more than 70% of employees saw every other passion session.

Employees with dominant interests in exclusively professional topics have been visiting mostly the "technical educational sessions" - presenters were agreed in advance as their topics of presentations, and this information has been published in internal slack channels. Besides socially connecting, in the discussion that followed the 15 minutes session, employees' knowledge base became larger as sessions progressed. Aftermath is vital because communication continued on separate open chat channels between 80% of attendees in the following months.

As a result, group chat rooms have become places where people express their thoughts, work-related problems, solutions from various perspectives, news from different locations worldwide, and shared funny daily content. People have felt the freedom to ask questions publicly or give their opinion.

	Emerging needs	Session establishment	Session innovations	Achieved success
OBJECTIVE	Engagement of people during remote work	Creating engaging sessions	To attract more participants; Organize effective sessions	Keeping the pace with fasted engagement results
ACTIVITIES	• Creating strategy for people engagement during Covid-19 pandemic • Developing approach to maximize engagement for various types of personalities • Continuously researching for best tools for virtual collaboration and knowledge sharing	• Daily 15 min session via Slack / Zoom video call • Free Topic sessions • One big chat room was established for all topics / participants • Local news sharing through geographically distributed chat rooms	We innovated by introducing: • Passion sessions • Technical knowledge sharing • Hobbies and other personal interest sessions • Quiz sessions • Game sessions • Dynamic of sessions changed from daily to two times a week	• During time we became even more agile in sessions planning regarding topics / presenters / time slots • We pivoted our activities based on people preferences and demands, as well as pandemic situation
OUTCOME	Agreed on objective and detailed execution plan	160+ participants In 2 months, 35+ sessions	More introvert people started to join sessions that were related to their interest	Adoption to new reality

Figure 1 - Session establishment process

They became engaged even after the work hours, entirely voluntarily. After a few months, we had 20+ channels, each having 30+ people.

As engagement got more significant over time, we organised a once-week 15-minute quiz using Kahoot! A platform for all employees that were infested to attend. Kahoot! is a game-based learning platform used as educational technology in schools and other educational institutions. This practice has shown that even bigger engagement has been established because we had quiz winners and recognition. Therefore, motivation for attending was even more significant and, consequently, the people's attention.

Bi-weekly, all employees active in slack had a challenge set by Slack activates organisations. After two weeks, the best three responses would be chosen as a winner in different categories. Medals and recognition have been tailored made by organisers and publicly shared with the whole group, presented in **Figure 2.** People continued sharing this recognition on their social media and got feedback from other employees, which also positively impacted the process of engagement.

To make the environment in which people felt welcome to share different content and bond, small prizes as gestures of recognition were established.

Criteria for receiving the award were different, depending on each case. Our idea was that as many participants as possible, who were active in the sessions, or in communication on other channels, receive awards in different categories to recognise their efforts.

Therefore, a voting system was in place for the awards to be distributed.

Besides thematic sessions, employees were eager to have topic free sessions to have small talk and express themselves about their day-to-day life, challenges or positive news. Donut tool was introduced to a group of Slackers as Slack Ad-in. Therefore, we managed to stay within the established platform, yet one more innovation helped people meet and greet using their cameras. Dount works in the following principle - when someone on your Slack workspace sets up Donut, they'll choose the channel, frequency of intros (multiple times per week, once per weekly, biweekly, etc.), the time zone, and the time that the openings will go out. Donut tries to introduce people who don't normally interact with each other. It does this by looking at who is in which channels and matching people who aren't in many channels together. Donut also keeps track of who has been introduced in the past to avoid frequent repeats. Once more, we have leveraged the benefits of the Dount tool and increased the number of people who interacted and had fun in a short rendezvous.

Statements of people who used slack and Dounat also helped us understand its impact.

Figure 2 - Medals and recognitions

Tool	# Active People	The main purpose of use
Microsoft Teams	200	Collaboration and meeting
Email	200	Communication
SharePoint	200	Sharing documents
Slack	160+	Chat rooms for various purposes (knowledge sharing & other personal topics)
Donut	100+	Meeting new people through randomize choice of participants
Zoom	130+	Meetings for knowledge sharing, passions session and thematic sessions
Kahoot!	70+	Quiz tool

Table 1 - Virtual collaborative tools engagement

3. RESULTS

When the pandemic started, we used different communication tools between employees, which led to the development of the company's social network.

Table 1 presents usage of different utilized tools and what is the main purpose for each of them.

Achieved levels of employee engagement were reminiscent of large yet intimate team building in a dream location for people bonding.

As a result of constant collaboration and communication among employees at various thematic meetings, sessions, Slack and MS teams channels, an inter-company social network has been profiled.

Emerge of the internal social network brought various benefits to the employees, and consequently to the work culture and the sense of belonging even though people were distributed.

We periodically measured the satisfaction and interest of employees [10] and therefore pivoted the offer of existing activities and introduced new one's. For example, as a brand new event, introduced passion sessions at the explicit request of engineers who wanted to connect with a broader circle of participants by demonstrating their hobbies, achievements and ideas.

This network-enabled team-mates to be together and updated yet not all the time dependant. It empowered more communication through conference calls and influenced more knowledge, know-how documents and other files via SharePoint groups.

- 80% of total communication was generated on Slack. Participants could be up to date with news and posts, yet their constant engagement wasn't required;
- 10% of overall communication was through conference calls using MS Teams. Morning standups and weekly calls were the main places for gathering while audio and video chatting on different topics, from sharing passions and valuable knowledge to attending the online party; and
- 10% of all communications can be sorted in type "other". The main types of these communications were written and included exchanging emails, sharing various documents on share points (presentations, videos, educational materials, courses, books etc.)

The successful results in advancing the communication between co-located teams and achieving a goal: to give people a sense of belonging and stay loyal to the company even when there was an opportunity to work anywhere on the planet, we owe to an Agile way working. The constant need to adapt to human needs and listen to the signals they sent us during the pandemic helped us form different personalised approaches according to different personality types, requirements and want; all this has allowed us to reach people and make a strong bond.

Table 2 presents a mix of different employee seniority needs and their competition. People who have felt more comfortable being involved and socialising more intensely in a work environment have retained this trait. Therefore, their involvement in all the mentioned activities was above 70% regarding all regular sessions. Also, people who sporadically participated in company initiatives and gatherings before the pandemic continued to be active in interesting content. On average, attended half of the regular sessions, about 50% of activity was marked. In the end, there is a third group, which we call lone wolves, which were sporadically included in only 20% of the sessions.

	Type of engaging sessions								
Employee Seniority	Weekly Conference calls	Virtual parties	Knowledge sharing sessions	Passion Session	Donut random meetings	Daily stand-ups	Slack chat rooms	Kahoot Quizzes	Zoom Calls
Junior engineer (0-3)	80%	90%	60%	70%	70%	50%	70%	70%	70%
Medior engineer (4-7)	50%	40%	50%	40%	50%	70%	20%	50%	50%
Senior engineer (7+)	20%	10%	20%	10%	10%	10%	20%	0%	0%

Table 2 - Distribution of employees according to motivation to participate in social network and collaboration

This trend did not deviate much from their pre-pandemic behaviour. Still, they could also passively follow the events on the channel by indirectly involved through liking, post-reading, voting etc.

4. BENEFITS

After conducting the results of employee engagement sessions, their visits, and individual involvement in communication and collaboration with other colleagues through the Slack chat group, we have determined that the group of active participants on thematic sessions grew by 50% from the moment of their implementation.

People whose interests were triggered by professional and personal topics attended almost 80% of the overall number of the sessions. A minority of these participants skipped sessions due to a lack of time or periodically overlapping the meetings. People whose interests were triggered by only personal or professional topics increased the number of visits to this specific session by 50% compared to the holidays before their introduction. Their communication after sessions also continued on dedicated knowledge sharing channels or other open format chat rooms for employees.

Feedback from anonymous surveys we conducted upon ending the pandemic showed that people noticed an advancement in their social skills and interactions with other people. Also, they shared that knowledge base built from technical educational sessions and channels for discussions on technical topics allowed them to advance their professional skills and work on new skills. This became a place for getting free training and top-notch experience from practice.

From the organisational point of view, we have learned that there is no one-fits-all approach to successful people engagement. We have managed to unify the distributed teams from 10+ countries worldwide; social isolation was banished, the distance was no longer a topic that bothered our employees.

5. CONCLUSION

Considering the results of people engagement during a pandemic, we can conclude that face to face contact is essential for people to stay connected, but it's not crucial. It has become apparent that internet-based communication through many collaborative tools while having mediums who connect people has made a significant impact regarding innovation on the way of work.

Yet our research showed that people interactions could be as effective and successful as when all employees spent 100% of the work time on-site with colleges. With dedication and special attention to developing exceptional tailor-made solutions regarding individual requirements and personality types, we achieved results that reveal that people have also reached higher levels of connectivity in personal and professional terms than before the pandemic.

The thesis of productive work from home, while having a sense of belonging and still feeling work culture, has proven favourable. This leads us to further think about the future of work, which seems to be hybrid from this point of view. The fact that teams must come together to solve grand challenges, regardless of geographical or disciplinary separations, will still be a requirement for successful delivery of various software solutions.

Using a face-to-face model is essential when establishing trust within the team. However, more research is needed to determine "clear hybrid work mode" and the best distribution of virtual and face-to-face work required to achieve the best possible results. The probability is high that there will not be a "one-size fits all" solution when applying the hybrid model in different organisations. The most crucial aspect will be to have high levels of agility to pivot quickly and make tailor-made solutions in line with the company's needs, team, individuals, and the global situation expected to be highly variable.

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SOFTWARE SYSTEM FOR SIMILARITY DETECTION IN THE PICOCOMPUTER ASSEMBLY PROGRAMS

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Abstract:

This paper tackles the problem of plagiarism in an academic environment with an emphasis on the detection of similarities between the source codes from student assignments in the programming courses. The detected similarity in these codes greatly helps a human expert to bring the final decision on which codes are plagiarised and to which extent. Since the manual comparison of the source codes is a tedious task, the system for automatic detection of similarities in the assembly programs written for the *picoComputer* architecture is envisioned and implemented. It relies on the application which first performs the scanning and tokenization of the source codes. The pair-wise similarity detection is carried out by the *Greedy String Tiling* algorithm upgraded with the hash-based *Karp-Rabin* modification. A convenient GUI is also provided for efficient communication for the users and the choice of necessary parameters. Two different approaches are pursued in the testing and evaluation of the system. The first test set consists of a starting program with several versions with intentional modifications to simulate plagiarism. The second test set represents a real workload which comprises 250 real source codes from the student assignments. In both cases, the system demonstrated good efficiency.

Keywords:

plagiarism, similarity detection, *picoComputer* architecture, tokenization, *RKR-GST algorithm.*

INTRODUCTION

Nowadays, information and knowledge are easily and widely accessible more than ever, either in paper form or in various electronic forms on the Internet. It is one of the reasons for increasing evidence of unethical conducting in producing different kinds of work (books, papers, source codes, etc.), partly or entirely, and presenting some others' work as own [1]. In order to fight against plagiarism, various tools are developed and exploited to detect the similarities of the submitted works, such as JPlag [2] and Moss [3] for source code similarity detection, or TurnitIn iThenticate [4] for text-based plagiarism.

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In an academic environment, the problem of plagiarism is extremely important and sensitive. Such a practice directly and adversely affects the regularity of acquiring academic diplomas and positions. In the university teaching practice, there is an apparent need to check for the plagiarism of the students' final thesis, homework, assignments, projects, etc [5]. This paper deals with the problem of similarity detection of the students' source codes written to fulfil their assignments in the programming courses. There are several malpractices that students conduct in such cases. Some of them take parts of the code or the entire code from the online sources. However, the students not rarely tend to copy the works of their colleagues, as exact solutions of the appointed problems in student assignments cannot be always found online. Some of them perform lexical and structural modifications in the code intended to hide the plagiarism from the examiner. We had in mind all those scenarios during the development of this system.

It is worth mentioning that, in this context, a similarity of the two codes does not necessarily imply plagiarism. Namely, especially in the first-year programming courses, during solving the appointed problems less experienced students frequently apply the templates and ideas recommended by their teachers. Consequently, a certain level of code similarity can be expected and allowed to some extent. Also, if a part of the project is already implemented and the students are supposed to build upon it, a similarity is inevitable. Therefore, extreme caution is necessary and the software tools for similarity detection only raise some kind of indication about possible plagiarism. The final decision of whether some work is plagiarised or not is always brought by a human examiner [6].

For the purpose of exposing the concept of low-level programming in the introductory programming course at the University of Belgrade, School of Electrical Engineering, the students are taught to write the programs in the assembly language for an educational hypothetical architecture – *picoComputer*. It imposed a need for an appropriate software system for similarity detection of the source codes submitted as homework solutions. Such system is based on the *Greedy String Tiling* algorithm for similarity detection augmented with *Karp-Rabin* modification (*RKR-GST*). The system is successfully implemented and evaluated.

Following this introduction, the second section presents a brief overview of the *picoComputer* architecture, to have an impression of the complexity of demands for the system to fulfil.

The third section describes the structure of the similarity detection application and the GUI along with some implementation details. After that, the system is evaluated by performing some representative tests, and the results of the evaluations are analyzed in the fourth section. Finally, the paper concludes with a summary of the work done and a proposal of the future work.

2. THE *picoComputer* ARCHITECTURE

The educational computer architecture *picoComputer* (*pC*) is developed by prof. J. Dujmović in 1989 [7]. The goal was to conveniently introduce the students at the School of Electrical Engineering to the basic principles of the computer architecture and programming in an assembly language. Being a minor part of an introductory course, the architecture was quite restrictive, as implied by the prefix *pico*.

pC is a 16-bit machine with the three-address instruction format, as an instruction consists of the operation code (4-bit) and up to 3 operand fields (4-bit each – one bit for the addressing mode and 3-bit for the address). The instructions are either one-word (16b) or two-word (32b). The main memory of 64K 16-bit words is logically divided into the fixed area (0-7) and free area (rest of the address space). All addresses are 16-bit long. The fixed area accommodates only directly accessible data, while program and indirectly accessible data reside in the free area. There is a system stack that occupies the top of address space and grows downwards. The layout of the main memory address space is shown in Figure 1.

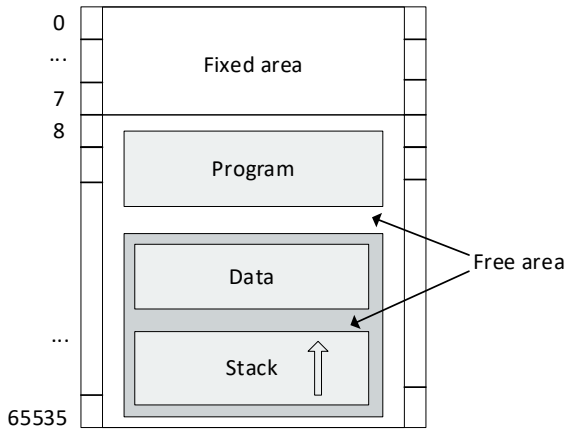

Figure 1 – The main memory address space.

In the *pC* architecture, the programmer can use three memory addressing modes:

1) *Direct memory addressing* – an operand resides in the fixed area, as only locations 0 to 7 can be addressed with 3-bit address;
2) *Indirect memory addressing* – the address of an operand resides in the fixed area, while the operand itself can reside anywhere in the main memory because of the 16-bit address;
3) *Immediate addressing* – an operand is a 16-bit constant found in the second instruction word.

The instruction set of the *pC* assembly language encompasses four typical groups of instructions:

1) *Data transfer instruction* (MOV) – enables the one-word memory-to-memory transfer or loading the constant to memory, or copying a contiguous memory block of data from source to destination, as well;
2) *Arithmetic instructions* (ADD, SUB, MUL, DIV) – enable the basic four arithmetic operations (addition, subtraction, multiplication, division);
3) *Control instructions* – there are three subgroups: conditional branch instructions (BEQ – condition is equality of the two operands, and BGT - condition assumes that the first operand is greater than the second), subroutine handling instructions (JSR for a subroutine call and RTS form a return from subroutine), and instruction for ending the program execution (STOP);
4) *Input/Output instructions* (IN, OUT) – enable the communication of a user and the program – input data entry from the keyboard and display of output data on the monitor.

There are also two assembler directives for defining the symbolic constants and determining the layout of the program in the memory address space.

3. THE SIMILARITY DETECTION SYSTEM

The system consists of two components [8]:

- the command-line similarity detection application implemented in *C++*,
- graphical user interface (GUI) implemented in *Java*.

The flow diagram of activities within the implemented system for similarity detection of the source programs written in the *pC* assembly language is presented in Figure 2.

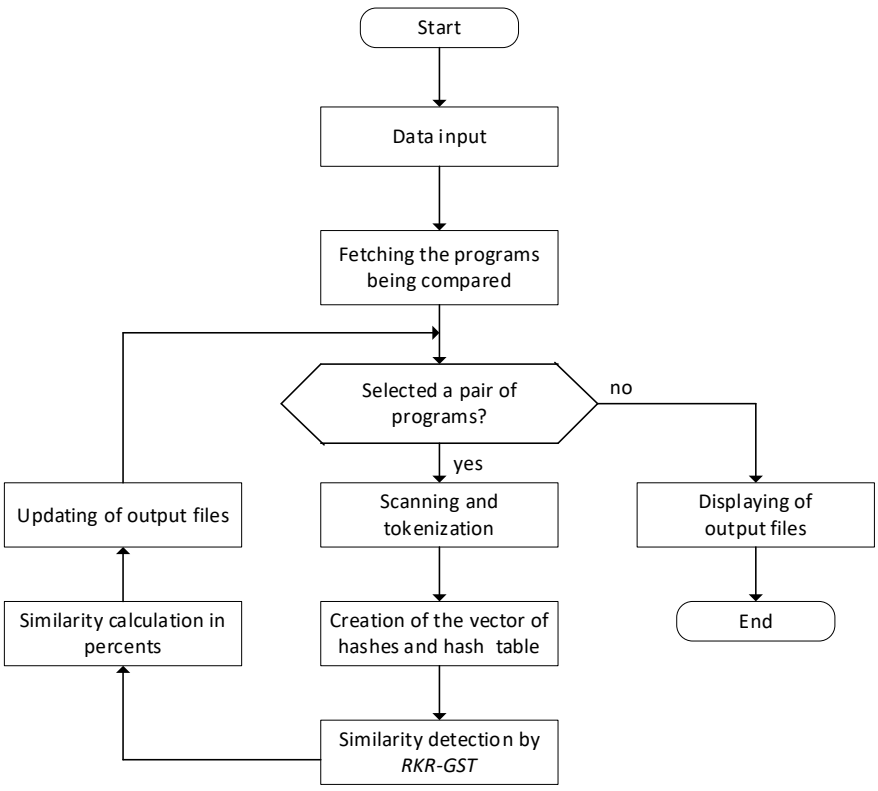

Figure 2 – The similarity detection system flow chart.

3.1. THE SIMILARITY DETECTION ALGORITHM

The algorithms for similarity detection usually apply a range of different approaches (strings, tokens, parsing trees, dependency graphs, various metrics, etc.) [9]. In an academic environment, a lower level of detection is regarded as effective since the functional similarity is quite expected in the student source codes. Also, those methods are much more effective in the case of large code repositories, which is common in an academic environment Therefore, in comparing the student assignments the similarity detection techniques are usually based on tokenization and string matching. A representative and widely used algorithm which relies on these two concepts is the *Greedy String Tiling (GST)* algorithm [10].

This algorithm performs searching for matchings in the two strings. It was firstly applied for DNA sequences matching, but also proved viable for the source code plagiarism detection, as well. It considers only matching of the sequences of the length no less than the MML (minimum matching length). The one-to-one matching is guaranteed and changing the positions of the matched subsequence would not affect the detection. The longer matchings are favored over the shorter ones since they are considered as better indicators of similarity.

The *GST* consists of the two phases which are executed iteratively until no one new matching longer than MML can be found. It incurs rather significant time complexity between $O(n^2)$ and $O(n^3)$. In order to decrease the time complexity of the *GST* algorithm, the *Karp-Rabin* modification is used which reduces the time-consuming character-based matching by the use of hashing. The rolling hash function calculates the hashes of substrings, and substrings with the same hash value are matched. This algorithm is known as *Running Karp Rabin Greedy String Tiling (RKR-GST)* [11].

3.2. THE SIMILARITY DETECTION APPLICATION

The application compares the similarity for each pair of files with the source codes written in the *pC* assembly language from a given data set. It is implemented in the *C++* programming language under *Linux Ubuntu* operating system.

The similarity detection is carried out in three phases:

1. Scanning and tokenization of a source program;
2. Hashing;
3. Running of the *RKR-GST* algorithm (with some potential optimizations).

The token set is based on the *pC* assembly language instruction set. It consists of 15 different tokens. Twelve tokens are based on instructions, one token for each instruction. Three additional tokens are introduced to model the labels and *pC* assembly language directives. The token set is chosen to balance both robustness to source code modifications and the precision of the system.

Phase 1: For the scanning process, the main class is *Scanner* with its methods scan (which scans an entire input file) and *scanLine* (which is called from the *scan* method for each text line of the input file to scan it).

The *scanLine* method firstly eliminates every blank, non-*ASCII* character (when writing in *Notepad*, especially on *Windows OS,* so-called *BOM* characters are inserted), as well as the comments from the entry text line. Then, the presence of the label at the beginning of the filtered line is checked. If the label exists, a new token is inserted into the token list which represents the output of the scanning process. Finally, the method tries to match the rest of the text line with some of the regular templates (*pattern, regex*). In case of a successful match, an appropriate token is added to the token list. One token from the token list is added for each regular expression.

Token and *TokenList* are the classes that represent the token and token list items, respectively. The T*oken* class contains appropriate member fields for token identification, for its location in the original file, and for keeping whether the token is marked or not. The *TokenList* class represents the list of tokens generated in the tokenization of one file, and such a list is used as one of two input strings in the *RKR-GST* algorithm. This class also contains the member fields related to hashing. The token list is implemented as a vector (*vector* type in *C++ STL* library) of pointers to objects of the *Element* class which, along with the pointer to the corresponding object of the *Token* class, contains also its ordinal number in the token list.

Phase 2: After the scanning and creation of the token lists for both programs are completed, the static *createHashesForTokenList* method of the *KarpRabinGST* class is called. It is a wrapper around the *fillHashes* method of the *TokenList* class. This method is responsible for generating the hashes of all consecutive substrings of the MML length for the tokenized program. The rolling hash function is used for this purpose. The chosen value of the base is 17 since it is the first prime number higher than the number of tokens (15).

During the generation of the hash values, they are also included in a vector of hashes and in the *map* hash table. These two structures are the member fields of the *TokenList* class and they have a role in the execution of the *RKR GST* algorithm. The *map* hash table is organized as an *unordered_map* structure from the *C++ STL* library. In this structure, each hash is connected with a vector of initial positions of all substrings corresponding to that hash value.

Phase 3: After the vector of hashes and the hash table for tokenized representations of both files under comparison are created, the static *runGST* method of the *KarpRabinGST* class is called. The input arguments of this method are the token lists for both files, the accuracy level of the similarity detection (the optimization level of the algorithm), and the value of MML. The output of the method is the vector of pointers to the objects of the *Match* class which contains the information about one matched substring (indices of the first substring token in the token lists for both files and the number of tokes in the matched substring). This method contains the implementation of the *RKR-GST* algorithm itself.

3.3. THE GUI SUBSYSTEM

For the purpose of the interaction with users, a Java application in Eclipse development environment is implemented using Java SE11. It is packed in the .jar file in order to enable the execution independently on the platform used. The appearance of a part of GUI is shown in Figure 3.

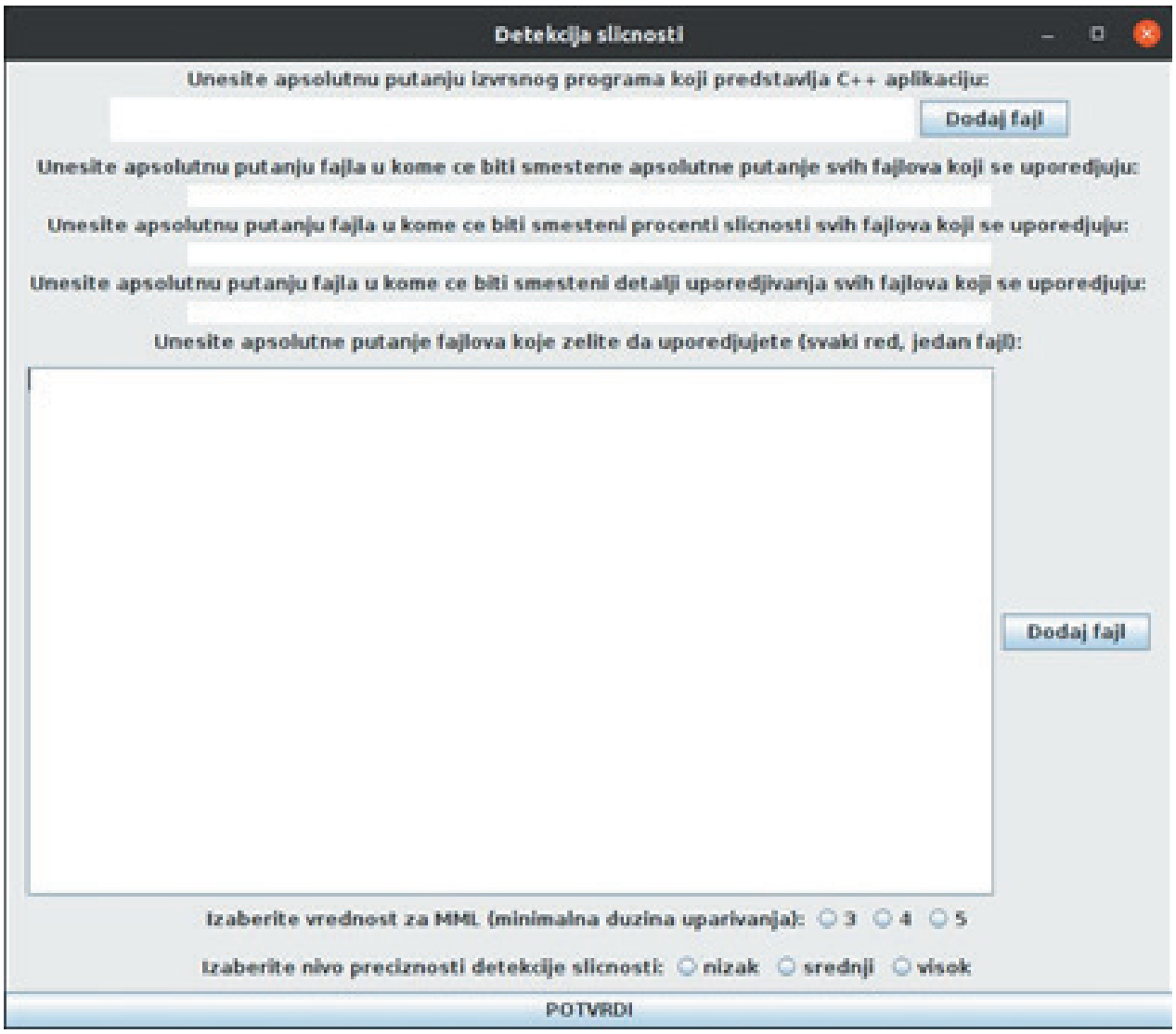

Figure 3 – An example of GUI.

It can be seen that a user should fill several fields and choose some options before starting the execution of the similarity detection algorithm. The first field requires the entry of an absolute path to the execution file of the *C++* application. The *JFileChooser* GUI component enables the choice of the execution file. Click on the *Dodaj fajl* button opens a dialog box where the desired file can be found and chosen or the path to the file can be manually entered.

The next three text fields are automatically filled with the directory part of the execution file path if it is selected using *Dodaj fajl* button. These three fields are used for entering absolute paths of: a) all files which should be checked for possible similarity, b) the file which represents the main system output, and c) the file which presents detailed information about the results of the similarity detection.

Below four text fields, there is a text area (*JTextArea*) where a user enters the absolute paths of all files (one file per line of entry) meant for similarity detection. This entry can be either manual or by using open dialog initiated with a click on the appropriate button.

Besides that, the user has to select the value of MML, one of the basic parameters of the *RKR-GST* algorithm. Only three values (3, 4, 5) are offered since a lower value would lead to some random matchings, while a higher value would be too restrictive having in mind that student *pC* assembly programs are relatively short. Finally, a level of precision in similarity detection must be chosen.

After all parameters and files names are specified, the execution of the *RKR-GST* algorithm is started by clicking the button on the bottom of the frame.

The main output result is stored in a file that contains the percentage of similarity for all pairs of files ('each with each') submitted for the similarity detection. An additional output result is a file with information about the token set used for tokenization in the *RKR-GST* algorithm, the starting positions of all matched subsequences in both files, and their lengths. The result of matching is provided from each pair of files.

4. TESTING OF THE SYSTEM

The system for similarity detection was tested using two different data sets:

1) Manually created set of the testing examples (simulation of plagiarism);
2) Real data set consisting of 250 student assignments.

In the first case, starting with the reference assembly program *prog_v0.pca*, three new programs, semantically equivalent to the reference one, are created. The intentional lexical and structural modifications are introduced in these three versions in order to hide plagiarism. A different time is spent for these modifications intended to deceive the system, so one hour was needed for *prog_v1.pca*, two hours for *prog_v2.pca*), and four hours for *prog_v4.pca*. Table 1 presents the results of the simulation for the given MML values and a high level of detection precision.

Comparison		Similarity (%)		
First program	**Second program**	**MML = 3**	**MML = 4**	**MML = 5**
prog_v0.pca	*prog_v1.pca*	87.7551	81.6327	73.4694
prog_v0.pca	*prog_v2.pca*	69.0909	52.7273	38.1818
prog_v0.pca	*prog_v4.pca*	53.913	33.0435	26.087
prog_v1.pca	*prog_v2.pca*	78.1818	72.7273	58.1818
prog_v1.pca	*prog_v4.pca*	59.1304	48.6957	27.8261
prog_v2.pca	*prog_v4.pca*	83.4646	83.4646	77.1654

Table 1 - The results of the plagiarism simulation.

Group	Similarity (%)									
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Group 1	0	4	37	123	100	31	4	1	0	0
Group 2	0	6	47	109	99	33	6	0	0	0
Group 3	0	8	46	114	95	30	6	1	0	0
Group 4	0	7	55	110	81	35	12	0	0	0
Group 5	0	1	22	108	111	48	7	3	0	0
Group 6	0	3	46	122	85	36	4	4	0	0
Group 7	0	2	25	96	115	49	11	2	0	0
Group 8	0	6	53	103	95	36	7	0	0	0
Group 9	0	3	48	125	87	34	1	2	0	0
Group 10	0	1	21	108	114	47	7	1	1	0
Total	0	41	400	1118	982	379	65	14	1	0

Table 2 - The results of the testing on a real data set

It can be seen from the table that the similarity scores are higher in the consecutive code versions. Differences between versions 0 and 1 are basically in the lexical changes and the RKR-GST algorithm can mainly detect them. The high similarity of versions 2 and 4 can be explained by somewhat fewer modifications done in the last two hours. Because of the simplicity of the pC assembly language, the number of possible modifications is limited. For MML = 3 the similarity percentage between the original and final version exceeds 50% which evidences that although the significant success in hiding the plagiarism can be achieved in four hours, it is still insufficient to fully remove the doubt about the possible plagiarism.

In the case of the real data set, it was not known in advance which programs were plagiarised and which are not. The data set of 250 student assignments is grouped into 10 groups (25 assignments per group). The comparisons on similarity are performed for each pair in a group (300 comparisons per group). Obtained percentages of similarity are classified into 10 ranges (10% each). Table 2 presents the obtained results for MML = 3 and a high level of detection precision.

It is evident that the percentage of similarity in several groups is relatively high, which raises the doubts about plagiarism. These are candidates for more careful manual examination by the instructor.

5. CONCLUSION

Contemporary information systems and wide accessibility to various kinds of knowledge have made the possibility of plagiarism easier than ever. Often some students in fulfilling their assignments cannot resist using the results of others' work, especially in the programming courses. In order to detect the similarities of the source codes written in the *picoComputer* assembly language, an appropriate similarity detection system is developed at the University of Belgrade, School of Electrical Engineering. The application written in *C++* for finding the similarities is based on the well-known *Greedy String Tiling* algorithm. In order to decrease its time complexity, the algorithm is extended with *Karp-Rabin* modification based on the rolling hash function. The GUI written in *Java* is also supplied for choosing the input data set and flexible choice of parameters. The system is successfully tested using two data sets: artificially simulated plagiarism of different levels in an example program and real data set consisting of 250 student assignments from an ongoing university course.

There are several avenues for prospective future work. By modification of the front-end part (scanning in the first phase), this system can be adapted for similarity detection in some other language. Also, the system is quite flexible and can be ported to a different platform (e.g., Windows). Finally, with an aim to increase its precision, some other token set can be envisioned which takes into account not only the instruction mnemonics

but also the addressing modes of the operands. The choice of a token set could be one of the parameters of the system.

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IT APPLICATIONS IN SPORT SESSION

CLOUD BASED MEDICAL PATIENT TRACKING SYSTEM (MPTS) FOR MULTIPLE SIMULTANEOUS RUNNING EVENTS

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Abstract:

Approximately two million people participate in long-distance running races in the United States annually. During marathons, the incident rate is significantly high - 1,01 per 100.000 runners experience cardiac arrest. Reports of race-related cardiac arrests have generated concern about the safety of this activity and the industry in general. The Race Associated Cardiac Arrest Event Registry (RACER) aims to address these issues. The registry collected data from the most recent decade of long-distance running races to determine the incidence, clinical profile, and cardiac arrest outcomes in these events. Ultimately, the system is supposed to provide real time medical information about runners to attending doctors in case of emergency. This paper presents a cloud-based medical patient tracking system (MTPS) to provide real-time medical information about runners to attending doctors in case of emergency.

Keywords:

Cardiac Arrest, Marathons, Patient Tracking.

INTRODUCTION

Big sports events, in general, have a problem monitoring the overall medical situation of events, either in case of emergency or in regular situations. Organizers of such events must be aware of the real time medical status (situational awareness) of all potential patients and medical infrastructure (medical tents, aid stations along the course, EMS – Emergency Medical Service vehicles or transportation to hospitals). [1]

MPTS system architecture proposed in this paper, relying upon the RACER registry [2] , extends the functionality of medical data acquisition to the real-time tracking of medical facilities and critical data on the race event day (medical bed occupancy, number of runners with medical problems and their diagnoses). The proposed MPTS solution shall provide the event organizers with the ability to:

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1. respond to an acute medical event (notify nearest Automated Defibrillator (AED) certified medical volunteer),
2. find patients in treatment at medical facilities along the course,
3. overview of cumulative patient treatments,
4. manage medical volunteers and provide medical licenses background checks.

The original contribution of this paper is the software architecture of the MPTS system designed and optimized for multiple simultaneous running events. The software implementation based on this architecture is already used by numerous running event organizers worldwide.

The proposed architecture is designed to respond to follow major challenges:

1. Provide a comprehensive and intuitive user interface (UI) for medical volunteers without training or minimal training.
2. Support secure medical data governance and medical volunteers' licenses background checks.
3. Ability to provide accurate and real-time data regarding the medical situation at the race (Medical tracking).
4. Prevent system overloading when there are simultaneous running-races events.
5. System reliability and availability in an environment with limited network infrastructure and low bandwidth.

2. EXISTING SOLUTIONS

The patient tracking systems often play a critical role in incidents to facilitate real-time situation awareness, information management, and communication. There are various approaches to solve the above challenges.

Visibility of patient whereabouts for providers and incident commanders across the incident, and certainly the hospital staff, is non-existent after EMS triage, treatment or transportation. Long-term documentation of patient tracking is also problematic with paper-based solutions. This was caused due to EMS's inability to provide an adequate unique identifier to the patient (a barcode or triage card was not suitable). [3] The suggested solution is to utilize a patient's face as an identifying feature.

This approach was interesting but, in our solution overwhelming since runners are already equipped with a unique identifier – their race number (BIB), which is used in our solution.

Some of the information systems did not optimally support incidents. Organizers found challenges with an unidentified patient naming convention, real-time situational awareness of patient location, and documentation of assessments, orders, and procedures.

One solution was to track RFID technology for tracking runners' location and medical facilities utilization. At most events, runners have an RFID tag in their race number (BIB). The systems use RFID technology to perform various tasks: locate patients in different areas and measure patient care times and waiting times.

However, the limitation of this approach was the low quality of acquired medical data. Plane number of injured runners and their location on the course is not enough information for medical directors to make a decision. Information about diagnoses, complaints and treatments could provide more insights, better situational awareness for organizers and support a decision if an event should be cancelled, for instance.

3. SYSTEM REQUIREMENTS

The whole system must fulfil the following base requirement regarding handling runner medical records and providing critical medical information.

The system is expected to be secure in dealing with runners' personal medical information and to be compliant with the healthcare data governance guide. In order to protect injured runners' data and medical records, MPTS keeps all communication between central servers and field devices over secured connections and all data located either on servers or mobile devices at medical facilities is also encrypted. Additionally, anonymization takes place on all medical data on mobile devices, and such data is stored on secured data storage.

The system must be reliable. To address the problem of reliability, we introduced the cloud computing concept and system disconnected functionality. The system is supposed to be fully functional in disconnected mode as it is in connected mode. In case mobile tablets in the field do not have access to the event network, all collected data is stored locally in the device, and it is synchronised as soon as a network connection is established again.

The system is scalable and flexible. MPTS must be configurable and able to adapt to each event's specific requirements. Configuration parameters depend on the event size and type, as well as base system parameters (patient diagnoses, complaints, weather information, attending doctors, number of medical units).

The system is designed to be open and implement an API to provide a way to collect patient data for remote locations regardless of the existing mobile platform (tablets, smartphones, laptops). Since data is synced with the central server in real time, the system can provide info about each medical unit's work overload. Information like this helps event medical service in better medical staff management.

Thus, MPTS will become a central repository of all runners running and medical data that could be used in an emergency.

4. FUNCTIONALITY OVERVIEW

MPTS system provides a real-case solution to automate the processes of:

1. acquire runner relevant medical information before the event,
2. collecting real time runners' medical information on the event day
3. reporting, alerting and notifying about the medical situation on the event day
4. processing, analysis and archiving of those data after the event
5. assists with medical volunteer staffing

MPTS is developed to collect information about patient location, admittance and discharging information and other important medical information from each medical unit (tent, aid station, EMS…) and sync that data with a central system. On the event day, this information is collected through mobile devices.

Real-world applications which are in usage at the moment use Android tablets since their size, weight and screen resolution appears to be the best for medical staff in the field.

On the event side, MPTS provides additional modules:

1. Family Reunion module where family members will be able to get the runner's whereabouts according to the BIB# or runner description. This application could be used by Red Cross staff.
2. EMS module - for tracking EMS vehicles' current status.

Long retention of the patient in each medical unit is also reported. Depending on the time period, the system will send alerts or warnings to a predefined list of event staff.

The central system provides support for two-way communication with medical staff in medical facilities, real time reporting to the event management about all medical parameters (beds occupancy, admitted participant per hour, frequency of diagnoses and complaints,) and notifying and alerting.

Data archiving is performed after the event. The system processes, organizes and synchronizes all event medical information in a central repository. Data stored: runners medical info captured during the event, all needed medical infrastructure - physician, medical staff, medical tents.

Thus, stored data present the medical history of each event, and it could be used for better and faster event organization in the future.

All collected medical data about the runner will be kept as a runner's medical history, which will be available in further events in case of emergency only with the runners' explicit permission.

In order to provide better medical support for the event, MPTS has defined pre-event, event day and post-event procedures:

1. pre-event procedures define event setup and all needed steps to prepare the system to be fully functional on event day. Pre-event procedure implies defining medical infrastructure - medical units, staff, doctors, translators, and other medical related info. In this step event medical history could be used.
2. Event-day procedures cover exact steps for emergency situations: runners checking in, checking out, transferring and transporting.
3. Post-event procedures contain steps that lead to the closure of medical units, data processing, archiving and reporting. [3]

Using the MPTS system, race organizers can understand participants' medical conditions throughout an event based on real-time visualization. MPTS data analysis has the potential to contribute to expanding knowledge on medical care at marathons and large endurance events and to improving resource allocation until predictive models are developed and validated. [4]

The central system is implemented as a web application developed in Microsoft .Net technology with an SQL database as storage in the background.

5. MPTS CLOUD ARCHITECTURE

5.1. ARCHITECTURE OVERVIEW

Relevant medical information is data provided by runners in the pre-event period and medical information collected about the runner during previous and current events. During event registration, runners should submit their medical records and other information estimated as useful in case of an emergency. The solution should provide for a bi-directional information flow. Thus, in case of an emergency, patients' relevant medical information is available to the operating doctor in real time at the event location.

From the system's business logic point of view, medical information is tracked across two main processes. The Medical process provides key data points: patients who required hospital transport, patients in treatment at medical facilities along the course, and cumulative patient treatments. Medical Tracking is responsible for providing data on the number of current patients, the overall utilization of beds, and the total number of patients seen for each medical location.

Since the majority of events take place on weekends and there are events varying in sizes that, in addition, can take place simultaneously across wide geographic areas, the system's workload experience differs temporally (picks are expected during weekends) and raises the issue of distributed data management.

Finally, the true value of the system proves itself in the case of an emergency, which requires the system to be available at any moment of the event - so a backup system must be ready in the case of the main system failure.

Having had all this in mind, we decided to accept a cloud computing architecture for MTPS. This approach allows us to create a scalable system that can process large amounts of distributed data but also can dynamically re-allocate resources as per demand (downgrade during idle periods).

The cloud system allows traffic segmentation and, in general, the ability to distribute traffic over multiple nodes. Traffic can be segmented by location (by event), pre-assigned criteria (user ID, specific IPs,) or load balancer. Cloud architecture is good for the provision of functionality that addresses the problem of collecting real time medical information during the event from the field.

The proposed solution consists of server-side modules and a mobile application. Mobile application is used by volunteers in medical facilities for collecting injured runners' medical data. A server-side application is used for storing and analysing collected medical data, and generating reports, alerts and notifications. Figure 1 depicts the proposed system architecture.

The system design strictly obeys a single responsibility principle: each component implements one set of functionally related features with no overlapping. Such design allows system functionality to be easily spread across different nodes, locations, and networks - so each function has the best chance to survive the failure of a specific server. In case of simultaneous events and large data load, the number of all components can easily be increased, thus contributing to system scalability.

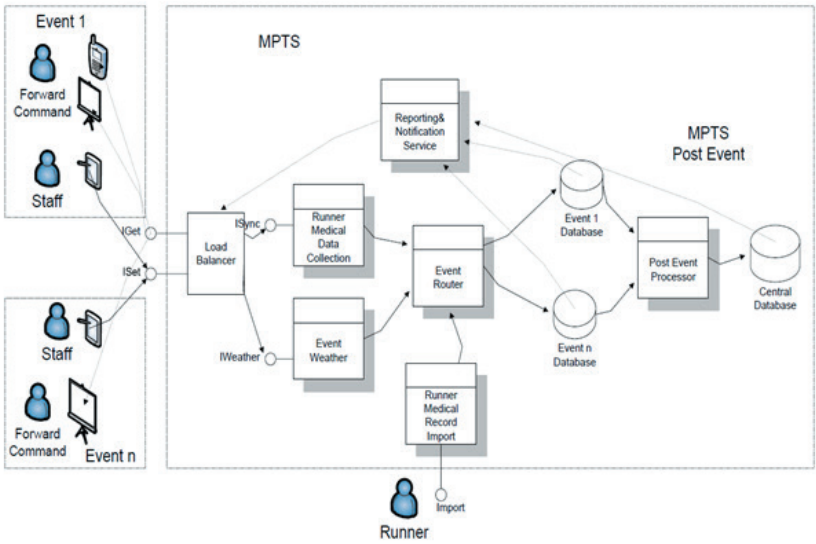

Figure 1 - MPTS Modules

5.2. MODULE'S OVERVIEW

MPTS consists of multiple modules (services) whose functionality is described below.

Runner Medical Data Collection module is designed to collect all medical information on event day. Depending on event size and system workload, the system could be configured to have multiple Data Collection components. This module communicates with mobile applications and synchronizes all the data collected in medical facilities and along the course.

For each medical treatment following data are gathered: runner details, exact time of check-in, complaints and final diagnoses. All details of medical treatment and further transportation are also kept. Figure 2 shows the MTPS medical questionnaire UI.

Event Weather module tracks exact weather conditions on event day. The medical situation at the event is dependent on weather conditions at the course. MPTS is also collecting parameters from third party services which provide accurate weather conditions on event day (temperature, humidity, wind speed…). Weather condition data will be part of various weather-dependent prediction models in future.

Event Router module routes collected medical information into the event's database. Collected information is kept in a separate database for each event.

The processor module processes all collected medical data after the event is finished, and all medical units are closed. Processing is done offline, and collected data is exported from the Event database to the Central Database.

Central Database is a central repository that stores medical information related to all events (i.e., list of diagnoses, runners' complaints, ...). It is also archiving all events' medical history and runners' medical info.

Event specific databases are relational databases that store all event-related medical information history.

Reporting & Notification module provides real time information on the event side, such as bed occupancy in medical units, patient medical information, etc. It also raises notifications about language assistance or alerts and warnings if a patient is waiting for treatment too long or is waiting for transportation. The critical time period for warning and alert levels is event-based. This component also shall be used for two-way communication with medical staff in the field.

Communication between server and client applications implements interfaces described below.

ISet interface

Authenticate - method for authentication and authorization users from the field. By providing credentials, the system determines one of user levels: staff, manager, EMS staff, ARC staff, system admin.

Check In - method through which field staff submit patient/runner check in information: patient personal information (wristband number, BIB number), in which medical unit patient is admitted, in which bad, patient initial complaints, does patient need language assistance and does runner's emergency contact need to be alert. In case elite runners check in, the system automatically notified event management (predefined list of contacts).

Check Out – the method by which check out info is submitted: patient diagnoses, attending doctor info, is

Figure 2 - MPTS medical questionnaire UI

patient discharged or transferred to a medical unit or transported to a hospital.

IGet interface

Get Patient List - return all patients to a specific medical unit (tend or aid station) and patient's statuses (active, discharged, transferred, transported), which bed is occupied at a moment and time period passed from runner check-in (visit duration). Thus, real time bed occupancy information is available.

Get medical record - provide all medical information runner submitted during registration for the event which could be relevant in case of emergency and also all runner's medical history from previous events (if there is permission)

Get patient details - get all patient/runner medical visit info: status, check-in and check-out info.

Get Transferred Patients - return a list of patients transferred to other medical units.

6. CONCLUSION

The proposed architecture is one of the solutions for the MPTS system which is conceived to implement the requirements of the RACER project. The described solution expands the functionality of the medical archive with the ability for real time medical data acquisition and reporting. MPTS became a useful tool for medical staff on running-race events. It is used in real world events, and the concept proves itself to be helpful and valuable for emergency situations. However, the system could be a subject for many improvements in the future.

Further development could be classified into several groups. The first one concerns improving the comprehension and quality of all data acquired by the system. Pre-event data of runners' training and health conditions could be aggregated through integration with most of the existing running gears and accessories in the market - like Nike Plus API. This will give additional insights into the runner's general medical conditions on the event day in case of urgency.

The second one concerns specific pace related data. Additional information could be collected on race day based on runner pace (time is measured each 5km) through integration with timing technology companies.

MPTS has been in use for some time. During the usage, system generated a large amount of data. Challenge will be to utilize those data for the prediction and management of medical emergency situations. For example, race organizers could introduce telemetry for the highly risky runners to monitor them continuously on the event day.

Finally, an additional effort should be made for improving data security and runner privacy by implementing formal medical data governance standards (HIPAA, GDPR) and other security standards.

7. ACKNOWLEDGEMENTS

We want to acknowledge the help of the company EMOS1 LLC, a leader in developing systems for supporting large event organizations, which is in charge of developing the MPTS system.

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DYNAMIC STABILITY ASSESSMENT FOR MONITORING RECOVERY FROM ACL RECONSTRUCTION A HANDBALL CASE STUDY

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Abstract:

Efficient postural balance/stability reduces the risk of injuries and contributes to motor performance in many sports disciplines. Handball is one of the most challenging sports for the knee joint. Continuous demands in strength and jumping alterations in movements are observed among athletes who have suffered anterior cruciate ligament (ACL) injury. In handball, as a typical "contact" team sport, these demands are enhanced with tactical and technical elements that make it more challenging in terms of dynamic stability. The scientific literature provides scarce information regarding the best clinical practices for rehabilitation programs or standardized functional and clinical evaluation criteria for resuming the sport after injury, different jumping performance tests have been widely employed to determine the readiness for sports participation after ACL reconstruction.

For this study, a descriptive case study was performed. This single case study involving a male elite handball player presents an example of how OptoJump Next Drift Protocol can be beneficial in monitoring the recovery process after ACL reconstruction. After the two ACL reconstructions, two Drift Protocol tests were conducted and a comparison between the two tests during the rehabilitation process indicates improvement in multiple measures. After the first test, according to the results, adjustments were made in order to balance the performance of both legs. At follow-up, 2 years after the second ACL reconstruction, the subject did not suffer any serious injuries in the meantime and had been pain-free since completing the rehabilitation program while continuing to participate in top-level handball.

Keywords:

Handball, ACL recovery, Dynamic stability, Drift protocol.

INTRODUCTION

Balance is an individual ability to maintain the line of gravity within the base of support. It is an essential ability for performing daily life motor functioning. Balance is often classified as static or dynamic, whereas static balance is seen as the ability to make adjustments to maintain posture while standing still, and dynamic balance is the ability to make necessary adjustments while the center of gravity and the base of support are in motion [1]. Efficient postural balance/stability reduces the risk of injuries and contributes to motor performance in many sports disciplines [2, 3]. Balance exercises are a key component of improvement in

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dynamic stability in many team sports such are basketball, handball, football, or rugby, where great demands on a player's ability to change direction when running were placed [4, 5]. Understanding of physical capacities that contribute to agility performance in team sports has shown two components: leg power [6, 7], and dynamic stability [8, 6]. In handball, as a typical "contact" team sport, these demands are enhanced with tactical and technical elements that make it more challenging in terms of dynamic stability. Furthermore, these two physical capacities influence agility, but they also interrelate with each other. Handball is one of the most challenging sports for the knee joint. Continuous demands in strength and jumping alterations in movements are observed among athletes who have suffered anterior cruciate ligament (ACL) injury. Although handball is a sport with a lot of "rough" contact between players from opposing teams, prospective studies aimed at investigating the incidence and risk factors of handball injuries are scarce. However, there is evidence that ACL injury is one of the most common and severe injuries among handball players [9]. Since standard static balance tests are not sensitive enough to detect the subtle changes in the proper functioning of postural control, we decided to use the dynamic test OptoJump Next System (Microgate, Italy) which has been proved to be valid and reliable [10]. OptoJump Next Drift Protocol is a test developed for verifying an athlete's dynamic stability. Unilateral functional jump tests, such as Drift Protocol, were recommended to examine deficits between extremities after ACL reconstruction [11. 12].

This study aimed to assess dynamic stability after two separate (one year between left and right leg injury) ACL-reconstructions of a rehabilitated elite handball athlete.

2. DRIFT PROTOCOL

The Drift Protocol is a test developed within OptoJump Next System for assessing an athlete's dynamic stability. An athlete needs to perform four jumping tests one after another on one leg measuring his/her displacement (drift) on the vertical and horizontal axis. The dynamic stability in the Drift protocol is expressed as displacement of the jumping point during the execution of 5 consecutive vertical jumps for each of the four tests, as seen in Figure 1.

The sequence of jumps in Drift Protocol is as follows:

- 5 jumps with RIGHT leg and feet PARALLEL to the OptoJump bars
- 5 jumps with LEFT leg and feet PARALLEL to the OptoJump bars
- 5 jumps with RIGHT leg and feet PERPENDICULAR to the OptoJump bars
- 5 jumps with LEFT leg and feet PERPENDICULAR to the OptoJump bars

The execution of 5 consecutive jumps in a given order requires adequate motor control and efficient postural stability. These factors are very important for jumping performance and they determine a good score in this test.

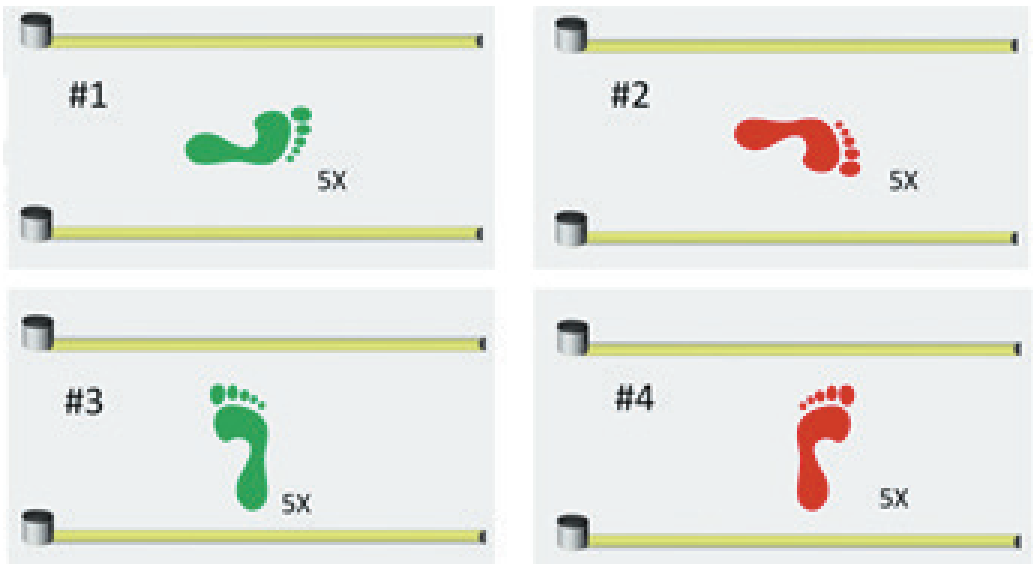
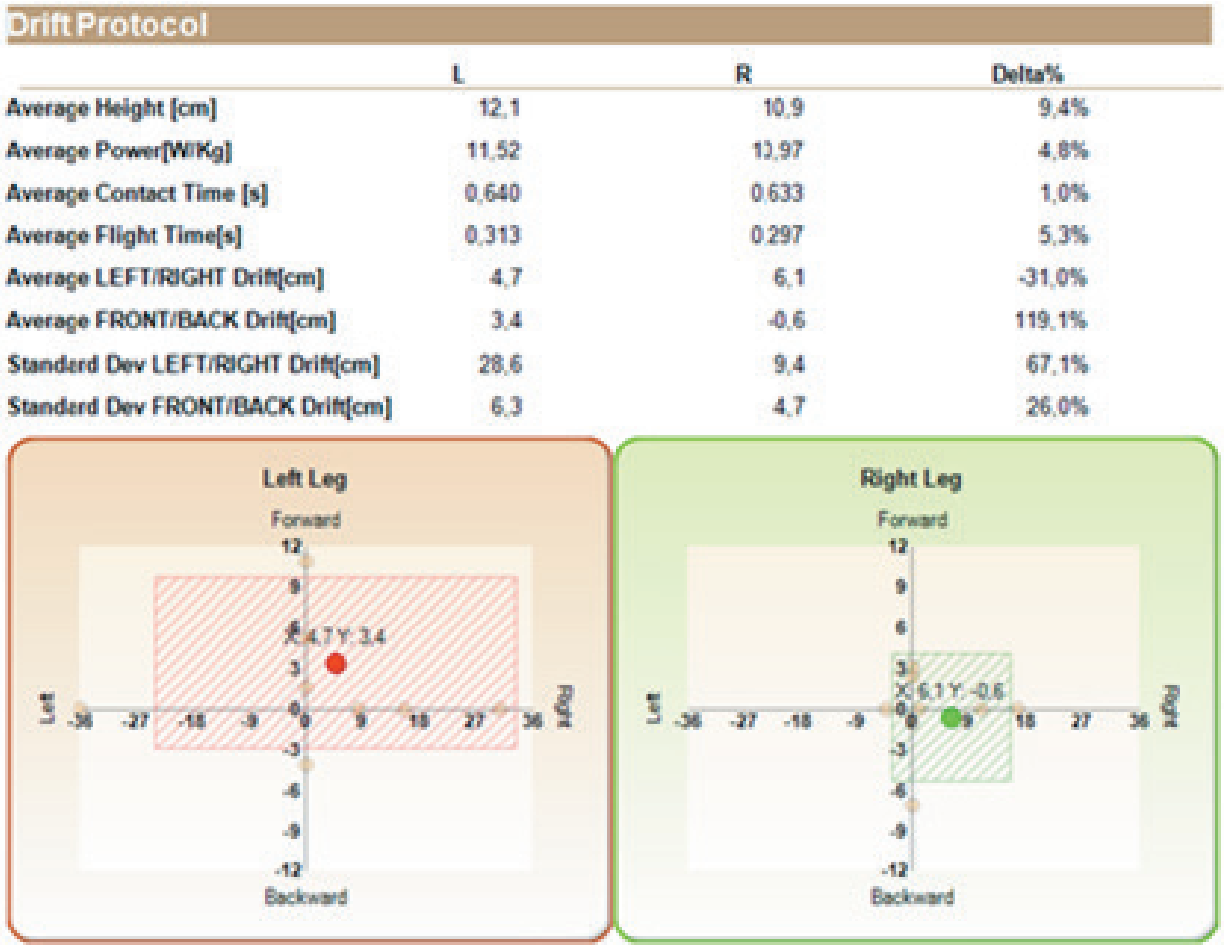


Figure 1 - Order of jumps in Drift Protocol



Drift Protocol

	L	R	Delta%
Average Height [cm]	12,1	10,9	9,4%
Average Power[W/Kg]	11,52	12,97	4,8%
Average Contact Time [s]	0,640	0,633	1,0%
Average Flight Time[s]	0,313	0,297	5,3%
Average LEFT/RIGHT Drift[cm]	4,7	6,1	-31,0%
Average FRONT/BACK Drift[cm]	3,4	-0,6	119,1%
Standard Dev LEFT/RIGHT Drift[cm]	28,6	9,4	67,1%
Standard Dev FRONT/BACK Drift[cm]	6,3	4,7	26,0%

Figure 2 - Example of standard output for Drift Protocol with different covered areas for left and right leg [13].

Each jump is displayed as a yellow dot; the two large red and green dots (left and right) represent the athlete's tendency to move in a certain direction, whereas the dotted triangle indicates the 'stability area', as seen in Figure 2.

The larger the displayed area, the more has the athlete drifted (moved away from the point of origin) when landing, and consequently his/her dynamic stability can be seen as lower [13].

3. METHODS

For this study, a descriptive case study was performed. This single case study involving a male elite handball player presents an example of how OptoJump Next Drift Protocol can be beneficial in monitoring the recovery process after ACL reconstruction.

3.1. THE SUBJECT

The subject was a handball player of the National team of Serbia. The subject suffered two ACL injuries (ruptures), the first one occurred when he was 18 years old on the left knee, and the second one a year later on the right knee. The first ACL reconstruction took place in November 2016, and the return to play happened at the beginning of August 2017. The second injury occurred in the September of 2017 followed by another ACL reconstruction in the same month. The second return to full training and competition was at the beginning of August 2018. After both ACL reconstructions subject was put through a controlled rehabilitation exercise program for the knee joint stabilizing muscles and gradual strength training. It is worth noting that his dominant leg was left since leg dominance appears to play a role in the etiology of ACL injuries, i.e. female recreational soccer players and skiers are more likely to injure their non-dominant leg, whereas males tend to injure their dominant leg [14, 15, 16]. Although an ideal method to

Measure	Drift Protocol 1			Drift Protocol 2		
	Left	Right	Delta%	Left	Right	Delta%
Average height[cm]	16.2	26.0	-60.3%	19.5	27.5	-41.3%
Average power[W/Kg]	16.17	23.44	-44.9%	18.25	25.46	-39.5%
Average contact time[s]	0.450	0.416	7.5%	0.418	0.389	7.1%
Average flight time[s]	0.364	0.460	-26.7%	0.398	0.473	-19.0%
Average LEFT/RIGHT drift[cm]	1.0	-0.5	151.2%	0.7	4.0	-519.2%
Average FRONT/BACK drift[cm]	-1.6	-1.9	-23.8%	-1.4	-6.0	-319.3%
Standard deviation LEFT/RIGHT drift [cm]	8.9	25.0	-180.9%	5.0	22.0	-343.6%
Standard deviation FRONT/BACK drift [cm]	14.4	22.7	-58.0%	16.6	30.9	-86.3%
Area [cm^2]	511.2	2268.4	-343.8%	329.8	2725.7	-726.5%
Power Density [$W/Kg/dm^2$]	3.16	1.03	67.3%	5.53	0.93	83.1%

Table 1 – Drift protocol 1 and 2 parameters for the left knee rehabilitation monitoring

determine leg dominance is still lacking, we agreed to define his leg dominance as the leg he would use when required to push off the ground and then throw a ball, as previously described in handball [17]. The exercise program effects and rehabilitation process was monitored by Drift Protocol test on two occasions after both ACL reconstructions.

4. RECOVERY MONITORING

4.1. THE FIRST ACL RECONSTRUCTION RECOVERY MONITORING

After the first ACL reconstruction on the left knee, in November of 2016, the subject underwent a controlled rehabilitation exercise program for the knee joint stabilizing muscles and gradual strength training.

The first control/recovery monitoring by Drift Protocol testing was performed on 25 April 2017 and the second one on 17 June 2017. The results of the two tests are compared in Table 1.

As shown in Table 1, the standard output report of Drift Protocol consists of 10 measures to consider. A simple comparison between the two tests indicates improvement in several measures: average jump heights for both legs were higher on the second testing (left – from 16.2 to 19.5, right from 26.0 to 27.5 cm); lower difference between the jump heights for both legs (Delta 60.3% to 41.3%); average power output increased for both legs (left – from 16.17 to 18.25 W/Kg, right – 23.44 to 25.46 W/Kg); average contact time with surface decreased and average flight time increased for both legs.

However, some measures have shown a certain inconsistency. Namely, the average left drift has improved from 1.0 to 0.7 cm, but the average right drift deterred from -0.5 to 4.0. A similar pattern was noticed in average front/back drift with left leg improvement from -1.6 to -1.4 cm, whereas the right leg drifted from -1.9 to -6.0 cm. Quite the same scenario happened in a measure of 'stability area' which decreased for the left leg from 511.2 to 329.8 cm^2, while the right leg covered a larger area in the second test increased from 2268.4 to 2725.7 cm^2. These findings could be explained with a more focused rehabilitation exercise program for the knee joint stabilizing muscles and strength training of the left leg in comparison to the right leg. After these findings, the physiotherapist continued to supervise the subject's rehabilitation exercise program which was adjusted to a more balanced approach.

Measure	Drift Protocol 1			Drift Protocol 2		
	Left	Right	Delta%	Left	Right	Delta%
Average height[cm]	22.2	18.1	-20.3%	24.7	19.2	22.0%
Average power[W/Kg]	22.17	16.44	-29.7%	24.46	17.97	26.5%
Average contact time[s]	0.370	0.482	26.3%	0.356	0.442	-24.4%
Average flight time[s]	0.421	0.311	-28.7%	0.448	0.396	11.7%
Average LEFT/RIGHT drift[cm]	-1.5	4.6	101.2%	-1.8	3.1	271.2%
Average FRONT/BACK drift[cm]	-6.6	-10.9	-49.8%	-5.7	-10.3	-79.9%
Standard deviation LEFT/RIGHT drift [cm]	9.9	6.2	45.9%	11.7	5.3	54.5%
Standard deviation FRONT/BACK drift [cm]	7.4	27.7	-115.6%	6.0	25.4	-326.6%
Area [cm^2]	295.2	658.4	-76.8%	278.8	541.1	-94.1%
Power Density [$W/Kg/dm^2$]	7.76	2.63	98.3%	8.77	3.32	62.1%

Table 2 – Drift protocol 1 and 2 parameters for the right knee rehabilitation monitoring

4.2. THE SECOND ACL RECONSTRUCTION RECOVERY MONITORING

After the second ACL reconstruction on the right knee, in September of 2017, the subject was put through a rehabilitation process that included an exercise program for the knee joint stabilizing muscles and gradual strength training.

The first control/recovery monitoring by Drift Protocol testing was performed on the 9 of March 2018 and the second one on the 13 of April 2018. Before Drift Protocol testing began, the subject performed a standardized warm-up consisting of basic athletic drills and unilateral jumps that are used in the given testing protocol. The results of the two tests are presented in Table 2.

As detailed in Table 2, a comparison between the two tests during the rehabilitation process indicates improvement in multiple measures: average jump heights for both legs were higher on the second testing (left – from 22.2 to 24.7, right from 16.44 to 17.97 cm); average power output increased for both legs (left – from 22.17 to 24.46 W/Kg, right – 16.44 to 17.97 W/Kg); average contact time with surface decreased (left – from 0.370 to 0.356 s, right from 0.482 to 0.442 s), and average flight time increased for both legs (left – from 0.421 to 0.448 s, right from 0.311 to 0.396 s). Moderate improvements were registered in average front/back drift with left leg improvement from -6.6 to -5.7 cm, whereas the right leg drifted from -10.9 to -10.3 cm. A similar scenario was noticed in the measure of 'stability area' that decreased for both legs (left leg – from 295.2 to 278.8 cm^2, right leg from 658.4 to 541.1 cm^2).

Similar to the results from Table 1, with the left knee rehabilitation monitoring parameters, some measures have shown a certain inconsistency, but to a lesser content. First of all, there was a higher difference between the jump heights for both legs (Delta -20.3% to 22.0%) which can be explained by a fact that the subject has a dominant left leg. Another difference was noticed in one of the drift measures. Namely, the average left drift slightly decreased from -1.5 to -1.8 cm, whereas the right drift improved from 4.6 to 3.1 cm. These findings indicate that the second rehabilitation exercise program for the knee joint stabilizing muscles and strength training of the right leg was an improvement in comparison to the left leg rehabilitation process. Furthermore, at follow-up in October 2019, 2 years after the second ACL reconstruction, the subject did not suffer any serious injuries in the meantime and had been pain-free since completing the rehabilitation program while continuing to participate in top-level handball.

5. CONCLUSION

Although the scientific literature provides scarce information regarding the best clinical practices for rehabilitation programs or standardized functional and clinical evaluation criteria for resuming to the sport after injury, different jumping performance tests have been widely employed to determine the readiness for sports participation after ACL reconstruction [18]. OptoJump Next Drift Protocol, as a test developed for verifying an athlete's dynamic stability, has been proved to be valid and reliable [10]. As detailed above, the perceived benefits of using OptoJump Next Drift Protocol in monitoring the recovery process after ACL reconstruction, were evident. The medical team that was taking care of the subject's rehabilitation program, after the first ACL reconstruction conducted two Drift Protocol tests. After the first test, following the obtained results, adjustments were made in order to balance the performance of both legs. These findings prove to be useful in planning the second ACL rehabilitation program, where the subject achieved more balanced scores in the majority of Drift Protocol measures.

6. ACKNOWLEDGMENTS

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IT APPLICATIONS IN SPORT SESSION

POWER OUTPUT IN RUNNING – ASSOCIATION WITH RUNNING SPEED, ALTITUDE AND HEART RATE

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Abstract:

In endurance sports, monitoring power output is a relatively novel practice that allows endurance athletes to quantify the work they generate during running. Therefore, the first aim of this study is to analyze the power output in the running using an ordinary GPS watch. The second aim of this paper is to investigate associations between the running speed, altitude, heart rate, and power output. The participant (age 35, height 1.87m, weight 80kg) ran continuously on trail paths in a hilly terrain for 45 minutes while wearing Garmin Fenix 3 GPS watch. Heart rate showed an initial increase with a steady rate later in the run. Running speed and power output showed variations, mainly due to an altitude change. Altitude difference showed moderate and significant negative correlation with the running speed ($p < 0.05$), while a large and significant positive correlation was revealed between altitude difference and power output ($p < 0.01$). Both endurance runners and their coaches can use power output to observe running efficiency or assess the load on skeletal muscles, which cannot be achieved by monitoring heart rate or running speed. The presented analysis can help runners recover faster, thus running more often and achieving better results.

Keywords:

Endurance, Accelerometer, Runners, Training, Recovery.

INTRODUCTION

Power output was considered an essential predictor of sports efficiency [1]. The power output was usually assessed on a cycle ergometer to predict maximal anaerobic power or capacity [2] and test force or power-velocity relationship [3]. That way, power output was only crucial for speed and power athletes (e.g., sprinters, jumpers, football, or rugby players, [4]. Moreover, these assessments were almost exclusively performed in laboratories [2], [5], thus limiting the results' practical application.

In endurance sports, cyclists and their coaches first started to monitor power output in Watts (W) to improve efficiency in training and competition [2], [6]. That allowed them to quantify the output of the work they were generating. Contrary to the fans' desires, almost all cyclists rely on power output in their training and competitions.

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One of the most recent examples was noticed on the Tour de France several years ago. Namely, Chris Froome, one of the most successful cyclists in the past decade, was looking in his power-meter while cycling uphill. He did not pay any attention to his opponents sprinting in front of him. Eventually, he could catch up with all of them and win.

In other endurance sports, such as running, monitoring power output is a relatively novel practice that allows endurance runners to quantify the work they generate during running [5]. Power in Watts, generated by a running human, corresponds to an output of the work during some time. So far, runners and their coaches were relying mainly on monitoring heart rate or running speed to quantify training load. However, heart rate only shows the load of the cardiovascular system and not the muscular. In addition, when monitoring the heart rate, a delay of the human system is noticed. It takes several seconds while the cardiovascular system reacts to a change in running speed or an increase in the terrain slope [7]. The heart rate can also be affected by the time of day, anxiety, weather conditions, diet, hydration, and fatigue [8]–[10]. On the other hand, running speed does not provide information on how much effort your body puts in, only the result of that effort! For example, uneven terrain significantly affects running effort, which can not be quantified by monitoring running speed.

Conversely, power output can provide runners with "real-time" information on the running effort. Moreover, power can reflect the metabolic cost of runners' efforts and assess the load on skeletal muscles [2], [11]. With the recent development of light and accurate accelerometers (in the form of foot pods), power output in the running became simple to monitor. Foot-pod comprises a triaxial accelerometer, a gyroscope, and a barometer embedded into a small shoe-mounted chip. Different foot pods (e. g., RunScribe™, Stryd™, or Myotest™) estimate running power and measure distance, running speed, cadence, or ground contact time [12]. A recent study also showed the high reliability and validity of the StrydTM foot pod (www.stryd.com). [13]. However, foot pods can be rather expensive and not easily obtainable. One of the solutions to overcome this issue could be using post hoc analysis from data extracted from an ordinary GPS watch utilized by endurance runners worldwide (both professional and recreational).

Therefore, the first aim of this study is to present a post hoc analysis of the power output in the running using an ordinary GPS watch. The second aim of this paper is to analyze possible associations between the running speed, altitude, heart rate, and power output.

2. METHODS

For this study, Garmin Fenix 3 GPS watch was used (Garmin International, Inc., St. Olathe, KS, USA).

2.1. PARTICIPANTS

The analyzed participant was a recreational runner (see Table 1 for more information).

2.2. EXPERIMENTAL PROCEDURES

Before the run, participant height was measured by the Martin antropometer (±0.1 cm; Siber-Hegner, Switzerland). Weight and Body fat percentage was measured via InBody 720 (Biospace, Korea). Body mass index (BMI) was calculated as weight divided by height squared.

The participant ran continuously on trail paths in a hilly terrain for 45 minutes, covering 9,12 km. Besides wearing Garmin Fenix 3 GPS watch, he was also wearing a Garmin heart rate monitor over his chest. This run was considered as long, steady, and aerobic.

2.3. DATA ANALYSIS

Raw data were extracted using GoldenCheetah software (https://www.goldencheetah.org; Figure 1), while power output was calculated using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, WA, USA).

Figure 1 - An example of the data obtained with the GoldenCheetah software

Initially, several variables were extracted from the software to Microsoft Excel and presented in 1 Hertz (Hz), including running speed (m/s), altitude difference (m), and heart rate (bpm) used for further analysis.

For power output analysis, running velocity in meters per second (m/s) and altitude difference in meters (m) were considered. Variables were filtrated using a moving average filter with an interval of 25. Furthermore, work (ΔA) was calculated as a change of energy ΔE. Both potential (ΔEP) and kinetic energy (ΔEk) were considered. Therefore, ΔA was calculated as a sum of ΔEP and ΔEk using this formula:

$$m \times 9.81 \times \Delta h + \frac{1}{2} \times m \times v^2,$$

Equation 1 – The sum of potential and kinetic energy

where m represents runners mass in kilograms, Δh altitude difference in meters, and v velocity of the runners in m/s. Consecutively, power output in W was calculated as work over the period of time:

$$P = \frac{\Delta A}{\Delta t}$$

Equation 2 – Power output

Finally, power per kilogram of body mass was also calculated:

$$\frac{P}{kg}$$

Equation 3 – Power per kilogram

2.4. STATISTICAL ANALYSIS

Descriptive statistics were calculated as a mean and standard deviation. Pearson correlation coefficient was performed to assess the correlation between running speed, altitude difference, heart rate, and power output. All correlation coefficients were interpreted as small, r = 0.10–0.29; moderate, r = 0.30–0.49; and large, r = 0.50–1.0 [14]. The level of statistical significance was set at $p < 0.05$. All statistical tests were performed using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, WA, USA) and SPSS 20 (IBM, Armonk, NY, USA

3. RESULTS

Variable	Result
Years of age	35
Height (m)	1.873
Weight (kg)	80.0
BMI (kg/m^2)	22.8
Body fat percentage (%)	11.6
Running experience (years of age)	20
Maximum heart rate (bpm)	201
Anaerobic treshold (bpm)	180
Vo_2Max (ml/kg/min)	56

Table 1 – depicts basic anthropometric data and other essential data regarding the participant.

Distance	Running speed (m/s)		Altitude difference (m)		Heart rate (bpm)		Power (W)		Power per kg (W/kg)	
	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev	Mean	St. Dev
1 km	3.157	0.964	0.344	3.118	140	8.75	207	31.3	2.591	0.391
2 km	3.342	1.445	-1.009	3.209	148	7.20	207	25.9	2.593	0.323
3 km	3.154	0.726	1.311	2.292	151	2.99	216	23.7	2.703	0.296
4 km	3.150	0.798	0.193	2.622	155	3.02	199	28.3	2.487	0.353
5 km	3.512	0.807	-1.225	1.958	158	1.02	228	39.1	2.850	0.489
6 km	3.219	0.397	1.430	3.502	161	0.91	220	19.0	2.756	0.237
7 km	3.470	0.820	0.373	2.825	163	0.98	244	35.1	3.053	0.439
8 km	3.422	0.597	-0.629	3.197	162	1.88	223	25.7	2.793	0.321
9 km	3.220	0.811	1.374	2.284	163	1.05	227	29.9	2.832	0.374
9.12 km	3.567	0.637	-3.636	2.719	163	0.98	190	25.2	2.380	0.315
Total	3.294	0.404	0.209	3.007	156	1.35	219	21.7	2.732	0.272

Table 2 – Results – obtained variables per kilometer and in total

Obtained variables of interest were presented in Table 2 as mean and standard deviation. Heart rate showed an initial increase with a steady rate later in the run. Since the running was performed on hilly terrain, running speed and power output showed variations, mainly due to an altitude change.

The variation of running speed and power output was further confirmed in Table 3. Namely, altitude difference showed moderate and significant negative correlation with the running speed ($p < 0.05$; see * in Table 3). Furthermore, a large and significant positive correlation was revealed between altitude difference and power per kg ($p < 0.01$; see ** in Table 3). Other than that, no further significant correlations were observed.

4. DISCUSSION

This study aims to present a post hoc analysis of power output in the running using an ordinary GPS watch. In addition, this study aims to analyze possible associations between the running speed, altitude, heart rate, and power output. The main finding of this study suggests that power output in the running can be calculated efficiently using the data extracted from an ordinary GPS watch. Furthermore, a large and significant positive correlation was shown between altitude difference and power per kg. In contrast, a moderate and significant negative correlation between the running speed and altitude was observed.

Although power output can be monitored in real-time with the foot-pod (see Introduction for more details), the results obtained from the GPS watch seem accurate and easy to obtain after the running is complete. It is shown (Table 2) that both running speed and

	Running speed (m/s)	Altitude difference (m)	Heart rate (bpm)	Power (W)	Power per kg (W/kg)
Running speed (m/s)	1				
Altitude difference (m)	-0.472*	1			
Heart rate (bpm)	0.357	-0.083	1		
Power (W)	0.328	0.297	0.159	1	
Power per kg (W/kg)	0.200	0.569**	0.224	0.341	1

Table 3 – Correlation matrix of the assessed variables

altitude fluctuate quite a lot in trail running. Contrary to that, the heart rate per kilometer showed an initial increase with a steady rate later in the run. Since this was considered a long, steady aerobic run, the runner adjusted his pace to be even according to the heart rate, not running speed. As a result, he was running in the aerobic zone. Even pacing proves the optimal strategy for long-distance running [15]. In particular, even pacing strategy might help runners achieve a faster race time, decrease the risk of musculoskeletal injuries, and increase the pleasure of running[16]. However, when running on the hilly terrain, there is a potential contradiction what is even pace? Is it even pace regarding the cardiovascular system (i.e., even heart rate), or even running speed? By monitoring power output, runners can also achieve an even pace for the muscular system.

Furthermore, only power output can help a runner monitor its efficiency. Running efficiency seems to be a "secret weapon" of successful long-distance runners [7]. In particular, running efficiency can also help recreational runners in the increasingly popular half-marathons and marathons [17], [18]. Conversely, running speed does not provide information regarding the effort runner's body puts in, only the outcome of that effort. Running on the hilly terrain, for example, can significantly affect running effort. The effect of the trail running was particularly noticed in Table 3., where power output per kg showed a large and significant correlation with the altitude. On the other hand, both power and power per kg showed a low correlation with the running speed and heart rate. As a result, power output in the running should be monitored separately.

Several limitations can be associated with this method:

1. Only one runner was considered for this study;
2. The runner's body mass is considered when calculating power output. Since the body mass can be reduced during the long run (mainly due to excessive sweat), this can affect power output results;
3. Wind can both increase and decrease running velocity, thus affecting power output; and
4. Finally, older models of GPS watches can be prone to navigation or altitude estimation errors.

5. CONCLUSION

In conclusion, this simple analysis can be used by both endurance runners and their coaches, mainly to observe running efficiency or assess the load on skeletal muscles, which cannot be achieved by monitoring heart rate or running speed. Regular monitoring of the power output in endurance running can help runners recover faster, thus running more often and achieving better results. Specifically, by observing power output and heart rate, runners can have insight into both muscle and cardiovascular stress. Therefore, they can plan their future training routine more accurately (i.e., maximizing intensity while reducing the risk of overtraining or injury). Finally, future studies might evaluate this method compared to the previously assessed methods (e.g., Stryd or Optogait).

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IT APPLICATIONS IN SPORT SESSION

SCOUTING IN BASKETBALL

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Abstract:
The development of information technologies has contributed to the application of more and more analyzes of opposing players and teams in the sports system, which is scouting. Scouting is the analysis and presentation of the most important results of a team or an individual player with the aim of improving performance, and thus the results of a team or players. In this study, based on the available literature, scouting and realization of certain software packages for analysis, scouting and creation of basketball actions are presented.

Keywords:
Scouting, basketball, player, information technologies.

INTRODUCTION

Throughout history since James Naismith invented a new game for his students in 1891. and to this day, basketball has undergone major changes, in terms of the game, the rules. Today basketball is a popular sport that requires, among other things, big analyzes and certain statistical parameters. One of the indispensable analyzes of a sports team is scouting.

The beginnings of scouting date back to 1948. In New Orleans. Then the scouts started to record only certain statistics, points and turnover percentages. There are at least twenty definitions of statistics in a basketball game. Statistics play a very important role in scouting because based on some events that have happened in the past, scouts try to accurately predict future events. In Europe, scouts appeared in 1969. in Italy. Nowadays, scouting has developed to unimaginable heights. Today, good and quality scouting cannot be imagined without the use of modern information technologies. "Advance scouting" has a special place in recent basketball history [1].

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Scouting is the analysis and presentation of the most important results of one team or a player with the aim of improving performance, and thus the results of that team or player. Scouting is collecting data and analyzing the competitive and training activities of athletes in order to achieve top sports results. Scouting is the specific preparation for data collection and analysis of competitive and training sports activities in order to select the best players [2].

Basketball scouting and analysis of one's own and your opponent's team has become an indispensable part of the preparation for all games in professional leagues. Using data mining programs in sports provides great benefits to its users. It allows you to see all the essential elements of the basketball game and to extract knowledge from the collected data. In this way, teams get to know themselves, because they are able to see what they need to win, where they most often make mistakes, and which elements of the game they need to improve [3].

"Advance scouting" has a special place in recent basketball history. It is one of the best basketball scouting programs that have appeared. Implementation of that program was completed in November 1989, and the first owners were the Chicago Bulls. Advance scouting costs a million dollars. Although they had strong individuals, with the best basketball player of all time, Michael Jordan, they did not manage to win any title. For a year, the Chicago scouts worked hard on that program. For the next three years, they were the undisputed rulers of the basketball scene. "Advance scouting 1.0" had the possibility of scouting during the game and after it [4].

The task of scouting is to collect, analyze, statistical processes as needed and use technical-tactical, physiological, motor, and sociological data in order to improve the performance of individuals and individual parts of the team, and then the performance of the team as a whole.

The importance of scouting is reflected in the fact that by systematically monitoring competitive activities, coaches receive a certain amount of exact information, unlike previous practice where conclusions were made based on subjective assessment of individuals, which is not enough in modern sports.

By using basketball analysis and data mining as the highest level of analysis, teams can get to know their opponents and prepare for the next opponent or tactics for the next game. [5]. The tools and techniques that are being developed aim to better measure the performance of both the player as an individual and the entire team. These new methods of measuring performance attract the attention of the largest sports associations because there is a large amount of money in sports today. Prior to the benefits of data mining, sports organizations relied almost exclusively on the expertise and knowledge of the people in charge of scouting. Statistics play a very important role in scouting itself because based on some events that have happened in the past, scouts try to accurately predict future events [4].

In the past, basketball statistics were a luxury available only to big professional clubs. For the average trainer, statistics were a real nightmare, requiring a large amount of time and effort, first in the collection of statistical data, and then in the manual calculation of various aggregate statistical parameters. For most coaches, statistics simply weren't worth that much effort [5].

However, computers have changed all that have removed a great burden and responsibility for keeping statistics from coaches, while at the same time providing them with a wealth of information that they have only they could dream of for fifteen years. And best of all, the prevalence and relatively low cost of computers and software make this information available to everyone. As the amount of data collected grew, sports organizations turned to find more practical methods to gain knowledge from the data [6, 7]. The second step was to find even more practical methods in order to extract valuable knowledge, is to start using data mining techniques. Properly applied data mining techniques can result in better performance of the whole team by preparing players for certain situations, identifying individual contributions of individual players, assessing play the opposing team and exploring any weaknesses. In order to be able to apply data mining, first of all data is needed. Depending on the amount and richness of available data, it is possible to extract appropriate knowledge [8, 9].

When we talk about basketball scouting, we have to point out some terms that are from essential for analyzing an opponent such as a team roster containing: last name and first name of the coach, last name and first name of the player with basic data jersey number, position which game, height, weight and year of birth, then the individual characteristics and habits of the player as well as the schedule of all matches with basic data (date, time and place of play) [10].

2. METHODS

Given the introductory remarks, a bibliographic-descriptive method was used for the purposes of this study. Based on the available results of relevant previous research, the presentation, definition, theoretical framework and possibilities of implementing scouting in basketball are given, as well as its importance for further development of sports analytics and application of scientific knowledge in modern sports.

3. DATA ANALYSIS AND SOLVING BASKETBALL SCOUTING PROBLEMS

Scouting can be done at the level of team, scouting teams - coaches are under constant pressure during the season and are always looking for a deeper insight into the abilities and tactical ideas of their opponents. Analytics can help coaches organize information they use regularly in a more efficient way. As video systems improved, so did coaches get more complete information at their fingertips. By analyzing video materials, it is possible to gain insight into the templates of the opposing team, as well as special actions that need attention. In addition, analytical systems can automatically detect trends in the upcoming opponent's performance and can determine the cause of any changes. For example, a series of wins or losses says nothing if the opponents and details from each game are not taken into account. It is not at all simple for a coach to go through each of these matches to determine patterns and causal relationships, which is greatly facilitated by the existence of Analytical Systems [12].

Individual Player Scouting - Standard player evaluation often involves scouting reports, studying videos, measuring the market value of players, and projecting the role of players in a team. As the information needed for analysis comes from different sources, only collecting it can be a challenging process. Analytics enables the integration of these information flows. Using analytics while reading a player's scouting report as a potential reinforcement, a decision-maker can effectively see statistics and videos from the game, the level of play relative to standard player games, and see if a scout's rating matches his own observations. In addition, analytics allows decision-makers to consider different scenarios of the player's role in the team and the type of contract offered, thus assuming the player's long-term impact on team performance. Assessment of abilities, primarily physical through various forms of testing players.

Talent Scouting – Decision-makers need to identify areas of play that the player should focus on in their development, determine player routines that need to be improved, and set goals so that the player and decision-makers know if the player is progressing according to plan. Analytics can play a key role in this process by assisting decision-makers in identifying goals for the player, as well as in monitoring, analyzing and projecting progress so that all stakeholders know if the player is evolving. In addition, analytics allow coaches and staff managers to know what a player is able to achieve in different areas and how that potential fits into the team's future. Combining development information with video analysis, in-game statistics and scout reports will further help decision-makers regarding the current and future value of players. A scouting program is shown. The project is modeled according to the UML (Unified Modeling Language) is a standard visual modeling language to document processes and software specifications. For the static aspect of the system, the Use Case Model and the Class Diagram were used, and for the dynamic aspect, the Activity Diagram was used. As today's operating systems have the feature of great user interaction, the natural choice is a graphical action editor where the desktop will be a drawing board. The main advantage of this application over the drawing board is the ability to record the action, print reports with observations during the exposure to players, as well as record actions in video format and the ability to play them at different speeds. Although similar editors have appeared on the market that meet such requirements, here is a framework (template) that can become universal for all graphic editors of this type for all team sports (football, basketball, handball). The paper presents a specific editor of basketball actions, but with minor changes, it can become a universal graphic editor of actions. The implementation was implemented in the Borland Builder 6 software package in the C ++ programming language. The open-source API – Open CV was used to create the video [1].

4. GRAPHIC EDITOR FUNCTIONALITY

One of the first steps in the process of designing and modeling the problem is the analysis and specification of requirements. In the process of analysis, it is important to get answers to the following questions at the beginning:

1. The main purpose of the software package that is being implemented, essential requirements of users regarding the functionality of the system. The application

is a graphical editor that allows the user to add elements to the desktop, adjust properties, and add actions to each element. Also, charts and their phased display must be displayed, then video creation and report printing.

2. Hardware complexity of the software package.

An object-oriented model is a graphical analysis of a system that uses UML symbols and symbols. UML is the standard language for object-oriented modeling. The language has well-defined syntax and semantics, which is clear and easy to use in object modeling. In the object-oriented model, the following are designed: usage case diagram, class diagram, sequence diagram, activity diagram, state diagram (dynamic) and development diagram. The usage case diagram represents the user requirements for the system.

It consists of Use-cases - They describe the sequence of actions that cause an effective change in the system. They are marked as horizontal ellipses; Actors - An actor is a person, organization or external system, who plays a role in one or more interactions with the system. Actors symbolize figures; Connections - Connections between Actors and Use-cases with solid lines with the possibility of placing an arrow at the end of the line. The connection always exists when the actor participates in the action, which is described by Use-cases. Cases of use for player reports and updates are listed. Analogous to player updates, other updates are also performed [1]. In Table 1 can be seen as adjustment options for players.

Reports
Specification:
Chronology of actions:
By clicking on the appropriate button on the form of the new game or by selecting the report on the initial form, the report (s) is called
Extension points:
1.) a. If the game is still in progress, it is possible to call the game statistics for the periods of the game separately, as well as for the halftime or regular course. Only possible for an ongoing game.
b. i.) The game is not in progress. Invitation of various reports from the initial form.
ii.) The desired report is selected
iii.) The game is selected
Exceptions:
Does not have
Prerequisites:
Does not have

Table 1 – Adjustment options for players [5]

5. CREATING VIDEOS

Based on the specification of the request, it is necessary to enable the user to record his basketball actions as a video file. This file can later be played outside the application and on other computers where the application is not installed.

The Open CV library was used to solve this problem. The following is a description of the methods used:

- cv Create Video Writer - create videos with set parameters,
- cv Release Video Writer - completes video writer entry,
- cv Load Image - load an image from a file,
- cv Write Frame - adds a frame to a video file [1].

6. SCOUTING REPORT PARAMETERS IN BASKETBALL

Scouting report in basketball is an essential aspect of preparing a successful game plan in coaching basketball. There is no universal way to scout. It can be seen in the example basic reports parameters for a scouting report.

Scouting reports parameters considered for scouting report:

1) Result: Made, Missed, Fouled shots
2) Value: 2-pt field goals, 3-pt field goals
3) Additional: And one-shots, Blocked shots, Assisted shots, ATO
4) FG Play-types: Catch and shoots, Transitions, Cuts, Catch and drives, Pick 'n' rolls Handler, Isolations, Putbacks, Screen offs, Post ups, Hand-offs
5) Game periods: I quarter (0_____10min.); II quarter (0_____10min.) III quarter (0_____10min.); IV quarter (0_____10min.)
6) Seconds to violation: 0_____24sec.
7) Contesting: Contested, Uncontested
8) Opponent
9) Hand: Right, Left
10) Shot type: Jumper, Tip in, Lay-up, Floater, Reverse, Dunk, Hook, Miscellaneous
11) Drives: Drives left
12) Assisted by
13) Dribble moves: Changing speed, Step back, Quick first step, Fake shot, Fadeaway, In & cut, Jab step, Changing direction, Spin move

Figure 1 shows an example of the analysis of successful shots chart percentage in a specific court zone of one team from the game. Figure 2 shows an example of marked successful and unsuccessful shots in the game. The black circles are successful shots, and the black x marks are unsuccessful shots.

7. CONCLUSION

In basketball nowadays, there are many different methods and ways of preparing a team for competitions. There is a physical, psychological, integral, technical, tactical type of preparation. Each of them is very important for the whole team and leads to a certain result and success. Today, good and quality scouting cannot be imagined without modern information technologies.

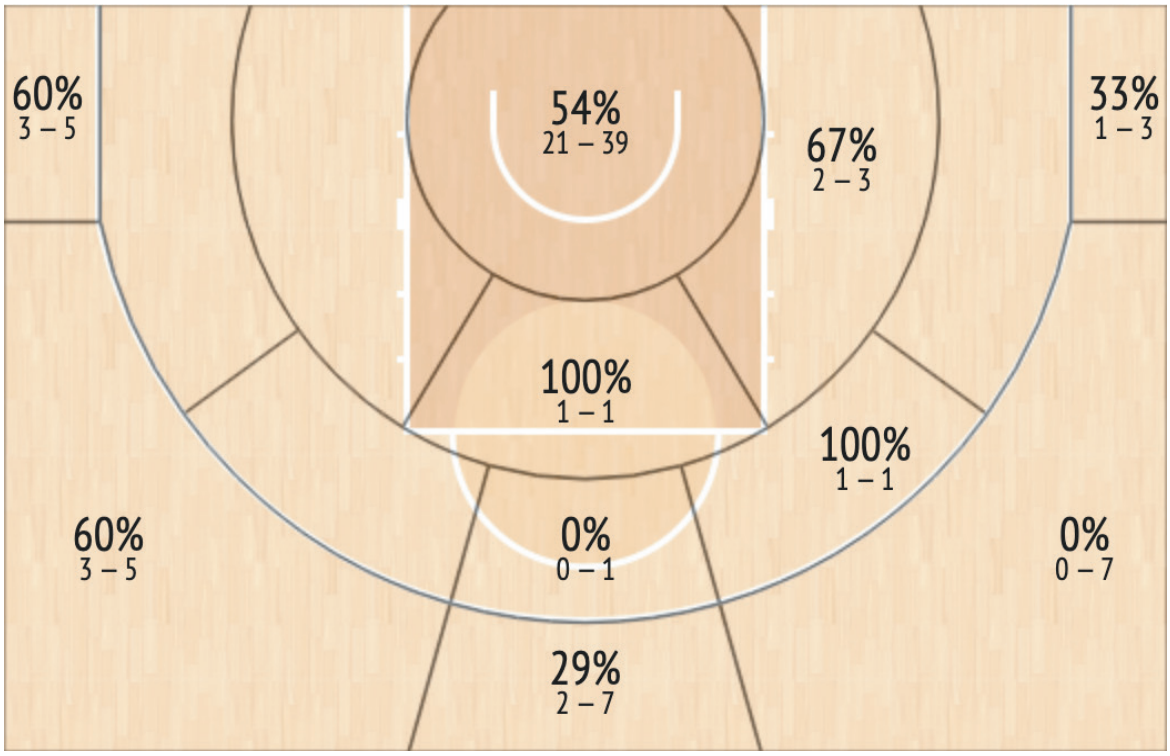

Figure 1 - Example of shooting chart percentage in specific court zones.

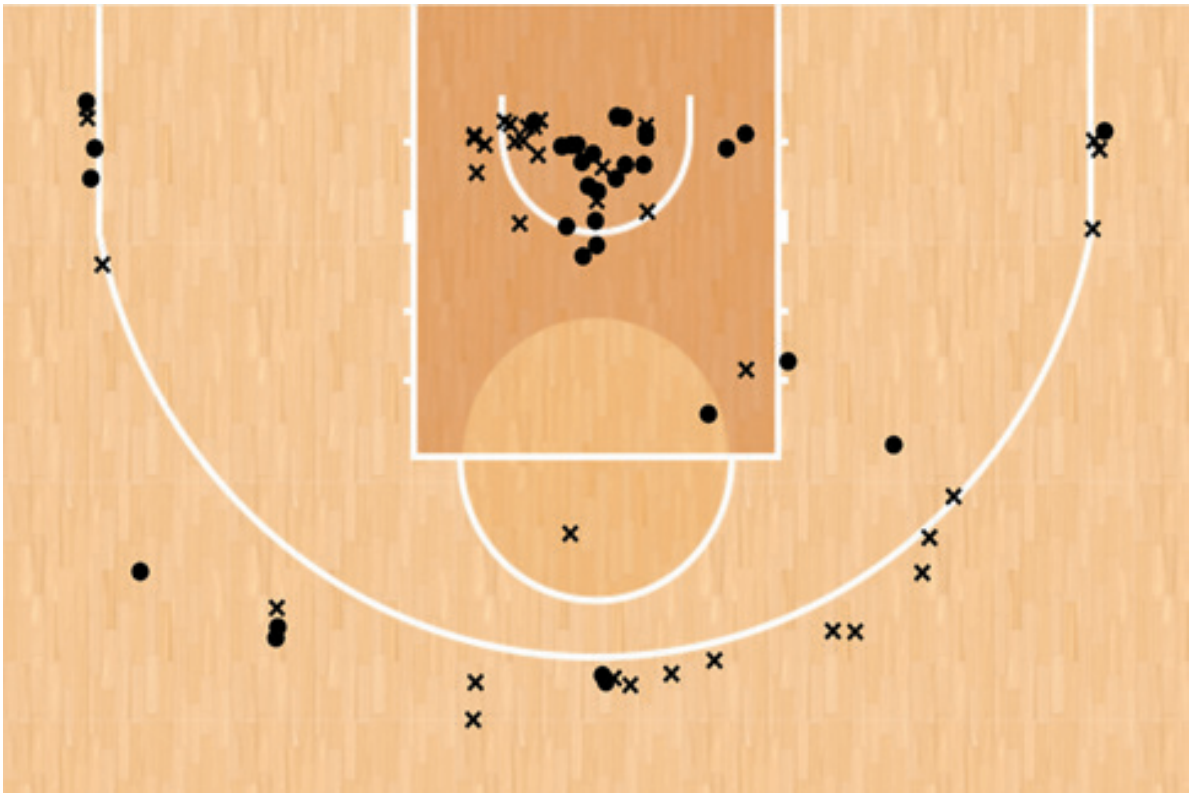

Figure 2 - Example of field goals shooting chart

With the help of scouting, all coaches are enabled to set the appropriate tactics in relation to the opposing team, as well as with the help of analysis of each opposing player, the coach draws attention to certain strengths and weaknesses of the opponent [4, 13]. The fastest and most comprehensive analysis should be the performance index. With the help of scouting, in addition to coaches, players, journalists, managers and others can get various information, including how many points were given in relation to certain types of defence, as well as what types of attacks a certain team used, how many points and counterattacks attack, pick & roll.

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IT APPLICATIONS IN SPORT SESSION

SOFTWARE SOLUTIONS FOR STUDYING MENTAL FATIGUE

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Abstract:

The aim of this paper is to present possible softer solutions for research in the field of mental fatigue. For this purpose, the concept of mental fatigue was defined in the first step, a brief history of its research was presented, as were key results of current research. In the second step, the most commonly used software solutions for inducing mental fatigue have been identified, presented, and analyzed from the aspect of validity but the efficiency of their use.

Keywords:

Psychology, Physiology, Sport neuroscience, Sports performance, Methodology.

INTRODUCTION

Research and expertise within the domain of one scientific discipline and even the entire scientific field have long been insufficient to properly meet the basic goals of science and scientific knowledge, creating a comprehensive system of knowledge about man and the world. An integrative and interdisciplinary approach to the subject of study represents a logical response to the described challenge [1]. Sports neuroscience is an expression of the aspiration to try to answer the questions of the nature of the human movement, motor abilities and skills, information and physiological processes that govern them, and the possibilities of their systematic change in the training process through the integration of cognitive sports psychological and neurosciences [2], [3]. The results of this research, of course, have implications in the broader field of research on the human body and behavior.

In the modern society which is shaped by digital technology and new media play [4], all theoretical assumptions and concepts are in a permanent state of significant transformation [5], which has important methodological implications [6]. This turns out to, in addition to all the easily noticeable threats, represent a great potential [7], which can be seen in the field of research of the physiological basis of human performance as well.

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Increasing the range of theta waves in the prefrontal cortex is an indicator of the occurrence of mental fatigue [8]. Mental fatigue is thought to be associated with decreased prefrontal cortex activation due to increased ATP hydrolysis and brain adenosine concentration [9]. However, it was found that mentally exhausted athletes improved their score after caffeine intake that did not affect the change in activity in the prefrontal cortex [10] even in placebo sessions [9] say that the psychological component must be taken into account in explaining the phenomenon of inhibition of activity due to mental fatigue. In this place, we primarily refer to research in the field of mental fatigue, which through the use of digital technologies get the opportunity to systematically and validly engage in research into a very complex and multidimensional phenomenon. Phenomena on the volatile boundary between physiology and psychology studied primarily in the field of sports and human movement sciences.

The aim of this study is to present to the scientific and wider professional public in the domain of Psychology, Physiology, Sport, and human movement science software solutions for causing mental fatigue, which allows a new degree of validity in its research. The aim is also to acquaint professionals and researchers in the field of programming and information technology with the potential space for their greater involvement in the field of research in social sciences and human movement sciences.

For the purpose of reviewing the current research results of studies on software solutions for studying mental fatigue, the PubMed electronic base was searched for relevant scientific scores. The following keywords for database search were used: "mental fatigue sports performance", "mental fatigue induction", "mental fatigue software", and "e-sport". The search was performed for titles, as well as for abstracts. Initially, 785 results were found, ranging from the year 1968 until 2022. After filtering the irrelevant scores, which wouldn't fit under the subject of sports neuroscience, 46 scores were left. After further narrowing research results to systematic reviews, only 4 studies were left. Having in mind the exploratory nature of this paper, as well as the redundancy of the results found when it comes to the application of software solutions, we can conclude that this choice is justified.

2. DEFINITION OF MENTAL FATIGUE AND DEVELOPMENT OF RESEARCH CONCEPT

The role of psychological characteristics of athletes [4], i.e. their emotional [11], cognitive [12]) and conative [13] abilities and processes in achieving top sports results, has long been known. Highly developed motivation as well as stress resilience [14] can be just as important as physical ability [15] or morphological characteristics [16], [17] when it comes to achieving top sports results.

In the research of motivational characteristics, there is a lot of important and open research questions. Among them, these are questions of the limits of human endurance and what is the primary nature of fatigue that leads to the cancelation of physical activities. Of course, there are numerous studies that describe the physiological limits of the human body [18], [19], primarily related to muscle fatigue and limits [3]. However, recent research suggests that the study of this topic should primarily take into account the physiological exhaustion of the nervous system [20] at all levels from sensory input, through the spinal cord and brain to autonomic functions and effector output [21]. Such side effects of physical activity and fatigue are related to the concept of mental fatigue. Mental fatigue is defined as a mental state caused by prolonged demanding cognitive activity [22] and refers to both physiological changes caused by activity and psychological interpretation[23]. Movement control can also be considered a demanding cognitive task, which is crucial for understanding mental fatigue in a sports context.

Studies of the effects of direct transcranial stimulation (tDCS) represent a new experimental method that should shed light on the neuroanatomical and neurophysiological basis of conative abilities and processes as well as causal links between them and athletic achievement [3]. After anodic stimulation of the primary motor cortex in experimental conditions, a significant increase in endurance was obtained associated with increased corticospinal excitability of the knee extensor muscles and decreased effort perception [24]. The research potential of the use of the method of direct transcranial stimulation in experimental research of conative processes and abilities in sports, but also its application in diagnostics, selection, and training, has yet to be fully used.

One of the important methodological issues in these studies is the cause of mental fatigue. How to provoke it, how to induce it, how to control its intensity and whether the results of studies that use different experimental treatments for this purpose can be compared? The use of information technology, as well as software solutions, are one of the possible answers to these challenges.

3. SOFTWARE SOLUTIONS

The usage of software solutions for mental fatigue induction is very popular since it is easily applicable, cheap, or free and shows adequate results. Some of the most popular software solutions used in research are AX Continuous Performance Test (AX-CPT) [25], Stroop Task [26], and some often used is Wisconsin Card Sorting Test (WCST) [27], [28]. What is characteristic about all these tests whose main goal is to induce mental fatigue is that they need to be performed for a longer period of time (at least 30-45 minutes) as previously mentioned. What is even more important is that all participants should be in a similar psychological state in order to obtain valid results [29].

In AX-CPT, participants have the objective to respond by pressing a particular button when a target is presented, and a different button when any other stimulus is presented. Typically, the target is represented as letter X, but only when it is preceded by the letter A. When a participant sees A-X-A-X, both X's are targets, but if it sees A-X-B-X, only the first X is a target (Figure 1). This is very convenient because the researchers have the ability to manipulate how often the target will appear and in which circumstances. If only A-X and B-X combinations are shown, the participant would soon have the assumption that when A appears on the screen, the X would follow. That is where the other part of this test comes in, which is the inclusion of Y. So, showing an A-Y combination would not be a target and the participant would give the wrong answer if only focusing on the first letter. This way AX-CPT has a dual-task, first it measures a person's ability to focus on a goal (X should be connected to A in order to be a target), and second, the person's ability to process context (if B is presented, the next letter will certainly not be a target, and if A is presented, the next letter is likely to be a target).

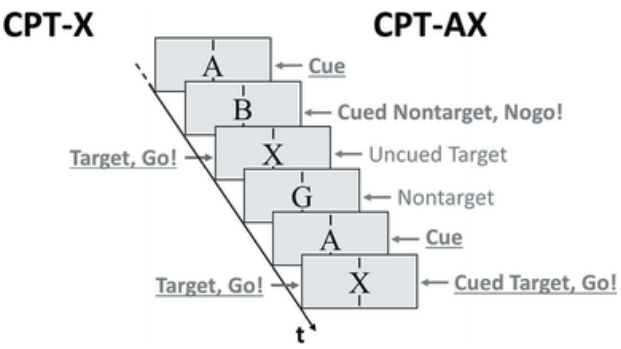

Figure 1 – An example of AX – CPT targeting

The Stroop task is one of the most used and best-known psychological tests. The test consists of words appearing on the screen in different colors. The goal is to state the color of the ink in which the letters are written. In this way, the word "GREEN" appears but is written in red ink (Figure 2). The software version measures the time needed to answer and accuracy. The Stroop phenomenon shows that it is difficult to name the ink color of a color word if there is a mismatch between them. It also shows that there is a delay in the reaction time between matching and mismatching stimuli.

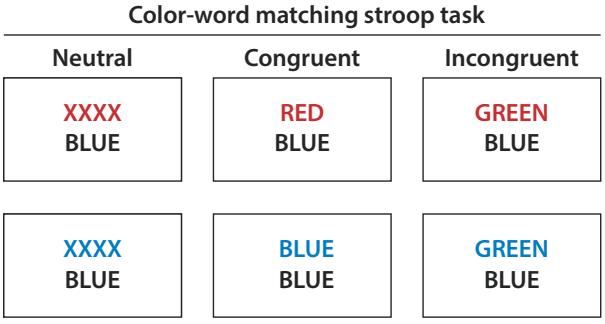

Figure 2 – An example of Stroop task

The WCST is maybe less conventional in research than the previous two but is a very significant tool when it comes to mental fatigue induction. In this test, the participant has 4 cards shown on the screen. Each card has a different symbol (e.g. circle, triangle, star, etc.), a different number of symbols shown on them (1, 2, 3, 4), and each symbol has a different color (red, blue, green, yellow). When the test starts, another card with a random number of symbols with random colors appears. The participant has the objective to match the shown card with one of the previously mentioned. When he chooses one of the cards, the sound indicates a right or wrong answer. The goal is to find out the indicated pattern.

There are three patterns where the participant should follow the number of symbols, their type, or their color. After a certain period of time, the pattern switches during the test, and the participant has the objective once again to find out the pattern type. This way, the person needs to be aware and focused during the whole process in order to perform the test right.

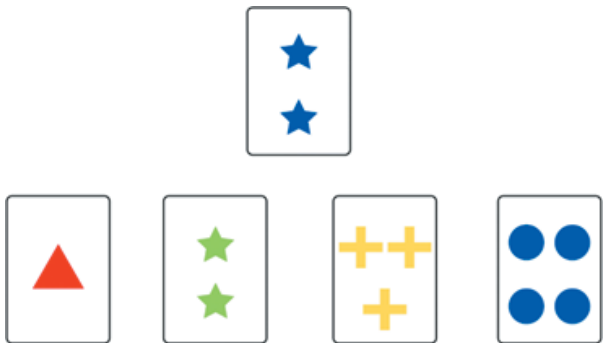

Figure 3 – an example of Wisconsin Card Sorting Test

4. DISCUSSION AND CONCLUSION

In this paper, we sought to outline the current importance and potential of using software solutions in studying mental fatigue. The significance of research findings in this area is widely used in clinical psychology [29], physiology [8], [9], and especially in sports science [12], [13], [15]. What is even more interesting to note is that specific branches in sports science, such as motor control deal with this phenomenon in terms of time reaction. It is well known that in all sports with a direct opponent, time reaction plays the key role [30]. On the other hand, mental fatigue shows different effects on physical fatigue, impairing endurance performance, decreasing time to exhaustion and self-selected power output, or increased completion time [22]. Further, some studies [29] show that neither cognitive flexibility nor attention to detail is associated with the level of eating disorder symptomatology, depression, anxiety, or OCD symptomatology. This leads to another trail when it comes to the connection between mental fatigue and physiology.

When it comes to experimental control of mental fatigue induction, all studies were mainly focused on time duration of the tests/objectives in which participants were included [26], [31]. There is also a significant difference in test type used in the experiment, but in general, most of the researchers agree that specific time duration plays a key role in the experimental control. On the other hand, depending on the sports expertise or job profession, it depends on which level the aforementioned tests would induce mental fatigue. This is very important for highly-stressful surroundings, where people tend to maintain focus under pressure, to perform and achieve high standards in similar situations. In sport, this is very significant, especially in sports branches where focus plays the main role [32].

Finally, the usage of the mentioned tests can be further upgraded by adding additional contents, making their validity even stronger when it comes to mental fatigue induction. Taking into account that today people's attention is much more stimulated than it was in the past [33], creating more complex tests would probably improve the validity of further research in this field.

There are also limitations in this paper, regarding the tests presented. First, there is a great number of tests that can be used for inducing mental fatigue, and the authors presented only a few of the most common ones. Second, there are multiple ways to induce mental fatigue, such as audio or electrodermal [34], depending on the research methodology and desired results. In this paper, only online solutions were presented, since it is the most simple and affordable way to implement them. Third, in specific sports situations, additional content including physical activation can be used by coaches and sports scientists to further induce mental fatigue, creating an environment where multiple answers are possible.

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IT APPLICATIONS IN SPORT SESSION

THE INFLUENCE OF PHYSICAL ACTIVITY ON THE HEALTH AND PLAYING QUALITY OF THE E-SPORTS PLAYERS

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Abstract:

E-sport has developed and became professionalized extremely quickly, but it is also becoming more demanding, so it is required from e-sport players to possess high technical and tactical knowledge and, also mental and physical readiness to cope with the demands of the e-sport scene. The aim of this paper is to study the impact of physical activity on the playing quality and the health of athletes. This primarily includes activities that affect the improvement of the physical and mental structure of each person, such as a healthy diet, regular exercise, an active lifestyle, the creation of transient art in nature, and quality time. With the help of modern technologies and devices (smartphone and smart watch), physical activity can be easily monitored, determined and studied by counting steps and hours of daily activity of e-sport athlete's, taking body composition in to the account. A smart device registers data on the e-sport athlete's wrist on the basis of which his general physical health is estimated. The smart device recognizes the moment when the user starts training, stores data recorded during physical and digital exercise, sleep, and other activities. Physical activity has an impact on the overall health status and playing quality of e-sports players, i.e. with the increase in the number of steps on daily basis, the total time of performing the tasks of the e-sport players, and the BMI decreases. E-sport players' performance is improved by integrating physical and artistic activity into the athlete's exercise program, and it has a positive effect on their health.

Keywords:

BMI, Number of steps, Smartphone, Smart watch, Video games.

INTRODUCTION

E-sport is becoming a significant part of the popular culture and represents a grand global industry with a rapid growth, as well as an important topic of research within the sport sciences [1]. The term e-sport is described as an organized competitive sport where one or more players compete in computer games.

The consensus over a clear-defined universally accepted definition of sport has not yet been attained among the researchers [2]. Taking into account the negative trends of reduced movement correlating with the rise of the digital technologies resulting in negative health consequences [3] [4] [5], the question of mental and physical health of the players in the e-sports domain arises.

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According to the results of the researches, it has been widely accepted that e-sports has negative effects on the physical health of the players, considering that the requirements of their sports are limited to the digital domain, resulting in a lack of holistic training structures. Monitoring and research of the lifestyles, daily habits and health status estimations are becoming easier to an increasing number of researchers owing to development of digital technologies.

Electro dermal activity (i.e., the electrical conductivity of the skin) carries important information about the brain's cognitive stress [6]. The new technology monitors sweat to infer brain stress and, when detected, sends a message through the smart watch. With the help of modern technologies and devices (smartphone and smart watch), physical activity is determined by counting steps, BMI, and hours of daily activity. A smart device registers data on the subject wrist on the basis of which his general physical health is estimated.

Literature concerning e-sports is quite rare despite the big popularity of the sport itself, especially considering the fact that available research is primarily focused on the health of the „problematic" (over)users of video games and negative consequences of the video games themselves, rather than on the health of professional e-sport players.

This paper aims at setting the foundation for further research of e-sport in our region, affirming the importance of physical activity with e-sport players and reminding that e-sport players aren't using the potential benefit of the physical exercise, as well serve for comparison in future researches.

The subject matter of this research is examining the influence of physical activity on the performance output and overall health status of e-sport players. Previous studies have identified similar factors that affect the general wellbeing and performance of traditional athletes, as well as fact that e-sport players have digital training without physical training, which results in a lack of holistic training structures.

This point is an especially important basis for research, generating a goal of this paper of determining the influence of physical activity on quality of performance and overall health of e-sport players.

2. METHODOLOGY

For the purpose of reviewing the research results of current studies on e-sports and physical activity, the PubMed and google academic electronic bases was searched. The following keywords for database search were used: "e-sport*," "esport*," "e sport*," "electronic sport*,"or "eSport*." Initially, over 39000 results were found, ranging from the year 1968 until the present day. Then search was performed only for titles and abstracts, which narrowed the search to 68 scores. After filtering duplicate and the irrelevant scores, which wouldn't fit under the subject of relations between e-sports and physical activity only 20 most relevant researches was chosen to be subject of this review. Having in mind the exploratory nature of this paper, we believe that this choice is justified.

3. RESULTS AND DISCUSSION

Players that practice on average from 3 to 10 hours per day report eye fatigue (56 %), neck and back pain(42 %), joint pain(36 %) and arm pain (32 %) as well as 40 % of e-sport players doesn't incorporate physical exercise in their daily routine [7] despite the researcher's suggestions that their body composition and physical activities level can be improved with adequate programs [8] . This results in negative changes of these players related to physical inactivity and increased weight gain. The only way to increase energy expenditure is physical activity and moderate intensity exercise that burns the fatty tissue and preserves other tissues, resulting in prevention of the aforementioned issues. Physical activity implies any movements conducted by skeletal muscles that generate energy expenditure greater than energy expenditure during idle state [9].

Behaviour of the e-sport players is akin to office work behaviour, programmer or an artist, carrying the similar profile of health risks, which spawns a logical conclusion that e-sport players are also more prone to cardiovascular and mental ailments, psychological problems connected to stress, weight gain, back problems, tendon injuries caused by repetitive movements and positions, all of which can present a career-ending cause. E-sport players are also not physically active enough because of the in-game time spent being sedentary, and physical exercise after prolonged sedentary periods doesn't compensate for the damage caused by sitting for extensive time periods, meaning they ought to have active breaks in between the matches, making screen time breaks [10].

Also, concerning the problems such as various addictions, violence desensitization, rapid weight gain, musculo-skeletal composition problems, physical injuries caused by excessive play time and other problems requiring attention and structured approach, it has been noted that more professional e-sport players are including physical exercise and diet plans [11].

Other side of e-sport is its positive effect on the basic motor skills of the players including accuracy, speed, agility, aiming, as well as on the psychomotor functions. Playing video games is a useful tool for increasing fine motor skills and movement coordination. Research has shown that action video games players have good hand-eye coordination and visual-motor capabilities, such as distraction resistance, peripheral vision information sensitivity and ability to locate greater number of objects in a limited time frame. Playing video games increases visual acuity, meaning that visual reaction time is becoming shorter, and the eye is becoming faster, which undoubtedly represents an advantage in everyday life.

Results show that the players have scored significantly higher results in hand movement accuracy tests, which is emphasized by shorter total time of task completion, 14.6 ± 2.9 s against 32.1 ± 4.5 s non player's times [12]. Some types of adventure games help developing problem solving, logic thinking and deduction abilities. In the researches of exertion, physiological and psychological processes taking place within e-sports, there are limited information's available.

Insight into present literature hints at questions revolving around the extent of physical activity and diet change on reduction of the health risks, as well as extent of the e-sport on increase of the same.

Individuals looking to become the best in e-sport competitions have to be in a good physical and mental condition, because the overall health wellbeing of the e-sport player is crucial, and only with an adequate physical state the it is possible to achieve peak levels of concentration, attention, reaction time and mental agility. Following the explosion of popularity of e-sports, research focused on organised and professional domain has quickly gained traction, but despite the e-sport popularity and video game evolution from recreational to professional levels, there is still a very limited number of studies aimed towards the professional e-sport players.

Most of the research is „focused solely on the violent action video games or on a specific game within a specific genre leaving aside numerous possible player habits in other game genres") [13]. Previous studies have also taken into consideration the influence of e-sport on physical activity of the players and the composition of their bodies, have dealt with the player movement, nutrition, sleep habits, effects of e-sport and can be used for developing later concepts of training. Research of identifying basic skills for success in e-sport is limited, but it has been noted that conditioning training and traditional sports training procedures can be beneficial for developing skills needed for good e-sports performance (attention span or reaction time)

Incorporating „real world", specific physical exercises, into the digital world could reduce the sedentary behaviour patterns and bring about big health benefits [10]. Physical training of moderate intensity, healthy cardiovascular system and balanced diet also have positive effect on the brain health and can significantly strengthen cognitive performance. That includes, among other, functions of memory recall and attention, as well as functions that benefit to execution of specific in-game actions. Conditioning coaches have a task to offer the foundations to healthy lifestyles, which results in forming of the structures and incorporation of measures that promote player conditioning in the domain of professional e-sport [10].

Technological explosion during the Covid 19 pandemics has executed a promotion of the „Physical e-sport". When the professional traditional sport has been put „on hold", the new Mixed-reality technologies and several others e-sport applications have been an important substitute and help for the elite athletes and users on all levels around the world, enabling them with alleviating the loss of conditioning.

Numerous digital solutions have been offered that enable the users to communicate while being the part of the virtual world of AR, VR and MR technologies, also enabling them to pursue their passions and profession without an increased infection risks [11]. Sport clubs have been very creative in offering virtual competitions using the network platforms (such as Zwift, Strava, Bkool), enabling some of the athletes to train in simulated scenarios and maintaining condition, and some of them have tried themselves in new discipline called „Physical e-sport" which has been built using the mobile VR system called VAIR Field which includes physical activity of players [14].

Delivered physical performances on virtual professional have been largely comparable to performances of the traditional sports. The claim that the main difference between e-sport and traditional sports is physical movement has been partially brought into question, which resulted in narrowing the borders between traditional sports and e-sports.

Another evident difference is noticed between the dedicated professional e-sport players and „problematic" players.

Good sign of possible improvements of the health condition and health behaviours is a result of a web poll which shows that a majority of players of e-sport supports the claim that conditioning, sleep and diet have a positive effect on their e-sport performances [15], whole more than half of the participants (55.6 %) believes that physical training has a positive effect on their e-sport performances [16]. Players that are serious in their pursuit of a professional career in e-sport spend almost all of their „waking time" in activities related directly or indirectly to e-sport in order to „practice and improve cognitive processes needed for fulfilling the requirements of the game and the skill of gaming itself" [17].

Modifications to training procedures in e-sport, which have been so far predominantly digital, and its incorporating into the „real world", is possible by integrating physical activity and other behaviours connected to health into training routines of e-sport players. New findings about the health of e-sport players in 2020 show that 80% of participants have been adhering to recommendations of the World Health Organization of incorporating physical activity for at least 2.5 hours per week [18].

Average sleep time per day of the total sample of the „eSport 2019" study has been 7.1 hours, and now is 7.4 hours on workdays and 8.3 on the weekends [18]. Like in the previous years, average level of the physical activity among the target group is significantly above the World Health Organization recommendations(more than 9.5 hours/week) which is one hour more than noted in the „eSport 2019" research which demands positive reaction of the increase of the physical activity levels within all e-sport players groups.

The exemption is the increased usage of energy drinks which is considerably higher than among e-sport players than within the other demographic groups. This is most likely present due to large number of various beverage producers present as sponsors [19].

It is obvious that e-sport players belong to the group that has bigger body fat values and that their everyday step count is still low. According to the findings gained by club member polls, body mass index (BMI) of e-sport athletes is 26.03 ± 1.85, number of steps is 6646 ± 3400, and daily e-sport hours are 9.35 ± 1.12. Previous research has shown that as game time in e-sports increases, BMI increases as well, and the step number goes down [8]. Simple, but effective approach to tracking physical activity levels is step counting by the individual within a given day. Result of the counting steps accuracy tests is 98.6 % [20].

Recent study has shown the scale of obtaining data of physical activity using the smartphone applications, describing the data on 717.527 iPhone users from 111 countries between the ages 16-44 [21].

Most of e-sport players did not fulfil the physical activities guidelines, indicating on potential future health risks [22]. Effects of physical activity on professional e-sport players health(as well as other e-sport players) are based on changes of vital functions of the organism and metabolism caused by exercise. For that reason it is very important to add the physical „assistance" training to „digital" training [23]. Portable smart devices are used to track physical activity and general health of e-sport players, estimate energy reserves during the day and conduct preparations for intensive playing [24].

4. CONCLUSION

The Physical activity represents irreplaceable source of physical and mental health. It is also directly and indirectly connected to quality of performance of e-sport players.

On the other hand, although e-sport players spend a lot of time in front of screens interacting with digital devices, they are not the most endangered digital media user category due to prevention of possible health risks through physical activity. This paper has shown value and potential of studying e-sports within sport sciences, and possible implications that results of e-sport research can have on general population.

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THE USE OF IT TECHNOLOGY IN SPORTS COMPETITIONS

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Abstract:

Information technologies are considered to be the main reason for the rapid development of the sports industry. IT industry has become necessary for the functioning and development of sports competitions and organizations. Thanks to new technologies coaches have the ability to analyze the impact of their athletes, increasing the precision of the athletes, enabling referees to make equitable decisions, improve the quality and design of sports companies, as well as providing fans a better view of sports performance, while managers can much more easily organize sports competitions.

Keywords:

Sports Industry, New Technologies, Internet, Software.

INTRODUCTION

Information technologies are considered to be the main reason for the accelerated development of the sports industry. According to research by consulting firm ATKearney, the estimated value of the sports industry is about $620 billion. [1] Today, new technologies have become necessary for the management of sports organizations, which include the global world sports organizations (International Olympic Committee, FIFA, UEFA, FIBA, NBA, NFL), national sports federations, sports clubs in charge for organizing sports competitions, production and promotion of sports products (Adidas, Nike, Puma, Under Armour, Asics), broadcast of the latest information and videos via sports media (Eurosport), entertainment industry which includes sports video games (EA) and sports betting (William Hill, Ladbrokes, bet365, bwin, Paddy Power, betfair, Unibet).

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Thanks to new technologies in sports competitions, coaches have the opportunity to analyze the sports performance of their athletes during competitions, increase the accuracy of athletes, enable referees to make decisions, improve the quality and design of sports companies' products, and give fans a better overview of sports competitions. New technologies have become an indispensable part of sports venues (stadiums, halls and swimming pools), which aim to monitor potential hooligans among fans, so that the police can react in time and prevent potential conflicts, both between fan groups and between fans and police.

2. THE ROLE OF THE INTERNET IN THE SPORTS INDUSTRY

Thanks to the Internet, information about your favourite athlete, club, national team, sports product or sports company can be found out in a few seconds. Each sports club has its own web presentation as well as on social networks such as Facebook, Twitter or Instagram, used by sports organisations to promote and inform their fans. Also, coaches use the web to analyze others athletes or teams before sports competitions.

Globalization has become one of the main topics today. "If we understand globalization as a process of international rapprochement in the field of economy, social order and culture, we see that it is ubiquitous. Marketing with its theoretical background and practical application are no exception. In addition to economic and political integration processes, largely thanks to the Internet, we are witnessing the globalization of the world. The Internet can intensively help sports marketers to develop the sports industry and sports products and dominate the sports market". [2, p. 105] Some important marketing constants, such as time and place, are being completely redefined and new theoretical and practical interpretations and applications are being sought. New possibilities of direct marketing communication with consumers are opening up. Although this topic is widely discussed in our professional circles, the Internet is mostly viewed as a medium for activities within certain marketing functions or even exclusively as a medium suitable for improving certain promotional activities, i.e., market research activities. Contrary to this established view, we believe that electronic communication through online environments can and must be viewed as one of the key ways to innovate in marketing. Today, every sports club or sports company uses the benefits of the Internet to present and promote novelties related to the club or company, whether it is a game played or new products that are yet to appear on the sports market.

Today, the Internet has become an indispensable part of everyday life, a necessary thing that makes life easier for ordinary people. Every famous athlete today has their own website, where their fans can find out details related to their career or life, promoting themselves and their skills, not only in sports but also in other markets. The Internet is considered to be the largest database and an increasingly successful one-on-one response mechanism. It is important to point out some of the often mentioned important determinants that must be respected when designing the connection between marketing and the Internet:

1. The digital age requires new ways of thinking and new business philosophies,
2. The digital age makes technology accessible and transparent,
3. In the digital age, people have never been more educated and confident,
4. People care about themselves, but also about the environment
5. The Internet primarily conditioned the revolution in communications, and secondarily in technology.

To illustrate the use of the Internet, we must mention the Nike website. The particular importance in the Nike promotion belongs to the website where sports products intended for sports competitions are promoted. Information about the company's history, products, activities, facts about the company can be found on the website www.nike.com. Impressive and recognizable strong slogans, thoughts and messages dominate the site. Adaptations were also made to users from different geographical areas with the possibility of choosing the desired language. Segmentation into continental markets has also been performed. Although there is a basic common logic and connection in the appearance of the site, certain deviations have been made depending on the market for which part of the site is intended. For example, the choice of sports and promoters is adjusted to the representation and popularity of certain sports.

1.1. INTERNET IN SERBIA

The Internet breakthrough in Serbia occurred in the mid-1990s, after the Dayton Agreement and the lifting of sanctions. Today in Serbia about 73% of the population has access to the Internet. We all agree that the internet is necessary. Internet brought about huge changes and made people's everyday lives easier. Online shopping has become very common in economically developed countries as well as in Serbia. For example, today the average American, due to lack of time, rarely goes shopping because they spend more time on the Internet, visiting various sites, buying sports products that interest them and that are delivered to their home address. Today, the citizens of Serbia are increasingly buying online sports equipment, both due to the lack of time to visit stores, and due to the greater offer of sports products online than in stores. When buying sports equipment, many companies offer discounts for online shopping. At the same time, consumers can find products of interest to them much faster with the help of filters, compare them with other products by different criteria such as new collection, footwear or clothing, size worn by consumers, product selections for men, women, boys or girls, as well as discount sizes.

2. IT IN SPORTS

Thanks to GoPro cameras, extreme sports began to develop rapidly and gain in popularity. Viewers can see from the angle of the athletes themselves what it looks like to compete under high adrenaline. The Euro-league, in cooperation with the company "First Vision Cam" and the TV station "Kanal Plus", made an experiment where the players of the Lithuanian basketball club Zalgiris played in the jerseys with installed mini cameras, which had the task of conveying to the audience an insight into the new dimension of basketball from the basketball court. [3] The point is to understand what it means to be dishonest from a technological point of view in a particular sport. Cheating in sports is a disagreement between what is possible with current technology and what the rules allow.

3. SOFTWARE IN THE SPORTS INDUSTRY

Software development has greatly contributed to the development of the sports industry. Ticket sales are increasingly taking place online. Thanks to the latest software, tickets for the most sought-after matches are sold out in 15-20 minutes from the time of sale on the Internet, while all Super Bowl tickets are sold out within minutes. Among the most popular software in the sports industry are SAP, KORE, EMS, CRM, Arial and others. Sports equipment companies already make extensive use of software such as SAP (System Analysis and Program Development), which provides a complete set of functionalities for business analytics, finance, human resource management, logistics and corporate services.

SAP [4] also offers programs such as: Advanced Planner and Optimizer (APO), Business Information Warehouse (BW), Customer Relationship Management (CRM), Supply Chain Management (SCM), Supplier Relationship Management (SRM), Human Resource Management Systems (HRMS), Product Lifecycle Management (PLM), Exchange Infrastructure (XI), Enterprise Portal (EP), SAP Knowledge Warehouse (KW) that have become essential for the functioning of any serious company. SAP is the third largest software company with about 40,000 employees and revenue of $ 9.4 billion. The operation of global companies without the use of the above software is unthinkable today.

The use of new technologies has become necessary for work in sports organizations. When someone is applying for a job in international sports organizations, the candidate is required to know computer skills. Candidates are expected to know how to use the MS Office package, which includes programs such as Internet, Outlook, Word, Excel, Power Point, while recently more and more companies and sports organizations are using the SAP program. Also, there is an increasing number of sports coaches and clubs that use the services of the Synergy program, which relates to scouting and detailed analysis of teams and players (corp.synergysportstech.com).

Performance analysis in sports teams has become a segment of the sports industry with a fast developing. Advances and the availability of technology and data have transformed this sector and expanded the game-changing benefits that clubs can achieve through the adoption of performance analytics. David Brailsford's term "marginal gain" is now a universal matrix for clubs and teams to gain that competitive advantage. Hoodle is at the forefront of this analytical revolution, developing commercial tools and talents to provide performance analy-

Figure 1 - Sports analytics.

sis to sports at all levels. We see behind the scenes how clubs implement Huddle technology to drive innovation and advancement and support talent for career development in this growing sector within the sports business. Derby County Football Club has one of the most advanced video analysis departments in English football. It is no surprise that the two-time champions of England decide to invest in technology. [5]

4. DIGITAL TECHNOLOGY IN SPORT

Thanks to the great innovations it has introduced into the sports industry, digital technology has made its functioning much easier. Media houses now have better recordings of sports competitions, sponsors can be graphically inserted on the screens to give viewers the impression that the sponsor's logo is on the field. Security is now at a much higher level because security cameras cover the entire sports facility, which in the event of an incident makes the job of the police and security much easier.

4.1. DIGITAL GRAPHICS FOR MATCH TRANSMISSION

The first example of digital graphics was "January 1997, when virtual marketing was tested in Italy during the Lazio-Victoria Guimareas match, i.e., processing TV signals to insert personal advertising messages or inscriptions on the football field that are not present in the replay". [6] Today, digital graphics have become commonplace, where the sports market is looking for advertising space in all possible ways that could be sold to sponsors. Digital graphics have become very important in TV broadcasts, where sponsors have increasingly promoted their logo or product during sports broadcasts. The video game industry has made "virtual stadiums" and moving players on the field in 2D technology, which today works almost the same as during the broadcast of football matches.

- Video game industry: e-Sports

The video game industry has been around for decades. With the development of new technologies, the video game industry has developed in parallel, retaining old users and at the same time attracting new generations. In recent years, the video game industry has become an increasingly important part of the sports industry.

More than 20 years after the first video game tournaments, e-Sports tournaments now attract an audience that builds on the biggest traditional sporting events; popular live streams attract more than 100,000 online viewers during the week. Companies such as Coca-Cola and Nissan have joined Logitech and Red Bull as tournament sponsors who have positioned themselves in a new segment of the sports market. Gaming is what every traditional sports league wants to become: young, global, digital and increasingly diverse.

How big is the video game industry? About 205 million people watched or competed in video games in 2014, according to market research firm Nevzoo - which means that if e-Sport represented the nation in terms of number of participants, it would be the fifth largest in the world. Although e-Sports has long been the largest in Asia, especially in South Korea, countries like North

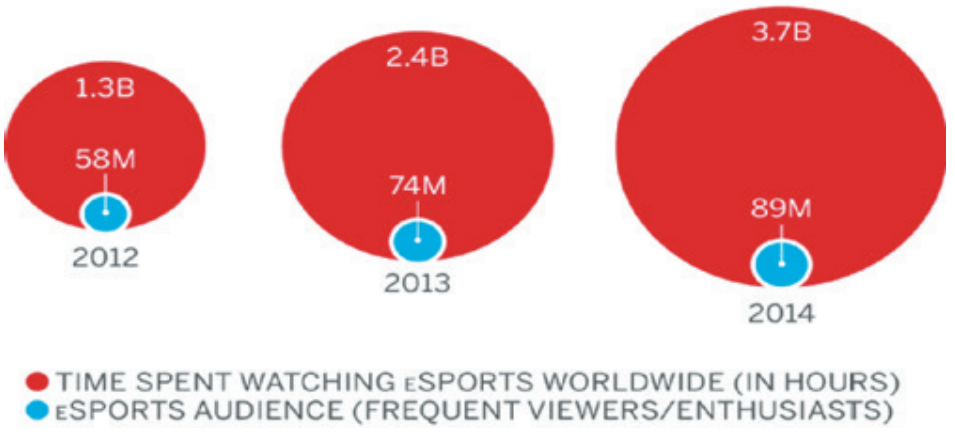

Figure 2 - Video Game Industry Market.

America and Europe have 28 million e-Sports fans, with that number growing by 21% a year. [7] In some countries (e.g., Japan), the best gamers have the status like the most popular athletes. Their competitions are broadcasted on TV and other media, while the interest of sponsors is growing every year. Sports video games have a role to give users the opportunity to be coaches or managers, to show their skills by competing with each other in the best sports leagues such as FIFA, UEFA, NBA, NFL, NHL and others. Users of video games are mostly young sports fans, aged 10-25. Among the most popular video games are Top 11 and FIFA (series).

4.2. DIGITAL TECHNOLOGY IN SPORTS BETTING

The development of the sports betting market is closely linked to the development of new technologies. Sports bookmakers account for 13% of the global betting market. The fastest growing segment is online betting. In 2012, William Hill betting had about $ 2 billion in revenue. Estimates say that the sports betting market is estimated at $700-1000 B, while the market of illegal betting is estimated at $500 B. The number of employees in the betting sector in the United Kingdom alone was around 55,000 in 2013. Currently, the largest sports betting market is Asia. [8] Thanks to the Internet, it is now possible to bet during the sports matches. With the help of new software, quotas are being created that should challenge sports fans to invest their money. In order to challenge sports fans, bookmakers allow people to bet in all possible ways. In England, the ticket paid by the father of the Manchester United football player attracted the attention of the media, betting that his son, who was only nine at the time, would one day play for the first team of Manchester United. For the £ 100 paid, the winner earned £ 10,000. The Internet allows betting service users to inquire about athletes, club and national teams, their current state of the championship and potential problems, in order to invest their money by betting on them.

Digital technology in the service of sports referee's

With the advent of new technologies, the quality of sports has risen to a higher level. New technologies have also contributed to calming passions on the field, both among the participating athletes and among the fans themselves. The human eye is not sinless, especially if the quality of the sports referee's vision is in question. However, no one questions the quality of new technologies. One of the most valued is Hawk - eye technology [9], which is one of the leading ways of visibility analysis that has the task of assisting referee's in making decisions in sports. Hawk-eye technology first began to be used in cricket in 2001 and was later used in sports such as tennis, football and baseball. Hawk - eye allows all kinds of statistical analysis, such as rebound trajectory, ball speed, whether the ball touched the line, whether the ball crossed the goal line. Their simulator has received positive reviews from Tech Radar [10], a magazine that deals with testing new technologies. In basketball, for analysis of controversial decisions, referees are allowed to use repeated slow motion from different angles to make a fairer decision.

Figure 3 - Hawk – eye.

4.3. DIGITAL TECHNOLOGY IN THE SERVICE OF SECURITY OF SPORTS VENUES

When organizing sports competitions, the following technical means are used for the implementation of security measures, such as: video surveillance systems, access control systems, counter-sabotage doors, counter-sabotage X-rays, counter-sabotage mirrors, hand-held metal detectors, alarm systems fire, means of communication (stationary and mobile).

These technologies make the police officers job easier to spot potential hooligans and remove them from the stadium, while footage from the stadium will serve as evidence in criminal proceedings before the court.

5. TECHNOLOGY IN SPORTS EQUIPMENT

Thanks to the development of new technologies, the largest sports equipment companies "Adidas", "Nike" and "Puma" have raised the quality of business of their companies to a higher level. A few decades ago, the company's system of work was reduced exclusively to the manual production of sports equipment, while today, the same companies rely on new technologies thanks to which they have increased their production and profits. Sport today is not only about achieving maximum performance of athletes, but at the same time minimizing the energy we spend while running or swimming [11]. New technologies have revolutionized sports such as swimming thanks to special polyurethane suits, but a few years later those same suits were banned because they brought a great advantage over the competition.

Figure 4 - Monitoring of sports facilities.

Figure 5 - Technology in sports equipment.

Helmets for cyclists and oars for rowing, kayaking and canoeing disciplines, made of lightweight materials that reduced the pressure of dragging through the air or water, contributed to setting new records. Many people condemn the use of technology in sports to improve the performance of athletes, although this has become inevitable, because the sports industry in which technology and sports equipment bring big profits by breaking records does not want to stagnate for moral reasons.

6. CONCLUSION

The development of the sports industry is connected with the parallel development of training, media, digital and software technologies, security technologies as well as technologies for the production of sports equipment. The IT industry has revolutionized the development of the sports industry. Sports literature, which in previous decades was manually procured from America and Europe, is now available in a few seconds thanks to the Internet, translated into all languages. With the advent of the Internet, the media has expanded its business to more segments. The Internet has raised the level of information of sports fans, developing online media that have accelerated the flow and amount of new information, while on the other hand due to too much information began to violate the privacy of athletes themselves, allowing everyone to learn about their family members, financial situation, personal problems. Thanks to new technologies, the career of professional athletes is today, on the one hand more difficult because it requires longer seasons, more matches, while on the other hand it has facilitated the way of advancement, improvement, analysis, preparation and recovery of athletes. Thanks to new technologies, today we have the opportunity to shoot new records that are being broken every day. Without new technologies, it would be difficult to know what is the fastest result in running, what is the strongest hit with a hand, foot, racket or stick, how much is the pressure on the human body in water, wind or while running.

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IT APPLICATIONS IN LANGUAGE TEACHINH SESSION

BLENDED LEARNING APPROACH TO TEACHING ESP AT TERTIARY LEVEL

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Abstract:

A new approach to language learning has arisen due to the Covid-19 pandemic. In order for classes to run smoothly, ICT has provided a new learning environment – blended learning. This paper aims to highlight the importance of blended learning in teaching ESP at tertiary level. The research was conducted on a sample of 44 students with the aim to analyse students' overall perception of blended learning. The questionnaire specifically designed for this research included opinions and attitudes of students on implementation of blended learning in language classes, namely for the purposes of ESP. Descriptive analytics was used whereas the results were analysed by applying statistical methods. Apart from considering advantages and disadvantages of applying blended learning in language learning, the paper also offers proposals concerning the improvement of teaching methods and forms. The research suggests that blended learning has positive effects on learning outcomes. Moreover, the analysis showed that this form of teaching fully satisfies students' needs.

Keywords:

Blended learning, ESP, Teaching/learning strategies, Tertiary sector.

INTRODUCTION

The covid-19 pandemic has changed a lot in education. Due to pandemic, online teaching has been proven as an indispensable tool in teaching process, especially at tertiary level where a great number of students is expected to attend classes at the university. In order to fight the virus spreading easily among student population, and thus among the citizens, certain higher education institutions in the Republic of Serbia switched to online classes that proved to be a timely and useful solution. This form of learning has had a positive effect on flexibility of approach and individual and collaborative learning. Nevertheless, lack of direct contact and social interaction, as well as lowered interest and motivation were also noticeable [1].

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Improvement in epidemiological situation in the Republic of Serbia has created room for a new approach to teaching to be introduced, namely blended learning. Blended learning is defined as an integration of traditional teaching methods conducted both in the classroom and online ("e-learning") [2] [3] [4]. This form of learning is particularly effective in groups consisting of a large number of students when it can help students better understand the segments taught in class [5] [6]. In learning English as a foreign language (EFL), blended learning is considered as an effective compensation for situations when students are not sufficiently exposed to the language [7]. In addition, integrating online and traditional learning environment has enabled teachers to provide their students with an opportunity to learn independently and, at the same time, to experience facilitated interactive learning in traditional environment [8] [9] [10].

Some of the aims of foreign language teaching include a constant effort to achieve learning outcomes, to have as many students as possible attend lectures, i.e., be exposed to the English language, and to actively participate in classes. This encouraged the introduction of a new teaching form where information and communication technologies (ICT) play a key role. ICT applied at the university level has introduced a new way of conveying and adopting knowledge [11] thus complementing traditional teaching and learning methods [12].

According to Sharpe & Benfield [13] blended learning at bachelor level has not been researched sufficiently, and the published papers focused on different teaching methods and introduced innovations. The above-mentioned research has not analysed students' experience [13] nor outcomes achieved through blended learning [14] [15] [16].

In March 2020, Singidunum University introduced online teaching through the Microsoft Teams platform which was considered a timely solution as classes went on smoothly. At the start of the academic 2021/2022 year, the university introduced blended learning which implied combining traditional teaching methods in the classroom and online educational materials which required active participation of students. The research conducted for this paper covered the period from October 2021 till March 2022. Students who took part in the research were given an opportunity to state their perception of blended learning and to indicate advantages and disadvantages of it in the ESP context.

2. BLENDED LEARNING IN EFL CONTEXTS

Some studies indicate that there are many advantages of applying blended learning [17] in foreign language learning. In language learning, blended learning is applied in order to enable students to learn the aspects of language which are not included in traditional teaching, and which imply various interactive tasks performed in online environment regardless of time and location differences [18] [19] [20] [21]. It also provides easier access to the teaching materials and flexibility in lecture attendance. Therefore, this type of learning is rather significant for the employed students who are not always able to attend lectures in a set time. When it comes to teachers, blended learning implies more time set aside for preparing teaching materials, well-organized classes, and knowledge of IT skills. Some studies indicate that application of blended learning in EFL helps master the language better [8], improve communication skills [22] and facilitate development of sociolinguistic, intercultural, and communication competencies of the students [23].

English for Specific Purposes (ESP) was developed as a result of the needs in different fields (economics, law, medicine, construction, etc.) and aims to meet the language requirements present in certain professions or specialties [24]. Unlike many other academic courses, teaching and learning English for specific purposes have had to confront various challenges, such as presenting new vocabulary to students, different situations in business environment, adopting and implementing professional vocabulary when writing a paper, and instructing students on how to translate professional texts.

Some studies researching implementation of blended learning in ESP courses have indicated that there are positive outcomes when it comes to students' general attitudes toward language learning, gaining new experience, and autonomy in learning [21] [25]. Having in mind that this paper deals with blended learning within ESP courses at tertiary level, the following should be considered: a large number of students in a group, different levels of language knowledge, students' motivation, and availability of teaching materials.

3. METHODOLOGY AND HYPOTHESIS

According to some earlier research, traditional learning combined with online materials creates a positive impact on learning outcomes [26] [16] [27], provides a learning environment that strengthens autonomy and

students' research skills [28] [29] [30], facilitates supervision and control of the learning process [5] [12]. Additional teaching materials provide better understanding of the knowledge acquired in the class, as well as better students' motivation, thus improving and supporting their learning process [31]. Blended learning enables students to get more involved in the learning process [32]. On the other hand, certain authors state that blended learning has had a positive effect on students' satisfaction [16] which is reflected in their relationship with the teacher, teaching materials, and other educational activities [33].

Null hypothesis: Implementation of blended learning in the context of ESP acquisition has positive effects on learning outcomes.

Hypothesis 1: Students express positive attitude towards learning ESP at the bachelor level which includes ICT.

Hypothesis 2: The implemented blended learning fully satisfies students' needs in the context of ESP acquisition.

The research designed for this paper was distributed to the students attending the courses Business English 1 (2nd year of studies) and Business English 3 (3rd year of studies) at the study programme Anglistics at Singidunum University. Blended learning model within the above-stated courses is organized in a way that students are given the option to choose to attend lectures online, through the Microsoft Teams platform, in real-time with the classes that are held at the university building, namely in the classroom. All materials are provided on the platform and students could do their assignments either in paper in the classroom or online by downloading the necessary materials from the platform.

The main objective of the courses was to improve students' knowledge of ESP and specific vocabulary related to various fields. In order for contents, both for traditional and online courses, to be successfully created, well-designed materials have to be developed so as to answer the need to present the particular vocabulary in its actual context of use. At the beginning of the class, students are introduced to the specific vocabulary by reading texts and doing appropriate exercises in order to master new terms and phrases. At this stage, reading materials are chosen so that students have the opportunity to learn the new vocabulary only from the given context, which proved to be a rather useful method in language acquisition. Then different types of exercises (filling the blanks, multiple-choice questions, matching exercises, etc) serve to check students' understanding of the covered segments. At the end of the class unit, students are given a task in the form of a text which is to be translated into/from English. Teacher correcting the translations provides feedback on translation and assesses students' participation in discussions.

4. RESEARCH RESULTS AND DISCUSSION

The questionnaire used in the research has been partly taken from the paper Blended Course Evaluation in the Context of English for Specific Purposes: Accountability and Development by Rui Zhang and adapted to the needs and objectives of the researchers [34].

The research included 44 second - and third-year students of Anglistics study programme at Singidunum University, Belgrade. They took the blended courses Business English 1 and Business English 3 in the first semester of academic 2021/2022 taught by the researchers. Course evaluation survey data were analysed to show whether the students' learning needs have been met or not and to what extent. There were 22 items in the questionnaire which covered six dimensions of this course – materials and content (four items), learning assessment (three items), tasks and activities (three items), learner support (three items), learning mode (five items) and learning platform (four items). The items were in the form of a five-point Likert type scale ranging from 1 – strongly agree to 5 – strongly disagree. Generally speaking, the results show that students are satisfied with the design of these courses and their implementation.

Regarding the first set of questions, which refers to materials and content, 86.3% of students state that the materials and content of the course meet their learning needs. The students' answers are presented below in pie charts, for visual analysis.

Additionally, even greater percentage of students, around 93% of them, agree that the materials and content support the stated course objectives. Approximately the same number of students say that the materials and content are easily accessible and that online video lectures are easily understandable. Attending the course Business English 3 helped students improve their legal vocabulary and essential skills of written and spoken legal English. The course is designed in such a way for students to be able to use legal vocabulary more accurately, concisely, and effectively, as well as to translate legal texts from English into Serbian and vice versa at the end of it. On the other hand, Business English 1 course is devised to help students become familiar with the English terminology, idioms, phrases, and specific linguistic structures used in the context of leadership and management.

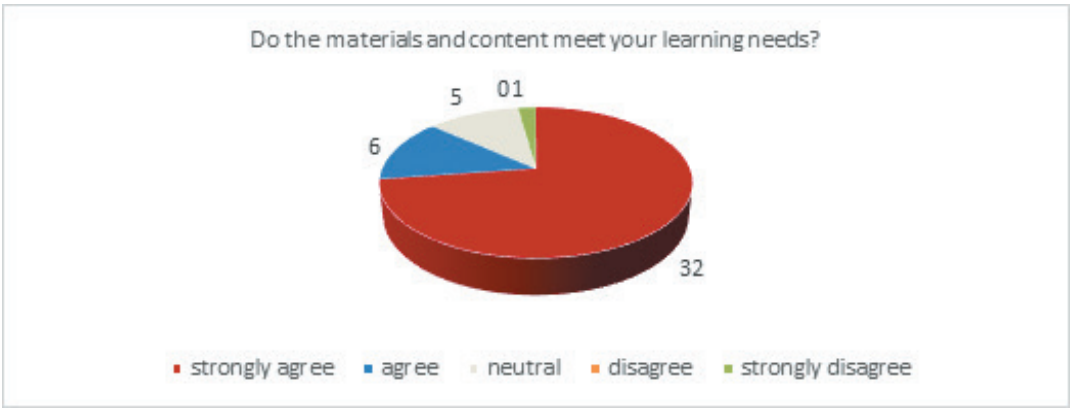

Figure 1 - Do the materials and content meet your learning needs?

The second set of questions is closely related to learning assessment. 91% of students believe the types of assessments are consistent with the course activities. In addition, a high 88.6% of students say they are provided with adequate feedback by the course instructors.

The third set of questions refers to learners' support. The findings reveal that students are mainly satisfied with the instructor-student interaction as well as content-student interaction. However, they believe the learning tasks and activities should foster more of student-student interaction. The results suggest that in the future particular attention should be paid to fostering student-student interaction in blended learning environment. It means that more effort should be put into creating disciplinary communities in the blended learning process in order to provide more interaction and collaboration between participants. The encouraging learning environment is of the utmost importance so that students can actively interact with their peers either face to face or online.

The fourth set of questions refers to the learning mode. 82% of students claim that a mixture of face-to-face and online learning (i.e., blended learning mode) makes it easy for them to follow the previously mentioned courses. The results also suggest that students have generally accepted the blended learning model. However, 11.4% of students say they have experienced difficulties since blended learning model was introduced. Further research is needed in order to identify the main challenges they face in order to help them successfully overcome all of them. It is necessary to understand how students learn best and how technology can support that for the blended learning model to be considered effective.

The instructors believe blended learning concept gives students flexibility. They can decide when and where to learn as well as manage their own time and learning process. In the long run, it could be said that this model stimulates independent learning and activates their motivation and engagement.

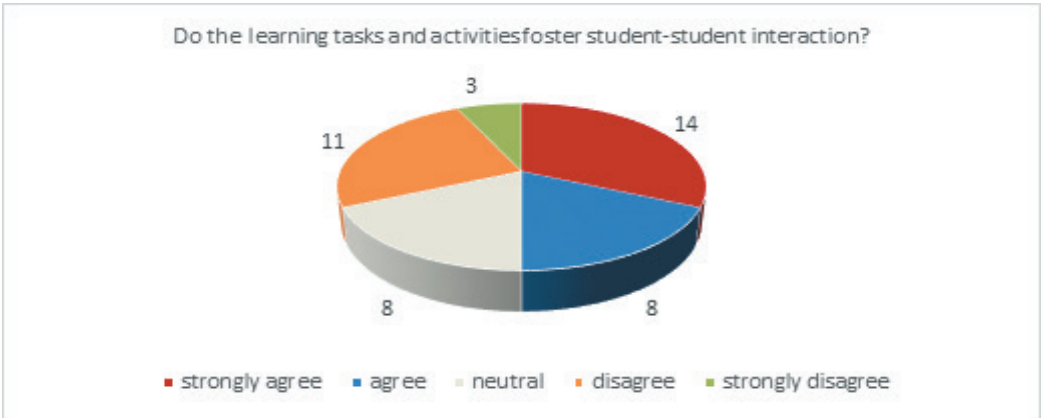

Figure 2 - Do the learning tasks and activities foster student-student interaction?

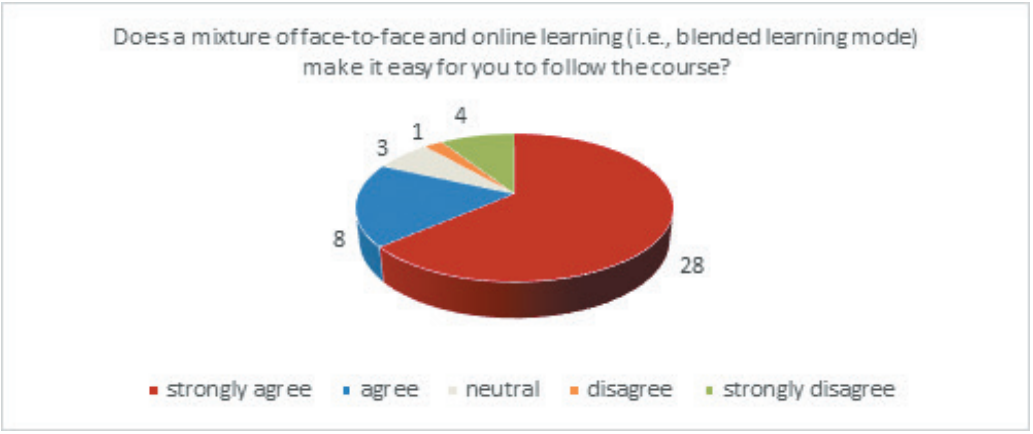

Figure 3 - Does a mixture of face-to-face and online learning (i.e., blended learning mode) make it easy for you to follow the course?

The employed students particularly appreciate the possibility to attend the lectures and have all the video materials available online, without having to disrupt their work schedules and waste their time on commuting.

The last set of questions address the learning platform, Microsoft Teams. 84.1 % of students find this platform easy to use while about 90% of them state MS Teams platform is available to use whenever and wherever they want.

The instructors agree that the platform is user-friendly and can be easily installed on any mobile device. Weak internet connection is the only negative issue which is mentioned.

5. CONCLUSION

The research conducted in this paper reveals that blended learning is perceived as beneficial and flexible for learners. The results show that students have generally accepted blended learning mode. They are satisfied with the design and implementation of the courses. The materials and content of the courses meet their learning needs. They also believe the types of assessments are consistent with the course activities. Regarding the learning platform, Microsoft Teams is considered to be user-friendly and it can be easily installed on any mobile device. The findings reveal that students are mainly satisfied with the instructor-student interaction as well as content-student interaction. However, it is implied that particular attention should be paid to encouraging student-student interaction in blended learning environment.

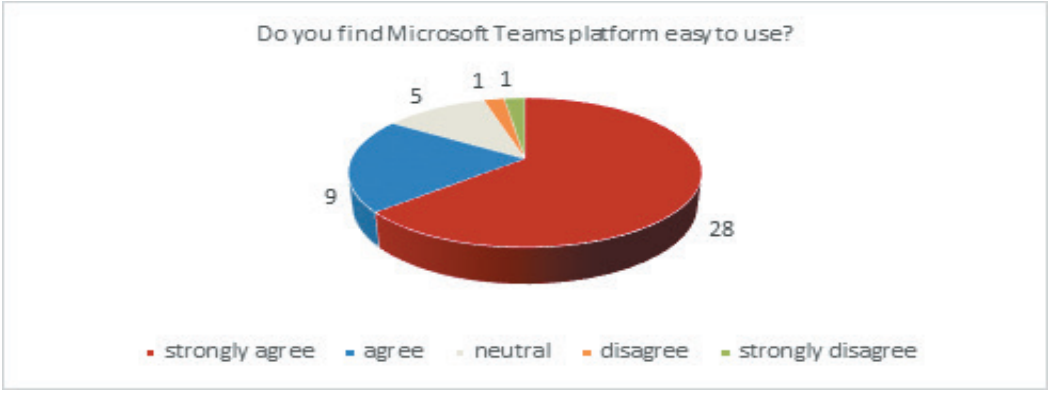

Figure 4 - Do you find Microsoft Teams platform easy to use?

Instructors should put more effort into creating a stimulating environment to motivate students to actively participate in social interaction through collaboration with their peers.

This paper considers the effectiveness of the ESP course evaluation from the perspective of students only. Therefore, further research is needed with the aim to evaluate the course from the perspective of both students and instructors.

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E-BOOKS IN FOREIGN LANGUAGE TEACHING

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Abstract:

Numerous research studies have indicated that e-books contribute to improving the quality of teaching and increasing students' achievements. As e-books imply various possibilities, the application of multimedia, and additional tools, they undoubtedly affect the interaction and dynamics of classes. The study aim of this paper is to shed light on the potential of e-books and to explore and present the advantages and disadvantages of their use. Based on the results of research (attitudes towards the use of e-books in foreign language teaching from both students of different ages and teachers' perspectives), a better and more effective implementation of e-books has been indicated.

Keywords:

E-learning, education, ICT, e-book, language education, improvement.

INTRODUCTION

Since the beginning of 2020 due to the COVID-19 pandemic, the whole educational system has encountered a huge challenge. A solution outside the existing system was sought. The world has faced an unprecedented phenomenon and involuntary migration to the online environment. Numerous digital contents were created for educational purposes in a short period of time.

Many years ago, the curriculum of the education system in the Republic of Serbia already implemented ICT in teaching with the idea that the teaching content and methods should be adapted to students and the so-called new culture of learning. In that regard, textbooks have undergone a great change not only in terms of structure but also in the overall view of their function and purpose. Nowadays, e-books have become an increasingly popular issue, and numerous research studies have been conducted to shed light on this phenomenon.

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2. WHAT IS AN E-BOOK?

Before we shed light on the role and importance of the application of e-books in teaching, it is essential to define the very term. E-books are still called online textbooks, e-textbooks, multimedia textbooks, or electronic textbooks. These are certainly not synonyms, even though all these terms refer to textbooks in digital format and are relatively similar. Some are only available online, some both online and offline. E-books are not electronic versions of printed textbooks (most often that is a PDF version of printed textbooks)

E-books are more than an online record of printed textbooks. They include a lot of functions, tools, and multimedia, as their integral part.

Nuli [1] "defines a multimedia textbook as "a textbook that contains multiple media", and a digital textbook as "a textbook that uses digital format as a way of record". Matijević & Toplovčan [2] define an e-textbook as "digital materials that strictly follow the list of content and expected outcomes that are written in the syllabus of a subject".

"A textbook that is created as a digital book with various multimedia elements that are didactically and pedagogically adapted to students to take advantage of digital and multimedia textbooks is called multimedia digital textbooks" [3]. Today, multimedia is an integrative part of e-books, and it is not necessary to emphasize that in the title.

Therefore, the term e-book shall be used in this paper. In addition to multimedia as a key feature of e-books, another important feature is feedback, and it actually provides interactivity in learning and further encourages students since they can notice the sense of their work.

A lot of e-book publishers offering additional digital materials have appeared in a relatively short period of time. Taking this into consideration, there must be standardization and valorization of e-books. According to Čanić [4], e-books must contain the following elements:

- navigation – located between chapters and subchapters, available on each page;
- search – the ability to search by keywords;
- interactive index – links in the text;
- interactive textbook map.

Nuli [3] states a few functions which e-books enable their users:

- the function of learning material;
- the function of managing tool;
- the function of learning support;
- the function of interactive resource linking.

One of the biggest advantages of using e-books is the abundance of interactive and accessible features they offer. Lecturers at faculties give priority to the implementation of new strategies in teaching, which allows students to manage their own learning. Thus, this change in teaching strategies has led to a change in the tools used in teaching [5]. For this reason, the roads towards new digital product models that will enable publishers of new content to enter the textbook market have been paved. The fundamental changes in patterns of learning materials purchase occurred and accelerated the formal adoption of open educational resources to increase outstanding digital content [6]. Innovations in this area have been still taking place, so the implementation of the most modern approaches to learning a foreign language is always necessary. The application of modern approaches and methods in foreign language learning is inevitable if the aims of learning a foreign language are effective outcomes [7].

There is a variety of advantages of e-books [8]:

- easy transport,
- easy to order and download in web stores,
- compactness,
- adequate timing (the possibility to update and improve current issues daily),
- more efficient search,
- encouraging motivation through innovation and additional functions,
- encouraging digital competence,
- strengthening individual support,
- providing feedback.

On the other hand, besides these advantages and opportunities e-books enable, there are disadvantages of using e-books as well [9], [10]:

- costs,
- distraction from details of content due to the appearance of a large number of media,
- environmental factor,
- the lack of professionalism in working with new media in the classroom due to insufficient training and media education,

- inconsistent file formats,
- pecial haptic properties (the lack of regular page-turning, the smell of paper, etc.),
- limited availability,
- illegal use (the risk of piracy).

Besides that, e-books are increasingly characterized by supplementary/additional materials. These are often downloadable and printable materials offered by most publishers. Worksheets with additional exercises, transcripts of audio exercises, task solutions, maps, dictionaries, and tests sorted by unites can be found there. They are often available for free.

When it comes to e-books in foreign language teaching, two terms are vital: interaction and cooperation in the digital environment. Interaction and cooperation in the digital environment represent the intentional, reciprocal, and partnership-oriented influence of participants for the purposes of understanding [11].

The question is whether the application of e-books necessarily leads to effective, innovative interaction and cooperation in the classroom. It does not matter whether it is a smaller online phase in blended learning or classes that are conducted entirely online. Another phenomenon has appeared – a new learning culture.

It is often considered how e-books are changing the culture of learning. Taking into account the accelerated technical progress, there is a growing call for the introduction of e-learning and e-learning materials. Regarding this, Honegger [12], highlights three possible situations:

- The culture of learning has not been changing – e-books transfer the old culture of learning
- The culture of learning has been changing – e-books show that the old culture of learning with digital tools and media is not efficient anymore. Changes in the culture of learning have occurred.
- The new culture of learning has appeared – e-books are the opportunity to implement the new culture of learning.

While textbooks used to be comprehensive and informative teaching materials, today, they are open to both teachers and students. Learning can be understood as an active process of processing, organizing, selecting, and filtering information. Research on teaching and learning has assumed that the digitization of teaching materials will lead to further steps towards constructivism or at least to an interplay of "constructive and instructive teaching elements" [13]. It has been increasingly important for students to work independently and at their own risk, for instance – to be encouraged to work with e-books at home and to prepare accordingly for units planned in class. Through these personal experiences of learning, students sometimes construct their own knowledge structure [13].

If a real change in the learning culture occurs, it should be emphasized that the use of digital teaching and learning media only makes sense, for instance, when e-books are integrated into e-learning platforms. This advances students‘ access to teaching materials since they are available for many years and a lot of subjects. Hence, e-books can be perceived as a middle phase until the moment they become an integral part of learning platforms and thus become a central component of the application of everyday school life for all students and teachers. Mazza [14] underlines this assumption by emphasizing that only the integration of digital textbooks with learning platforms ensures a flexible, interactive, and collaborative learning outcome.

2.1. RESEARCH METHODOLOGY, STUDY AIMS AND HYPOTHESES

The main aims of our research are to examine if students and teachers evaluate the use of e-books in foreign language teaching positively and to check which language skill is the easiest (or the most difficult) to be acquired while using digital coursebooks. We wanted to examine which function of e-books coursebooks is considered the most useful. Prior to the very research, the following hypotheses were set:

1. It is assumed that students/teachers evaluate the use of e-books in foreign language teaching positively.
2. It is assumed that e-books are used in the majority of classes.
3. It is assumed that reading is the easiest to be acquired.
4. It is assumed that students find audio and video clips most useful.

2.2. RESPONDENTS

The respondents are primary school (5-8 grade), and secondary school students, university students, and language (English, Spanish, Russian, French, German, and Italian) teachers who teach in primary and secondary schools, Singidunum University, and a language school

called My School from Obrenovac. The respondents who voluntarily agreed to participate in this electronic research attend the following schools: elementary school Živojin Perić, Stublin (Obrenovac); elementary school Nikola Tesla, Novi Sad; IT high school Smart, Novi Sad; Grammar School in Obrenovac; high medical school Dr Andra Jovanović, Šabac; and school center Nikola Tesla, Vršac.

Taking into consideration that respondents are of different ages (12-60), who learn and teach different foreign languages and use different e-books written by different authors and published by various publishers, we find the sample very relevant. 539 primary and secondary school students, 174 university students, and 68 foreign language teachers from different parts of the Republic of Serbia contributed to this research. More on respondents shall be shown in Conclusion.

2.3. INSTRUMENTS AND PROCEDURE

In order to receive the required data, the authors created three questionnaires – the first one for primary and secondary school students, the second one for university students, and the third one for foreign language teachers. The questionnaires were created in the Microsoft Forms application and distributed to respondents via email and Viber.

The number of questions in each questionnaire is identical so that the received data can be compared. We opted for quantitative research bearing in mind that it is more relevant to express individual attitudes and experience in foreign language learning and teaching.

3. RESULTS AND DISCUSSION

In the first part of the questionnaires, it was examined if the students go to primary or secondary school. Moreover, we examined the study program and the year of students who took part in the questionnaire. When it comes to teachers, we checked which educational institution they teach at. The results are shown in Table 1.

Taking into account all these results, it can be concluded that our sample is very heterogenic since the users of e-books differ in age; they learn different foreign languages, live in different places, and use different e-books by both foreign and domestic publishers. Everything mentioned shows that the listed data could provide a more objective image of the implementation of e-books in foreign language teaching in the Republic of Serbia.

Based on the results, we have noticed that e-books are used in foreign language teaching at Singidunum University more than at schools. This has confirmed the assumption of the authors.

Teachers		**Students**	
Primary school	35.1%	Primary school	50.2
Secondary school	21.6%	Secondary school	49.8
University	24.4%		
Language schools	18.9%		

Table 1 – Respondents

	Primary and secondary school students	**University students**	**Teachers**
Spanish	0.6%	13.1%	4.5%
French	9.7%	4.4%	3%
German	67%	60%	11.9%
Italian	0.9%	5.6%	3%
Russian	21.8%	16.9%	7.5%
English	/	/	70.1%

Table 2 – Languages Taught and Learnt

	Primary and secondary school students	University students
Yes, on each class	21.7%	8.9%
Yes, a few times per month	16.4%	15.6%
For independent work only	5.8%	5.4%
We do not use e-books	56.1%	10.1%
For homework only	/	/

Table 3 – How often do you use e-books?

The initial task was to question if students and teachers evaluate the use of e-books positively, which was done through a task – "Evaluate the use of foreign language e-books" on a scale from 1 to 5. Primary and secondary school students evaluated it with an average grade of 3.18, while university students evaluated e-books with 4.48. The average grade of teachers was 3.94. This has led us to the conclusion that university students have a very positive attitude towards e-books, whilst primary and secondary students are less satisfied with them.

The second hypothesis (that e-books are used in the majority of foreign language classes) was examined through a question – "Do you use e-books?". The following results have been received:

In accordance with the obtained results, our hypothesis that e-books are used in the majority of foreign language classes has not been fully proven. In fact, only university students use their e-books in each class (68.9%), whilst only 21.7% of primary and secondary school students use them in each class. As 24.3% of teachers work at university, it can be concluded that the answers of teachers and students match when it comes to this question.

The third hypothesis of ours is that reading is the easiest skill to be acquired. Choosing more than one answer was possible in this question. These are the results:

Teachers had a differently posed question (The use of e-books helps my students to acquire easily:). They were provided with different answers, as well. Furthermore, they could choose more than one answer:

	Teachers
vocabulary	24.5%
grammar	17.9%
speaking	15%
writing	6.1%
listening	22.4%
reading	12.9%
e-books do not help them	1.2%

Table 5 – Acquisition from teachers' perspective

Comparing the results, it was noticed that the majority of the respondents (28.2% of primary and secondary school students and 34.6% of university students) believe that vocabulary is the portion that is the easiest to be acquired. It is followed by grammar (17.9%) and speaking (15%). Considering the results, our hypothesis cannot be confirmed.

	Primary and secondary school students	University students
vocabulary	28.2%	34.6%
grammar	21%	26.3%
speaking	21.4%	15.9%
writing	10%	16.2%
e-books do not help me	19.4%	7%

Table 4 – Acquisition from students' perspective

The fourth hypothesis was about the most useful element of e-books. It was assumed that students would choose audio and video clips. The question for both students and teachers (The most useful functions of e-books are (more than one option is possible)) provides us with the following results:

The insight into the obtained results confirmed our hypothesis regarding teachers and their opinion. Primary and secondary school students find educational games the most useful, whilst university students opt for PowerPoint presentations.

4. CONCLUSION

Based on the obtained study results, it can be concluded that e-books have largely found their place and application in foreign language teaching in many educational institutions in the Republic of Serbia, especially in higher education institutions. Students mostly consider e-books useful. Therefore, the majority of them have evaluated them positively.

The application of e-books in primary and secondary schools is less than expected (21.7%). The reason for such application is primarily the lack of technical equipment in classrooms.

The research showed that the largest percentage of respondents think that using e-books facilitates the acquisition of vocabulary the most. Students find educational quizzes and games the most useful function of e-books, whilst teachers opted for audio-video clips.

An interesting fact that has been obtained from this research is that a large percentage of respondents, mostly those who attend primary schools, state that the issue they encounter when applying e-books is code activation.

Furthermore, e-books and access to them should be further simplified in the upcoming period. As discussed in the paper, e-books have both advantages and disadvantages in terms of their use. The fact is that technical progress and development clearly favor the quality and advantages of e-books. At the same time, there are negative comments which highlight the disadvantages of e-books.

Textbooks, learning materials and foreign language teaching itself are undergoing major changes. Nevertheless, the impact of these changes on success in foreign language learning has not been sufficiently explored yet. The use of e-books should eventually lead to learning autonomy.

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	Primary and secondary school students	University students	Teachers
PowerPoint presentations	20.8%	37.6%	15.3%
Educational games (quizzes)	41.3%	31.2%	31.8%
Video and audio clips	28.5%	28.5%	43.5%
QR codes	6.6%	2.7%	8.2%
Other	2.8%	/	1.2%

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MEDIA LITERACY AND CYBER SECURITY: THEORY AND PRACTICE IN EDUCATION

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Abstract:

The ubiquitous digital communication platforms and the growing significance of virtual reality platforms have brought along the dawn of the post-postmodern cyber era. The new historical times have also resulted in the rising importance of digital applications aiming for spreading mass persuasion, disinformation, propaganda and fake news, primarily targeting users belonging to two distinguished age groups: teenagers, young adult and senior citizens. The pandemic and the war in Ukraine have also demonstrated the enormous power and influence of informational warfare and cyber security operations, which may threat even the normal operation of democratic societies and jeopardize the right of millions for reliable and authentic information resources and knowledge. The article presents a designated educational module and a special game book on media literacy with the objective to prepare both students and educators for the various challenges of the new cyber era.

Keywords:

media literacy, news awareness, digital technologies, cyber security.

INTRODUCTION

This paper aims to highlight upon the theoretical background and the various challenges, best practices of a highly sophisticated and important topic, namely teaching and sharing awareness raising techniques on media and news literacy and facilitating rudimentary cyber security measures to be implemented by secondary and tertiary education students and their educators alike. This endeavor is particularly relevant and significant, in the light of the devastating current events taking place in the war in Ukraine. It is a commonly shared wisdom and durable experience drawn from our common 20th century European history that in times of military conflicts, political turmoil, or extraordinary events, such as a pandemic, the amount of fake news, disinformation, misinformation, hoax stories and misleading propaganda materials along with all sorts of new types of criminal activities tend to soar and prevail in an unprecedented manner and amount.

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As one may expect unfortunately, neither the students nor their educators are generally prepared for the unprecedented challenges posed by the flow of incomprehensible amount of digital information and the power of online communication and media platforms in the 21st century. The educational toolkits and useful methodological techniques are mostly missing from the national curricula and syllabus of most countries for various reasons, though many zealous educators tend to come together, merge their skills, expertise and experiences to tackle this problem all over the world. The author of this paper, together with several other global educators coming from dozens of countries from the United States through the Czech Republic to Hungary, had analyzed the intriguing academic topic of media (news) literacy and tended to find and elaborate appropriate educational tools and guidelines applicable in practice.

They came to the revelation and bitter conclusion that despite the powerful counter-trends waging a seemingly windmill fight against the antihuman dark segment of the post-postmodern world [1] still proves to be one of the ultimate splendid pedagogic objective to accomplish. This rather Huxleyan 'brave new world' and the unfolding new paradigm of cyber era are dominated by cutting edge technological innovations, such as smart devices and featured by virtual communication platforms and digital applications, which pose versatile challenges and threats for the unprepared users.

2. DIGITAL GLOBALISATION AND ITS CHALLENGES

The Washington DC based Spy Museum share its famous motto at the main entrance hall: "Trust nobody, question everything" that might as well be the most suitable slogan of our weird over-communicated and under-grasped world. In the tormented present era, when Europe faces the most devastating large scale regional conventional war in Ukraine, we can state that there are few more important and influential factors than the reliable, objective, factual information resources and descriptions about the ongoing bloody conflict in our neighborhood. With the quick rise of global digital culture and internet-based communication platforms since the mid-1990s, information has become a power tool and a weapon, as well. Informational operations within the context of strategic information warfare along with its cyber counterparts have also become the fourth and fifth new military domains [2] in the 21st century.

The much quoted virtual dimension or cyber sphere tends to be the actual living condition and almost primary sense of reality for about half of the world's population [3], though all the same the other half of the world still faces daily problems of getting fresh water, enough nutrition and electricity not to mention computers and smarts devices to communicate and learn.

The various cyber threats prevailing in the new informational dimension can also be labelled with the growing importance and prevalence of malicious side-effects and new phenomena, such as fake news, extreme political demagogy, socio-psychological influencers, disinformation, echo chambers, cognitive bias and paradoxically the more information resulting in less informed and more disoriented people. The rise of artificial intelligence with the dawn of robotic chat networks, news editing algorithms and computerized content creation altogether turn the unfolding digital universe even less humanistic and, basically more antisocial in a self-generating and seemingly unstoppable manner. These new technological trends affect not only common users' attitudes and lifestyles but even reshape the frameworks and political dimensions of international relations in the 21st century [4].

Many philosophers and futurologists tend to claim that the means (technology) has become the ultimate goal (more technology) [5] leading towards an unprecedented new futuristic dimension of prevailing general artificial intelligence and human-machine interfaces, which will certainly dominate and alter even the course of human history as wittily predicted by John von Neumann or Ray Kurtzweil decades ago [6].

3. PRACTICE IN EDUCATION

The article tends to present the various experiences, feed-backs and reviews gathered through years-long educational projects concerning media and news literacy, internet security issues and best practices carried out and experienced in institutions of secondary and tertiary education in the Central East European region.

To provide a general outline and overview of the conditions prevailing among adolescence and young adults, especially in Hungary, several studies and specific surveys have been conducted both by academics as well as by common educators in the field. These studies share some common points, which may as well be relevant for other young people in the countries of the Visegrád Four region and in South East Europe, too. Namely, the results and conclusions of the rather

comprehensive surveys and study book compiled by sociologist scholars András Bíró-Nagy and Andrea Szabó [7] claim that young people aged between 15 and 29 years are predominantly determined and affected by their peers, social media-driven influencers living, learning and having fun within the dimensions of their convenient information bubbles or notoriously powerful echo chambers determined by virtual 'talking head influencers'. Even the political affiliations (mostly Right or Left without political philosophical refinements) tend to be affected and elaborated by these information clusters also providing examples of self-declared prophets and experts of Dunning-Kruger effect's [8] manifestation of cognitive bias.

These latter factors prove to be significantly relevant and influential elements upon the life conducts and habits of the mind of both teenagers and young adults, since even their social, political and cultural attitudes, optimistic or pessimistic outlook concerning their personal objectives and nationwide future prospects are predominantly shaped by their online activities and the impacts, inputs received from various media platforms.

The personal experiences of the author of this paper also supported by minor scale survey conducted among few hundred Hungarian, American and Czech students tend to justify the presumptions that students belonging to the Western civilization, in broad context, tend to share similar or identical attitudes, internet usage patterns and media literacy skills irrespective of their nationalities or affiliations. Some sort of naïveté and sound skepticism are also common features of young users from Hungary to the United States, supplemented by the lack of applying rudimentary security measures on their smart devices and superficial naive trust laid in their internet service providers for protecting them from malicious intruders. Most of the students involved in the surveys or in the projects mentioned above, have received some preliminary educational modules and training sessions on safe internet usage and possible cyber threats. However, in terms of the versatile and multilevel hazards and challenges they might encounter or may have to cope with in the cyber space or on their favorite digital platforms, they prove to be rather unprepared, vulnerable as well as unskilled. The distinguished target group of multimedia video sharing and chatting platforms, featured by the unfiltered controversial contents flooded upon the users, happen to be the adolescents or young users primarily aged under 25 years. The other much targeted and highly vulnerable age group significantly exposed to disinformation, fake news contents and various conspiracy theories are meant to be the senior citizens [9].

These preferred target groups are eager to fall into the trap of sophisticated miz, and disinformation campaigns, deep faking footages not hanging the proper background knowledge and technological expertise. Despite the commonly held topology and misconception of generations of *digital immigrants* (generations X,Y,) versus *digital natives* (millennials, generation Alpha) coined by an American web-geek Marc Prensky [10] in 2001, these categories fall short of depicting the complex reality, vulnerability and attitude of young and senior people, nowadays in this matter. Namely, provided that one learns and thoroughly prepares for tackling with the new technology-driven challenges and brand new cyber paradigms surrounding the end-users, ultimately no one can really navigate safely on his/her own among the clusters of information and grasp the true authentic message of all the digital content. To put it into context, the daily amount of digital information generated by more than 4 billion internet users is around 44 zettabytes [11], which is about four times the amount of digitalized volume of the biggest library in the world, the Washington D.C.-based American Library of Congress with more than 45 million separate book volumes. It may not come as a surprise that common users seem to be losing ground against the exponentially growing flood of digital information and much less and less are inclined and bound by the classic paper based Gutenberg galaxy of printed knowledge content.

In other words, nowadays students around the world are inclined to be left alone with facing the data generator platforms and infinite flow of information on unprecedented scales and manners. They are also advised to obtain the fundamental background knowledge and develop the necessary skills to be able to navigate and find the answers for their queries in this new chaotic, virtual paradigm. As many surveys convey youngsters stand on their own without proper guidance and solid intellectual fundaments to find their way around in the digital maze of online scams, hoaxes and fake news [12]. Furthermore, their primary helpers and alternative gatekeepers of knowledge and information resources have become their own peers, friends and social media influencers list which is followed by their teachers and parents with tertiary importance.

Without the prerequisite set of skills and knowledge toolkit, based on critical and creative thinking and analytic problem solution skills, the aforementioned young or aging people of the cyber era are and will be utterly unable to differentiate between authentic, real information resources, and great variety of hoaxes, distorted or fully fake news, mass manipulation, disinformation and

even extremist warmongering hate speech. The dramatic American events around the siege of Capitolium on January 6, 2021, with the addlepated QAnon [13] cult believer mob demonstrated the disruptive power of disinformation, online conspiracy theories. Moreover, suffice it to mention the conspicuous phenomena of fake theories related to the devastating Covid-19 pandemic as well as the various propaganda and information warfare campaigns witnessed at the virtual battlefields of the Ukrainian war.

The lack of so-called gatekeepers of knowledge, such as medieval scholarly monks, teachers, academics, who used to be functioning as the ultimate sources of reliable information on the world and authorities of knowledge for centuries have basically vanished, or were pushed to their limits of oblivion in the postmodern open societies. Nowadays, it is common to deal with instant superficial answers on the internet featured by the virtual omnipresence of data of all kinds, leaked confidential information, and even data bases from the 'dark web', which pose significant threats in their sheer existence for the users without any proper guidelines, skills or user's handbook to the twilight zone of the internet [14].

To create and spread a manual or guideline of the kind mentioned above, useful both for students and teachers alike, has been the primary objective of the author when he elaborated the 4-class teaching/learning educational module [15], based on the inputs and experiences he gained at the media literacy and cyber security workshops accomplished in the US and in Hungary. The special cross-curricular lessons focus on methods and techniques which may directly foster and develop critical creative thinking skills in a feasible way in formal school-based or informal educational environment. The 4W questions or the famous Ciceronian query '*cui prodest* ? or who benefits ?' are discussed with pragmatism and accuracy during the lessons, along with other important fundaments of media and news literacy and internet security.

4. FAKE IT till you MAKE IT: GAMING ON HOAXES

The new game book entitled *Fake News* [16] on promoting media literacy skills development, initially was the project idea of Edina Kőműves, a young high school teacher of English and French from Budapest, Hungary, when together with the author of this paper they spent some inspiring months together at Kent State University, OH, United States, with Fulbright scholarship on media literacy in the fall of 2019. Their award winning project and game book, with the kind support of the US State Department Alumni Fund aim to foster and spread the skills and competences of news and media literacy, internet security among adolescent young learners in an enjoyable, gamified way [17], easily implementable both in formal school-based and out-of-school, non-formal educational environment. The book available both in print and online versions, focuses on providing a comprehensive, clear, easy to understand description of ten basic notions of media literacy and internet safety, security through a board game, which can be completed in group or even individually in about 60-80 minutes time span.

Figure 1 – Cover of the game book. Courtesy of the author.

The ten core concepts analyzed and elaborated on through the plot of the book are the following: *content analyses, critical thinking, deep fakes, disinformation, media bias, fake news, misinformation, propaganda, selective exposure and stereotypes*. At the end of the chapter-like game episodes, the book also provides the players, users with a useful list of informative websites that could be a highly beneficial toolkit for future news explorations, fact checking, content analyzing endeavors for open-minded students and educators.

Besides offering an enjoyable and knowledgeable pastime for young learners, the game book is also supplemented with a series of complex awareness raising questions and topics for further discussions involving queries, issues like:

- Mention a media literacy related term from the book that you didn't know / didn't understand before !
- What were the skills that proved to be especially useful in dealing with situations connected to media literacy ?
- What is the role of the media in our society?
- Are there any areas in personal or professional life, where media literacy is especially useful?
- Why do you think having strong media literacy skills is important when we consume / create content?
- How do stereotypes influence us when we read/ listen to the news?
- Mention examples of propaganda, when it a) used visual symbols of power, b) used specific language, or c) monopolized communication sources/channels.
- How can you detect whether there is a biased ideology behind the message you read?
- Can you think of an example where the same piece of information can be presented/framed two (or more) completely different ways?
- What are the pros and cons of getting news from social media?
- What are the concrete news sources you consider reliable and unbiased?
- Give an example of a conspiracy theory that you have heard of?
- What can be useful strategies for identifying fake news and hoaxes?
- What is the difference between a fact and an opinion?
- How does the media have an effect on the operational democracy?
- Why should social media platforms be used with a critical mindset?
- Have you ever seen news when you were not sure if it is (fake) news or parody?

According to the present knowledge of the authors, there is no similar style, genre and in-depth educational book available online and in printed form, too on the niche media market and academic educational sector in Europe. Though, the major English-language news outlets and media agencies do have educational platforms based on their own news material contents thematically reframed for media literacy educational purposes, those are not so popular and easy to comprehend for adolescent users and news consumers.

5. CONCLUSIONS

When the present article started getting its final shape in early February 2022, and the experiences from teaching and implementing the 4-lesson plan media literacy module content, along with the Fake News game book, the author did not know the topic would become even much more relevant and globally outstanding than it has been for the past years. The 'black swan-type' [18] Covid-19 pandemic that everyone feared but no one really expected struck upon human race with unprecedented social, economic and cognitive effects, while the war in Ukraine demonstrated the enormous power of digital media and the rule information bubbles upon modern societies. It is quite a well-established common revelation that media has been the fourth power branch ever since the beginning of the 20th century, and it is so even on larger and deeper scale in the digital age. The online communication platforms, particularly the social media sites, have managed to obtain previously unprecedented power on people's opinion, worldviews, attitudes and values. As we could witness along the American elections or the Brexit-referendum, the big tech corporations and their political affiliations can truly influence, manipulate elections and drastically shape the future of societies, furthermore in worst case scenarios even jeopardize the sound, unbiased, impartial functioning of democratic societies. In order to mitigate the emergence of these risks and to hinder the unsolicited hazardous phenomena to prevail in the postmodern digitalized societies, more and more users, primarily belonging to the younger generations must be educated and prepared, shielded with the proper intellectual toolkit for this uneven and unprecedented challenge in human history. They have to tackle with the controversial though attractive virtual reality of overwhelming alternative facts, fake news, cyber threats and information warfare operations on global scale targeting each and every one of them linked to the ubiquitous matrix.

The game book and the educational module presented above try to provide guidance and intellectual fundaments in this battle for the primary target group

of hoax contents. As it reveals from the work classic fundamental knowledge accompanied with common sense and analytic critical thinking skills prove to be good recipes and manuals for reliable navigation in and out of the digital maze.

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STUDENTS' ATTITUDES TOWARDS A SPECIALLY DESIGNED LANGUAGE LEARNING PLATFORM IN A RUSSIAN ONLINE LANGUAGE SCHOOL

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Abstract:

Extreme times call for extreme measures, thus the request for using technology in teaching during the previous couple of years was inevitable. Suddenly, all people, regardless of their age, had to get used to the idea of a computer or mobile phone as a means of connection between a teacher and students. Moreover, learning content was adapted to the new media. This consequently led to the occurrence of a large number of platforms for online studying, interactive concepts the aim of which was to motivate, intrigue students and make them feel comfortable in using them.

Not only was it challenging to adapt the teaching to the new situation, but the question of which platforms to use was of paramount importance. There were not enough research data about the effectiveness of their usage, what is more, students became fastidious and required their needs to be catered for. Therefore, this research has tapped into the question of students' attitudes towards the specific platform as a learning tool used in an online school for learning English in Moscow. The level of appreciation has been found to be rather high. Nevertheless, it has been discovered that the weaknesses which concerned them are mostly connected to the mistakes in materials and they require more choices, more additional materials and tests, which is a food for thought for the school itself.

Further research about attitudes towards similar platforms could outline the needs and expectations of students for the future.

Keywords:

Online platform, e-learning, learning languages, attitudes.

INTRODUCTION

Ever since the first notion of digital natives occurred in education with Prensky's [1] discussion about the fundamental differences in processing information for the generations nowadays compared to their predecessors, the question of using technology in education became the pinnacle of modern research. The times of the pandemic only highlighted the importance and provoked a plethora of research on the given topic such as [2]. Moreover, a number of new platforms, digital tools, learning contents and systems appeared during the pandemic [3]. It is obvious that people of all ages and educational backgrounds had to get used to the idea of studying online.

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For digital natives such concept was not intimidating, moreover, it seemed quite natural, whereas digital immigrants found the idea challenging. The needs of modern learners altogether seem to have been covered by e-learning. Overall, students' preferences still need to be explored, hence this study focuses on assessing the opinions and attitudes of language learners towards a specialized learning platform.

2. REVIEW OF LITERATURE

2.1. BASIC CONCEPTS

IT, or more precisely ICT (Information and communication technologies), represents the main constituent of modern education and intertwines the present teaching and learning processes [4]. We are perceiving a paradigm change in our schools, moving from teacher-centred to learner-focused studying [5]. Learner-focus leads to more learner autonomy, which, consequently, increases the importance of self-study sections in learning tools.

E-learning can be defined in various ways. According to Oxford dictionary e-learning is "a system of learning that uses electronic media, typically over the internet" [6]. Some researchers called it "the learning supported by digital electronic tools and media" [7] considering it to be a part of digital learning. Anderson claims that e-learning implies learning via all electronic media, whereas online learning focuses only on learning via net. [4] He also added that e-learning embraces learning with and through ICT.

It is not an easy task to create a web-based learning environment. There are a lot of different aspects to be taken into consideration starting from pedagogy, psychology, software and knowledge engineering and ICT technologies [8].

The most favourable prospects of using technology in language learning classes is the opportunity of connecting learners in authentic communication to the native speakers, both synchronously and asynchronously [9] in which case language learning platforms are of paramount importance.

2.2. LANGUAGE LEARNING PLATFORMS

A challenging task placed in front of most educators today is the choice of appropriate language learning platform. There are myriad options and the number is constantly increasing. Pragmatic choices need to be made having in mind pedagogical implications, costs, user-friendly interfaces, possibilities for using the platforms on various devices. Bates [10] discusses the challenges of deciding on the right model, claiming that there cannot be only one "best" model.

Special attention should be paid to the interfaces of e-learning programmes, since they are becoming more and more elaborate, catchy and intricate, packed with information and highly developed graphics. This could lead to students focusing more on technology and not the materials [11]. Additionally, Pang and Pang mentioned that personalization is a significant constituent of e-learning and that it is important to choose learning preferences according to students' needs. All of these points have to be taken in consideration when choosing the right learning platform.

2.3. E-LEARNING EFFECTIVENESS IN LANGUAGE TEACHING

According to Hodges et al. [12] attitudes of students towards online instruction and everything implied by such instruction can affect the perception of success in their studying. Yang and Chen [13] reviewed in their study a lot of research which has been performed so far, proving that the use of multimedia technology resulted in positive effects on language teaching in quite a few respects: facilitating communication, reducing anxiety and increasing confidence, encouraging oral discussions, improving motivation and all the language skills, as well as creating cultural awareness.

It was concluded that new computer technologies provide more visually stimulating material, can address various learning styles, incorporate authentic material and provide authentic communication via web in the target language, encourage cultural comparisons and bring competency in language skills [14]. Studies were conducted to prove the efficiency of various tools and most of them found statistically significant difference showing that computer-based learning contributed to more retention and better results [15] [16] [17].

3. RESEARCH

3.1. CONTEXT

The research was performed on a group of 36 students of an online English language school, TreeWords, from Moscow, Russia. The school started working in 2013. focusing on one-to-one lessons with students of all ages and levels. However, initially the target group were adult students. In 2014, a special platform was developed by a team of computer programmers using Ruby backend programming language, Rails programming framework, AngularJS front-end javascript framework, PostgreSQL database management system. Furthermore, this platform was incorporated as a part of the website and a group of methodologists produced materials for learning English through 17 different types of courses.

TreeWords platform offers learning materials with activities such as drag-and-drop, fill-in-the-blanks, write an essay question, upload a video answer, matching, multiple choice activities and similar. It is designed to function in combination with Zoom, additionally, it tracks students' progress, the time spent on doing the activities and generates an archive of recorded videos teachers create when having face-to-face lessons with the learners.

The aim of the research was to analyse the students' attitudes towards the TreeWords platform and their assessment of the impact the platform has on their learning.

3.2. PROCEDURE

An online survey was sent to a group of 100 students studying at the given moment and 36 of them completed the form. The survey consists of 16 questions, 6 multiple choice closed-ended questions asking about the gender,

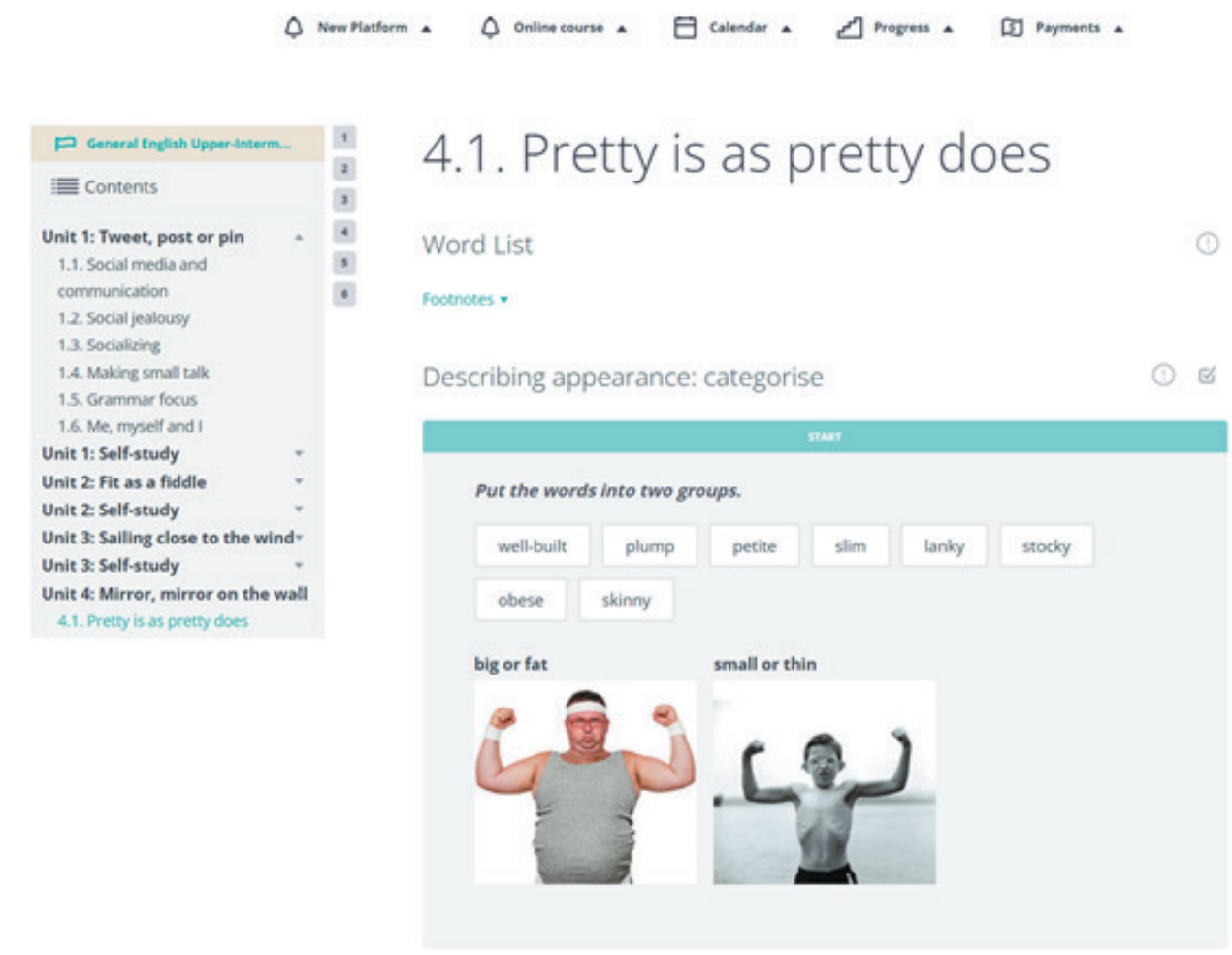

Figure 1 - TreeWords platform sample page

age, level of English, the time spent studying at school, the frequency of using the platform and their personal feelings about the effectiveness of the platform on their studying. Furthermore, 6 additional closed-ended questions were added using a Likert scale from 1 to 10, specifically checking the attitudes towards the platform: general satisfaction with it, its appeal, ease of use, availability, interactive content. The final part has four open-ended questions asking the students to write about the things they like the most, then those they like the least on the platform, their previous experiences using any other learning platforms and possible comparison, as well as an open space for suggestions.

A mixed method was applied for the analysis using IBM SSPS Statistics software, version 26, for quantitative descriptive statistics review of the closed-ended questions in this small scale research and a description of answers to open-ended ones as a qualitative part of the research.

3.3. DESCRIPTIVE STATISTICS

For the six questions specifically about the platform, where Likert scale was used on a scale from 1 to 10, the mean value is from 8.44 to 9.08 which is an amazing result, showing that as a rule students are satisfied with the platform, its availability, ease of use, appeal and would recommend studying with it. The highest standard deviation is 1.66 meaning that most of the answers were highly positive.

All age groups are present in the study. The largest number of students is between 36 and 45 years old. Having in mind the difference in the mindset among different ages, it comes as a bit of surprise that satisfaction with the platform is so high with the older students. The mean value for the satisfaction was the smallest for people older than 56 and the age group 26–35 with it being 6.00 and 6.60 respectively. Standard deviation for the group in the middle is stunning 2.30, which could be explained by higher expectations of these students. The youngest students are the most satisfied with the platform (M: 9.75, SD: 0.50).

According to Pearson correlations there is no significant correlation between the variables of age, gender, level of English and satisfaction, ease of use, appeal of the platform. The only weak correlation, which was expected, is between the number of years studying at TreeWords and the level of English with the Pearson correlation of 0.462.

It can be concluded that the higher the level the less students use the platform, as presented in the Figure below.

3.4. QUALITATIVE OVERVIEW

It is obvious from the Likert scale answers that the majority of students approve of the platform, however, they listed some weaknesses that annoy them. Most of those are connected to the problems with mistakes in materials and situations in which a platform does not recognize their correct answers first, if they are written in a short form (e.g. isn't instead of is not) and then if there is a possibility of having more than one correct option. On the other hand, the main advantages of the platform are predominantly connected to a good interface and the ease of use. The table below shows some of the answers for these two questions.

The platform has courses with two parts: one intended for face-to-face work with a teacher using Zoom, and another as self-study material which is used asynchronously for homework.

Question	Minimum	Maximum	Mean value	Standard deviation
How satisfied are you with the platform?	3.00	10.00	8.4444	1.66381
How would you rate the availability of the platform?	6.00	10.00	9.0833	1.02470
How would you rate the ease of use of the platform?	6.00	10.00	8.8889	1.14087
How would you rate the appeal of the platform?	4.00	10.00	8.6667	1.53064
Do you think learning a language is easier with such interactive content?	5.00	10.00	8.9167	1.33898
How likely are you to recommend the TreeWords platform to others?	5.00	10.00	9.0833	1.36015

Table 1 – Descriptive statistics for questions about platform satisfaction

Age	Mean value	N	Standard deviation
Up to 10	9.7500	4	0.50000
11-15	9.1667	6	0.98319
16-25	8.4000	5	1.34164
26-35	6.6000	5	2.30217
36-45	8.2000	10	1.54919
46-55	9.4000	5	0.89443
Over 56	6.0000	1	
Total	8.4444	36	1.66381

Table 2 – Correlation between age and satisfaction with the platform

The idea of having the self-study section appeals to students, since the platform can give an immediate feedback. For this reason accuracy is of great concern for the users.

Only one student used another platform for learning a language, which was focusing more on the listening tasks and audio approach to learning, but there was no comparison to the TreeWords platform. No specific suggestions were given. Majority of students simply skipped the question or gave supportive words for the future of the school.

4. CONCLUSION

This narrowly focused research showed an incredible level of satisfaction with the language learning platform for students of all ages. They can feel it helps them with the progress, mostly use it on a weekly basis and are happy with the design. However, in the rapidly changing world the platform as a tool needs to keep up with the developments and retain the cutting edge quality it possesses at the moment. Furthermore, it is essential to regularly update learning materials, as one of the main

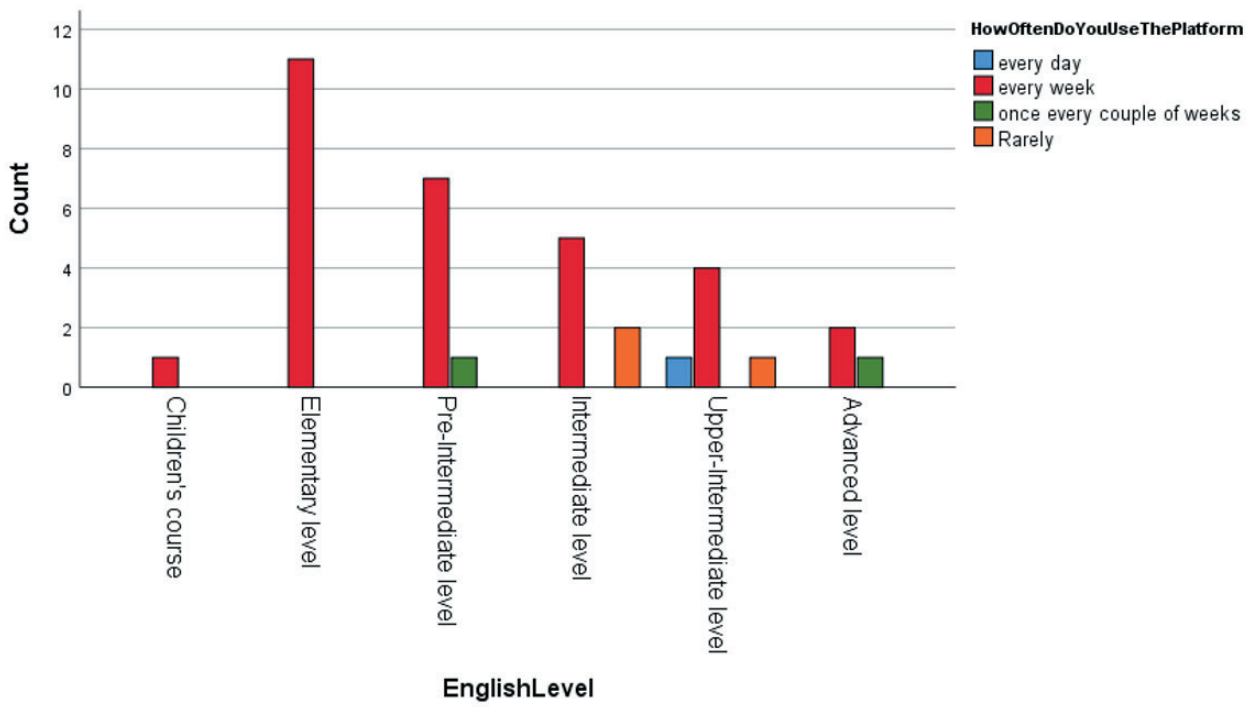

Figure 2 – Bar chart on the correlation of the English level and the frequency of using the platform

What do you like most about the platform?	What do you like least about the platform?
That I can use it whenever I want.	Mistakes in the materials.
The possibility to discuss the materials on the platform with a teacher.	Sometimes I don't understand the questions.
Just the experience of using it.	Menu with sections.
I like pictures and links to authentic materials.	Sometimes difficult to use. The things you need are in the wrong places.
I like the design.	Sometimes there are bugs.
Very convenient.	We need more additional materials.
There is a diversity of topics.	You need to constantly log in and not stay logged in all the time.
It's easier to learn when you use it.	More tests.
I like the time tracking option.	Explanations are in pictures and you can't copy the text.
Available lessons archive.	The platform sometimes does not open on a place I stopped the previous time.
It's easy to use.	

Table 3 – Advantages and disadvantages of the platform

shortcomings, perceived by the students, is not having enough materials or mistakes that appear to be present within the activities. A multitude of the inaccuracies mentioned are connected to having more than one possible answer to a question which were not all recorded in the system and were then seen as mistakes. Such observations highlight the importance of IT experts collaborating closely with content writers and constantly working on the improvements of the possible answers.

Additional challenge would be to have the students use more than one platform as an online learning tool and make a research about their opinions afterwards and definitely test the effectiveness by comparing the results of working with the platform to using a different one or no platform at all. This comparative view would definitely show the preferences of learners in general. A suggestion for the further research would be to include teachers as well, check their standpoints and compare them with the students' points of view. This kind of analysis, focusing a bit more on the attitudes of both sides in the learning process, can help in developing the exceptional platform which could further motivate and promote e-learning.

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TEACHING SOCIOLINGUISTICS IN A HYBRID CLASSROOM

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Abstract:

The purpose of this paper is to present the differences and similarities between online teaching and teaching sociolinguistics in a hybrid classroom. The theoretical section of the paper comprises basic information about teaching sociolinguistics, the definitions of the traditional classroom, online teaching, and the hybrid teaching model, along with the advantages and disadvantages of each of these teaching models, whereas the research section includes methodology and results from a focus group with students of sociolinguistics at the study program of Anglistics at Singidunum University. The research results have shown that students do not experience significant differences in learning sociolinguistics in a hybrid model when compared to the online model. The results have also confirmed the fact that students are aware of the importance of sociolinguistics for their future careers and that they are willing to study both in a hybrid classroom and an online setting, as their goal is to acquire the necessary knowledge.

Keywords:

Hybrid model, sociolinguistics, online teaching, traditional classroom.

INTRODUCTION

Having in mind that socialization is one of the significant factors in language learning and the teaching process, one cannot help but wonder whether online language classes have had any consequences on the social aspect of education. As Van Herk points out, a change in a social situation will lead to changes in the sociolinguistic situation' [1]. In other words, the link between language and society is so strong that there is almost no possibility that the events in one sphere (society) will not have any influence on the events in the other sphere (education). Therefore, this paper aims to analyze the differences between traditional classrooms, online classrooms, and hybrid teaching models, with special reference to teaching sociolinguistics as a course that is of immense importance for future language teachers. Since there are so many studies about the differences between traditional and online teaching methods in general, what this paper aims at is to highlight these differences in terms of teaching a specific course, with its advantages and disadvantages.

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Moreover, specific attention is given to a higher education institution where this course is offered in the fourth (final) year of Bachelor's studies. These differences are shown both in theory and in practice, from the perspective of sociolinguistics teachers and students, to enhance the teaching process in the future, for the benefit of students and teachers likewise. As the authors of this paper have been teaching sociolinguistics at Singidunum University, their goal is to discover which teaching methods suit their students' needs in order to adapt their teaching model, but also to realize whether there are any disadvantages of the current hybrid teaching model.

2. TRADITIONAL CLASSROOM

Traditional teaching is known as the use of classical teaching tools, which consist of blackboards, chalk, books, notebooks, and pens. According to Ilic, one of the most common theoretical approaches to traditional teaching implies three main educational methods, which were used separately in the classroom, but their intertwining occurred in the 21st century as a consequence of the need for changes in the educational system around the world [2]. The teacher-centered method empowers students to simply receive the knowledge from their teacher without building their commitment level. However, most lecturers used to practice the student-centered approach to encourage interest, analytical research, critical thinking, and feelings of fulfillment among students. However, the most commonly used method in contemporary society is the teacher-student interactive method, in which we can see the characteristics of both teacher-centered and student-centered methods [3]. Although it has already been proclaimed old-fashioned in some societies, the traditional classroom offers certain advantages, such as a wide range of projects and student interaction. Moreover, attending lectures implies following and respecting the university schedule, which provides students with the necessary punctuality and a sense of order. Additionally, studying in a group with their peers, students are more motivated, as they all have similar goals (e.g., to pass the exam, learn new vocabulary, etc.) [4]. Less than twenty percent of the traditional classroom is dedicated to language production and lacks creation, interaction, and critical thinking [5]. According to another study, more than half of the 29 interviewed students stated that they preferred a workbook and a textbook, which is a form of traditional language teaching. Furthermore, the same study has shown that the vast majority of students could imagine themselves studying in a traditional classroom setting without the use of modern technology. They pointed out that traditional approaches to teachers' lectures are far more effective than the use of ICT (Information and Communication Technology) tools for language learning [6].

3. ONLINE CLASSROOM

Hiltz & Turoff [7] claim that 'Online teaching is the latest in a long list of social technologies that have been introduced to improve distance learning by adding various augmentations, substitutions, or blending of new pedagogical approaches and technologies. Face-to-face courses blended with online learning technologies and methodologies are generally rated by students as significant improvements over traditional face-to-face (only) classes. Some of the benefits of the online classroom include the following: the usage of video and other pre-recorded media places online classes under the control of students: they are able to watch, rewind, and fast-forward when needed; they can be watched more than once, which may help someone who has a problem with language acquisition. Moreover, according to many previous studies, flexibility is one of the greatest advantages of an online classroom, as both the teacher and the students can create an atmosphere at home which will make them feel more comfortable. Furthermore, teachers are able to follow all the students' improvements and they can easily discern who carries out the assigned activities by giving them online assignments. It has been observed that online classes are especially supported by introverted students, those who are usually quiet and inactive in a traditional classroom [8]. According to European Center for Modern Languages (A Guide to Teacher Competences for Languages in Education), digital literacy and digital competences of language teachers are considered to be one of the most significant factors in contemporary education [9].

4. HYBRID TEACHING MODEL

In the critical review of the role of technology in providing education of quality, Garson states that "as a supplement to face-to-face education, online technology is useful. As a replacement, it is a threat to liberal education." [10]. One of the sectors which are highly affected by the worldwide pandemic of COVID-19 is most certainly the higher education area. According to

UNESCO, 'On 1 April 2020, schools and higher education institutions were closed in 185 countries, affecting 1 542 412 000 learners, which constitute 89.4% of total enrolled learners [3]. In order to avoid future closures, many schools and universities chose a hybrid teaching model, which is defined as the combination of both traditional and online classrooms. In other words, the hybrid flexible model is delivered using a combination of face-to-face seminars and electronic delivery and communication tools [11]. According to Petrova, 'the hybrid model relies on self-motivation and on the belief that using the Internet is only one of the means of delivering the course, which enhances effective learning [12]. The same author also states that the 'hybrid model incorporates various methods of content delivery and guided and self-centered student learning, but more importantly it is capable of recognizing multiculturalism and diverse student learning needs' [12].

Regardless of whether students opt for attending the course face to face or online, there are certain students who are never willing to participate or, on the other hand, those who are looking forward to participating. According to the authors' experience, depending on whether students are introverts or extroverts, they will choose their level of engagement during the classes. This implies that choosing the appropriate teaching model is often not the factor that influences students' participation. On the contrary, it is more often the question of how much students are interested in the topic, if they like the teacher, or if they like to participate in classes in general. Furthermore, it has been shown that the same students who participate online also participate in person and vice versa. Also, simply being physically present doesn't mean that students are actively listening or participating. What is even more important, participating in order to be heard or noticed does not necessarily entail that you are contributing anything meaningful to the classroom experience, which is why teachers should allow their teaching model to be the only judge of students' participation and motivation.

5. TEACHING SOCIOLINGUISTICS

Sociolinguistics is defined as the branch of linguistics which studies the correlation between language and society. It is also related to the social implications of the use and reception of language. With that in mind, its significance is implied, especially when it comes to foreign language students, as their knowledge about sociolinguistic topics is crucial for their future careers either in teaching or translating. Therefore, at Singidunum University, a course in sociolinguistics is held in the final (fourth) year of bachelor studies (Anglistics study program) and it covers all the main topics related to language and society: language variations, language maintenance, loss, shift and death, speech communities, dialects, accents, registers, language and age, language and gender, language and ethnicity, etc. Lectures include theoretical and practical aspects of these topics, whereas practice includes covering various essays related to sociolinguistic issues, approaches, and practices around the world.

This year, the authors of this paper started teaching sociolinguistics in a hybrid model, due to the current situation with the COVID-19 pandemic. Both lectures and practice classes are held both online, via the Microsoft Teams platform, and simultaneously face-to-face, in the classroom. Students can choose either of the two options, and it has been noticed that they prefer online attendance. It has also been observed that some students opt for attending class in person for one week, but then switch over to following online, and vice versa.

During the harshest months of lockdown during COVID-19, classes for all courses were held exclusively online. At the university where the authors teach sociolinguistics, this took place initially over the Google Meet platform. This was ultimately switched out to Microsoft Teams, which proved to be an improvement in terms of administrative tasks which, among other benefits, allowed the professors to track which students entered class, and for how long. In addition, Google Meet did not have as many options like the Microsoft Teams platform in terms of organizing an online classroom. To be more precise, Google Meet had the chatbox and the share screen option, whereas Microsoft Teams now offers a wide range of possibilities, from posting information about the course, adding handouts and study material at any time, chatting, or having a video call with students whenever they feel the need to ask a question, to organizing assignments which can serve as midterms and testing for students. Another benefit of the Microsoft Teams platform is the fact that it is connected with Microsoft Stream, so you can share the video of your class to your students immediately after the class, and they can watch it whenever it is convenient for them.

It must be noted, however, that this was not necessarily an accurate reflection of how much they participated or comprehended the materials covered in class, as the students themselves are the ones who choose to speak up or communicate with their classmates or their teacher.

Though in both cases these class sessions were recorded and promptly uploaded for students to re-watch (or, in the case of employed students, watch for the first time), the process of measuring quantitatively and qualitatively student participation would have implied a painstaking and time-consuming process, and would not necessarily be a direct factor influencing the students' grade at the end of the semester. Ultimately, as in the case of the 'traditional' classroom, there were several instances of students not attending classes while they were 'live,' and choosing to simply read the notes at the end of the year, thusly preparing themselves for their midterms and final on their own time. To sum up, the Microsoft Teams platform might be considered a mixture of all course requirements in one place.

Due to a series of circumstances, the professors found themselves in the unique position of being able to teach sociolinguistics to the same generation of students during both their junior and senior years at university. The first year in question represented a lighter and more accessible approach as an introduction to the intersecting world of language and culture. These classes were held online in their entirety, with the professor covering one chapter per week on a variety of topics, ranging from time, age, gender, sociolect, ethnolect, language policy and planning, and many others. The agreement was for the students to read the chapter ahead of time and for all to discuss the most salient points together though, in these fast-paced and busy times, this was not often the reality of the situation. What tended to happen instead was that the professor would most frequently go through the information via PowerPoint presentations, which had previously been compiled of notes gathered from the contents of the textbook. Oftentimes, these presentations would be supplemented with audiovisual clips from the Internet, which would allow for their stimulation and provide the students with, perhaps, a well-needed respite from the sound of their professor's voice. In cases such as these, the online model would, if the internet connection worked sufficiently well on both ends, end up being the superior medium for transmitting sound, given that the in-person amphitheater setting could sometimes include acoustic echoes, which would sometimes make it difficult for many of the attendees to discern what was being communicated clearly. In addition to content provided from the textbook, the course notes, and audio clips, personal anecdotes to supplement the information often proved most successful when it came to student retention. By appealing to the experiences and sensibilities of the students, it became possible to bring the course material to life, a place in which practice (even through other peoples' lives) trumps theory.

This is especially important for students who are employed, as it is now easier for them to both attend classes and sit for midterms and exams. In the past, when only the traditional teaching methods were used, employed students were given an option to join consultations with teachers after 5 pm, but they did not have an option to replay videos of classes or to attend lectures if their classes were scheduled between 9 am and 5 pm, which was often the case. However, by using an online and/or hybrid teaching model, employed students now have the opportunity to both watch the videos of lectures and practice classes at any time and to sit for their midterms, as their physical presence is no longer obligatory. Also, they can now address their teachers at any time by either using chatbox or using video call, which is an option they gladly use, especially when they have a question related to the course itself.

The following year became an opportunity to expand students' knowledge by delving even further into the world of sociolinguistics. Given that a whole academic and calendar year had passed since the last time the students had studied these particular topics, there was uncertainty as to how much they had been able to retain since then. This was a particular concern, as the past year's courses had taken place online. The following year, however, with a seeming improvement in the global pandemic situation, the students were allowed to attend classes at the university in person once again. This entailed the teacher's physical presence in a classroom setting, though students themselves could also choose to follow the in-person classes remotely, ostensibly from the comfort of their own homes, behind a screen, be that a computer or a mobile device. Perhaps unsurprisingly, the varying experiences reflected a combination of outcomes: the students who had consistently proved themselves to be the most focused and engaged in the past-both in person and online-indeed also demonstrated that they were successfully able to recall the concepts which had most often been discussed and debated in class. On the other hand, many other students found themselves having to re-learn the materials that they had, theoretically, already mastered during the previous year. In terms of both subject matter and approach, this new academic year has been challenging. The textbook is now an anthology, which consists of a collection of essays covering the world of sociolinguistics from a more global perspective. This marks a significant shift from the English-speaking world, in that it goes beyond it, and the more Anglo-centric perspective they had been accustomed to learning from in the past, particularly when compared to the previous year.

It was important for the professors to ensure that their students maintained a broad perspective of the world, and to open their minds to parts of the globe they had no previous knowledge of.

As far as the approach goes, the hybrid model does essentially compel the educator to split or even double their attention between and/or towards both the students in front of them (who tend to be a numerical minority) and those attending online. This approach requires shifting attention to focus on the screen as well, as when they are sharing a screen, be it in the form of a video or a map, they are unable to follow the chatbox conversation. There is a mixed manner of participation from the students online-some simply turn on their microphones and chime in their responses, as they might in an in-person setting, while others patiently 'raise their hand' and wait to be called upon-which, again, is tricky as the platform is set up in a way so that only one window is visible at a time. Others online still participate only by commenting in the chat box-which can be advantageous for the professor, as a chiming sound is turned on and this brings their attention back to that window. Ultimately, however, it is difficult to state with certainty whether either model is superior to the other. Students can show up in person and still lack focus and participate with reticence, only when called out. The same goes for those online-many simply log in to receive participation points, and plan on studying for midterms/their final by going through the textbook. The students who do tend to show up, even if their participation is sparse and insufficient, tend to have had the opportunity to travel and are often quite interested in the world around them, having grown up with more access to the world, if nothing else then through the scope of their mobile phones. This helps ease the course material for them to process as we take a trip around the world and continent-hop.

6. RESEARCH METHODOLOGY AND RESEARCH RESULTS

With the aim of investigating the reasons behind students' choices between online classes and face-to-face attendance, the authors of this paper have conducted a qualitative analysis by organizing focus groups during regular sociolinguistics classes. The focus group consisted of 5 male and female students who were asked 2 open-ended questions and 6 multiple choice questions related to the hybrid model and teaching sociolinguistics. After they gave the answers to the questions, the moderators of focus groups (the teachers of sociolinguistics who hold lectures and practice classes) asked students to elaborate on their answers in order to gain more thorough answers.

When asked if, compared with last year, when sociolinguistics classes were exclusively online, they think that they are learning more in a hybrid setting this year, 80 % of students gave a positive answer, whereas 60% of them said that it is important for sociolinguistics to be taught face to face. Also, 80% of them claim that sociolinguistics is important for their professional development, which means that they are completely aware of the significance of this course, especially since 80% of them confirmed that their knowledge has been enriched by learning sociolinguistics. When asked about the biggest benefit of learning sociolinguistics, students gave the following answers:

- *Because it's incredibly important for our future endeavors*
- *Learning a lot about other nations and their tradition*
- *Knowing the language trends and how they change and affect us*
- *Learning about and understanding other cultures and people*

On the other hand, when asked about the biggest disadvantage of learning sociolinguistics, they said that:

- *Maybe the proximity(similarity) to other subjects*
- *There are no disadvantages*
- *Having to study for the grade*
- *There is no true disadvantage to sociolinguistics*

Finally, when asked whether they find the videos after the lectures and practice classes helpful, 60% of them gave a positive answer.

Those students who participated in the focus group are those who attend classes regularly face to face, so it should come as no surprise that they find classes in the classroom more suitable than online classes, as face-to-face communication provides them with feedback both from their teachers and their peers. Also, according to these students, learning sociolinguistics is better in the classroom as they feel more comfortable sharing their own thoughts, ideas and asking questions than it would be the case if they attended classes online only.

What we can conclude based on these answers is that students do find this course to be relevant for their overall linguistic knowledge, but they also think it is quite important to have the opportunity to attend these class-

es in the classroom, rather than having online classes. In other words, the hybrid model is considered to be a much better option for learning sociolinguistics than the online model.

7. CONCLUSION

Bearing in mind that education, in general, has suffered enormous changes in the previous period, it is extremely important to be able to define all teaching models and to choose the teaching model that suits the needs of your students. In the case of sociolinguistics, according to students at Singidunum University who regularly attend sociolinguistics courses, the hybrid model has most certainly been demonstrated to be the best option, as it combines online and traditional teaching models, taking the advantages of both models while, at the same time, eliminating their disadvantages. What we as teachers can conclude is that we should carefully analyze our students' needs in order to teach them about some of the main linguistic aspects, which they will later be able to use and put into practice as the basis of their professional careers. Moreover, it must be underscored that the students who participated in the focus group have yet to sit for their first midterms, let alone their final exams. Several weeks of coursework, revision, and knowledge assessment yet await, so it would be premature to reach definite conclusions with a degree of certainty when it comes to determining the advantages of the hybrid model over a traditional classroom setting.

Additionally, it has come to light that not every educator's experience teaching online or in a hybrid model setting has necessarily been universal. To be more precise, there are teachers who, due to their lack of experience or exposure when it comes to digital literacy, find themselves struggling with new technologies. Those hurdles can ultimately be overcome through practice and training but do require a learning curve. Furthermore, even those educators who are well-versed in new technologies in education and beyond have discovered that they prefer the dynamics of an interactive, in-person classroom setting. The goal is for students to be satisfied with the knowledge, but also for them to have the opportunity to grasp all the concepts in the manner which suits them best. For employed students, this usually defaults to online courses.

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THE COMPARISON OF MOST POPULAR MOBILE APPLICATIONS FOR LEARNING FOREIGN LANGUAGES

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Abstract:
Mobile-assisted language learning (MALL) stimulates students' motivation and improves their foreign language skills. The primary aim of this paper is to compare the most frequently used mobile applications for learning foreign languages, primarily English, by students in Serbia. Additionally, we wanted to reflect on students' views and experiences. Qualitative research, in the form of a focus group, was conducted in order to determine the clearest possible picture of students' views concerning the usefulness of different language apps, primarily Duolingo, HelloTalk and WordUp app. The respondents are Singidunum University students who voluntarily agreed to participate in this research. The results showed that innovative ways of perfecting foreign languages, such as mobile applications, are captivating for students. In addition, they highly value visual and engaging materials. They believe Duolingo is the best app for improving vocabulary and grammar, whereas HelloTalk is an ideal app for developing speaking skills. WordUp is recommended as a dictionary and as a revolutionary app for learning new English words. Students agreed that the combination of all three mobile applications would be optimal, depending on their language level and learning goals.

Keywords:
Mobile Applications Comparison, Foreign Language Learning, Duolingo, HelloTalk, WordUp.

INTRODUCTION

When talking about foreign language learning and teaching, besides various learning strategies and second language acquisition approaches, factors such as personal learning styles, motivation, attitudes towards learning and language anxiety should be taken into consideration as well [1]. Teachers have a vital role in a learning process [2]. They are believed to be educators, leaders and role models with a sense of responsibility, independence and authority in their classrooms. However, outside the classrooms, students must find ways to improve motivation and develop their own learning styles.

With the rapid development of foreign language learning applications and popularity of various powerful mobile devices among students, they have become increasingly interested in multiple learning benefits the apps can provide. Mobile assisted language learning (MALL) is

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considered to be an efficient language learning tool used by both teachers and learners. It is a teaching method which uses mobile phone technology in order to encourage learner autonomy as it enables students, after they receive initial scaffolding by the teacher, to take responsibility for their own learning [3]. It stimulates students' motivation, their engagement as well as upgrades all language skills. Having such powerful devices available anytime, anyplace, provides tremendous opportunities for educational use. Nowadays, the tertiary learners face the challenge of which of the thousands of educational apps they should choose.

Spending more time at home due to corona virus related lockdowns or social distancing has made learning a foreign language in traditional contexts even more challenging. The popularity of language-learning apps has boomed around the world during the coronavirus lockdowns. US firm Duolingo says that its new user numbers soared in 2020, especially in the UK. It says that globally they were up 67% compared with 2019, while in the UK they shot up by 132%, almost double the worldwide average [4]. From apps to podcasts, COVID-19 has forced language learning online.

The advantages of these apps, which enable you to brush up on a new language for yourself, are numerous. Firstly, most of them is free to download. Depending on your learning goals, the apps can help you build your vocabulary in a target language, develop proper grammar or even become more fluent. Even seemingly similar, each app has a different focus. The apps simply accommodate your personal style and suit your current needs. Some people are visual learners. Some prefer audio. Some enjoy games and drills. Due to the fact that everyone learns in a different way, you may want to try using several apps at once.

According to Forbes, the best language learning app overall is Babbel, whereas Duolingo offers the best free language lessons [5]. Bloomberg journalists, who have tested and reviewed five most popular language apps, consider Duolingo to be the best one for a long-term commitment [6]. The results of all previous studies we have conducted on language learning mobile applications showed that students want to learn foreign languages in an innovative and fun way [7] [8] [9] [10] [11]. Students' enthusiasm even leads us to believe that mobile applications for learning foreign languages should be introduced into curricula.

2. MOBILE APPS FOR LANGUAGE LEARNING

Recently, mobile learning apps exploded in popularity and there are so many of them that it seems a real challenge to narrow it down to the best one for you. The most frequently used internet platforms and mobile applications are Duolingo, Babbel, Rosseta Stone, Busuu and Memrise [12]. Duolingo is mainly used in European and South American countries while Rosseta Stone is very popular in the USA. In Russia and Asian countries, Duolingo and Babbel proved to be the most attractive ones. Interestingly, Babbel has the lowest departure rate. The best app for learning on the go is Pimsleur, an app that has an average rating of 4.7 of 5 stars. Pimsleur is specifically designed to help you learn vocabulary and listening comprehension quickly by listening to native speakers [13]. Kahoot! should also be mentioned as a game app which draws attention to the classroom and strongly encourages interaction. Six billion players have played on the Kahoot! platform cumulatively since its launch in 2013 [14].

2.1. WordUp

WordUp is a mobile application for learning new English words and improving vocabulary in an innovative and fun way. There are numerous vocabulary applications, such as Vocab1, Vocabulary.com, Vocabulary Builder App and VocabMagic. However, WordUp is a unique educational app due to the fact that it has ranked all the words in the English language in order of how useful they are by using Computer-Assisted Corpus Analysis. Therefore, every user makes the most of their learning time because they focus on what matters the most [11]. This mobile application analyses millions of movies, TV shows, songs, stories, newspaper articles, famous people's quotes and similar captivating material in order to bring the most helpful, exciting and enjoyable examples for each word to its users. One of the main objectives is to learn in context; in other words, to learn how to use each word in real life, while truly enjoying the process of learning [15]. One of the features that make this application truly unique is personalisation. The WordUp first detects where the gaps in users' knowledge are and then creates a personalised learning plan that focuses on one word at a time, always ensuring that the users learn the most useful word first [15]. Users particularly like its "remember forever principle" and often describe the app as one of the best pastime activities. You can read news and other articles on the app as well.

Moreover, the app curates the news according to your liking and shows new articles every day [16]. You can also test your knowledge with exams. This option really stands out and is particularly suitable for intermediate and advanced English learners who want to take IELTS, TOEFL, PTE, GRE exams. It enables its users to get better scores by focusing on the exam vocabulary. In that way, users can prepare independently for every test previously mentioned using WordUp mobile application.

2.2. HelloTalk

HelloTalk is a mobile application for foreign language learning by chatting with native speakers all around the world. The app supports over 150 languages. Native speakers teach you their language, while you teach them yours [17]. It seems to make learning a foreign language a joyful and intuitive experience. HelloTalk allows its users to connect synchronously with their language partners, but asynchronously as well due to the fact that sending messages is possible even if a partner is offline at that moment. Once you find your perfect partner in language learning, you can chat with them via text, voice recordings, voice calls and video calls. It creates collaborative learning conditions. HelloTalk supports you through the whole learning process – built-in aids for translation (one-click translation service), pronunciation, transliteration, and corrections make conversations run smoothly [17]. All these functions help you keep conversations going. There are four categories: Talks, Moments, Search and Learn. One of the most popular activities is posting Moments which are public posts and can be seen by all native speakers of your target language. It helps users get a whole lot of extra exposure to the target language and creates an immersion environment [18]. Some researchers claim that this application is the first global language learning and culture exchange community, connecting you with native speakers of other languages for free [19].

On the other hand, it is worth being aware of the fact that some users view HelloTalk as a dating app so it is advisable not to share personal information when setting up a profile. In addition, the focus of this app is more on informal expressions and even slang, so it might not be suitable for those who want to improve their language for business settings.

To summarize, HelloTalk is a great app for connecting with native speakers of the target language all around the word, having real-life conversations and making cultural immersion, but one should be very careful when choosing language exchange partners.

2.3. Duolingo

With more than 500 million learners, Duolingo is one of the most popular language applications worldwide and definitely the most popular one in Serbia. This application helps you improve your vocabulary and grammar through daily lessons and quizzes. Important features are personalised learning, immediate grading, staying motivated with rewards and improving quickly – gamification is poured into every lesson [20]. Many teachers and even entire governments around the world already view Duolingo as the perfect blended learning companion for their classrooms [20]. Recently, a possibility of certifying your English proficiency has been introduced. You can take the test online and it is accepted by over 3000 institutions worldwide. Colourful interface and user-friendly layout should also be mentioned. Duolingo succeeded in becoming part of learners' daily routine.

3. METHODOLOGY

3.1. STUDY AIMS AND RESEARCH QUESTIONS

The aim of this paper is to compare the most frequently used mobile applications for learning foreign languages, primarily English, by students in Serbia. Additionally, we wanted to reflect on their views and experiences. Our previous studies in relation to mobile applications for foreign language learning analysed Duolingo, HelloTalk and WordUp apps. We have conducted several researches with the aim of determining these applications' usefulness as additional tools in foreign language acquisition at university level. This study is guided by the following research questions:

- List the main benefits and shortcomings of Duolingo, HelloTalk and WordUp mobile app.
- Why did you choose a particular mobile app? List your reasons.
- Can you compare Duolingo, HelloTalk and WordUp?
- Which app would you recommend to your friends and/or colleagues and why?

3.2. RESPONDENTS

The respondents are Singidunum University students who voluntarily agreed to participate in this research. They are fourth-year students of the Faculty of Informatics and Computing and the Faculty of Tourism and Hospitality Management, as well as second-year students of the Faculty of Business in Belgrade. Qualitative research, in the form of a focus group, was conducted in order to determine the clearest possible picture of students' views concerning the usefulness of different language apps, primarily Duolingo, HelloTalk and WordUp. Six students who have used and/or still use these mobile applications participated in qualitative research; therefore, their opinion can be considered relevant. It should be noted that this is a deliberate, not a random sample, since selected students are talkative, open-minded, extroverted and motivated to learn foreign languages according to data from practice (active participation in the learning process and extra-curricular activities at the university). We opted for qualitative research considering it more suitable for expressing attitudes and describing experiences.

The goal of this research is also to emphasise modern trends in learning a foreign language and to discuss advantages and disadvantages of the apps listed above in order to incorporate one or all of them into teaching curricula in the most effective way.

4. RESEARCH RESULTS

When asked to comment on some of the most attractive mobile applications for foreign language learning, students agreed that Duolingo is the most popular and reliable one. They all use Duolingo for learning different languages, mainly Russian, French and Turkish. The possibility to learn languages other than English is one of the most significant features of this app. Students believe that Duolingo is an ideal mobile app for beginners. They also liked its grammar explanations and exercises. The app has been constantly improved so it has become less predictable and more amusing. It encourages competition – some students believe they stay motivated with rewards, game-like features and fun challenges. With the introduction of Leagues, Duolingo aroused the competitive spirit of its users and encouraged them to use it on a daily basis. One respondent noted she prefers the computer version of Duolingo as opposed to the mobile app. Respondents also believed an excellent Duolingo's marketing strategy to be one of the factors that greatly contributed to the status of this app today. To conclude, it mainly improves your vocabulary and grammar knowledge.

On the other hand, WordUp is aimed at those who want to improve their English. It is highly recommended for intermediate English learners. As its main advantage, students stated its usefulness. They found the app more relevant and reliable than the most popular translation platform, Google Translate, and believed it should be included as one of the English dictionaries on the Google Play Store. However, the app's creators believe the mission of WordUp is not to be just a dictionary. This app is primarily focused on the most useful words based on how frequently they are globally used [15]. Respondents believe one of the main advantages of the application was its wide range of topics, the learning in context concept, knowledge gap detection and personalized learning plan. The possibility of choosing between British and American English proved to be really popular as well. Words and phrases are visually presented, via photos and pictures. It facilitates the process of learning and memorizing. Respondents especially like regular reminders option. They can choose the best time of day to learn English (just woke up, around breakfast, way to work / school, around lunchtime, way back home, in bed), as well as the amount of time they want to dedicate to the app, depending on the set goals (casual, regular, serious, champion). Lack of communication with other people is one of the most mentioned disadvantages. Another con is the fact that WordUp is intended only for learning English. Respondents would like to learn languages other than English in the same way. In conclusion, it mainly improves your vocabulary but also develops your listening skill.

Discussing HelloTalk mobile application, students said that it offers a unique opportunity to learn a foreign language for free by chatting with native speakers around the world. The idea itself is great, language acquisition the natural way, learning a language, exploring new cultures, and making friends around the world, but it also triggers concerns. It has been reported that some users sometimes behave as if HelloTalk platform was a social media site or even worse a dating site, so learners, especially female learners, often feel uncomfortable and find themselves in awkward situations. Learning experience depends completely on language exchange partners. In order to overcome the problem previously mentioned, one can join group chats for a collaborative learning experience. In conclusion, it mainly improves your speaking skill. By chatting with

native speakers, you learn how to use informal foreign language expressions and practise casual conversations. According to respondents, HelloTalk can be very helpful in reducing foreign language anxiety. Communication with real people who are willing to provide almost instant feedback and share knowledge is seen as one of the app's greatest advantages.

The participants unanimously said that they would recommend all three language applications. They would recommend WordUp as a dictionary and as a useful, modern tool for English language learning. Duolingo would be the best option for learning languages other than English. It is also seen as a great pastime activity. Finally, students would recommend HelloTalk to those learners who would like to improve their foreign language fluency and catch the spirit of the language being taught. At the same time, they would advise them to be very careful when choosing language exchange partners. Generally speaking, respondents mainly view mobile language applications as an additional tool for improving foreign language skills. However, they still believe foreign language teachers and class interaction to be irreplaceable.

5. CONCLUSION

This research explicitly confirms that innovative ways of perfecting foreign languages, such as mobile applications, are captivating for students. They have the opportunity to combine the best aspects of traditional and m-learning thus enjoying innovative and entertaining lessons. An important pedagogical implication of this research is to acquaint students with innovative ways of learning a foreign language and specially to maintain their interest in learning. Foreign language teachers have the opportunity to contribute to making classes more engaging and interesting. Gamification plays a significant role when studying topics that students do not particularly like or do not find challenging. The competitive spirit, which many mobile applications develop, stimulates the learning process and hopefully makes it more enjoyable.

Due to the fact that even seemingly similar apps offer slightly different approaches, students agreed that the combination of all three mobile applications would be optimal, depending on your language level and learning goals. In that way, learners would benefit from varied exposure to language being learned. As technology changes society, attention spans have also changed for students, especially for those belonging to Millennials and Generation Z, compared to other age groups. In order to keep their attention, teachers are trying to design classes and adapt the course delivery methods and pace. These modern students want to be challenged, and they value interaction [21]. One of the ways to challenge them is to introduce intensive but short activities. By using mobile language apps, students stay in touch with the language on a daily basis and maintain continuity in their work. We suggest that various activities, available through foreign language learning mobile applications, should be introduced into teaching curricula either as icebreaker activities or as homework.

By regularly using language learning mobile applications, we believe students can improve all language skills, expand knowledge, achieve their academic goals and overcome specific language challenges.

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THE DISADVANTAGES OF ONLINE FOREIGN LANGUAGE TEACHING AT THE UNIVERSITY LEVEL

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Abstract:

Under the new circumstances in education and the altered approach to teaching due to changes caused by the global pandemic, hybrid teaching has proved to be a flexible and efficient approach to the organization of the teaching process which involves combining direct work in educational institutions and distance learning system. Recognizing the numerous studies that represent significant advantages of this type of teaching process, this paper primarily focuses on the disadvantages of the online teaching model from the perspective of the protagonists of the learning process, students from different study programs who study various foreign languages.

In this context, this paper aims to present and analyze the attitudes of students toward foreign language teaching in the same higher education institution where the online teaching model has recently been applied, i.e. the hybrid model of teaching and learning. By analyzing the results of the study and students' attitudes, we strive to improve the quality of foreign language teaching in higher education, with the appropriate application of modern technologies in a hybrid teaching environment.

Keywords:

Online learning, hybrid learning, foreign languages, disadvantages, students.

INTRODUCTION

The two main terms discussed in this paper, online learning and hybrid learning, are defined based on the document published by [1] which refers to both online and hybrid learning models. In this document, online teaching is defined as a type of education that is conducted through ICT (information and communications technology). This is the most practical type of distance learning model as teaching takes place to a greater extent synchronously, i.e. in real-time, which enables better interaction. Asynchronous online classes are also represented, as students are provided with additional materials on the chosen learning platform (either in the form of PowerPoint presentations or recorded video and audio materials).

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On the other hand, hybrid teaching is defined as a flexible approach to the organization of teaching, which involves a combination of direct work in the institution and distance learning. At Singidunum University, teachers had the opportunity to experience this teaching model since October 2021. To be more precise, the class is simultaneously attended by students who are absent from the classroom, as well as by students who are on the university premises. This paper places special emphasis on the online model of this combined learning and aims to investigate its disadvantages. In the previous academic year, we had the opportunity to experience only the online model of teaching, due to the epidemiological situation, whereas now we have the opportunity to compare these two models of teaching. We are a little surprised that the majority of students still opt for the online model, even though they can come to their classrooms. Classrooms are quite often empty, and more students prefer to attend lectures online. According to [2], 'online education has slowly begun to take precedence over the traditional way. Different materials become available to students through online platforms or even the whole process of education takes place through one of the numerous online platforms. Technology has helped make physical distance no longer a barrier to learning, and young people are increasingly opting for online learning.'

Telephones and computers (laptops, etc.) have become an integral part of our daily lives. Younger generations, also known as generation Z are so used to their usage that they can no longer imagine their lives or education without their usage. However, the belief that only Generation Z is used to them is wrong. Other generations that did not grow up with the use of these technologies have also become completely accustomed to them and have completely come to terms with their usage. Digital literacy is obligatory in contemporary society if one wants to be successful in almost any field, and when it comes to education, digital literacy is a prerequisite for positive results, for educators and students likewise. Moreover, it is highly likely that this trend will continue in the future and that ICT will be an inevitable part of our everyday lives, let alone of our education at all levels.

According to [3], the measures which have been taken to prevent the spread of the virus have dramatically changed the education system and forced lecturers and students around the world to quickly adapt to virtual teaching. Many have not experienced that before, so for them, it is a completely new experience both in primary and secondary schools and at universities. There have been numerous studies about new teaching models, their influences, advantages and disadvantages. This paper does not deal exclusively with either the advantages or the disadvantages of ICT in teaching, but it aims to explore how traditional and modern methods can be combined and how they can contribute to better learning and acquisition of study materials. The paper aims to analyze these issues from the students' point of view and thus contribute to better teaching. What the paper mainly focuses on is teaching foreign languages, as all authors of the paper are foreign language teachers at a private higher education institution in Serbia.

2. THE DISADVANTAGES OF ONLINE TEACHING FROM THE PERSPECTIVE OF FOREIGN LANGUAGE TEACHERS

This paper emphasizes the disadvantages of the online teaching model for foreign language teaching, with special reference to some of the most common hurdles that teachers in primary and secondary schools may encounter. Also, we have added some examples from higher education institutions, especially at Singidunum University, as the students of this university participated in our study, and their answers have been presented to contribute to improving our teaching methods when it comes to the following foreign languages: English, German, Spanish, Italian, Russian and French. In this way, we hope to combine the experiences of teachers and students in order to reach our final conclusion. According to [4] some of the main difficulties are:

- Poor internet connection and the lack of computers at home for families with more children
- It is more difficult to see the reaction of students to the given exercises, especially if the camera is not turned on during classes
- Feedback is often late until the answer is visible in the chatbox, there may be a waste of time during the class (many students prefer communication through chat than communication by using their microphone)
- Digital (il)literacy of some students - this is very rare in higher education institutions, but some individuals lack digital literacy
- The inability to verify the authenticity of students' papers and exercises, copying - it is more difficult to control the validity of papers by using the camera than by being present in the classroom

- Decreased motivation, lethargy, and inertia are becoming more and more common among students. According to the research conducted by [5, pp.76], the motivation to learn the first and second foreign languages is not the same. Research has shown that the motivation to learn English is much higher than is the case with other foreign languages - in this case, German. English is the language of global communication, lingua franca, and this research has shown that the motivation to learn it already exists and lasts longer than in the case of other foreign languages. When it comes to another foreign language, motivation is initially at an enviable level, but already after the first year of learning, it decreases rapidly. Students are satisfied with low language levels and state that it is enough for them to know how to communicate, i.e. to manage basic life situations, without any need to bring it to perfection. research on the same topic was conducted by [6, pp.226] who concluded that one of the main motives for learning German is getting a job, the importance of German in Europe, and the European Union. When we asked Singidunum University students why they choose some foreign languages, we got interesting answers: *I am learning Spanish because it sounds nice. I am learning Italian because Italians know how to enjoy life. I am learning Russian because Russians are our brothers. I am learning French because it is the language of fashion, culture, and diplomacy*.
- It is more demanding to motivate all students to participate (in the classroom students with less knowledge can participate in the class as well as students with more knowledge, the teacher can easily make the task suitable for all groups; in the online model those who know better participate more often)
- The teacher dominates the teaching much more than in the classroom, face-to-face contact leads to greater responsibility for students, they state that in the classroom they are somehow forced to participate which is very important for them, and in the online model they do not feel responsible for having to speak
- The teacher must be ready to be technical support to students and to solve technical problems as they occur
- Unrealistic results of certain students
- Sitting at the computer all day, carrying the phone all day (this is especially problematic for the kinetic type of students who learn language through movement, long-term sitting in front of the computer affects the attention of students, there are many language exercises in the classroom, not only traditionally when sitting at a desk. As an example, we can use various role-playing games in which a certain real-life situation is acted out and simulated in a foreign language)
- Lack of non-verbal communication when communicating live
- It is tiring for the eyes
- Lack of competitive spirit due to isolation from peers
- Having problems in the organization of working time
- According to [5] the biggest problem in learning another foreign language is different language levels. French, Russian and German are taught in schools and when students come to the University, they happen to have great previous knowledge. Also, there are always those who start learning the language from the beginning, and no matter how much the teacher tries to suit their needs or divide them into groups, the most diverse levels will always exist in the classroom. This is especially problematic in the online model, as in the classroom knowledge differences are easier to control and weaker students are given some less demanding tasks. The online model is often dominated by only the best.
- On the other hand, based on the results of recent research, which compared the attitudes of students and foreign language teachers toward the application of new technologies, online and traditional foreign language teaching, it was concluded that the role of teachers with their pedagogical and digital competencies is crucial in the learning process, taking into account the attitudes and needs of students, regardless of the circumstances and models of teaching that are required in the modern age [6].

3. RESEARCH RESULTS

Having in mind that the opinions and attitudes of the protagonists in the teaching process (students and teachers) are the most important parameters for consideration in the teaching and learning process, to improve the quality of language teaching, this research was conducted with students of different foreign languages at Singidunum University. Since there have already been some previous studies related to the attitudes of teachers, the authors of this paper found students' opinion to be of greater importance when it comes to sharing experience related to hybrid teaching model. Moreover, if teachers want to modify and improve their classes, they cannot do it without discovering their students' requirements first. The data were collected by distributing an online questionnaire, edited by the authors of this paper, so we can conclude that this was a quantitative analysis.

A total of 213 respondents, 150 female students and 63 male students at Singidunum University in Belgrade participated in the research, conducted by the method of quantitative analysis. Respondents study various study programs within the university, and of the total number of surveyed students, 57% study at the Faculty of Tourism and Hotel Management, 31% are students of the Faculty of Business, 10% study at the Faculty of Informatics and Computing, while there are fewer students from Faculty of Physical Education and Sports Management (1%) and Anglistics (1%). These statistical data are in accordance with the overall number of students at these study programs.

Foreign language	Percentage (%)
Faculty of Tourism and Hospitality Management	57 %
Faculty of Business	31 %
Faculty of Informatics and Computing	10 %
Faculty of Physical Education and Sports Management	1 %
Anglistics	1 %

Table 1 - Overview of respondents by faculties/study programs

The higher percentage of students from the Faculty of Tourism and Hospitality Management compared with other study programs can be explained by the fact that the Faculty of Tourism and Hospitality Management is the only study program at Singidunum university where a second foreign language is studied for all 4 years of study (higher level of language learning), unlike all other programs where second foreign languages are studied for two years. Regarding the choice of the second foreign language, 105 students study German, 48 of them study Italian, 38 respondents learn Spanish, 18 students study Russian and 4 of them learn French. All students who participated in the survey also learn English, which is mandatory in all study programs and is studied 4 years.

The instrument used for this research is an anonymous online Google questionnaire that students filled out during their foreign language classes. The questions were based on the principle of multiple-choice, and students could choose one answer or more answers. In this way, the examinees managed to grasp the key concepts related to students' experience with hybrid model of teaching.

At Singidunum University, foreign language teaching is performed in a combined, i.e. hybrid model, and as it has previously been mentioned, the Microsoft Teams platform is a key tool in teaching all courses. Microsoft Teams platform offers the ability to post materials in the form of PowerPoint presentations, videos, various links, assignments, and notifications that are available to students at all times. In addition, video recordings of the lectures are available and visible immediately after class, so that students who missed the class or did not properly understand the material have the opportunity to understand it better. Also, students are enabled to download any necessary handouts, powerpoints or other materials from classes that they are interested in. They can also easily approach their teachers, as they can use chatbox or video call at any time.

Apart from all advantages that have already been mentioned, this type of teaching certainly has its disadvantages, but we were interested in the disadvantages experienced by students who learn foreign languages. The majority of respondents stated that teamwork is the weakest function of the Microsoft Teams platform and online teaching in general. Since they are not physically present in class, students claim that there are technical problems (poor internet, camera off, interference ...), the lack of verbal and non-verbal communication, and therefore insufficient activity in class, which are comments that we have expected. It could also be added that similar disadvantages were named in previous studies which examined the advantages and disadvantages of online teaching model.

Foreign language	Percentage (%)
German	49%
Italian	22%
Spanish	18%
Russian	8%
French	2%

Table 2 - Overview of respondents by foreign languages

Teaching a foreign language involves simultaneous working on developing all four language skills (listening, comprehension, speaking, and writing). One of the questions in the questionnaire was which language skill is the most difficult to develop during online teaching. Of the total number of respondents, 39% answered that the speaking skill is a language skill that is least acquired by this type of teaching; 32% of students consider it is the writing skill; 16% of them claim that the listening skill is the least developed skill, while 13% of the surveyed students chose comprehension as the weakest link. The conclusion is that online teaching inevitably slows down the development of speaking skills, as well as writing skills, which is expected, given that the physical presence of students in the classroom and direct contact and interaction with professors and colleagues (teamwork) is crucial in the development of these skills.

Language skill	Percentage (%)
Speaking	39%
Writing	32%
Listening	16%
Comprehension	13%

Table 3 - The language skill that is most difficult to develop during online teaching

When asked about the disadvantages of online teaching, 89 students answered that the main disadvantage is a technical issue (poor internet, computer problems, sound, camera ...), 80 of them claim that they lack live contact, while 77 respondents think they have poor concentration when attending classes online, that there is a distraction factor (family members, social networks, TV, noise ...), 55 respondents believe that the biggest disadvantage is limited feedback (feedback from teachers and colleagues), and 19 of them answered that the biggest problem is that they do not have adequate opportunity to participate in this type of teaching.

Disadvantages of online learning	Percentage (%)
Technical issues (Internet, computer)	42%
Lack of direct interaction	37%
Poor concentration	36%
Limited feedback	26%
Active participation during classes	9%

Table 4 - The main disadvantages of online teaching

Based on the given results, it can be concluded that despite the advantages of Microsoft Teams (the availability of teaching material, video lectures, communication with teachers) certain disadvantages directly influence the learning process and the acquisition of language skills such as speaking and communication. However, there is no clear answer to the question why students still prefer online learning now that they have the opportunity to attend classes regularly.

4. CONCLUSION

Online teaching as a model of education that is organized with the help of modern technologies in the teaching process (presentation of content, exercises, feedback, assessment, and evaluation) proves to be a very practical form of education, as it allows teaching to be combined, synchronous and asynchronous. Students are enabled to attend classes in real-time, but also to access teaching materials from a remote location and at any time, using the selected learning platform (PowerPoint presentations, links to interactive content, video and audio content).

In this sense, hybrid teaching is a flexible and efficient approach to teaching that involves a combination of direct work in an educational institution and a distance learning system.

Since this is a newer teaching model, and bearing in mind that the opinions and attitudes of the protagonists in the teaching process are the most important parameters for considering the quality and efficiency of teaching and learning, this paper has presented a study conducted with students from different study programs at Singidunum University.

At Singidunum University, all courses, including foreign languages, are taught with the help of the Microsoft Teams Learning Management System (LMS system). Teaching materials, video recordings of lectures, presentations, video content, links to interactive materials, assignments, questionnaires, and announcements are available to students at any time and from any location.

However, in addition to all the advantages, this type of teaching also has disadvantages that students have identified and reported in this research. The majority of respondents stated that teamwork is the least represented, i.e. the lack of direct interaction with teachers and classmates. Since the research focuses primarily on foreign language teaching, the development of language skills in the online environment is one of the most important aspects presented to the respondents. Students who participated in the research recognize the greatest difficulties in developing communication skills and speaking skills, but also cite writing and comprehension skills as aspects where they have difficulties when it comes to distance language learning.

On the other hand, a significant number of students cited reduced concentration during distance learning due to the negative impact of a non-classroom environment (home atmosphere or other non-institutional location) as a disadvantage of this type of learning. What is also important is the fact that students cite technical issues as a disadvantage of combined teaching, i.e. the availability of adequate modern devices and fast internet. This disadvantage is stated by the largest percentage of students (almost half of the respondents). The smallest number of students named the inability to actively participate in classes as one of the disadvantages (9%).

As it can be concluded from these results, the disadvantages related to the online teaching process are objective and subjective, which should be taken into account and carefully considered to improve the existing circumstances to achieve an effective language learning process. Therefore, it is necessary to train teachers in the field of application of digital tools in teaching and their pedagogically justified use. On the other hand, it is important to enable students to develop digital skills and digital literacy to reduce the disadvantages they have recognized and improve opportunities for more effective foreign language learning. In this context, the development of digital competencies of all participants in the teaching process is one of the prerequisites for effective foreign language teaching in the modern digital environment.

The affective factor should also not be forgotten, especially in foreign language teaching. In other words, what should also be considered crucial is the motivation of students to attend language classes either online or in a hybrid model. In other words, teachers should motivate students to join their language classes regardless of the learning model that they prefer. This motivation can be achieved by using numerous online applications, which is why foreign language teachers always need to be well-informed about new teaching materials and ICT sources.

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THE USE OF KAHOOT! IN FOREIGN LANGUAGE TEACHING

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Abstract:
Due to a widespread use of technology in the previous period, as well as the fact that the learners mostly belong to generations Alpha and Z, who are technology literate, there is an increasing need to implement ICT tools in the context of teaching foreign languages. Since the attention span of young learners is getting shorter, the teachers are trying to find ways to make lessons livelier and more engaging, which is not that difficult any more due to an abundance of online games at our disposal. One of the most efficient and most often used platforms in modern language teaching is Kahoot!, which is a free game-based learning platform, easy to use in all learning environments. This paper deals with the use of Kahoot! in foreign language teaching with the intention to prove that it affects the classroom dynamics, raises learners' motivation and contributes to more efficient acquiring of new language content. The comparative survey has been conducted in Radoje Domanović Primary School and Singidunum University, confirming that the impact of games on the learning process and motivation is the same with no regard to the age difference. The results indicate that the proper student engagement and interaction in the classroom increases the learners' willingness to attend classes and improve their knowledge. What is more, learners should be encouraged to make their own Kahoots! for homework, which could be a challenge and additional motivation in the process of learning foreign languages.

Keywords:
Kahoot!, language content, learners, motivation, age difference.

INTRODUCTION

There is a widespread use of technology in everyday life and it has become a reality for all generations, especially Z and Alpha. Generation Z is the generation which was born between 1995 and 2010, and the Alpha generation is the generation born from 2011 to 2025[1]. Generations Z and Alpha are "technology literate" generations. In other words, generations Z and Alpha are in the midst of technological developments that are identical to instant instruments (email, SMS, Facebook, line, path, Instagram, WhatsApp, and Twitter) and ignore the monotonous things[1]. Therefore, everything needs to be adjusted accordingly and our focus will be the educational context.

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In the past children didn't use to have mobile phones and it wasn't a real challenge for teachers to motivate them in the classroom, since the trouble with short attention span wasn't omnipresent as it is now. Nowadays, teenagers spend many hours a day playing games, being indoors, living their lives in virtual settings and feeling the urge to be amused all the time. Therefore, they are used to flashing images, music and sounds and it is becoming more and more difficult for them to focus on the teacher himself or the traditional tools used in the classrooms.

Over the past five years, the proportion of 8- to 18-year-olds who own their own cell phone has grown from about four in ten (39%) to about two-thirds (66%) [2]. Since even toddlers are given phones to amuse themselves and become acquainted with some games at this stage of their lives, it is only logical to focus on their benefits and try to implement them in the learning process. Games have always been recognized as an important aspect in the development of people: they stimulate creativity, encourage communication and socialization, develop body and senses and serve as a manner of expression and emotional control. Play is a free and meaningful activity which is common to all cultures, and which existed before all cultures [3]. In order to improve the process of learning in the contemporary educational environment, teachers are turning to online games as a way to improve rapport and boost students' motivation to participate. The combination of traditional ways of teaching with the incorporation of (on-line) games, or "gamified activities" proved to be a good strategy in foreign language teaching. As a relatively new pedagogical strategy, gamification implies the use of game elements and game design techniques in a non-game context, such as classroom[4].

However, it is not just the language we need to teach them, we have to do our best to form a good relationship with our learners from the early age and make a positive atmosphere so we can accomplish our teaching goals. The initial students' interest in learning a foreign language must be maintained and nourished, which can be achieved by the use of mobile applications in the teaching process, among other things. What is more, this way teaching materials wouldn't be considered the only acceptable resource in teaching anymore and therefore, traditional, formal and informal context of learning and activities would be meaningfully connected [5].

Although one may suppose that children are the ones who get motivated through games, the authors will try to prove that games can be equally efficient in the process of learning foreign languages at the tertiary level. There are numerous games at our disposal on the Internet, but one of the most efficient for both young learners and the adults is Kahoot!, since it can be adjusted to fit any level of learners, i.e., any level of language that is being taught. In order for any change to be successfully implemented in the classroom, teachers need to overcome their fear of the unknown and accept new methodologies with the same zest their learners have. Becker (2007) notes that instructors cannot be expected to embrace games as a tool for learning unless they have a sound understanding of the potential of games and the confidence in their abilities to employ them [6].

The comparative survey has been conducted in Radoje Domanović Primary School and Singidunum University in order to try to prove that the impact of games on the learning process and motivation is the same with no regard to the age difference. What is more, the authors will try to determine the advantages and disadvantages of using Kahoot! as a teaching tool.

2. KAHOOT!

Kahoot! is a game-based learning platform which affects the classroom dynamics, boosts students' motivation to participate and therefore learn, and improves the relationship between teachers and students[7]. It can be used to review students' knowledge and it is a way of formative assessment and a refreshing break from traditional classroom activities in which teachers write on the board and students daydream. Kahoot! is a tool which is easy for teachers to make and as easy for students to use. The platform gives both teachers and learners an opportunity to make an interactive classroom setting participating in competitive knowledge games using the devices (computer, mobile phones, tablets) and a good Internet connection. It provides teachers with the opportunity to create their own quizzes and surveys, or to use the existing quizzes made accessible for public use. Scores are displayed at the end of each game and teachers are able to save the information in a digital document. As for the learners (players), they are not required to register for a Kahoot! account and will instead be provided with the game PIN prior to joining a specific game at https://kahoot.it/#/ as directed by their teacher (game host) [8].

It can be used as an icebreaker activity, at the beginning of the lesson, during the lesson itself or at the end of it. If there is a lack of time or you would rather use somebody else's Kahoot, you can click on Discover and

choose the right one among the abundance of already made quizzes, that people around the world are willing to share. However, we always advise making your own Kahoot, since it doesn't take too much time to do it and you can adjust it according to your own wishes and needs. After they overcome the initial anxiety, learners become relaxed and willing to participate in the game, partly because the presented graphs do not show individual mistakes and partly because only the ones who give the correct answers are shown on the screen. It improves both teacher-learner interaction and interaction among learners and consequently affects the overall classroom atmosphere which is the first step in the learning process. It releases the learners from stress and encourages wider participation, willingness to ask if explanation is needed and creates lively classroom atmosphere as opposed to traditional classrooms in which discussions are generally dominated by a small number of extroverted learners.

There is also the competitive factor in games such as Kahoot! which motivates learners to participate, especially because only your positive scores are rewarded and published, while the negative answers remain unseen and unnoticed. Since there is a break after each question, teachers are given the opportunity to provide students with additional information, or repeat and explain the question already done. Students with different learning needs can also participate in Kahoot! since it uses different colors and shapes, the questions are simple due to the limitation of the number of characters and the teachers who actively participate can read both the questions and the answers to their students.

Learners are often eager to make their own Kahoot! and share it with their peers, which is also a part of learning process. Students can also create their own Kahoot! quizzes as an assignment or to study for a test. Kumar (1999) reinforces this methodology when he notes that computer games as educational tools have an intrinsic motivation factor that encourages curiosity and creates the impression that students are in control of their own learning [9].

3. METHODOLOGY

3.1. STUDY AIMS AND HYPOTHESES

The aim of this paper is to determine whether the use of Kahoot! increase learners' motivation when it comes to acquiring new language content, regardless of their age. Prior to the research, the following hypotheses were set:

- The authors' assumption is that with no regard to the age of learners, the use of Kahoot! increases their motivation to acquire new language content.
- The use of Kahoot! creates more dynamic atmosphere in the classroom and contributes to the interactive environment.
- The use of Kahoot! contributes to more efficient acquiring of new language content.
- The authors' view is that there are more advantages than disadvantages of playing Kahoot! in the classroom.

3.2. RESPONDENTS

The comparative study was conducted in Radoje Domanović Primary School and Singidunum University and the survey included 55 pupils from elementary school and 110 students from the Faculty of Business and the Faculty of Tourism and Hospitality Management. The research was conducted in March 2022. The survey was anonymous and all the respondents willingly gave their contribution. Students were asked to fill in the online questionnaire, whereas pupils were given the same in the paper form.

4. RESEARCH RESULTS

The authors' intention was to try to prove that the online games implementation in the learning process is equally beneficial for both young and adult learners. Based on the research results, the perception of the effect of games on the motivation of learners does not change regardless of the age, level of education, experience or the intention of respondents. Another point worth mentioning is that foreign language learners become aware of the benefits of games and willingly and intentionally implement them in the learning process at the tertiary level of education whereas primary school pupils focus more on the entertaining aspects of the game. Furthermore, the vast majority of respondents aged 11-15 and the respondents aged 19-23 find playing Kahoot! interesting and fun, which is definitely the first step to making the atmosphere and the rapport in the classroom better, thus providing the good basis for acquiring knowledge and increasing motivation of all the participants in the learning process.

4.1. THE POSITIVE ASPECTS OF PLAYING KAHOOT!

Almost all the respondents agree that the implementation of Kahoot! in the classroom is useful and fun,which supports the statement that it is both a leisure time activity and a learning tool. The main difference between the respondents from primary school and university is that pupils are willing to play games, namely Kahoot! all the time, with no difference whether it is played at the beginning, in the middle or at the end of the lesson, whereas most students consider that playing games should be done at the end of the lesson, when the learners' concentration is on the lowest level.

Figure 1 – Students' answers: Do you find playing Kahoot! interesting and fun?

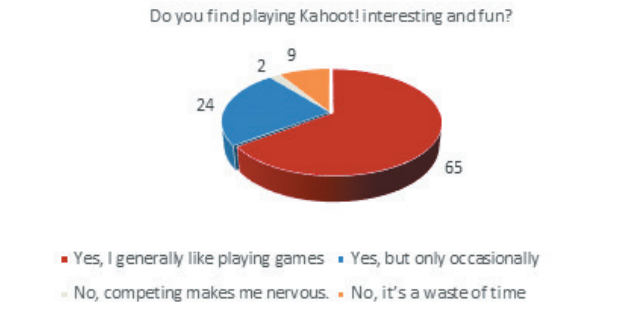

Figure 2 – Pupils' answers: Do you find playing Kahoot! interesting and fun?

We find it interesting that pupils prefer learning new vocabulary primarily from the book, which could be the result of teaching methods in the traditional classroom. On the other hand, students consider that the combination of both options is the most efficient, which is in connection with their ability and experience in using the variety of different sources when gathering information in the learning process. When asked to make comparison between vocabulary and grammar Kahoot! 42% of pupils thought that learning vocabulary was easier than grammar, 47% could not see the difference and found it equally difficult and only 11% considered memorising grammar easier. When asked the same question, 70.9% of students found playing vocabulary easier that playing grammar Kahoot!. Only 9.1% of them prefer grammar and 20% said that they did not see the difference between them. A small percentage of all the respondents agreed that learning grammar is better than learning vocabulary through games like Kahoot!, which proves that for some aspects of learning process, especially when it comes to grammar, traditional way of teaching is still irreplaceable.

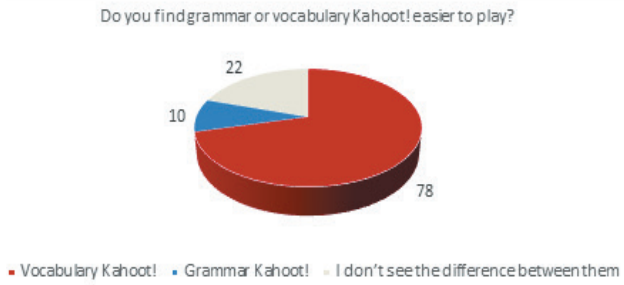

Figure 3 – Students' answers: Do you find grammar or vocabulary Kahoot! easier to play?

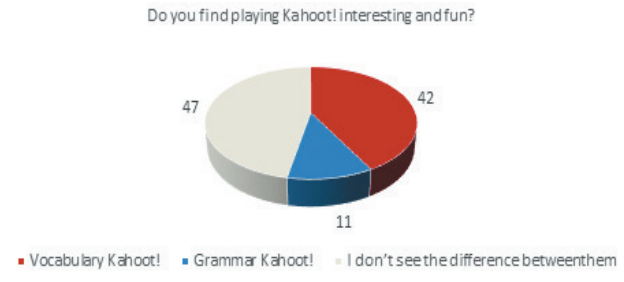

Figure 4 – Pupils' answers: Do you find grammar or vocabulary Kahoot! easier to play?

We have also tackled the issue of competitiveness as a powerful source of motivation. It can trigger students' willingness to participate and thus improve their engagement in the classroom, which is supported with our research results. 64% of pupils and 73.6% of students always do their best in order to win, some of them even revise vocabulary prior to the lesson so as to have better score. Negative effect of competitiveness has been noticed only among 24% of pupils and 12.7% of students, either because they cannot think under pressure or they just focus on being fast.

When it comes to music as an additional feature of Kahoot!, the results show that the respondents are pretty indifferent and notice it only until the quiz starts and just a small percentage of them find music a distraction.

However, most of them agree that pictures are useful and helpful.

One of the research questions is connected with the learners' active engagement in the learning process, which means that they are given a chance to make their own Kahoot!. 53% of pupils and 45.5% of students find making their own Kahoot! a great way to learn new vocabulary and grammar, 22% of pupils and 38.2% of students agree with this statement but think that it takes a lot of time to do it and 25% of pupils and 16.4% state that they can only study from the book.

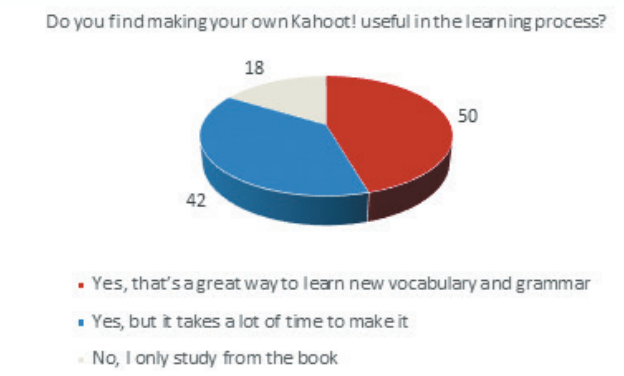

Figure 5 – Students' answers: Do you find making your own Kahoot! useful in the learning process?

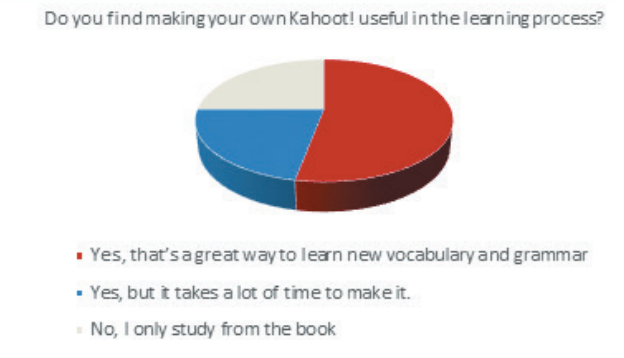

Figure 6 – Pupils' answers: Do you find making your own Kahoot! useful in the learning process?

4.2. THE NEGATIVE ASPECTS OF PLAYING KAHOOT!

When asked about negative aspects of playing Kahoot!, respondents stated various disadvantages:

- 40% of pupils and 43.6% of students sometimes have the Internet connection problem.
- 25% of pupils and 38.2% of students sometimes know the answer to the question, but due to bad Internet connection do not write the answer on time.
- 42% of pupils and 38.2% of students think that the time limit for the questions is short and that they are under pressure to give the correct answer before others.
- 18% of pupils and 17.3% of students sometimes have trouble reading the questions on the screen.
- 20 % of pupils and 16% of students become upset if they do not know the answer.
- 29% of pupils and 11.8% of students sometimes find the topics of Kahoot! boring.
- 18% of pupils and only 7.3% of students are sometimes more focused on picking their nickname than playing a game itself.
- 16% % of pupils and 6.4% of students say that the questions are difficult.
- 13% of pupils and 2.7% of students think that Kahoot! lasts for too long.

5. CONCLUSION

First of all, the authors are of the opinion that the study represented in this paper is relevant, having in mind the total number of respondents who willingly participated and contributed to our research. The sample size of primary school pupils is solid, since 55 respondents participated, while the number of university students who were part of a survey, which is 110, is more than enough for us to come to a relevant conclusion.

Our research unequivocally confirms that innovative ways of learning foreign languages, such as Kahoot! or any other easily used online game, are appealing to learners. They undeniably bring fun into the classroom thus enabling the creation of friendly atmosphere which boosts learners' motivation to participate, interact and effortlessly acquire new language material. Based on learners' answers, we have come to a conclusion that playing games should be carefully implemented in the learning process in combination with the traditional

ways of teaching, especially when grammar is concerned. Both pupils and students find playing grammar Kahoot! more difficult than playing vocabulary Kahoot!, especially since they can connect pictures with words, which they find extremely useful.

Another factor in favour of implementing online games in the learning process is that the learners' fascination with the game element does not change or diminish with time. The only difference is that pupils enjoy playing games all the time, without realising the importance of traditional ways of studying. However, students are well aware of the learning process and even though they enjoy having the fun element in the classroom, they prefer to do it at the end of the lesson since it is then that they lose focus and energy to process new pieces of information.

Even though there are some disadvantages to playing online games in the classroom, we have come to a conclusion that the only real problem is the Internet connection and some other technical problems. Only few respondents had negative remarks concerning the content, the difficulty or the length of Kahoot!.

Taking everything into consideration, the authors' view is that games like Kahoot! should be implemented in the learning process but only as an additional learning tool in combination with traditional ways of learning. The topics should be carefully chosen in accordance with the language material provided in study books, thus enhancing the learners' chances to acquire new knowledge or check the existing one. We believe that the proper student engagement and interaction in the classroom increases the learners' willingness to attend classes and improve their knowledge. What is more, learners should be encouraged to make their own Kahoots! for homework, which could be a challenge and additional motivation in the process of learning foreign languages.

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UTILIZING LUDIC FOREIGN LANGUAGE PEDAGOGY AT THE TERTIARY LEVEL

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Abstract:
This paper aims to draw attention to the utilization of ludic activities and their effectiveness in foreign language teaching, learning, and assessment at the tertiary level. It focuses on the description of the ludic language pedagogy and its characteristics. Representing valuable formative assessment instruments, game-based educational tools can be used in both traditional and blended teaching and learning contexts. This paper also explores how game-based assessment tools can be incorporated in the language classroom as beneficial instruments for more effective teaching practices, particularly in the online environment. The evaluation of the use of game-based assessment tools in different language classes shows how these tools can contribute to the achievement of learning goals and outcomes. The examples analyzed in this paper led to the conclusion that those students who actively participated in ludic assessment activities developed their language competence and content knowledge and also reinforced self-assessment skills. Moreover, the interplay of knowledge construction and the ludic design of learning activities and competitive elements made the whole learning process more motivating, engaging, and effective.

Keywords:
Ludic Language Pedagogy, Tertiary Level, Foreign Language Teaching, Game-Based Activities and Assessment.

INTRODUCTION

Various social, cultural, and industrial influences have caused changes permeating all levels of education, and foreign language teaching is no exception. The existing teaching methods and approaches are being reevaluated, adapted to the newly created circumstances, and supported by new models. The learner-centered approach has been emphasized for several decades, and teachers have been encouraged to utilize methods to organize the teaching process and, thus, support students' full engagement.

New approaches and models such as gamification, serious games, or game-based learning and the use of various assessment tools have become a popular topic of studies both in industry and in educational contexts since its popularization in early 2010 [1], [2], [3]. The role of plays and games has always been considered important in various

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aspects of human society. The COVID-19 pandemic has encouraged educators to reexamine the existing teaching practices and approaches and incorporate the adapted ones into various learning management systems.

Although primarily used with children, plays can be beneficial for adult learners as well. The topic of the use of ludic activities with adults has gained in popularity, and the significance plays can exhibit has provoked researchers to investigate educational aspects of ludic activities at the tertiary level. The increasing number of studies from higher education shows that students can benefit from the use of play and game-based activities incorporated into the curriculum.

This paper aims to draw attention to the increasing popularity of using ludic activities and creative approaches to foreign language teaching at the tertiary level. On the one hand, it explores the ludic language pedagogy and its characteristics; on the other, it focuses on one aspect - the use of game-based assessment tools and how they can contribute to more effective teaching practices, particularly in the online environment. The analysis of their application provided in this study illustrates how game-based assessment tools, as one example of the organization of ludic activities, can be used in teaching and how they can contribute to the learning outcomes.

2. THE STATUS OF LUDIC PEDAGOGY AT THE TERTIARY LEVEL

In the field of early stages of education, a game as a symbolic activity is considered to be a fundamental tool for the cognitive and language development of children [4], [5]. In that context, a game as a common activity for all cultures has been recognized by Huizinga [6] as a serious activity with clear rules and a potential tool to be used in different fields, such as language, philosophy, law, and art. Sicart [7] has introduced the concept of playability and defined it as the ability to use the game beyond the game, which means to adopt coherent actions for certain purposes, with a psychological, physical, and emotional perspective that is adopted towards people, things, and situations. Perceived from this point of view, game design and playful techniques can be applied as effective instruments not only in social activities but also in education.

In education, the gamification of learning has a long history and the principles of gamification had already existed in the pre-digital world [8], [7]. On the other hand, Prensky [9] points out the potential of games and game-based learning to enhance learning, motivate and engage students, but only if they are designed and planned with pedagogical background and for educational purposes.

Krashen [10] argues in his hypotheses of affective filters that variables such as motivation, self-confidence, and anxiety can significantly affect learning and L2 acquisition. Currently, in the digital era, characterized by the dynamic progress of technology integration in education and the popularity of digital games, the ludic activities, supported with ICT tools and game designs, have become revalued in various contexts aiming to produce game-like experiences to support different activities and behaviors [1].

Although the integration of games in the teaching and learning process is usually perceived to be more appropriate for young learners, there is a growing number of higher education institutions considering the implementation of ludic pedagogy into the curriculum. In order to respond to the reforms at the tertiary level stirred by the Bologna Process, universities started reconsidering the methodologies, techniques, tools used in teaching, and researchers reported on the benefits of such shifts [11], [12], [13]. What is emphasized as the important aspect of ludic pedagogy is its reliance on a positive learning environment and the use of games, but, at the same time, on academic standards supporting the intellectual and cognitive students' development.

3. THE USE OF LUDIC ACTIVITIES IN FOREIGN LANGUAGE TEACHING

The application of a ludic pedagogy in language teaching became more recognized in the last quarter of the 20th century, and it was in a close connection with the integration of the communicative approach into the language teaching process. As mentioned earlier, according to Krashen [10], second language acquisition is affected by elements known as affective filters that can significantly impact the learning process. By creating an engaging atmosphere through the use of various teaching strategies, language teachers can help students with motivation, help them build a positive attitude towards their skills and abilities, and reduce learning anxiety. In that context, playful activities and ludic strategies have always played an important role in achieving a pleasant learning environment, regardless of the learners' age. Their use can result in various pedagogical benefits, such as motivation, pleasant working conditions, and a relaxed atmosphere in the classroom [14].

Nowadays, many authors devote their research to the topic of game strategy, game-based learning, and the application of ludic activities in the foreign or second language teaching and learning [15], [16], [17], [18], [19], [20], [21], [22].

As regards a formal recognition of the implementation of ludic activities in language teaching, The Common European Framework of Reference for Languages has devoted a section within Chapter 4 to the relevance of ludic uses of language for effective learning and language development. According to the CEFR, several categories of ludic activities have been recognized; these include social language games, individual activities, and verbal joking [23, pp. 55-56]. These types of activities can be adapted to the level, language skills, and linguistic-communicative objectives that language teachers intend to achieve with the learners. The linguistic games should also be considered as an instrument of language learning and pedagogical tools, in such a way that they should be incorporated into the curriculum and the common language classroom activities [24]. According to Sandoval [24, p. 98], the use of linguistic games can be beneficial in the classroom, and they can enhance motivation, contribute to the creation of an active and interesting learning process for the learner, and boost both productive and receptive language skills. Furthermore, their proper use can also help teachers to create a pleasant atmosphere and become closer to the students. Overall, these tools have the potential to facilitate a more relaxing but, at the same time, more effective teaching and learning process.

Although the ICT-mediated instruction and the use of various learning platforms and tools had been present in teaching foreign languages, the sudden and unprecedented changes in the organization of teaching practices around the world, caused by the COVID-19 pandemic outbreak in 2020, made language teachers reexamine the existing habits, approaches, methods and tools [25]. The online learning environment posed challenges not only in terms of content delivery and lesson organization, but, more importantly, it affected students' motivation, active involvement, cooperation, and assessment. Within such an educational context, thoroughly planned and organized pedagogical utilization of ludic activities can provide a good framework for a motivating and engaging atmosphere that promotes not only the development of all language skills and language competence but also creativity, critical thinking, and cooperation among students [26], [27].

4. THE USE OF GAME-BASED ASSESSMENT TOOLS

The use of ludic activities should have clear pedagogical aims. When choosing the applications and tools for the realization of such activities, a foreign language teacher estimates their purposefulness and what learning outcomes can be achieved. Among the wide scope of such activities and tools, various game-based tools possess characteristics that can ensure the realization of the aimed outcomes. The examples below illustrate good practices in different classes and subjects.

During the spring term of the academic year 2020/2021, a group of 65 students attended the English Semantics course at the Anglistics study program at a private university in the Republic of Serbia. The course lasted for 15 weeks, and before the final exam, the students took two midterm tests - after the fifth and eleventh week of lectures. Due to the COVID-19 pandemic, the course was conducted exclusively online. The game-based tool Quizizz was used every week with the purpose to collect information related to the students' learning progress. The study included the analysis of a corpus of tests taken by a group of 65 students. The continuous assessment process was conducted with the aim to improve students' learning outcomes and to create a teaching process according to the formative assessment results. The tasks were graded and provided careful scaffolding - they included multiple-choice questions, cloze-ended, and open-ended questions. When the course was over, all the results were collected, analyzed and the outcomes compared. The purpose of the analysis was to investigate how digital tools can be utilized for continuous assessment of students' learning progress in an exclusively online teaching and learning environment.

The results showed that those students who regularly took these tests scored higher in the midterm and final exams. They also show that those students who actively participated in these game-based assessments improved their language competence, and some even considerably improved the learning outcomes. The use of a game-based assessment tool did not only show effectiveness in terms of assessment but also helped students with self-assessment because they received immediate feedback on their progress. The continuous self-assessment process helped students identify which aspects should be improved. The elements of games, competition, and animations used in the classes made the whole learning process more motivating and engaging, and, thus, the elements of fun were effectively supported by academic

and intellectual rigor. The results obtained in every class also served as a solidified diagnostic tool that directed lesson planning and reaching the aimed course outcomes.

Similar results were obtained with another group of students who attended another course subject. During the winter term of the academic year 2021/2022, a group of 20 fourth-year students regularly attended the ICT and language learning course. The course lasted for 15 weeks, and before the final exam, the students took two midterm tests. This course was conducted according to a hybrid or blended learning model: face-to-face and online. The gamification tool Kahoot was used in every lesson with the aim to practice the presented learning content and continuously assess students' learning progress, both in a virtual and face-to-face classroom context. The tasks and exercises were created with multiple-choice and true-false questions. Each question was designed with visual and auditive elements (image, animation, short video, music) and playful components, such as collecting points, rewards, competition feeling, leaderboard with tracking progress, time scale.

The results showed that those students who regularly participated in these playful activities obtained higher results in the midterm and final exams than those who did not take these tests. At the same time, those students who regularly played Kahoot improved their content knowledge significantly and developed self-assessment skills by receiving instant feedback on their progress. The most remarkable characteristics that students showed during these activities were their enthusiasm, team spirit, and cooperation with peers, which made the whole course interactive, conducted in an engaging and motivating environment for all participants in the teaching and learning process.

The last example illustrating similar teaching strategies shows that game-based assessment tools could be successfully applied in other courses, such as general foreign language courses. Both the above-described game-based tools - Quizizz and Kahoot - were used in the classes of Spanish as a foreign language course with students of other study programs, such as Tourism and Hospitality Management, Business Economy, and Information Technology. These tools were used with the same purposes - to motivate students and create an engaging and interactive teaching and learning environment on the one hand, and on the other, to provide continuous formative assessment [28]. The results proved the effectiveness of the regular use of these tools in Spanish language classes - those students who regularly participated in language games, based on language aspects covered in every lesson, showed better development of language skills (especially grammar and vocabulary) and content knowledge (topics). Additionally, the analysis of their replies showed a higher percentage of correct answers and better results in summative assessments.

5. CONCLUSION

Continuous and unpredictable changes in all areas of modern living have resulted in the need to adapt teaching contexts and practices at all levels of education. The COVID-19 pandemic has accelerated these changes and stirred educators and foreign language teachers to adapt their teaching methods and techniques so as to respond to the newly created teaching context. This paper emphasizes the importance of incorporating ludic activities and game-based tools which are motivating and engaging for students, and, at the same time, driven by sound and solid pedagogical rationale. This paper also shows the importance of introducing/reinforcing outcome-oriented teaching practices at the tertiary level as an inevitable part of the higher education reforms.

The common conclusion is that games (digital or traditional) can transform the pedagogy of second language teaching at the tertiary level. This paper draws attention to the importance of applying the interactive approach to foreign language teaching and creating effective second language learning games and tools, relying on the expertise and collaboration between language teachers and game designers. The use of game-based tools can create a rather positive learning environment, motivate students and encourage them to actively participate in knowledge creation. These tools can be used in both online and blended educational environments and they can serve as a valuable instrument for formative assessment. The examples provided in this paper illustrate how the utilization of one aspect of ludic activities can keep students engaged and motivated during online and hybrid lessons. Their use also contributed to the creation of an enjoyable environment where students wanted to participate. Furthermore, what made these tools invaluable in the online environment relates to their use for continuous assessment, as a diagnostic tool and helpful feedback students received on their progress which helped them improve and score better at the exam.

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COMPUTER SCIENCE IN DRUG DESIGN IN PHARMACY AND MEDICINE SESSION

IN SILICO APPROACHES FOR DRUG DISCOVERY FOCUS ON VIRTUAL SCREENINGS

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Abstract:

The field of medicinal chemistry has become increasingly dynamic and medicinal chemists face the challenge of rapidly evolving new technologies. In the last decade, medicinal chemistry methodologies have been largely replaced from an individual scheme to an interdisciplinary approach. Furthermore, the shift from traditional to Omics-based applications is needed to develop computational, chemo, and bioinformatic tools that could help medicinal chemists to analyse, link, and compare the research results. Hence, drug research has necessarily oriented drug discovery toward more rational strategies. In silico Virtual Screening (VS) is one of the most promising approaches to accelerate the drug development process. Efficient analysis of key compounds and target properties is crucial for carrying out a virtual screening process. At the same time, it can reduce the attrition rates in drug development. Of course, the main purpose of VS is to identify novel chemical scaffolds as hits for further optimization using medicinal chemistry approaches. An overview of the most employed methods for VS, challenges, and new directions will be discussed.

Keywords:

Drug Discovery, Virtual Screenings, Ligand-based, Structure-based.

INTRODUCTION

Pharmaceutical research is moving towards a more interdisciplinary endeavour. Indeed, drug development requires information on a broad range of topics: not only chemical structures and reactions but also target structure, biological pathways, drug-target interactions. Hence, the collaboration between the researchers working in different disciplines is essential to maximize the potential benefits of drug discovery (DD).

DD involves various steps: a discovery phase, which includes target discovery (only 10% of the human genome is druggable) and the identification of active molecules or hits. This phase ends with the identification of lead molecules. The second phase consists in the lead optimization. This phase focuses on optimizing lead activity and ADMET (absorption, distribution, metabolism, excretion, toxicity) properties.

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The third phase includes the product development, with the preclinical and clinical trials (I, II, and III), and, finally, the registration phase, which will enable distribution on the market and the clinical use of drugs.[1]

The estimation of the median cost of efficacy trials for new drugs approved by the FDA amounted to $19 million.[2]

Using computational approaches, many of the steps involved in the drug discovery projects can be more efficient and rewarding. Nowadays, computational tools are useful not only for hit/lead identification and optimization, but also for target identification, prediction of druggable pockets, and accurate prediction of ADME-Tox-related properties and metabolism.[3-5]

Several marketed drugs such as oxymorphone, saquinavir, imatinib, zanamivir, dorzolamide norfloxacin, and several clinical candidates, have been discovered or optimized with the aid of molecular modelling techniques.[6]

One of the most promising techniques to accelerate the DD process is to perform *in silico* virtual screening (VS).[7] VS hit identification rates vary from about 40% to 1%,[8] with most active hit compound activities ranging from μM to nM.

However, hit rates can provide a loose measure of the success of the VS method since the main aim is not necessarily maximizing hit rates and reaching nM activity, but identifying novel active compounds that contain new scaffolds, are synthesizable, and provide a basis for hit-to-lead optimisation.

There is a continuous flow of publications reporting ligand-based (LB) and structure-based (SB) VS applications where new active compounds have been identified employing a variety of VS methods.[9]

The huge computational demand of such VS applications requires developing parallel algorithms and exploiting the computational power of large high-performance computing (HPC) systems to accomplish such screenings, within an affordable time. In fact, DD can be significantly boosted using big data resources.

In this framework, VS approaches, their applications, new trends, and challenges need to be examined and discussed.

2. OVERVIEW OF CURRENT APPROACHES USED IN VS

VS methodologies can be broadly grouped into two main categories: LBVS and SBVS. The former requires a set of known active ligands for structure similarity search, while the latter requires the 3D structure of the target.

When both ligand and structural information exists, it is possible to combine methods to yield improved results. In general, the combination of more approaches, in a hierarchical or parallel way, can lead to an increase in both scaffold diversity of the retrieved hits and hits rate.[7, 10]

VS methods are typically validated by retrospective analysis on benchmark datasets considering the diversity of targets, the diversity of ligands, and the selection of appropriate decoys. This led to high-quality and reliable benchmarking datasets, proving their strength.[11]

Benchmark datasets consist of series of active and inactive molecules, each associated with a specific target. Often the active compounds are experimentally validated, instead, the documentation of experimentally validated inactive molecules is scarce. For this reason, assumed inactive molecules (decoys) are frequently employed.

When new targets are studied consensus approach and studies of target similarities can help to maximize the VS success.

Similarity LB methods are based on the calculation of molecular descriptors, which consider molecular properties of different complexity 1D-, 2D- or 3D.[12, 13] In particular, these methods estimate similarity metrics considering coefficients such as Tanimoto index, Dice coefficient (Hodgkin index), Cosine coefficient or distances, Soergel distance, Euclidean distance, Hamming (Manhattan or city-block) distance.[14] Furthermore, also quantitative structure-activity relationship (QSAR) methods are largely applied for LBVS. QSAR model development and application include preparation of data, analysis of data, model development, model validation, and VS of chemical databases.[15]

SBDD and SBVS have contributed to the introduction of ~50 new compounds into clinical trials and numerous drug approvals.[16] To improve the predictive power of docking experiments, it is necessary to have well-established protocols and robust metrics to measure it. Docking approach benchmarking for VS application includes two properties:

a. RMSD computed for the predicted binding pose against the experimental pose;
b. Binding free energies/docking energies which are proportional to experimental inhibition/dissociation constants.

If the binding mode prediction is recognised to be often accurate (RMSD < 2 Å), the second is not equally as precisely determined. In fact, docking ends often with several false-positive hits because of a lack of exactness in predicting binding affinity.

Many factors can influence the performance of docking experiments. Some limitations can be overcome considering alternative protonation states for critical residues, the flexible side-chain minimization, consensus scoring, rescoring of the docking complexes with different scoring functions, or the inclusion of solvation effects through specific protocols.[17]

No single docking software is superior to the others in all respects.[18] The validation process can help to choose the most appropriate program and protocol for a specific target. However, in a new target VS context, consensus docking can improve the reliability of docking by using different docking programs.[19] Pre-processing and curation of data are mandatory to correctly assess the quality of information and avoid any potential bias in VS methods validation.[6]

Aiming at finding new scaffolds, fragment-based VS has emerged to be a powerful approach by exploiting molecular fragments with molecular weight <150–250. Ideally, the different identified small fragments can be subsequently connected by opportune linkers to increase the hits potency.[20]

Pharmacophore modelling (LB or SB) is an important and useful method for drug discovery.[21] Among the 3D methods, no doubt that the pharmacophore approach for VS is the most appreciated by medicinal chemists because of a common language.[13]

SBDD is also important to derive structure-activity relationships of a chemical series, especially in the lead optimization phase, when very accurate modifications are needed to adjust an ADME/tox profile while maintaining binding affinity.

All VS methods have their strength and pitfall, over the time many improvements have been obtained. In the last decades, Artificial Intelligence (AI) methods appeared in the panel of new strategies.

3. AI METHODS IN VS

Computer science advances and speeds find AI broadly benefitting several fields. AI refers to an algorithm capable of mimicking cognitive functions without supervision or user input.

In pharmaceutical research, because of the complex nature of big data, some relations may not be apparent at first glance and might lead to wrong results or hypotheses.

Among AI methods, machine learning (ML), and in particular deep learning (DL) using deep neural networks (DNN), has been responsible for recent progress.[22, 23] DL involves scaling machine learning using multi-layered neural networks to attempt to model the abstraction of big data.

However, because of the poor interpretability of AI methods, and the limited accuracy of prediction results for molecules with large structural differences from the training compounds, HTVS rather than DL methods remain the dominant choice in drug design.[19]

Of course, their application is growing and many studies showed interesting results,[24] but particular attention should be given to data collection and cure.[25]

Great efforts are being made to produce better algorithms. Nevertheless, software is not (yet) meant to replace chemical intuition or deep knowledge of the biological target, which is essential for the identification of hits.

The combination of ligand- and structure-based methods has become a common approach in virtual screening since it has been hypothesized that their integration can enhance the strengths and reduce the drawbacks of each method.

4. PITFALL AND CHALLENGES

The druglike chemical space is estimated to be around 10^{63} molecules.[26] However, a drug candidate needs to possess the right combination of properties to provide efficacy and safety, and formulation. Only a small fraction of chemical compounds possesses these properties. Furthermore, accessible synthetic pathways of compounds and purchasability are not guaranteed. This would make the use of virtual libraries more appealing.[27]

The sizes of screenings databases range from a few thousand (e.g. DrugBank) to almost one hundred million (e.g. Pubchem). But, are bigger screenings better?[28]

Of course, a large database gives more chance of finding new scaffolds, but the analysis of published works highlighted the interesting conclusion that even less complex studies can lead to success stories.[29] This is encouraging for small labs where, albeit the access to thousands of CPUs/GPUs also via the cloud is feasible, the cost of thousands of licenses for virtual screening software may be unaffordable.

CADD still faces many challenges, which include increasing the efficiency of virtual screening; further developing the computational chemogenomic field; predictive animal models, more attention for earlier toxicology evaluation, data curation, and quality.

Moreover, there is a large room for improvement on studies that involve multiple molecular targets, for both synergy and side effect prediction.[30] In fact, many studies suggest that the partial inhibition of a small number of targets, involved in a specific disease, can be more efficient than the complete inhibition of a single target. In this regard, VS that consider the polypharmacology aspect might solve the problem of fighting challenging diseases by retrieving more efficient weapons.

5. CONCLUSIONS

Researchers are currently attacking diseases of great complexity such as virus infections, cancer, and neurodegenerative disorders. Furthermore, drug targets being tackled include a growing number of less druggable targets than those pursued previously. In addition, the entry bar for new drugs is becoming higher because of the enhanced standard of care. Indeed, the VS approaches can help the DD process. However, the awareness of how a method can fail is as useful as knowing how it works. Hence, it is mandatory to maintain a critical attitude when dealing with results. The VS success rate may vary considerably, depending on the target and the expertise of the user. But, if a “first-in-class hit” or a novel scaffold is identified, it should be considered as a success, regardless of its potency. Therefore, the recommendation is to pursue VS for DD, even on a relatively small scale.

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ANTI-INFLAMMATORY SCREENING OF THIOUREA DERIVATIVES BASED ON MOLECULAR DOCKING STUDIES

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Abstract:

Computer-aided drug design has emerged as an efficient tool of developing candidate drugs for the treatment of many diseases. The thiourea derivatives represent one of the most promising classes of compounds that exhibit various biological properties. The aim of this mini literature review was to analyze the molecular fitting of synthesized thiourea derivatives into the actives sites of COX-1, COX-2 and 5-LOX.

Lipinski's rule of 5 is widely used in rational drug design to predict drug similarity and druglikeness. Among selected compounds with available druglikeness data, all molecules meet criteria for Lipinski's rule except compounds **2**-**4** and **41**-**46**. *In silico* molecular docking analysis were performed in Molecular Operating Environment, OpenEye, AutoDock Tools and AutoDock Vina to explore the binding modes of these compounds into the active sites of target proteins. Within the molecular docking analysis, the interactions of key amino acid residues of enzyme's active sites involved in ligand-protein interactions were investigated.

Based on the results highlighted in this review we can conclude that certain structural features of thiourea derivatives contribute to high binding potential to interact with active sites of COX-1, COX-2 and 5-LOX. It was observed that insertion of carboxyl functional group to the parent compounds increased interaction strength due to formation of additional hydrogen bonds. On the other hand, introduction of pi-reached heterocycles increased the number of hydrophobic interactions that leads to higher binding affinity towards target proteins.

Keywords:

Thiourea Derivatives, Druglikeness, Molecular Docking, COX, 5-LOX.

INTRODUCTION

Computer-aided drug design (CADD) comprises two different approaches, structure based drug design (SBDD) and ligand based drug design (LBDD). SBDD uses knowledge of the target protein structure to calculate interaction energies, while in LBDD, chemical similarity search is performed based on knowledge of known active and inactive molecules [1].

The thiourea derivatives represent one of the most promising classes of compounds that exhibit various biological properties such as anti-inflammatory [2], antiviral [3], anticancer [4], hypoglycemic [5] and antimicrobial [6] activities. Inflammation is a complex biological response of vascular tissues against aggressive agents such as pathogens, irritants, or damaged cells [7].

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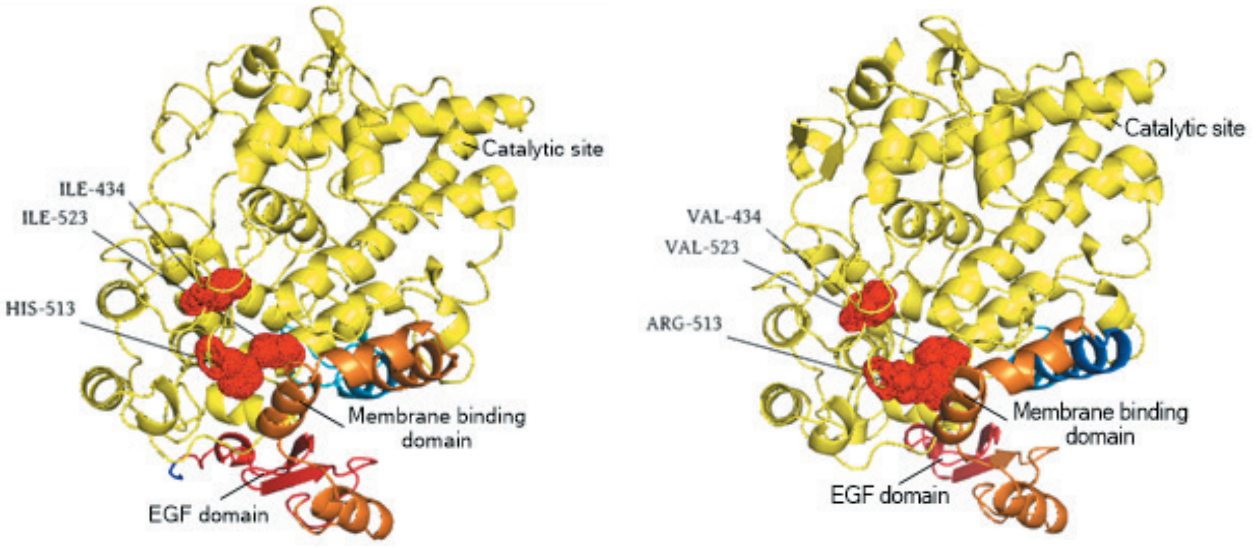

Figure 1 - Molecular structure of human COX-1 (left) and COX-2 (right) enzymes. Membrane binding domain (brown), epidermal growth factor binding domain (red), and catalytic site (yellow) of COX-1 and COX-2

Traditionally, inflammation is treated with non-steroidal anti-inflammatory drugs (NSAIDs) and corticosteroids. Long treatment with these drugs is followed by multiple severe side effects, which causes significantly limited efficacy. Due to this fact, there is a constant need to develop new anti-inflammatory drugs [8].

Anti-inflammatory drugs usually act by inhibiting cyclooxygenase-1 (COX-1), cyclooxygenase-2 (COX-2) [8] and/or 5-lipoxygenase (5-LOX) [9] COX enzymes mediate the biosynthesis of prostaglandins (PGs) from arachidonic acid (AA) and have 60% of structural homology. COX-1 is a constitutive enzyme responsible for the production of the cytoprotective PG in gastrointestinal tract and kidneys, while COX-2 is an inducible enzyme that is expressed at the site of injury in response to the release of proinflammatory mediators [10]. In addition to the high similarity, the COX-2 active site is approximately 20% larger than binding site of COX-1.

These differences are due to the presence of less voluminous valine at position 523 in COX-2 concerning isoleucine in COX-1 at the same position. COX-2 has an additional hydrophobic side pocket available for drug binding, which is located in the extension of the main pocket. The size of this hydrophobic side pocket is the result of the "replacement" of isoleucine at position 434 and histidine at position 513 in COX-1 with valine and arginine in COX-2, respectively. Mentioned amino acid differences may provide additional interaction in the selective binding of COX-2 inhibitors [11]. Scientists identified an epidermal growth factor binding (EGF) domain, a membrane-binding domain, and two catalytic domains in structures of human COX-1 and COX-2. Both cyclooxygenase isoforms have two active sites within the catalytic domain: peroxidase active site and cyclooxygenase active site (Figure 1) [12].

5-LOX converts the AA to leukotrienes (LTs) that are lipid mediators with strong proinflammatory properties.

This enzyme is associated with acute inflammatory reactions, colon cancer, asthma, atherosclerosis, and pulmonary arterial hypertension [13]. Human 5-LOX comprises two domains, an N-terminal regulatory C2-like domain (residues 1–112) which consists of two antiparallel β-sheets and C-terminal catalytic domain (residues 126–673) which is made up of predominant α-helices and ferrous ion located inside. Non-heme ferrous ion, essential for 5-LOX catalytic ability, is held inside by three conserved histidine residues (His367, His372, His550) and one carboxylate group of the C-terminal Ile673 (Figure 2) [14].

The aim of this mini literature review was to analyze the molecular docking studies to assess anti-inflammatory potential of synthesized thiourea derivatives.

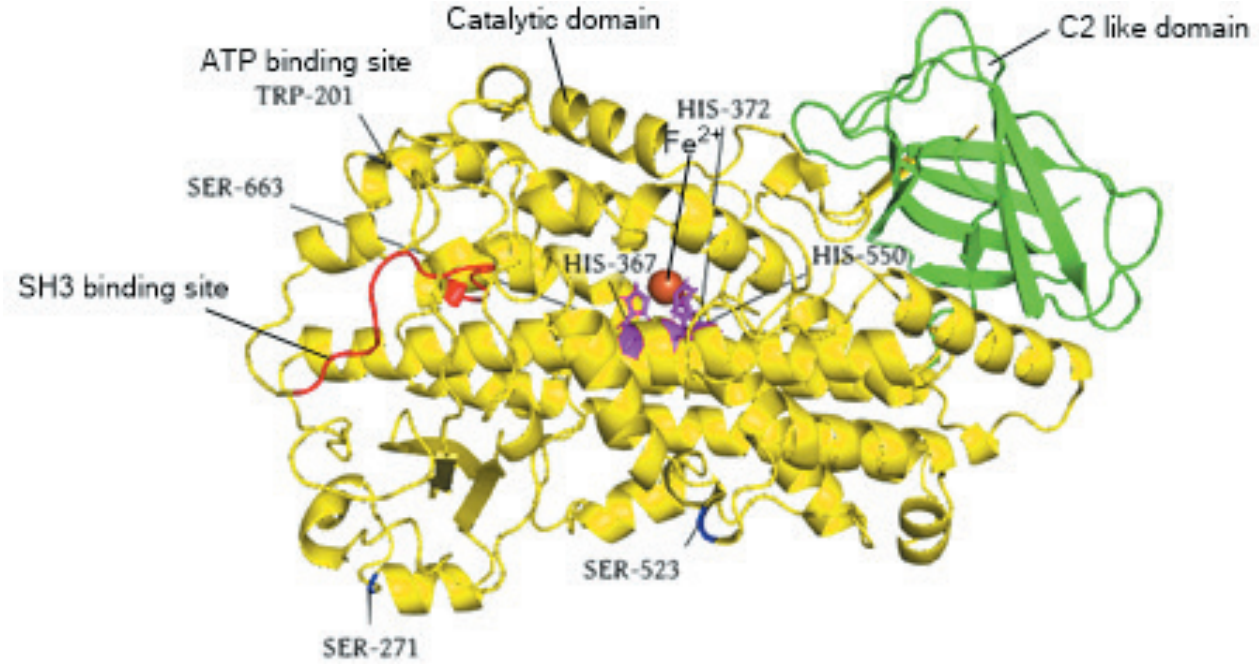

Figure 2 - Molecular structure of human 5-LOX. C2-like domain (green), catalytic domain (yellow), serine phosphorylation sites (blue), Src homology domain 3 (SH3)-binding site (red), a putative ATP binding site near the Trp201 (dark grey), histidine residues (purple), and ferrous ion (brown) of 5-LOX

2. DRUGLIKENESS ANALYSIS

Drug-like compounds are molecules, which contain functional groups and/or have physical properties like majority of known drugs, so they can be biologically active or might show therapeutic potential [15]. Properties such as oral bioavailability or membrane permeability are often correlated to partition coefficient (log P), molecular weight (MW) and number of hydrogen bond acceptors and donors in a molecule.

These parameters are included in Lipinski's rule of 5, and are widely used in predicting drug similarity. The key factors used to describe druglikeness in the Lipinski's rule are molecular weight <500; partition coefficient <5; hydrogen bond donor atoms <5 and hydrogen bond acceptor atoms <10. Molecules that violate these criteria show poor pharmacokinetic properties for oral administration. In this way, the molecules are filtered in the early phase of drug development, which allows focusing on promising compounds [16], [17].

Present research summarizes the molecular modelling studies conducted on selected thiourea derivatives (**1-46**) (Figure 3).

Among the compounds with available druglikeness data (**1-5, 31-46**), all molecules meet criteria for Lipinski's rule except compounds **2-4** and **41-46** (Table 1).

3. MOLECULAR MODELING STUDIES

In silico molecular docking analysis were performed in Molecular Operating Environment [10] [18] [19], OpenEye [19] AutoDock Tools [20] and AudoDock Vina [21] to explore the binding modes of these compounds into the active sites of COX-1, COX-2 and 5-LOX. Within the molecular docking analysis, the interactions of key amino acid residues of enzyme's active sites involved in ligand-protein interactions were investigated.

The key residues involved in binding interactions of flurbiprofen, celecoxib and arachidonic acid during molecular fitting into the active sites of COX-1, COX-2 and 5-LOX were presented in Figures 4 and 5.

3.1. MOLECULAR DOCKING INTO THE COX-1 ACTIVE SITE

The study of El-Kerdawy et al demonstrated that compound **1** bound to the COX-1 with a highest affinity, thereby achieving two hydrogen bonds with Tyr130 and hydrophobic interactions with residues Glu44 and Arg466 [18]. However, flurbiprofen does not achieve any of these binding interactions during molecular fitting into the active site of COX-1.

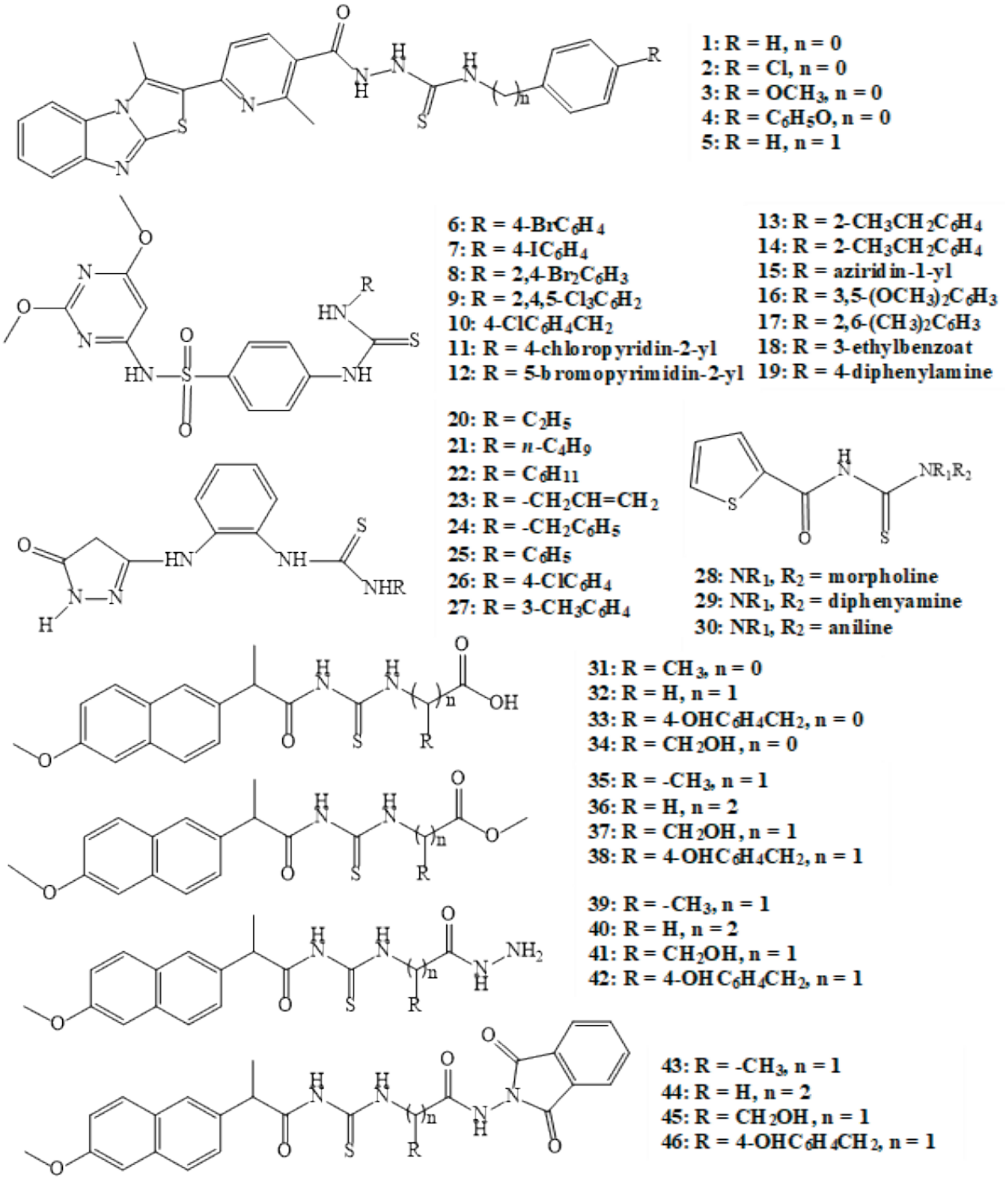

Figure 3 - Analyzed thiourea derivatives

Compound number	Molecular weight (g/mol)	Partition coefficient	Number H-bond acceptors	Number H-bond donors
1	472.6	3.36	7	3
2	507.0	5.47	7	3
3	502.6	4.83	8	3
4	564.7	6.62	8	3
5	486.6	4.77	7	3
31	360.4	2.69	6	3
32	360.4	2.32	6	3
33	376.4	1.66	7	4
34	452.5	3.92	7	4
35	374.5	2.96	6	2
36	374.5	2.58	6	2
37	390.5	1.92	7	3
38	466.5	4.18	7	3
39	374.5	1.54	7	5
40	388.5	1.17	7	5
41	390.5	0.51	8	6
42	466.6	2.77	8	6
43	504.6	3.49	9	3
44	504.6	3.12	9	3
45	520.6	2.46	10	4
46	596.7	4.72	10	4

Table 1 – Druglikeness data of analyzed compounds

3.2. MOLECULAR DOCKING INTO THE COX-2 ACTIVE SITE

Analyzed thiourea derivatives demonstrated different binding patterns during molecular fitting into the active site of COX-2. Table 2 summarizes the binding parameters of selected compound during molecular docking into the active site of COX-2. Celecoxib docked into the COX-2 active site, forming hydrogen bond with residue Gln189, while thiourea derivatives bearing sulphonamide moiety (**1** and **6**) achieved hydrogen bonds with completely different residues. On the other hand, substituted thiourea derivative **23** demonstrated hydrogen bond interactions with residues Tyr385 and Ser350, which were identical as hydrogen bonds achieved by reference diclofenac during molecular fitting into COX-2. It should be also emphasized that derivatives **20** and **22** achieved the same polar interactions with residues Arg120 and Tyr355 as co-crystallized flurbiprofen. Finally, derivative **25** formed even three key hydrogen bonds with residues Arg120, Tyr385, and Ser530. The study of Elhenawy et al illustrated that binding interactions of the naproxen derivatives increased after insertion of an acidic fragment to the initial compound.

Therefore, it was observed that interaction strength decreased in order free acids (**31**-**33**) > methyl esters (**35**-**38**) > hydrazide derivatives (**39**-**42**). Reference naproxen was docked into the COX-2, achieving two hydrogen bonds with residues Tyr385 and Ser530. Among tested compounds free acids derivatives **31** and **38** formed important hydrogen bond interactions with above-mentioned residues. Free acid derivative **32** demonstrated the lowest binding energy of -122.22 kcal/mol, while methyl ester derivative **35** and hydrazide derivative **40** achieved also the lower binding energies of -107.78 and -101.83 kcal/mol, respectively.

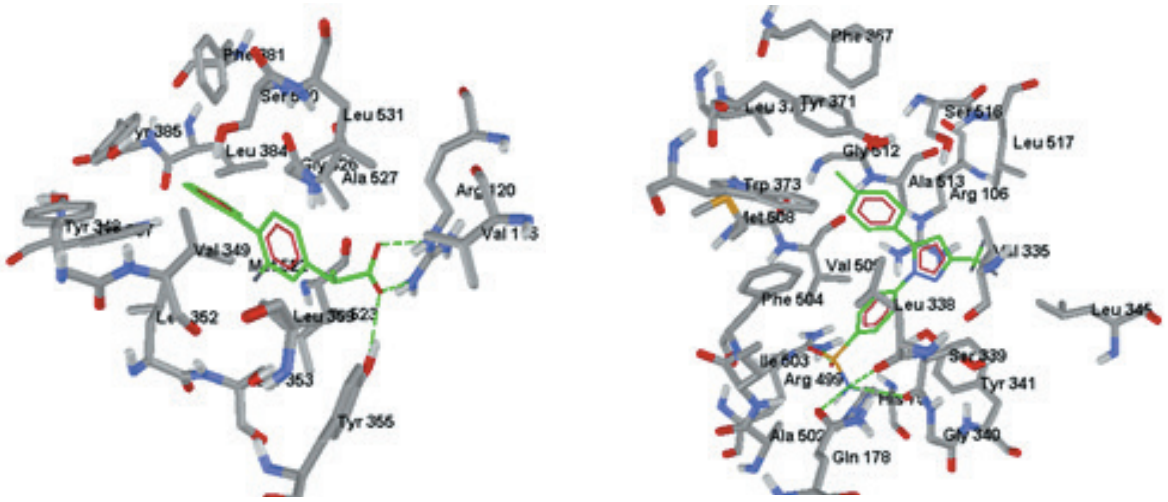

Figure 4 - X-ray crystallographic binding modes of flurbiprofen bound to COX-1 (PDB ID: 3N8Z) (left) and celecoxib bound to COX-2 (PDB ID: 3LN1) (right). Hydrogen bond interactions are shown as dashed green lines

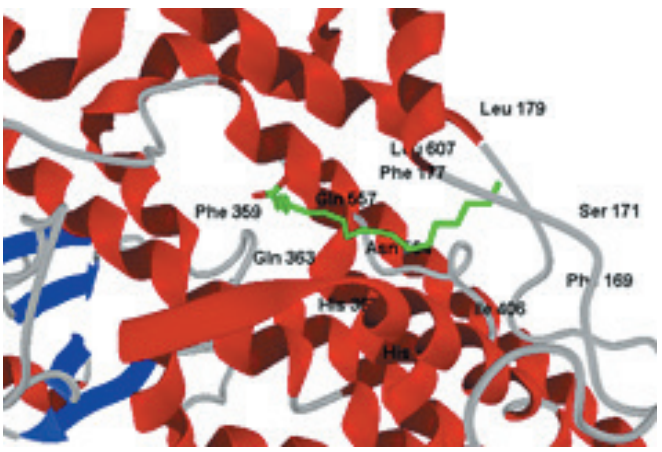

Figure 5 - Close-up view of the key residues involved in binding interactions of arachidonic acid and active site of 5-LOX (PDB ID: 3V99)

3.3. MOLECULAR DOCKING INTO THE 5-LOX ACTIVE SITE

Jacob and Manju showed that thiourea derivatives have a high potential for 5-LOX inhibition. Free binding energies of the analyzed compounds (**28-30**) were approximately -7.00 kcal/mol and were lower in comparison with the reference drug zileuton (-6.43 kcal/mol). Tiophene sulphur atom of tested compounds formed one hydrogen bond with Gln417 residue. Hydrophobic contacts were established with residues Ala157, Thr40, Asn148 and Glu412, while Met145 formed one pi-sulphur interaction with analyzed molecules [20].

4. CONCLUSION

Based on the results highlighted in this review we can conclude that certain structural properties of thiourea derivatives contribute to high binding potential to interact with active sites of COX-1, COX-2 and 5-LOX. It was observed that insertion of carboxyl functional group to the parent compounds increased interaction strength due to formation of additional hydrogen bonds. On the other hand, introduction of pi-reached heterocycles increased the number of hydrophobic interactions that leads to higher binding affinity towards target proteins.

Compound number	PDB code	Hydrogen bond interactions	Hydrophobic interactions	Co-crystal	Reference
1	3LN1	Phe186	Phe184, Gln189, His372, Tyr371, Leu377	Celecoxib	[19]
6		Trp373, Asn386	Ala185, Phe186, Tyr371, His372, Leu377		
20	3PGH	Arg120, Tyr355	Pro86, Val89, Leu93, Val116, Ser119, Val349, Ser353, Glu524, Ala527	Flurbiprofen	[10]
22		Arg120, Tyr355	Val116, Val349, Val523, Ala527, Ser353		
23		Tyr385, Ser530	Val116, Arg120, Tyr348, Val349, Leu352, Tyr355, Phe518, Val523, Gly526, Ala527, Leu531		
25		Arg120, Tyr385, Ser530	Val116, Val349, Leu352, Ser353, Tyr355, Phe381, Trp387, Gly526, Ala527, Leu531		
31	1PXX	Ser530	Gln192, Phe205, Val344, Tyr348, Val349, Leu352, Val523, Ala527	Diclofenac	[21]
33		Ser455	Tyr460, Leu507, Thr521, Leu525		
38		Tyr 385, Met522	Phe209, Val344, Tyr348, Val349, Phe381, Trp387, Leu534		

Table 2 - An overview of key binding interactions achieved between selected compounds and COX-2

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THE USE OF ASR TO MAKE CLINICAL DOCUMENTATION IN SERBIAN

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Abstract:

Medical information systems are used to manage electronic medical records (EHRs) which store information about patients' health and medical treatments. These records store data daily in a structured, semi-structured, and unstructured form. As unstructured data preserves details about the health of patients written in natural language, artificial intelligence techniques, such as natural language processing (NLP) techniques, can be applied to this part of medical reports. To obtain as useful knowledge as possible from patients' data, before data processing, it is necessary to make adequate preparation. Due to the limited duration of the examination, physicians often make typos when writing clinical documentation. The processing of misspellings that occurred during the writing of the electronic medical records is one of the steps in data preparation. If the ASR (automatic speech recognition) is used when creating a medical report, some common typing errors can be avoided. In this paper, a set of electronic medical data written in Serbian is read through using the ASR, and differences in the distribution of misspellings is analyzed compared to manually entered anamnesis. The high-level architecture of the healthcare knowledge extraction system has been proposed, which would serve to take a patient's data using ASR, and then further processing of the NLP to correct errors and classify the text.

Keywords:

Electronic health records, automatic speech recognition, Serbian, misspellings processing, natural language processing.

INTRODUCTION

Medical Information Systems (MIS) [1] plays an important role in modern health systems. In addition to keeping patient health data and being centralized, easier search and overall management are enabled, and space for analysis of this data is opened. Also, these systems can keep track of medical personnel, the state of necessary resources, reduce administration costs, so these systems have many advantages and have quickly become an indispensable part of health care systems.

Electronic medical reports Electronic Health Record (EHRs) [2] stores data on patients' health and is usually written by doctors. EHRs can have structured, semi-structured, and unstructured parts. The structured part is created by entering text in marked text fields and their

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structure is fully known (e.g., examination date, personal number of insurers, diagnosis, etc.). The semi-structured part has a partially known structure, unlike the unstructured part consisting of free text, in which a physician gives additional observations about the health of patients that cannot be expressed through previous data entry fields. Most commonly in this part are notes on the results of laboratory tests, previous or related diseases, symptoms, diagnoses, therapies, or other data of importance. Due to the limited duration of the medical examination, usually, this part of the medical report is susceptible to typos. Errors in medical reports can be fatal, for example, may lead to the wrong therapy if the name of the drug is misspelled. The existence of errors in medical reports makes its analysis more difficult, as the gain of new knowledge too. Therefore, adequate preparation of these records before processing is the main motivation of this research. There are numerous examples of the application of free text analysis from medical reports, but one of the current ones would be to conclude on changing symptoms over time for a suitable disease, given the current situation with the corona virus pandemic and the emergence of various strains that carry different symptoms.

In this paper, natural language processing techniques were applied over a set of Serbian-language electronic medical reports collected by the information system MEDIS.NET [3], to detect and correct errors in the free text of medical reports. Data entered by typing and entered using ASR was analyzed. This research aims to analyze errors that occur in free text in Serbian-language medical reports to form rules for their autocorrect. The main contribution of the paper is the classification of the types of errors and displaying of their distribution in analyzed medical reports for each method of input. Therefore, the pros and cons of both text input methods will be given. The architecture of a knowledge extraction system with EHRs entry using ASR has also been proposed, with the error detection and correction based on specialized dictionaries, natural language processing, a training set consisting of hand-marked reports, machine learning, and rules.

The paper is organized as follows. The second chapter gave an overview of works dealing with a similar theme. The third chapter describes the data and methods used for analysis. The following is a view of the classification and distribution of found errors in the analyzed set. A proposal has also been made to the architecture of the system for entering patient data with ASR possibility and for detecting and correcting errors in medical reports, and further knowledge extraction in Serbian. In the end, the conclusion and direction of further research were given.

2. RELATED WORK

Data mining and text mining [4] differ in terms of the type of data they process. While data mining processes structured data (e.g., databases), text mining deals with unstructured text data (e.g., social media posts) [5] [6]. Both use a wide range of features to convert available data into knowledge. Data mining combines disciplines that include statistics, artificial intelligence, and machine learning over structured data. Text mining requires an additional step in retaining the same goal as data research. Text mining deals with unstructured data, so before any data modeling or pattern recognition feature is applied, unstructured data must be organized and structured in a way that enables their modeling and analysis. This process is usually associated with an artificial intelligence technique called NLP – Natural Language Processing [7] and enables the system to understand the meaning of data in human language. The NLP's goal is to read, decrypt, understand, and find meaningfulness in a natural language. Most NLP techniques rely on machine learning to determine the meaning of data in natural languages.

Authors from various speaking areas dealt with the detection and correction of errors in medical reports. In a review paper for misspelling processing techniques [8] [9], three issues have been identified: detecting non-word errors, correcting isolated word errors, and correcting errors depending on context. Non-word error detection techniques fall into two categories. In n-gram analysis [10], which is mainly used in optical character recognition systems, unusual character sequences are error recognition indicators. In the paper [11] n-gram analysis is used to correct errors in the medical domain in Persian. Often, error correction systems use dictionaries: any word that is not in the dictionary is probably misspelled. Most systems for isolated word error correction use some form of minimal distance to edit or rank suggestions. In the paper [12] states that over 80% of spelling errors consist of one of the following operations: an inserted letter, a deleted letter, a letter replaced by another letter, or two transposed or replaced letters. The DL distance represents the number of operations it takes to transform one word into another and in the paper [13] is used for the Russian language.

Correcting errors depending on the context is used when a spelled word is replaced with another. These techniques use statistical language models to detect poorly formatted sequences of words. The paper [14] provided a way to detect and correct errors used by Name Entity Recognition (NER) [15], the NLP methods, and Shannon's model for noise in communication channels.

The most popular software using NLP techniques for knowledge extraction from EHRs in English are Apache CTAKES [16] and CLAMP [17]. These NER tools provide automated labeling of clinical documentation.

ASR in healthcare is detailly described in the review paper [18]. It increases medical staff productivity, facilities completeness of medical documentation, and inspires patient management.

Regardless of the medical domain, the detection and correction of errors in the Serbian language are discussed in the dissertation [19].

3. MATERIALS AND METHODS

A corpus consisting of 100 EHRs was used for this research. These reports were written in Serbian from health care institutions belonging to the Health Care Center of the city of Nis and were collected by the information system MEDIS.NET [3]. This corpus is built according to all ethical standards, with the removal of the identities of patients and medical staff.

The following scientific methods were used in this paper: description, content analysis, experimental and comparative methods. The description was applied to existing methods for detecting and correcting errors in medical reports, while the described data set was first analyzed for content, to find the types of errors that occur in the corps and create methods to correct them. Also, the same set of anamneses was read using the ASR system (Google Text to Speech API) [20], and the types of errors that appear here were also analyzed. The types of errors that occur during anamnesis entry in one way and in another are discussed. NLP methods have been proposed to detect and correct errors in free (unstructured) part of EHRs in Serbian.

4. TYPES OF MISSPELLINGS IN EHRS

By analyzing the contents of the described data set, eleven types of errors occur in electronic medical reports manually entered, while only one error type occurs when EHR is entered using an ASR system (type 5 – replacing with a similar word), which is expected since ASR systems already have built-in NLP functions. Table 1 lists these types of errors and an example for each of them from the analyzed data set.

Misspelling's Type	Description	Example	Correct word
Type 1	omitted double letter	Poštreno	pooštreno
Type 2	Replacement of letters	Malakslaost	malaksalost
Type 3	additional letters	Trupzu	trupu
Type 4	missing letters	Temeratura	temperatura
Type 5	replacing with a similar word	Zrelo	ždrelo
Type 6	joined words without spaces	Thbrufen	th. brufen
Type 7	conjoined words with a random letter instead of a space	Pomtelu	po telu
Type 8	omitted (replaced) diacritic symbol (e.g. "c" instead of "č" or "ć")	Kozi	koži
Type 9	incorrect letter	Uirus	virus
Type 10	use of letters that do not belong to the Serbian alphabet ("x" instead of "ks")	Extremitetima	ekstremitetima
Type 11	multiple errors in one word	Makolozma	makulozna

Table 1 - Types of errors identified in EHRs

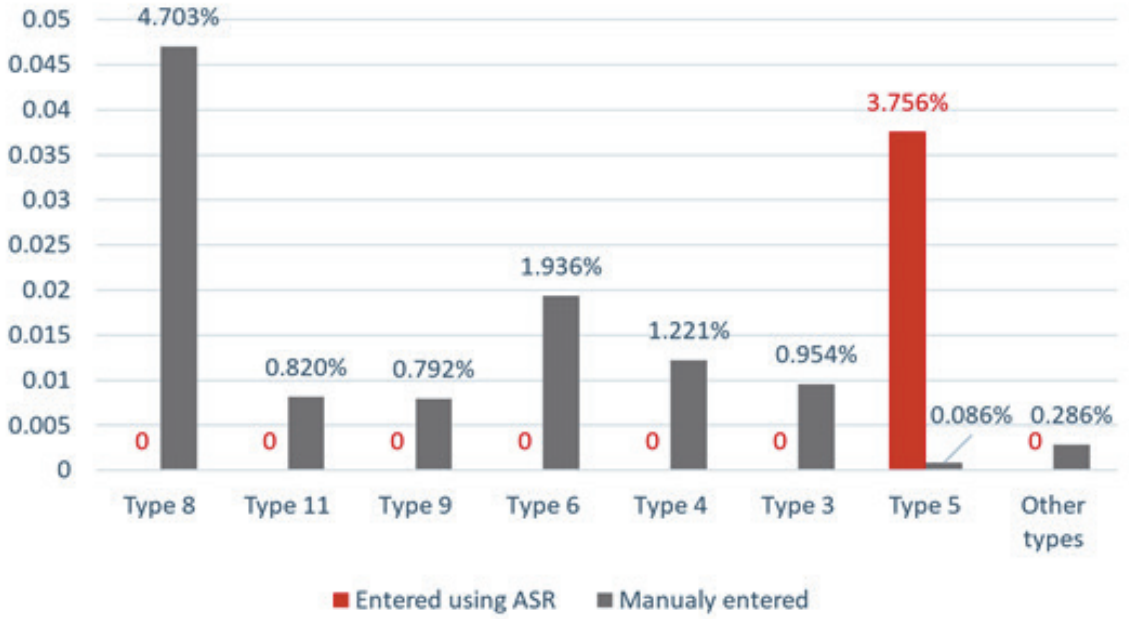

Figure 1 - Percentage of misspellings frequency in EHRs

By analyzing the data set, the percentage of errors in electronic medical reports manually entered is 10.7981% and entered using the ASR system is 3.7559%. Figure 1 shows the distribution of errors in the data set.

Based on the percentage of errors that appear in the processed data set, the types 8, 6, 4, and 3 are the most prevalent in manually entered EHRs, and only type 5 in EHRs entered through ASR, so that error correction rule formulation should resolve these errors.

5. SYSTEM FOR KNOWLEDGE EXTRACTION FROM EHRS IN SERBIAN

Although entering EHRs through ASR reduces the number of errors, the ability to enter through the keyboard must be left to provide the writer with the ability to correct the error before saving EHR entered in the system. Therefore, input through ASR can be used to reduce input time and give better results for errors that occur, but NLP methods must still be used to process the entered EHRs. Because the type of error that occurs during an ASR entry is the wrong word, which does not contain a typo, but does not belong to the syntagma by context, then techniques such as NER should be used for these purposes.

Figure 2 shows the architecture of the knowledge extraction system from EHRs in Serbian with the detection and correction capability. The first layer is the user interface, with the possibility of entering EHR manually using a keyboard or using Text to Speech API. Considering Type 5 of error which can be found after ASR entrance of EHR, before saving, a manual correction of an incorrectly recognized word is allowed. Due to time limitation and large number of examinations it is very possible that this feature would not be always used.

The second layer (application logic) uses techniques for preprocessing, classifying, learning, and suggesting correct words. Precondition for using NLP techniques is normalization of EHRs (tokenization, stop words removal, processing of abbreviations, negation, reducing words to a basic form). These steps are detailly described in paper [10]. Error detection can be performed by trying to label words using the algorithms in Serbian medical texts. Methods based on dictionaries or machine learning that use a labeled set of electronic medical reports may be used for error detection [15]. If the word is not labeled, it will be considered a misspelling. Error correction can also be made using methods based on dictionaries or on learning about the training set, but these methods need to include the use of algorithms for normalization [10] based on n-gram analysis and Serbian language stemmer [21] and to use additional steps to correct errors as error correction rules [15]. To correct a misspelling, first, for each doctor's ID special vocabulary should be created and searched. The performance of labelling EHRs in Serbian using proposed methods is quite high, considering that F1-score is over 90% [15]. The goal of such EHR data structuring is to reach the structure which enables semantic search and, possibly, automated reasoning.

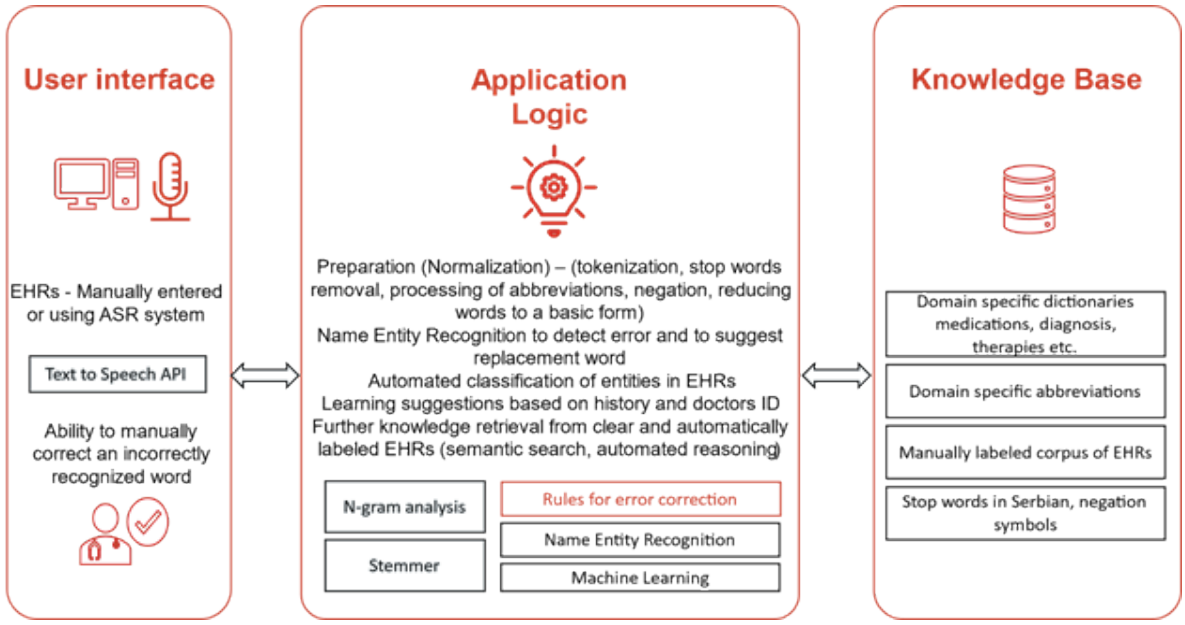

Figure 2 – The architecture of the knowledge extraction system from EHRs in Serbian with the detection and correction capability

Third layer is knowledge base which consist of training set (manually labelled EHRs) and domain specific dictionaries (therapies, diagnoses codes, diagnoses, anatomic organs, Latin word, etc.), stop words, negation symbols etc.

6. CONCLUSION

Correctly written electronic medical reports can affect the success of treating patients, and their incorrectness can have dire consequences. A set of medical reports was analyzed in this paper, and errors were found and marked in it, to create methods for their detection and correction. The main contribution of the paper is the classification of the type of errors, the display of their frequency in analyzed medical reports both manually entered and using ASR and the proposal of the architecture of the system for EHRs entry using ASR and manually, error detection and correction based on specialized dictionaries, natural language processing, training set consisting of hand-marked reports, machine learning and rules, and further processing and knowledge extraction. The subject of further research will be a quantitative analysis of the proposed methods and their experimental performance and a comparison of results with similar methods for detecting and correcting errors in similar languages.

7. ACKNOWLEDGMENTS

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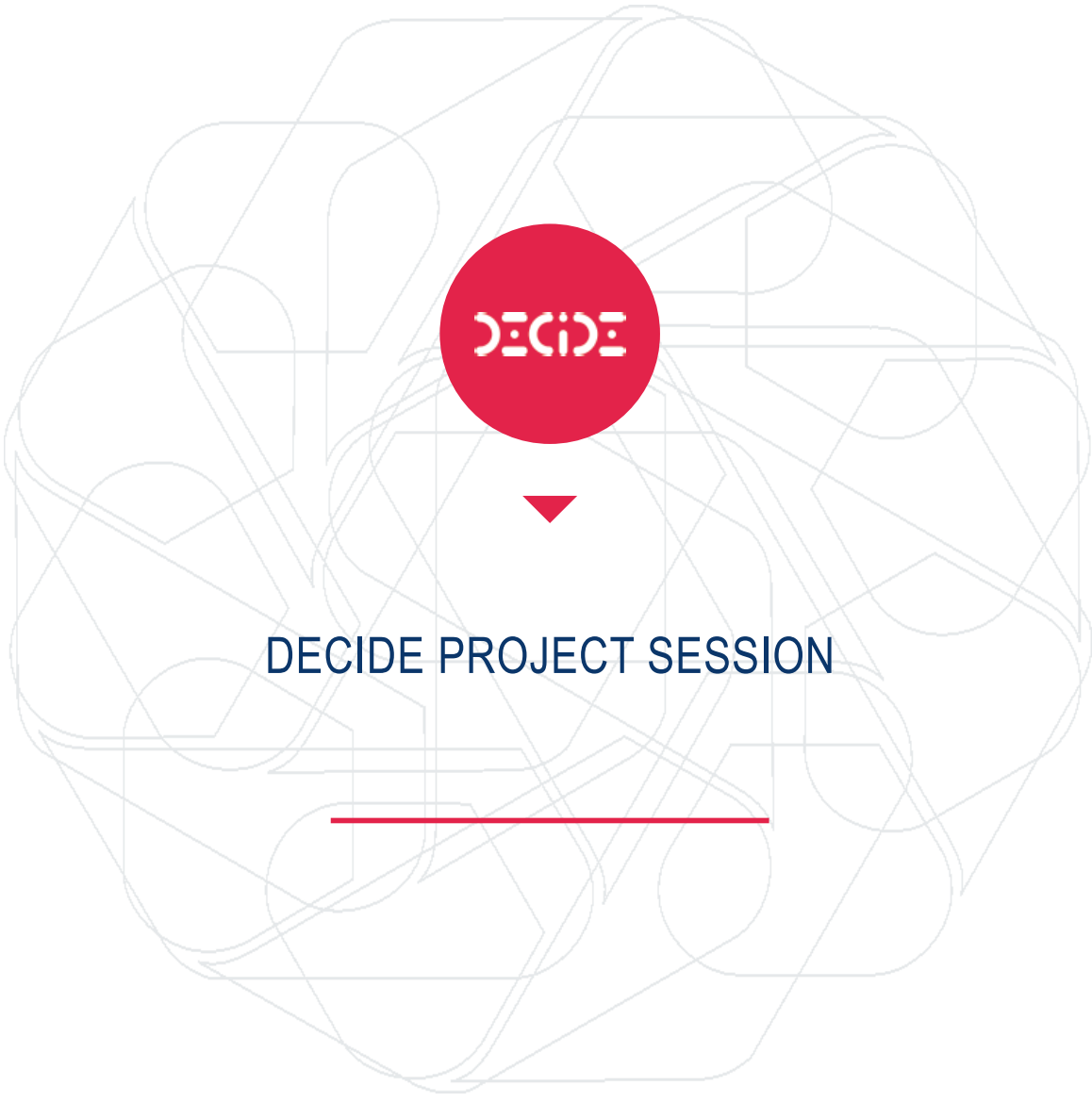

DECIDE PROJECT SESSION

AUTONOMOUS DRONE CONTROL FOR VISUAL SEARCH BASED ON DEEP REINFORCEMENT LEARNING

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Abstract:

Autonomous flight of drone using Deep Reinforcement Learning is an attractive area of research in recent years that gives excellent results. Autonomous drone flight is defined through a set of complex tasks for understanding the environment and navigating independently through it. Understanding the environment means that the drone knows its location in respect to other objects and that it can easily reach the desired location without collision. Extending the problem with a target search task increases the complexity and the necessity for using new tools and algorithms. In this paper, we present an approach in which a drone, in addition to learning to navigate in an unknown environment, learns how to find and approach an object a priori assigned to it as a target. In our approach, the drone uses RGB and RGB-D cameras as the only source of information about environment. Our proposed solution incorporates, into the framework of deep reinforcement learning, appropriate fast object detection, feature extraction, as well as efficient existing algorithms for avoiding obstacles. The proposed model uses the sensed RGB-D image of the drone as the main factor for estimating the distance to the obstacles, while, on the other hand, our model also requires two RGB images for a Siamese network as feature extractor used to identify the target in the environment, group of these images represents the current general state, based on which drone performs the action for which it can potentially receive the highest reward. We used a 3D simulator (MS AirSim) to validate the performance of our approach. Based on the simulation results, we conclude that the proposed method exhibits promising performance in terms of the rate of successful approach to the required target.

Keywords:

Deep reinforcement learning, drone, target search, computer vision, autonomous flight.

INTRODUCTION

In the last decade, there has been a rapid development in the field of artificial intelligence, especially machine learning algorithms. Advances and variations of multilayer neural networks, as well as great advances in computer technology, have allowed us to solve very complex and demanding problems of machine learning. In supervised learning and unsupervised learning, new approaches have yielded results that are close to, or in some cases, better than, human performance. For this type of learning, it is necessary to invest a lot of time in data collection and prep-

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aration in order for such algorithms to have exceptional results [1]. They tend to show the power they have and in which direction modern algorithms are going, but what will make a real difference in the future and change the way the world works are algorithms that can be trained without predefined data/instructions, the systems which can learn independently through behavior. Such algorithms belong to the field of reinforced learning [2].

Reinforcement learning algorithms play a major role in creating systems, agents or robots that can perform tasks independently, such as autonomous vehicles, factory plants, food delivery systems, and similar systems. These algorithms gave the first observed results in [3]. In the first approaches in which these algorithms were combined with deep neural networks, results were shown that give performance close to humans. But, by further improving the algorithms, human performance is far surpassed in some complex tasks such as the board game Go, in which the world champion in this game has no chance against the algorithm [4], or the video game Dota 2 in which there are a number of virtual characters that solve the problem by communicating with each other versus the team of 5 professional players who compete against them [5].

In this paper, we deal with solving the problem of autonomous drone search for a specific object in real world environment using a combination of the previously mentioned approaches. This problem was chosen because drones are already used today to solve search and rescue missions and inspect large plants or areas. The disadvantage of this use is that the person controls from a distance and in that way, it is difficult to coordinate the object in space, especially if a larger number of drones are involved. For this way of usage, people have to go through special training, but even after that, it is very difficult for them to move by drone through an unknown space because a person cannot have a completely clear picture of the environment while controlling remotely. If drones could understand and move through unknown space on their own and have the ability to identify the objects they see during the flight, then they would not need a man for direct control, and one person could be responsible for a larger number of drones.

Guided by the problem presented in this paper, we will present an algorithm that has good potential to solve this problem. The proposed solution uses Deep Q Learning as the base algorithm [3], whereas auxiliary, pre-trained supervised algorithms are also used to extract object features and localize target on the image. The problem of searching for an object is not only the identification of objects in space but also includes another set of complex problems, of which we list the two most important for us. The first problem is autonomous flight through the environment without colliding with other objects, whether static or dynamic. The second problem is the problem of localization in space. If a drone is not aware of the environment, it can endlessly repeat the search in the same area.

The localization and search can be successfully solved by using deep reinforcement learning. One approach was presented in [6], where the algorithm is always trained for a predetermined space. In [7], it has been shown that deep reinforcement learning can solve the problem of exploring an unfamiliar environment. Finding an object in an image can only be an initial task in one of the cases such as tracking a specific target as described in [8]. When objects are known in advance, the search for them can be facilitated by adding markers, or stickers with special visual characteristics, which is usually the case when locating landing sites, [9] and [10]. The searching process can also be defined through different types of recognition, such as estimating the position in [11], which can be used in systems with drones intended for surveillance. Based on the potential presented in the above cited algorithms, in our approach we use deep reinforcement training which is using information from two types of camera sources: color image and the corresponding depth map (distances to the objects in the image). Drone behavior is defined through discretization of the possible action values.

2. DRONE OBJECT SEARCH ALGORITHM

In order to find an object in an unknown dynamic environment, a number of problems must be solved. We will propose an algorithm and show that by using it, a drone can solve the search problem on its own, without human assistance, and without a combination of a number of complex algorithms. Our algorithm relies entirely on deep reinforcement learning with a combination of object detection and recognition algorithms.

For a drone that can autonomously move to find an object, the following indirect problems must be solved:

1. Avoiding obstacles in dynamic space
2. Recognition and identification of the required object
3. Localization of the drone in the environment

2.1. ALGORITHM ARCHITECTURE

The proposed algorithm's architecture is based entirely on deep Q learning. State-based Q value approximation is generated as a result of 3 tracks of neural networks. At the input to the algorithm, 3 images of the same dimensions 128x128 are given. The first part of the system is a network whose task is to approximate the distance and shapes of objects in the image. The other two images pass through network number 2, based on the ResNet50 architecture [12] which is used to extract the characteristics of objects in the image. The ResNet50 network was chosen because it gives one of the best results in the feature extraction process. One of those images is what the drone sees at a given moment and we get all the features from it. We repeat the same for the image on which the requested object is; however, unlike the first one, we temporarily store the features of this image in memory. The relationship between these two images is found through the new 3 layers of the neural network. After that, the approximation of the distance of the objects and the approximation of the features in the image are merged. At the output, there is a layer of 6 neurons for each of the possible actions. The architecture is shown in Fig. 1.

2.1.1. State

The algorithm is inspired by the way human searches for a certain object, in particular, by the information a person needs for searching. First of all, human needs to know what the object he is looking for looks like, for example, he needs to know visual characteristics such as shape, size, color. The next thing is to determine in which space we are performing the search. In order for a human to move through spaceit is primarily needed to use sight in order to avoid obstacles. Human visual sensing is typically based on two receivers, two eyes, which makes it possible to get the information about shape and color with the same signal, and also to estimate the distance from the objects. The last thing that is necessary is localization in space and environment mapping; for instance, a person does not want to look twice in the same place when searching. In relation to this explanation, we can define what we need during the search process. Since this algorithm is based on the algorithm of deep Q learning, we need to appropriately define states, actions and rewards. The algorithm expects 3 components of the input state:

1. Target image - an image in the red-green-blue (RGB) spectrum that clearly shows the desired object and occupies the surface of almost the entire image, this image should be in 128x128 format. This image is used to extract the main features of the desired object
2. Image from the drone camera - we assume that the drone is equipped with a monocular camera, from which it gets a real-time image in the red-green-blue (RGB) spectrum, the image should be 128x128. This input signal primarily serves us to identify the characteristics of the required object if the drone is aimed at it.

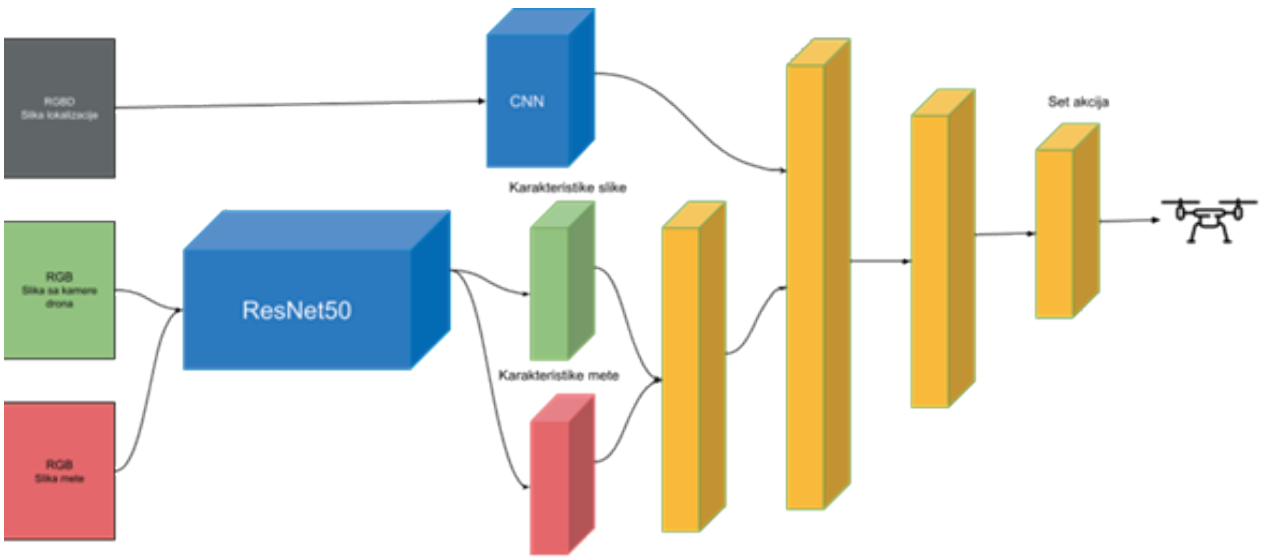

Figure 1 - Network architecture

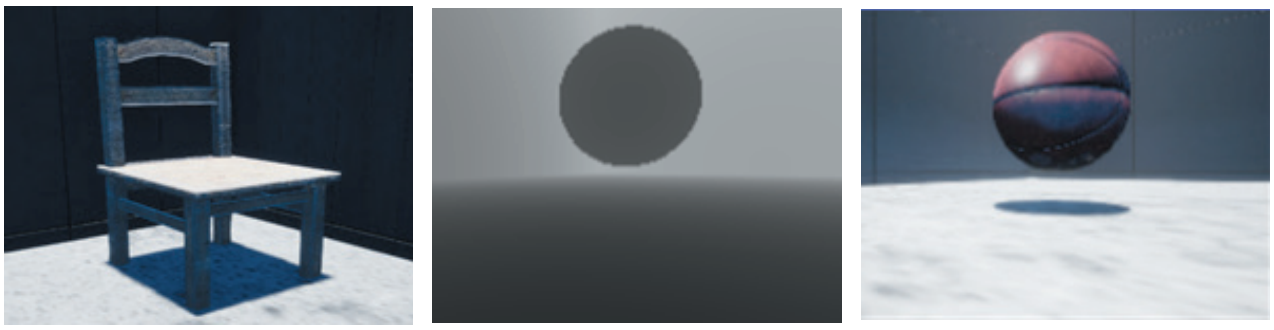

Figure 2 - Example of 3 input images, target (left), RGB-D (middle), RGB (right)

3. Depth camera image - it is assumed that the drone is equipped with an additional, RGB-D camera which, in addition to the classic color image, determines the depth in space, i.e. how far the objects in the image are. In the algorithm, this input signal is primarily intended to contribute to the easier avoidance of obstacles.

These three components provide enough information to be able to define the state of the drone, taking into account the target, the type of drone, and the relative localization of objects in space.

2.1.2. Action

A drone is an object that can move freely in all 3 axes x, y and z; it does not have a defined front because it can move in all directions equally. For this algorithm, the front of the drone is the side on which the camera is pointed forward. The set of actions that a drone can perform are up, down, forward, turn left and turn right for 30°, as well as stopping.

As can be seen from the sequence there are 6 possible actions, movement up and down is determined by moving at a constant speed for a given constant time in one of these two directions. A 30 ° rotation of the angle was chosen so that the drone could determine the visual movement of the characteristics of the objects in the image when moving. In order for the drone to turn in the opposite direction, it is necessary to perform 6 left or right turns. Although the drone has the ability to move backward relative to the camera, this is not provided by this algorithm.

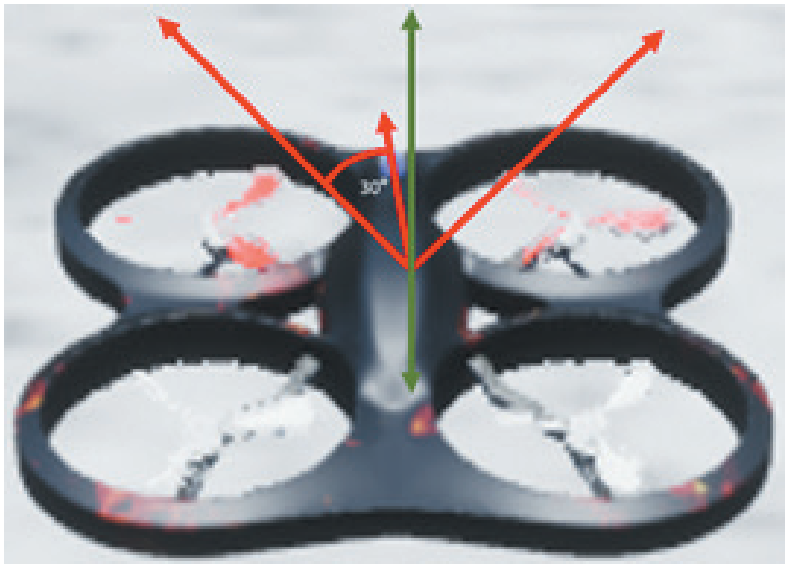

Figure 3 - Image describes directions in which it can moves

2.1.3. Reward

After the described conditions and actions, we can define the way of awarding prizes for the behavior of the autonomous drone.

To prevent a drone from stopping for a long time, each time the stop action is chosen 2 times or more in a row the reward the agent received is negative, amount of -0.2, and each time in a series of stop choices the reward value is reduced twice as much as before.

$$f(x)=\begin{cases} 0, & x<2 \\ -0.1*x, & x\geq 2 \end{cases}$$

Where x is a number that determines how many times in a row the stop action is selected.

When the drone hits one of the objects in space, the execution of the episode is stopped immediately, and the drone receives a negative reward of -100.

In order to receive a positive reward, a drone must have in its field of vision the required object or object that looks like it more than 70%. Estimation of similarity is determined by running an image of the object through the described feature extraction algorithm (ResNet50) and its approximate values are stored throughout the episode. The input RGB image from the drone, which is forwarded to the input as the state of the algorithm, is also passed through the YOLO [13] algorithm, after detecting all objects in the image for each object, the feature values are determined using the ResNet50 algorithm. The estimation of similarity for each object in the picture in relation to the required object is determined by the Euclidean distance. Then, for each object that has a similarity of more than 70%, it is determined which surface it occupies in the picture, which is proportional to the distance of the drone from the object. The closer the drone is, the larger the object occupies, so the final prize is calculated $r=\frac{p}{10}*2$, where p is the area object covers in percentage.

Acceleration of agent search is achieved by giving a small negative reward when there is no object in sight with a similarity greater than 70%.

$$r_t=-0.05$$

2.2. LEARNING

The learning process is performed using the deep Q learning scheme, with the above defined variables. The exploration/exploitation strategy is based on the ε-greedy policy, with the exploration probability ε being reduced by a small step after each completed episode. For good generalization, the originally proposed architecture with two networks is used: the final neural network and the training Q neural network. The use of a standard optimizer and the use of a system to replicate the experience gained is also retained. Neural networks responsible for extracting features from the image and localization of objects in the image are used in their original form, with the parameters with which they give the best results.

3. EXPERIMENT AND RESULTS

The proposed algorithm was trained and tested in the AirSim simulator [13] ,which is open source and is intended primarily for researchers in the field of artificial intelligence. The Python programming language with the Torch library, deep neural networks framework, was used to implement the algorithm.

In the simulator, we created a simple training environment surrounded by walls to limit the space the drone searches. No physical element has been placed on the upper side of the environment to limit the movement of the drone, but the upper limit is conditionally limited to 20 units. When the drone went out of this frame, it was considered as it hit one of the objects. The shape of the environment can be seen in Figure 4.

Figure 4 – Training environment

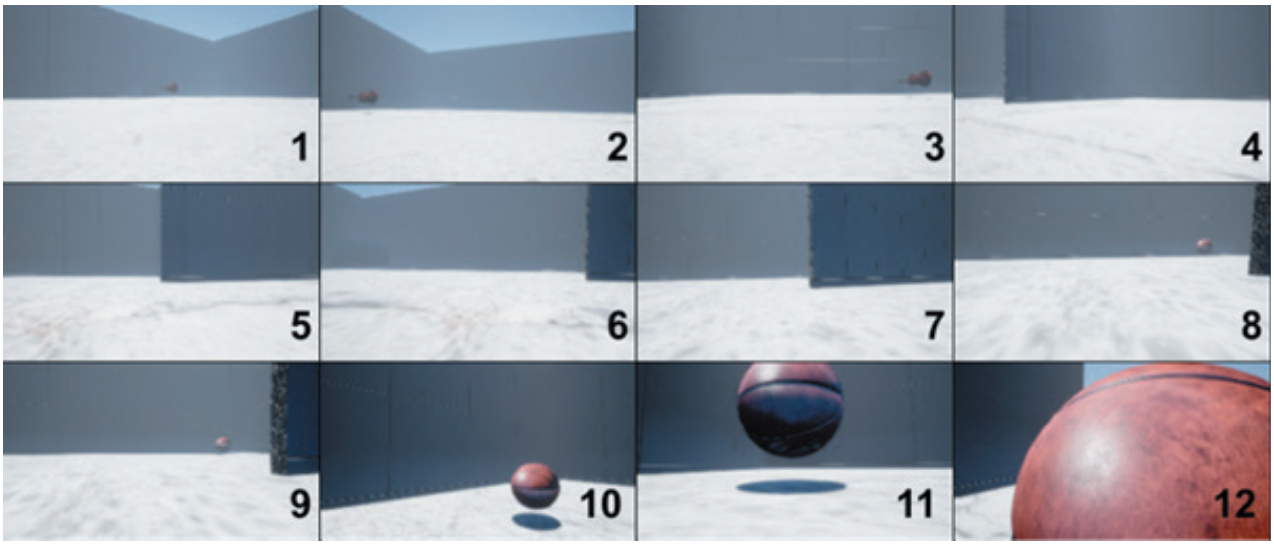

Figure 5 – An example of selected frames from drone in one episode

The simulator contains 4 items that can be searched for: a chair, a TV, a ball and a bicycle. These 4 objects were not chosen at random, they were chosen because the previously presented YOLO algorithm has available weights that give reliably good results with these objects. Photographs of each of the objects were created before the start of the training, so that it would be possible to specify the image on which the target is located. Each of the elements in each new episode is placed in a random position within the walls. Every element is always included in the environment whether it is sought after or not. In this way we get a higher degree of generalization for parameters.

After a training process that lasted more than 40 hours on standard PC with Intel i7 CPU, 1660Ti GPU supported with 32GB of RAM, we determined the success measure according to whether the drone successfully performed the task for which it was trained. In the following image, we can see 12 selected photos generated in the moment of searching for the ball, where the photo with number 1 is the beginning of one episode, and the photo with number 12 is the end of that episode, photos in between are taken at random moments in the given order.

5. CONCLUSION

In this paper, we presented a new object search algorithm by an autonomous drone using only visual and depth inputs, based on deep reinforcement learning, together with deep learning-based object detection schemes. With the presented algorithm, we have shown that the visual information obtained from the drone camera can be used efficiently, similar to eyes used by humans and animals. The fact that the drone "independently" overcame the problem of finding the required object shows how much potential and effectiveness is hidden in the reinforcement training algorithms. With this work, we have shown that deep neural networks can be used in the process of determining rewards, and not only as approximators of the Q table of values.

The potential further development of this research can go in several directions. One is the enhanced approach to deep Q training. In the presented work, the actions are discrete values with precisely defined drone displacement. A possible generalization is to use continuous values instead of discrete ones, for example, speed in all three directions, which would enable the drone to move much more precisely, but also much more aggressively if necessary. With this improvement of our algorithm, we would bring its architecture closer to the deep deterministic gradient algorithm. In addition to improvements in the way they move, there is potential for improving the detection of the desired object. For example, an introduction of the division of parameters at multiple levels of the neural network when extracting characteristics would strengthen the link between what the drone sees and what it seeks. In order to improve the search speed, we could extend the algorithm to work in a decentralized multi-drone setting.

6. ACKNOWLEDGEMENTS

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DECIDE PROJECT SESSION

DISTRIBUTED ON-POLICY ACTOR-CRITIC REINFORCEMENT LEARNING

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Abstract:

In this paper, a novel distributed on-policy Actor-Critic algorithm for multi-agent reinforcement learning is proposed. The algorithm consists of the temporal difference scheme with function approximation at the Critic stage, and a policy gradient algorithm at the Actor stage, derived starting from a global objective. At both stages, decentralized agreement among the agents is achieved using the linear dynamic consensus strategy. Compared to the existing schemes, the algorithm has improved convergence rate and noise immunity, and a possibility to achieve multi-task global optimization.

Keywords:

Multi-Agent Systems, Reinforcement Learning, Actor-Critic, Distributed Consensus, Function Approximation.

INTRODUCTION

Under the framework of Markov Decision Processes (MDPs) it is possible to model general decision-making problems in modern complex systems, including Networked Control Systems (NSC), Cyber-Physical Systems (CPS) and Internet of Things (IoT). Reinforcement learning (RL) has been generally accepted as a powerful method for solving MDPs based on online data-based trial-and-error approach, even in the case of very large state and action spaces (see, e.g. [1, 2]). In this case, function approximation represents an important factor, and the problem setup is modified such that the value or policy function is estimated using a limited number of parameters, including the possibility of using (deep) neural network approximators [3, 4, 2]. Three approaches can be, in general, distinguished: a) *value-based methods*, which perform parametrization of the state-value function (in *on-policy* or *off-policy* scenario; see e.g. [5, 6, 4]); b) *policy gradient methods*, which parameterize the policy function typically using a gradient descent algorithm (e.g. [7]); and c) the *Actor-Critic (AC) methods*, which are based on the simultaneous estimation of the parameters of both value function (Critic) and policy function (Actor) [8, 9, 10, 11].

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In this paper, we deal with multi-agent distributed and decentralized RL methods, which are currently in a strong focus of researchers and practitioners in the modern fields of NSC, CPS and IoT (e.g. [12, 13, 14, 15, 16, 17, 18, 19, 20, 21]). Distributed AC algorithms have been treated in [22, 23, 24, 25, 26, 27, 28] under different settings. In our approach, we assign an independent MDP to each agent and assume the *on-policy setup*, in which in each time step the agents are applying the control policy which is currently estimated as the optimal one. We assume a linear approximation of the state-value function at the Critic stage, and a general nonlinear approximation of the policy function at the Actor stage. The derived Actor stage provides estimates of the policy parameters based on a global objective given in the form of a sum of weighted locally averaged state-value functions, and an exact policy gradient algorithm which we derive from the TD(λ) scheme implemented at the Critic stage. In our multi-agent setup, we propose the agents to collaborate using a linear dynamic consensus scheme aimed at achieving agreement on the policy and value functions between the agents (see, e.g. [29, 19, 16]). The proposed distributed algorithm can be effectively used in multi-task RL problems [24], and as a parallelization tool, significantly improving the rate of convergence, and reducing the overall estimation variance.

The paper is organized as follows. Section 2 contains the problem formulation and the main definitions. In Section 3 we introduce the Critic stage, while in Section 4 we derive the exact policy gradient and the entire AC algorithm in two time-scales. In Section 5 we provide some concluding remarks.

2. PROBLEM FORMULATION

Consider N agents operating in Markov Decision Processes MDP$^{(i)}$, i=1,…,N, defined by the quadruplets $(\mathcal{S},\mathcal{A},\mathcal{P}^i,\mathcal{R}^i)$, where S and A denote finite sets of *states* and *actions*, $\mathcal{P}^i:\mathcal{S}\times\mathcal{S}\times\mathcal{A}\to[0,1]$ is the local *transitional probability* $P^i(s'|s,a)$ of agent i and $\mathcal{R}^i:\mathcal{S}\times\mathcal{A}\times\mathcal{S}\to\mathcal{R}$ is the corresponding local real-valued *reward function*, such that the random reward $R^i(s,a,s')$ is characterized by the distribution $p^i(\cdot|s',a,s)$, with the expectation $r^i(s',a,s)$, i=1,…,N.

Communication among the agents is modeled by a *strongly connected digraph* $\mathcal{G}=\{\mathcal{N},\mathcal{E}\}$, where $\mathcal{N}$ is the set of nodes (agents) and $\mathcal{E}$ the set of directed arcs representing inter-node communications. We assume *strict Information Structure Constraints* (ISC), such that node i cannot directly obtain information about the states and actions from MDP$^{(j)}$, $j\neq i$ and such that inter-agent messages can be obtained at node i only from the neighboring nodes [19, 29, 16, 30].

The agents learn from data received by interacting with their *local environments*. In the so-called *on-policy case*, agent i at time t applies an action $a_t^i \sim \pi^i(\cdot|s_t^i)$, where π^i: $\mathcal{S}\times\mathcal{A}^i\to[0,1]$ is a *policy function* (a *conditional probability distribution* on the set of the local state/action pairs). As a consequence, the state of agent i changes to s_{t+1}^i receiving the random reward R_{t+1}^i, i=1,…,N. The *local state value function* at node i, under policy π^i and with the discount factors $\gamma^i\in[0,1]$, is given by Equation 1, where $E_{\pi^i}\{\cdot\}$ denotes the expectation over data generated by the Markov chains induced by π^i, i=1,…,N.

$$V^{\pi^i,i}(s)=E_{\pi^i}\left\{R_{t+1}^i+\sum_{j=1}^{\infty}\prod_{k=1}^{j}\gamma^i(s_{t+k}^i)R_{t+j+1}^i\middle|s_t^i=s\right\}$$

Equation 1 – Local state value function.

Introduce the following assumption ensuring that state value functions are well defined:

(A1) $P^{\pi^i,i}=\sum_{a\in\mathcal{A}^i}\pi^i(a|s)P^i(s'|s,a)$ is such that $I-\gamma^i P^{\pi^i,i}$,i is nonsingular, for all π^i, i=1,…,N.

In the context of the *Actor-Critic (AC)* methodology in the single agent case we consider two kinds of *local parametrization*:

a) At the Critic stage, the local value function $V^{\pi^i,i}(s)$ is approximated by $V_{\theta^i}^i(s)=\theta^{i\mathrm{T}}\varphi^i(s)$, where θ^i is the local parameter vector and $\varphi^i(s)\in R^{L_\theta}$ the local *feature vector*, typically satisfying $L_\theta<<M$;

b) At the *Actor stage*, policy π^i is parameterized using the *policy parameter vector* $w^i\in R^{L_w}$, $L_w<<M$, so that $\pi^i=\pi_{w^i}^i$. Agent i is aimed at getting a *locally optimal value* w^{i*} in the sense of a pre-selected criterion using the current estimates θ^i and the local tuples $(s_t^i,a_t^i,R_{t+1}^i,s_{t+1}^i)$.

The *expected linear approximation* of the *local value* function for a given w^i is defined by Equation 2, where $\theta^i=\theta^i(w^i)$ is the local parameter vector.

$$J^i(\theta^i)=\theta^{i\mathrm{T}}E_i\{\varphi_t^i\}=\theta^{i\mathrm{T}}\sum_s d_b^i(s)\varphi^i(s)$$

Equation 2 – Linear approximation of the local value function.

The locally optimal value is $w^{i*}=Argmax_{w^i}J^i(\theta^i(w^i))$, i=1,…,N.

In the adopted *multi-agent* setting, we are faced with the set of N local criteria $J^i(\theta^i)$ with N possibly different optimal parameter values w^{i*}. We are looking for a solution of a *multi-objective optimization problem* by introducing a convenient *global utility function* denoted as $J(\theta^*(w^1,\ldots,w^N);c)$. This function depends on the global vector $\theta^*(w^1,\ldots,w^N)$, $|\theta^*|=L_\theta$, obtained at the collec-

tive critic stage characterizing the value function of the whole multi-agent system, and on some parameter vector c, $\dim(c)=N$, $0\le c^i\le 1$, $\sum_i c^i=1$ defined *a priori*, giving different importance to the agents. Hence, we introduce the *global criterion* in Equation 3 which enables getting N local optimal policies.

$$J(\theta^*(w^1,...,w^N);\ c)=\theta^{*T}(w^1,...,w^N)\sum_{i=1}^{N}c^i E_i\left\{\varphi_t^i\right\}$$

Equation 3 – Global criterion

However, our goal is to learn a *single policy* that performs optimally for the averaged tasks, so that the goal is to learn a vector w^* characterizing the common policy function $\pi^1_{w^*}=...=\pi^N_{w^*}=\pi_{w^*}$.

3. CRITIC: DISTRIBUTED TD(λ) ALGORITHM

The Critic part of the proposed AC scheme aims at generating recursive estimates θ^i_t, $i=1,\ldots,N$, using local data and communications with the neighboring nodes trying to asymptotically achieve agreement so that $\theta^1=\cdots=\theta^N=\theta^*$. The algorithm consists of two characteristic parts: 1) an update of the local parameter vectors θ^i based on the locally acquired observations, and 2) convexification of the parameter vectors obtained from the neighborhood following a linear consensus scheme. We shall consider in this paper a *distributed version* of the popular temporal difference TD(λ) algorithm, equivalent in the sense of asymptotic behavior under on-policy learning to both the Gradient Temporal Difference GTD(λ) algorithm and the Emphatic Temporal Difference ETD(λ) algorithm [11, 5].

Introducing the bootstrapping parameters λ^i (assumed to be constant, for the sake of simpler notation), we come to the generalized Bellman operators $T(\pi^i,\lambda^i,i)$ $V^i=r^{\pi^i,\lambda^i,i}+P^{\pi^i,\lambda^i,i}V^i$, where $P^{\pi^i,\lambda^i,i}=I-(I-\lambda^i\ P^{\pi^i,i}\Gamma^i)^{-1}(I-P^{\pi^i,i}\Gamma^i)$ and $r^{\pi^i,\lambda^i,i}=(I-\lambda^i\ P^{\pi^i,i}\Gamma^i)^{-1}\ r^{\pi^i,i}$. The gradient TD-algorithms GTD(λ^i) for local linear value function approximation are derived using the following objective function: $J^i_{GTD}(\theta^i)=\frac{1}{2}\left\|\Pi^i\left(T^{(\pi^i,\lambda^i,i)}V^i_{\theta^i}-V^i_{\theta^i}\right)\right\|^2_{d^i_b}$. where Π^i is the projection operator onto the approximation space $\mathcal{L}_{\Phi^i}$ w.r.t. the weighted Euclidian norm $\|\cdot\|_{d^i_b}$) [6].

The value function approximation can formally be expressed as $V^{\theta^i,i}=\Phi^i\,\theta^i$, where $\Phi^i\in R^{M\times L_\theta}$ is a feature matrix with its s-th row equal to the corresponding vector $\varphi^{iT}(s)$. We also adopt the following assumption:

(A2) a) the column vectors of Φ^i are linearly independent;

b) the feature vectors $\varphi^i(s)$ are bounded and with number 1 as their L_θ-th element [11].

The locally optimal parameter vectors θ^{i*} are solutions w.r.t θ^i of equation $E\left\{\delta^i_t e^i_t\right\}=0$,where $\delta^i_t=R^i_{t+1}+\gamma^i\theta^{iT}_t\varphi^i_{t+1}-\theta^{iT}_t\varphi^i_t$ represents the *temporal difference* and $e^i_t=\varphi^i_t+\gamma^i\lambda^i e^i_{t-1}$ the *trace vector* ($e^i_0=0$).

Accordingly, part 1) of the Critic algorithms attached to the nodes is defined in Equation 4, where $\alpha^i_t>0$ is the step size (to be specified later).

$$\tilde{\theta}^i_t=\theta^i_t+\alpha^i_t\rho^i_t\delta^i_t e^i_t$$

Equation 4 – Part 1 of the Critic algorithm

The part 2) is defined in the form given in Equation 5, where α^{ij}_t are elements of an $N\times N$ random matrix $A_t=\left[\alpha^{ij}_t\right],i,j=1,...,N,\alpha^{ij}_t\ge 0$, which is row-stochastic ($\forall t\ge 0$), with $\alpha^{ij}_t=0$ for all (j,i) not belonging to the set of directed arcs $\mathcal{N}$.

$$\theta^i_{t+1}=\sum_{j\in N_i}\alpha^{ij}_t\tilde{\theta}^j_t$$

Equation 5 – Part 2 of the Critic algorithm

The complete Critic algorithm will be denoted as AlgC.

4. ACTOR: ALGORITHM DERIVED FROM DISTRIBUTED TD(Λ)

4.1. POLICY GRADIENTS

The starting relation is $\nabla w^i\sum_{j=1}^{N}\overline{\psi}^j E\left\{\delta^i_t e^i_t\right\}=0,i=1,...,N$. Consequently, Equation 6 is obtained.

$$\sum_j\overline{\psi}^j E\left\{\nabla\left(w^i\rho^j_t\right)\delta^j_t\in^j_t+\rho^j_t\nabla\left(w^i\delta^j_t\right)\in^j_t+\rho^j_t\delta^j_t\left(w^i\in^j_t\right)\right\}=0$$

Equation 6

From Equation 6, the following expression for $\nabla w^i\theta^{iT}$ is obtained directly (see [11] for the single agent case), *i.e.*,

$$\frac{\partial\theta^{iT}}{\partial w^i}=\overline{\psi}^j E_i\left\{\rho^i_t\delta^i_t\left(\nabla w^i\log\pi^i_{w^i}\left(a^i_t\middle|s^i_t\right)\right)\in^{iT}_t+\nabla w^i\in^{iT}_t\right\}\left(\sum_j\overline{\psi}^j A^{\lambda^j,j}\right)$$

Equation 7

where $A^{\lambda^j,j}=E_j\left\{\rho^j_t\left(\varphi^j_t-\gamma^j\varphi^j_{t+1}\right)\in^{jT}_t\right\},j=1,...,N.$

Let $\eta=\left(\sum_j\overline{\psi}^j A^{\lambda^j,j}\right)^{-1}\sum_j\overline{\psi}^j E_j\left\{\varphi^j_t\right\}$, $f^{\lambda^j,j}_t=\in^{jT}\eta$ and $f^{\lambda^j,j}(s)=E_j\left\{f^{\lambda^j,j}_t\middle|s^j_t=s\right\}=E_j\left\{\in^j_t\middle|s^j_t=s\right\}\eta$. Accordingly, we have Equation 8:

$$\sum_j \overline{\psi}^j A^{\lambda^j,\lambda^j} = \sum_j \overline{\psi}^j E_j \left\{ \rho_t^j \left(\varphi_t^j - \gamma^j \varphi_{t+1}^j \right) f_t^{\lambda^j,\lambda^j}(s) \right\} \sum_j \overline{\psi}^j E_j \left\{ \varphi_t^j \right\}$$

Equation 8

Therefore, the expression for the gradient of the global criterion is given by the following Equation 9.

$$\nabla w^i J\left(W\overline{\psi}\right) = \frac{\partial \theta^T}{\partial w^i} \sum_j \overline{\psi}^j E_j \left\{ \varphi_t^j \right\} = \overline{\psi}^i E_j \left\{ \rho_t^i \delta_t^i \nabla w^i \log \pi_{w^i}^i \left(a_t^i \middle| s_t^i \right) f^{\lambda^i,\lambda^i}(s) \nabla w^i \in_t^{iT} \eta \right\}$$

Equation 9

In general, the policy gradient defined by Equation 9 can lead to nontrivial implementation problems, especially in relation with the terms $f_t^{\lambda^i,\lambda^i}$ and $(\nabla w^i \in_t^i)\eta$. However, when the value function is estimated in the Critic part by TD(λ), the solutions become simple and computationally attractive [11, 25].

4.2. POLICY GRADIENT IN THE ON-POLICY SCENARIO

It is easy to demonstrate that the algorithms TD(λ), GTD(λ) and ETD(λ) are equivalent in the on-policy scenario. In order to derive an algorithm for the Actor part on the basis of the exact gradients of the criterion function presented in Section 2, it is necessary to reconsider the derivation presented in the preceding subsection.

Theorem 1. *For the problem of on-policy estimation, the following holds:* $(1-\gamma\lambda^i)\nabla w^i J\left(W;\overline{\psi}\right) = \left\{ \delta_t^i \nabla w^i \log \pi_{w^i} \left(a_t^i \middle| s_t^i \right) \right\}$.

Proof. The proof is based on demonstrating that, in the case of on-policy estimation, f^{λ^i,λ^i} satisfies Equation 8. We can derive the following expression $E_j \left\{ \rho_t^j \left(\varphi_t^j - \gamma^j \varphi_{t+1}^j \right) f_t^{\lambda^j,\lambda^j}(s) \right\} = \sum_{s',a} \left(d_{w^j,\lambda^j}(s) - \gamma\lambda^{j m w^j,\lambda^j}(s'|s) \right) \frac{1}{1-\gamma\lambda^j} \left[\sum_s d_\pi(s) \varphi^j(s) - \gamma\lambda^j \sum_{s'} \left(\sum_s d_{w^j,\lambda^j}(s) P^{w^j,\lambda^j}(s'|s) \right) \varphi^j(s') \right]$ $= E_j \left\{ \varphi_t^j \right\}$ where we have exploited the fact that. $\sum d_{w^j,\lambda^j}(s) P^{w^j,\lambda^j}(s'|s) = d_{w^j,\lambda^j}(s')$ Hence, the result follows. □

4.3. ALGORITHM FOR THE ACTOR STAGE

According to the derivation from the previous subsection, we use the basic relation for the on-policy scenario, and obtain for t≥0 the corresponding iterations for the estimation of the local policy parameters in the Actor part, given in Equation 10, where $\tilde{e}_t^i = \nabla w^i \log \pi_{w^i} \left(a_t^i \middle| s_t^i \right) + \gamma^i \tilde{e}_{t-1}^i, \tilde{e}_{-1}^i = 0$,while δ_t^i is defined above.

$$w_{t+1}^i = w_t^i + \beta_t^i \rho_t^i \delta_t^i \tilde{e}_t^i$$

Equation 10 Actor part of the algorithm

To achieve two-time-scale functioning of the whole AC algorithm, we adopt $\beta_t^i \ll a_t^i, i = 1,...,N$.

In the case of the idea exposed in Section 2 to find the optimal policy function common for all the agents, it is, simply, necessary to add to Equation 10 a "consensus" part of the algorithm, identical to the one formulated in Equation 5 obtained after replacing θ for w. Then, under appropriate assumptions the algorithm asymptotically provides consensus, i.e. $w^1=\cdots=w^N=w^*$. The meaning of such a result is intuitively clear: the obtained solution provides an "average" solution maximizing the scalarizing objective function, but not fulfilling, in general, optimality conditions for any of the agents within the scope of the multi-task problem posed.

5. CONCLUSION

In this paper, we proposed a new distributed on-policy Actor-Critic algorithm using the TD(λ) algorithm with function approximation and dynamic consensus at the Critic stage, and the consensus-based policy gradient algorithm at the Actor stage. The gradient has been derived starting from a multi-task problem formulation and a global objective representing a weighted sum of local criteria. The algorithm can be highly effective in practice, achieving improved rate of convergence and general estimation covariance reduction.

Future work will be directed towards rigorous convergence analysis of the proposed scheme, as well as in depth simulation-based verifications.

6. ACKNOWLEDGEMENTS

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IMAGE SEGMENTATION PROCESSING FOR THERMOGRAPHIC ANALYSIS

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Abstract:

Thermography is commonly applied for determining abnormalities in various systems. Thermal image analysis can identify different issues on objects. Infrared inspection has wide application in various fields such as medicine, electrical engineering, and construction. The images in this technology are obtained by colouring using pseudo-colours that correspond to the radiative energy of detected items. The infrared detector registers surface temperatures in the surrounding and maps them to the corresponding colours according to the specific colour palette. This paper presents methods that can be applied in the processing for thermal images in order to simplify the inspection of temperature levels.

Keywords:

infrared, image segmentation, neural network.

INTRODUCTION

Due to the increases in computational power and available datasets, todays CNNs can overperform normal visual capabilities. They are applied in many areas e.g., self-driving cars, automatic video classification, voice recognition, natural language processing.

Image segmentation represents the division of images according to different classes of objects where classification is represented by different colours. Convolutional Neural Network (CNN) is commonly applied in image segmentation as it detects objects by extracting specific characteristics from the image, that are then classified and differentiated on pixel basis. [1]

Figure 1 represents the principle of Convolutional Neural Network CNN operation that is similar to the visual cortex. Neurons in the first convolutional level process defined small segments of the input image. Neurons in subsequent layers are associated with limited groups of neurons from the previous layer.[2] The first level extracts low level features e.g., shapes and curves and following layers process high-level features. In the convolution stage various filters can be applied in order to obtain the feature map.

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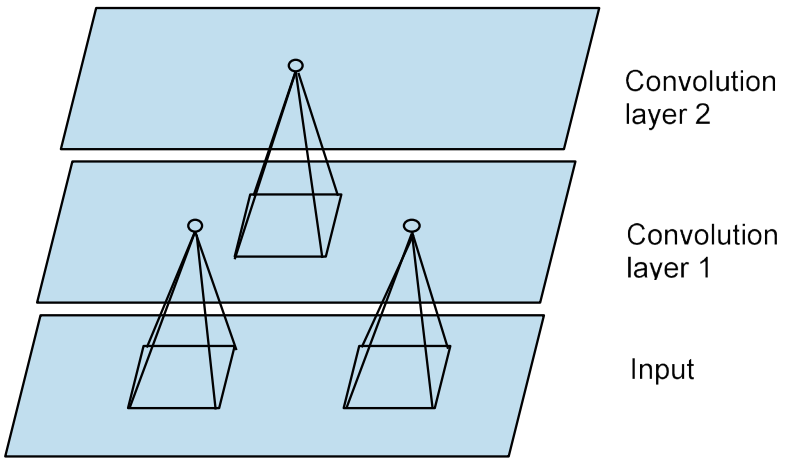

Figure 1 – CNN principle

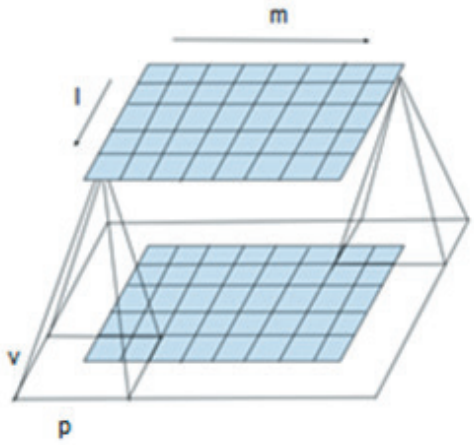

Figure 2 – Operation between layers

In the pooling stage the image dimensions are reduced commonly by taking the average or the maximal values from the defined regions, that enables obtaining smaller image representations.

The neurons from the second layer are connected to neurons from the previous layer where the receptive field is given by dimensions v and p as represented on Figure 2.

The Equation 1 represents the output function of the neural network that equals to the inputs from the previous network layers multiplied by the corresponding weighted factors.

$$f = \sum_{l}\sum_{m}\sum_{F} x_{l,m,F} w_{l,m,F} + b$$

Equation 1 – Output of neurons in convolutional layers

where f is the output from the CNN in the position l, m on the convolutional layer for the feature map F that represents the number of feature maps from the previous layer, x represents the input sequences, w stands for corresponding weighted sums for those inputs, and b is bias value.

2. RELATED RESEARCH

Hespeler et al. [3] provide the brief overview of various algorithms for object detection including their accuracy comparison. Arjoune et al. [4] propose combined image segmentation with heat loss quantification for inspecting building thermal performance. In [5] the authors represent the detailed thermography principles and non-destructive tests.

3. METHODOLOGY

If specific image segments can be isolated, the specific temperature of that segment can be determined, and the temperature differences of individual segments can be compared. One of the common methods for image segmentation is the Mask R-CNN. In this way, certain elements on the image can be isolated to avoid the influence of individual parts in the infrared analysis.

Mask R-CNN detector distinguishes pixels that belong to different items. It is based on the Faster R-CNN structure that uses the CNN to extract features. In this methodology more than 2000 anchor points are generated on the image as references for proposed regions where objects can potentially be registered. After predicting bounding boxes, the Mask R-CNN performs pixel-based classification. [6]

For more comprehensive analysis, the deeplabv3 model can be used that can efficiently differentiate global objects of interest. DeepLabv3 is composed using the ResNet-50 or ResNet-101 backbone. The DeepLab model relies on the Atrous convolutions and Atrous Spatial Pyrmid Pooling (ASPP) framework. In DeepLabv3 model the features are extracted from the backbone network, the ASPP network performs the classification of each pixel and finally the image is passed through the convolutional network to obtain the output image. [7]

In case when there are parallel visual images available that correspond to thermal images, the desired objects can be selected with corresponding bounding boxes using Faster R-CNN for the object detection on the visual image. The object can then be extracted from this region on the corresponding thermal image.

For precise separation of segments, the images can be processed by separating the contours. Contours are displayed with the near colour intensity, and it differentiates shapes across the image. Contours represent arrays of coordinates of object boundaries. In this way the desired shapes can be extracted from the image if the boundaries are provided.

4. RESULTS

The background can be extracted using the Mask R-CNN and DeepLabv3 in order to perform inspections on relevant regions. Figures 3, 4 and 5 represent the segmentation of the visual image with the deeplabv3 pretrained model that is then used for fine-tuned differentiation of relevant objects.

Figure 3 – Captured visual image

Figure 4 – Segmented thermal image with deeplabv3

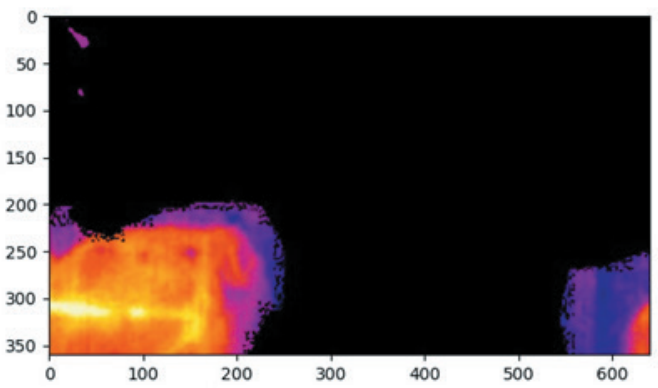

Figure 5 – Extracted items from thermal image

Figures 6 and 7 display the method for extracting the region by applying the object detector and then separating this area on the corresponding thermal image.

Figure 6 – Detection using Faster R-CNN

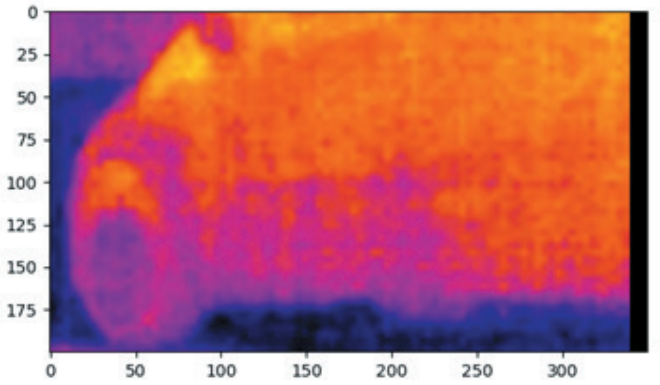

Figure 7 – Separated thermal region

5. CONCLUSION

Image processing of thermal captures can detect unusual characteristics in different systems. In order to facilitate the complex analysis of thermal images, image processing techniques based on AI can be used to draw special attention to the temperature characteristics of individual objects. This method should simplify the inspections of systems by focusing on smaller elements, specifically those characterized by higher temperatures that are displayed in light colours. However, thorough temperature analysis and improved methods are still required for qualitative thermal inspections.

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DECIDE PROJECT SESSION

MOBILE ROBOT PATH PLANNING OPTIMIZATION BY ARTIFICIAL BEE COLONY

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Abstract:

The main goal of this paper is to set a new approach in optimizing the problem of path planning for an autonomous mobile robot in static and dynamic environments. The development of computing and information technology has made life easier for people in many areas. With the increase in computing power, new branches of science have developed, such as artificial intelligence, machine learning, and deep learning. As this is an area that is developing very fast, so has its application in various spheres of society. Currently, robots are considered an important element in society. This is due to the relief of humans by robots in basic and dangerous conditioning. Still, designing an effective navigation strategy for mobile robots and ensuring their securities are the most important issues in autonomous robotics.

Keywords:

Path Planning, Mobile robot, Metaheuristic, ABC.

INTRODUCTION

One of the areas that are imposing itself due to the growing volume of ground-breaking applications, is the area of mobile robotics. Today, mobile robots are increasingly used in various fields. Mobile robots, especially drones, have found their applications in agriculture, where the use of such devices facilitates field monitoring, all the way to the increasing use in the military industry. The main aspect of mobile robots that must be considered is route/path planning [1]. Route planning involves finding the most optimal route for mobile robots to move without obstructing obstacles, from the starting point to the endpoint. Solving this problem is also the most demanding part of the development of autonomous mobile robots. This complexity arises due to different aspects of the path itself that need to be optimized: distances, travel times, or energy consumed. Various studies suggest that metaheuristic methods can help to solve this problem [2].

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2. PROBLEM DEFINITION

The problem of path planning is one of the most researched problems in robotics today. This problem involves finding the most optimal path from the starting point to the endpoint. In this paper, a metaheuristic approach to solving the path planning optimization problem is proposed, specifically, the artificial bee colony (ABC) algorithm was used in this paper [3].

The results show the advantages of the proposed approach. In particular, different quality metrics are used to evaluate the obtained results, demonstrating high performance and high applicability under general conditions. This indicates that the proposed multi-purpose evolutionary algorithm is a good choice for solving route planning problems.

3. SWARM INTELLIGENCE

Like most technological innovations, swarm intelligence finds inspiration in nature. The most famous examples from nature that are taken as an example for application in the Intelligence of swarms are birds, bees, and ants. As this field progresses, so has its application in various fields such as medicine, robotics, blockchain, etc.. [4] [5]. There are many examples from nature, from bees in creating complex nests to bees and ants. Today, swarm intelligence techniques are mainly used in optimization processes which is present and necessary from applications in computing, the Internet of Things to medicine and financial systems. In practice, people have always wanted to optimize either to reduce costs or energy consumption or to increase efficiency. Specifically, in swarm intelligence, each swarm member must communicate with other members and thus contribute to collective intelligence. Some of the main principles according to which such systems should work are that members must exchange information with each other, solve real problems and be very effective in learning together. Solving the problem of optimization using intelligence swarms is certainly more efficient than some standard, traditional ways, especially in terms of robustness and decentralization. Some of the algorithms that have proven to be the most effective are Artificial Bee Colony, Ant Colony, PSO, and Firefly Algorithm [6] [7] [8]. Let's say that the Ant Colony is inspired by the phenomenon of ants that find the shortest way from the nest to the food. This phenomenon has been observed by biologists for a long time and they have come to the conclusion that this phenomenon can be explained by the rules according to which ants function in their colony [9]. Namely, none of the units functions separately, all the ants within one colony work at the same time in order for the entire colony to survive.

4. METAHEURISTIC

Metaheuristic algorithms are inspired by nature and represent the field of stochastic optimization. Stochastic optimization methods use some degree of randomness and search for optimal or near-optimal solutions. Each metaheuristic algorithm has two main phases: Intensification and Diversification. Diversification is responsible for the global search space, while intensification performs a local search. In metaheuristic algorithms, it is important to find a good balance between intensification and diversification. Two main categories of metaheuristic algorithms are swarm intelligence (SI) and evolutionary algorithms (EA). Swarm intelligence algorithms are motivated by nature's evolved intelligence, where the entire population tends to act in an intelligent, global manner. There are numerous swarm intelligence- based algorithms with different designs, but they all share certain common characteristics. First, the population is randomly generated in the initialization phase. Random generation is used to explore the search space and avoid congestion in the local optimum [10] [11]. The location of each solution changes after each iteration and when the algorithm satisfies the interrupt condition returns the best solution. Updating the position allows the system to develop and approach the global optimum. Metaheuristic approaches based on swarm intelligence have successful applications in various fields such as the design of a revolutionary neural network in deep learning [12], the grouping of images [13], application in computing in task scheduling cloud (user requirements), etc. Each evolutionary algorithm includes the following elements: solution definition, random population initialization, assessment of fitness function, reproduction, selection, strategy substitutions, and termination criteria. In each iteration, new solutions are generated from old solutions called phases reproduction. The reproduction phase uses different operations to create new individuals, such are crossbreeding operations and mutations. Metaheuristic hybridization is a very successful category of metaheuristic studies. It's a hybrid algorithm with parallel or distributed implementation of two or more algorithms, which combines the benefits of different metaheuristic algorithms, using

algorithmic ingredients of different optimization methods or a mixture metaheuristic with different artificial methods intelligence. The result of the hybridization technique is a synergistic synthesis of fused algorithms. Some metaheuristic algorithms have fast convergence, while others are slow to converge. Hybrid optimizers are often significantly more powerful in terms of convergence rate and solution quality; they can produce more efficient and higher performance flexibility when dealing with complex problems. A necessary part of the design of a metaheuristic algorithm is creating an optimal balance of global research and local exploitation. Early convergence is a consequence of small diversity; on the other hand, greater diversity allows more careful research, allows research in the field of global search, and avoids jams in local optics. In the process of hybridization, the algorithm becomes more complex so the structure needs to be put together for easy implementation. There are many successful applications of hybridized metaheuristics in different fields. a hybrid metaheuristic is applied to deep learning variations to optimize convolutional architecture neural networks as well as various applications in cloud computing [14].

5. ARTIFICIAL BEE COLONY

The Artificial Bee Colony (ABC) algorithm is a swarm-based metaheuristic algorithm inspired by the behavior of honey bees. The algorithm consists of three components: employed and unemployed bees, and food sources. The first two components, employed and unemployed bees, search for the third component, food sources. In ABC, a colony of artificial bees (agents) searches for artificial food sources [15]. To apply ABC, the optimization problem under consideration is first transformed into the problem of finding the best parameter vector that minimizes an objective function. Then, artificial bees randomly discover a population of initial solution vectors and iteratively improve them by applying strategies: They move toward better solutions using a neighborhood search mechanism, while abandoning bad solutions [16]. The distribution of bees is such that the first half of the swarm consists of employed bees, and the other half consists of observer bees. The number of employed bees or observer bees is equals to the number of solutions in the swarm. After all, employed bees complete the search process, they share the information of their food sources with the onlooker bees [17]. An onlooker bee evaluates the information taken from all employed bees and chooses a food source with a probability associated with its nectar amount [18].

This probabilistic selection is described as follows:

$$\rho_i = \frac{fit_j}{\sum_{j=1}^{SN} fit_j}$$

Equation 1 - probabilistic selection

We can divide the process of the ABC algorithm into a few steps or phases. The first phase is the initialization phase. In this phase population of food sources is initialized by scout bees and control parameters are set:

$$.X_{ml} = l_i + rand(0,1) * (u_i - l_i)$$

Equation 2 - Initialization phase

where l_i and u_i are lower and upper bound of the parameter X_{mi}. After this, we enter the employed bee phase where agents search for new food sources within the neighborhood of the food source. After employed bee phase, starts onlooker bee phase. Unemployed bees are divided into two groups: onlooker bees and scouts. Employed bees share their food source information with onlooker bees and then onlooker bees choose their food sources depending on this information.

In ABC, an onlooker bee chooses a food source depending on the probability values calculated using the fitness values provided by employed bees. The last phase is the scout bee phase. In this phase, we have two types of bees unemployed bees or scouts and employed bees. If employed bees cannot be improved become scouts and their solutions are abandoned. After that scouts start to search for new solutions.

6. SIMULATION SETUP AND RESULTS

The proposed optimization algorithm for mobile robot path planning was implemented using Matlab R2015a. Experiments were performed on the platform with Intel Core i7-10700KF CPU at 3.8GHz, 32GB RAM, Windows 10 Professional OS. Parameters for the proposed methods were set empirically by conducting several pre-tests. Population size for the ABC algorithm was initially set to 10 and the number of Handle Points was 4. The maximum number of iterations was 150. Later population size was changed to 20. The main goal of this algorithm is to find the most optimal route from the starting point to the endpoint. Figureure 1 and Figure. 2 show the results of robot movements with different values for the population. It can be concluded that

both values give similar and very good results. The variation in fitness function is shown in Figureures 3 and 4. Although the higher the population size, the larger the number of computations, we may notice the better performance of the fitness function as the population grows.

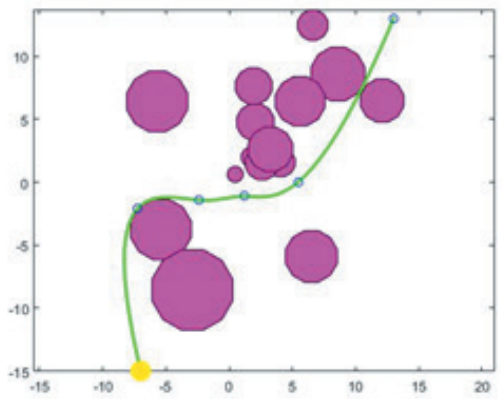

Figure 1, population size nPop = 10

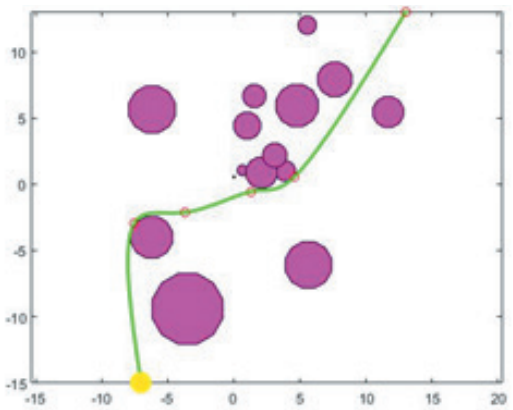

Figure 2, population size nPop = 20

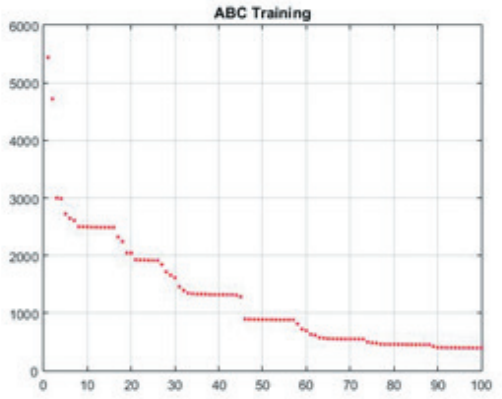

Figure 3, Fitness function nPop = 10

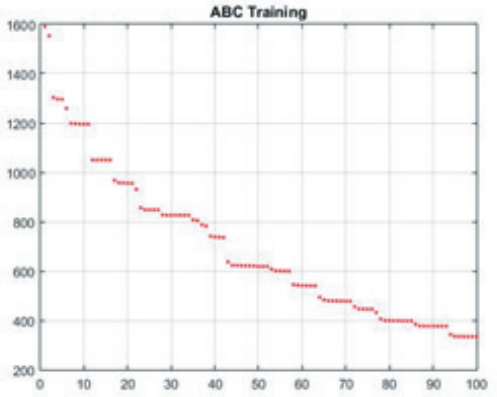

Figure 4, Fitness function nPop = 20

7. CONCLUSION AND FUTURE WORK

This paper proposes an approach to the advanced optimization of an increasingly necessary problem of mobile robot path planning. The approach to solving this problem suggests the use of algorithms based on swarm intelligence. This paper proposes to use one of the most popular algorithms lately. Future work will include testing this solution in the real world using real mobile robots. Future work will also include testing other metaheuristic methods to solve this problem and a mutual comparison of the obtained results to find the most optimal solution. Also, as a next step, hybridization of algorithms based on swarm intelligence with the Genetic Algorithm can be introduced to obtain the best and most optimal solutions.

8. ACKNOWLEDGEMENT

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STUDENT SESSION

ARITHMETIC OPTIMIZATION ALGORITHM FOR SPAM DETECTION

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Abstract:
We've all dealt with spam emails, which regularly fill our inboxes and require just a few seconds of our time to remove them. When businesses are forced to develop spam filters and use filtering software, genuine emails may be mistakenly redirected to spam folders. When businesses take on spamming customers, it results in negative consequences for their network and IP reputation, as well as extra expenses associated with employing additional staff to deal with spam and abuse complaints exclusively. When you check off a list of emails that are spam and then delete them each time you log in, it may not seem like a major matter, but there are additional issues involved with sending and receiving spam communications. We do not often consider the expenses connected with spam concerns for organizations or Internet Service Providers, which might be significant (ISP). Non-stop email transmission is disrupted, and an increase in bandwidth utilization, a decrease in in-service performance, and decreased staff productivity are all consequences of this practice. This research paper will explain how the logistic regression linear model determines which emails are spam and which are not by using arithmetic optimization algorithms in machine learning.

Keywords:
Spam email, CSDMC2010, logistic regression, machine learning, swarm intelligence.

INTRODUCTION

A surge in e-commerce has led to an increase in advertising emails, as well as malicious actors attempting to obtain sensitive information by using phishing techniques. Technology experts refer to unsolicited bulk emails as spam. In recent years up to 55% of global email traffic has consisted of spam emails [1]. These unwanted emails waste network bandwidth, storage space, inconvenience the recipients, and may even propagate malware in the attachments [2]. However, spam prevention technology has come a long way in recent years. With many approaches aimed at reducing spam emails being developed [3]. These can roughly be divided as static methods that use pre-defined lists or as dynamic techniques that make use of text categorization approaches developed using statistical techniques or artificial intelligence (AI).

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In the field of (AI), one field that has shown several possibilities and continues to do so is machine learning (ML). Due to AI being employed in a broad range of industries, several approaches and algorithms are available within this domain. The most common classifications of AI are metaheuristics and ML. With metaheuristics being problem-independent and applicable over a very broad range of domains. Moreover, metaheuristics may be split into two subcategories: those that are inspired by nature and those that are not inspired by nature, depending on the sort of phenomenon that is emulated. Tabu search (TS) [4] and differential evolution (DE) [5] are two examples of metaheuristics that are not based on natural phenomena. Evolutionary algorithms (EA) [6], which simulate natural evolution, and swarm intelligence, which mimics a group of organisms from nature are two of the most prominent types of nature-inspired metaheuristics.

Swarm intelligence makes use of a random population as an evolutionary unit as well as mechanisms for interpersonal collaboration amongst individual agents to excel at addressing a variety of optimization issues [7]. Additionally, swarm intelligence metaheuristics may improve a wide range of AI approaches and techniques. As a result, hybrid approaches that combine swarm intelligence with several machine learning models and are tailored to a wide range of real-world issues are one of the most current and popular study areas.

The arithmetic optimization algorithm (AOA) presents an exception among swarm intelligence algorithms [8]. While population-based it does not draw inspiration from natural behaviors but rather models behavior on abstract mathematical concepts, making use of arithmetic operators such as multiplication, division as well as addition and subtraction during optimization. Additionally, it shows exceptional results when tackling demanding optimization problems.

This study presents a novel logistic regression (LR) methodology [9], trained with the AOA that aims to combine the advantages inherent to LR, simplicity, efficiency, and fast classification while avoiding the drawbacks of fast convergence to non-optimal local minima by applying the AOA for training purposes.

The contributions of the conducted research may be summarised as the following:

- The first-ever application of the arithmetic optimization algorithm to the problem of filtering spam emails
- A performance evaluation of this application on a real-world data set.
- A comparative analysis with another contemporary algorithm, the ABC algorithm, addresses the same challenge to demonstrate a comparison of their performance.

The remainder of this work is structured per the following: Section 2 provides an overview of LR, swarm intelligence, hyperparameter optimization through a review of related literature; Section 3 provides a detailed description of the proposed approach. Details on the datasets, data pre-processing operations, feature selection methodology, as well as the conducted experiments, are given in Section 4. Finally, Section 5 provides a conclusion to the paper and provides proposals for future work.

2. BACKGROUND AND LITERATURE REVIEW

As an AI subfield ML emphasizes data and algorithm usage to imitate how humans learn. It uses algorithms and statistical approaches to make predictions and classifications, thus uncovering essential insights within information mining projects. The insights gained help in decision-making within businesses and applications. These algorithms predict or classify events depending on input data (labeled and unlabelled). As a result, the algorithm generates an estimate concerning a pattern in the data. In addition, an error function within the machine-learning algorithm assesses the prediction and classification, which can enhance the outcome accuracy. Similarly, a model optimization process ensures data in the training set and the weights are modified to decrease discrepancy between the model estimate and the known example.

Some notable uses of ML algorithms are to predict traffic, recognize speech and images, as well as filter email spam and malware. Traffic predictions happen through real-time location and the average time that is taken. Through supervised machine techniques, machine learning helps solve different problems. For instance, the technique aids in classifying spam in a distinct folder from a person's email inbox. The supervised machine learning methods used in traffic prediction include LR, support vector machines, neural networks, and random forest. In email spam and malware filtering, machine-learning methods use multi-layer perception, naïve Bayes classifier, and decision tree. Nevertheless, ML techniques are vulnerable to high computational costs, slow operational speeds for real-time applications, misclassifications, overfitting in a local minimum, the curse of dimensionality, and sensitivity to feature weights.

2.1. LOGISTIC REGRESSION (LR)

The LR model is often utilized for predictive modeling and analytics. The method extends to ML applications. In the analytic technique, the independent variable is categorical. The model helps in understanding the association between independent and dependent variables by approximating probabilities utilizing an LR equation. This approach reduces mistakes related to the output computed by a logistic activation function. In email classification, the LR model applies a trained online gradient descent algorithm to determine authentic and unauthentic emails. In addition, Predictive models used in the logistic analysis include probity, ordered logit, generalized linear model, multinomial logit, mixed logit, and discrete choice. Predictive models designed and developed using the LR method help in examining different categorical outcomes. Binary LR helps in determining event probability for a categorical reaction variable with two results. Conversely, multinomial LR classifies subjects into separate groups depending on a categorical range of variables to analyze and predict behavior. Consequently, the LR model assists in predicting the probability of an event happening.

2.2. SWARM INTELLIGENCE

Swarm intelligence refers to a group of often nature-inspired artificial intelligence concepts based on collective habits of social colonies. Examples of swarm intelligence applications include artificial bee colonies (ABC) [10], artificial immune systems, cat swarm optimization, particle swarm optimization, and ant colony optimization. The nature-inspired algorithms comprise adaptive features that improve artificial intelligence applications. For example, a swarm intelligence system can combine a negative selection algorithm (NSA) [11], the primary algorithms in the artificial immune system (AIS) [12], with particle swarm optimization (PSO) to detect spam emails [13]. Similarly, ant colony optimization (ACO) uses pheromone laying/pheromone based on the habits of the real ants. The method can solve different optimization problems including numerous medical applications [14] [15] [16], task scheduling [17] [18] [19], wireless sensor network optimization [20] [21] [22]. Swarm intelligence optimization techniques achieve high accuracy. The classification performance relies on the predetermined parameters and the problem type.

2.3. HYPERPARAMETER OPTIMIZATION

Model optimization presents many challenges in machine learning execution solutions. The goal of hyperparameter optimization in machine learning is to deduce the hyperparameters for a given machine learning algorithm so that the algorithm's performance will be efficient. Notably, hyperparameters can influence the training of machine learning algorithms. Engineers need to understand how to optimize the algorithms to achieve optimal functionality. Hyperparameters are utilized by swarm intelligence algorithms to search within a problem domain. These parameters are representative of solutions to the problem being optimized. Swarm Intelligence applications, such as AOA maintain and enhance a collection of viable solutions during the guided search until the user meets some predefined stopping. The Swarm intelligence rule requires solutions to improve their fitness value when they have more space and computational power. By applying swarm intelligence to various established ML algorithms an overall performance increase can be seen [23] [24] [25].

3. OVERVIEW OF THE ARITHMETIC OPTIMIZATION ALGORITHM

Much like other population algorithms, the AOA initializes a random population at the start of an optimization. Following this, the solution set is evaluated through the use of an objective function and gradually refined over numerous iterations. Owing to the stochastic nature of this approach, an optimal solution cannot be guaranteed, however, the chances of locating the global optima improve through repeated iterations. The optimization process is comprised of two stages, exploration that includes covering large areas of the search space with agents in an attempt to avoid local optima and exploitation that involves refining the accuracy of the solutions attained during exploration

The base inspiration for the AOA comes from number theory and calculus, with simple mathematical operations including addition, subtraction, multiplication, and division forming a hierarchy that is the basis for the algorithms function.

After the initial random population creation, the AOA evaluates each agent. This evaluation is repeated following every iteration, and the best performing agent (x) is considered the new optimal solution. However, before the optimization begins phase selection needs to be performed. The math optimizer accelerated (MOA) function shown in Eq. (1) is used.

$$MOA\left(C_{iter}\right) = Min + C_{iter} \times \left(\frac{Max - Min}{M_{iter}}\right)$$

Equation 1 - The math optimizer accelerated (MOA) function

In which C_{Iter} is the current iteration, M^{Iter} determines the maximum number of iterations, while Min and Max are dictated by the minimum and maximum possible values of the accelerated function.

During the exploration phase, the AOA makes use of Division (D) and Multiplication (M), to cover larger sections of the search space. However, high dispersion rates limit search accuracy, and thus during this phase, the algorithm focuses on finding near-optimal solutions, that can be improved upon in later iterations. The models for the main operations used during exploration are shown in Eq. (2).

$$x_{i,j}\left(C_{iter}+1\right) = \begin{cases} best\left(x_j\right) \div \left(MOP + \in\right) \times \left(\left(UB_j - LB_j\right) \times \mu + LB_j\right), r_2 < 0.5 \\ best\left(x_j\right) \times \left(\left(UB_j - LB_j\right) \times \mu + LB_j\right), r_2 \geq 0.5 \end{cases}$$

Equation 2 - Math operations governing exploration

Where C_{Iter} is the current agent of the i-th iteration, $x_{i,j}(C_{Iter})$ defines the jth position of the ith agent, best(x_j) is the current optimal solution, ∈ a small integer value. The upper bound is represented by UB_j, while the lower bound is denoted by LB_j. Finally, μ represents a control parameter used to fine-tune the search process.

The exact operation used in the exploration is determined by the value MOA function, and conditions r1 are a random value. Should the value of the second conditional $r_2 < 0.5$ the division will be used in the exploration, while in the case of $r_2 \geq 0.5$ multiplication will be used instead. The math optimizer probability (MOP) function is shown in Eq. (3).

$$MOP\left(C_{iter}\right) = 1 - \frac{C\,iter^{\frac{1}{a}}}{M\,iter^{\frac{1}{a}}}$$

Equation 3 - The math optimizer probability (MOP) function

Where $MOP(C_{Iter})$ denotes the ith iterations MOP value, C_{Iter} the current iteration, M_{Iter} the maximum number of iterations, and α is the parameter that defines the accuracy over iterations.

The other phase in the AOA algorithms focuses on exploitation. In this phase, the higher density search required for attaining accurate results is met by replacing the previously utilized methods with addition (A) and subtraction (S). With their lower rate of dispersion, an optimum is more easily approached. This mode is entered when the MOA function value for r1 is greater than $MOA(C_{Iter})$. The models for the main operations used during exploitation are shown in Eq. (3).

$$x_{i,j}\left(C_{iter}+1\right) = \begin{cases} best\left(x_j\right) - MOP \times \left(\left(UB_j - LB_j\right) \times \mu + LB_j\right), r_3 < 0.5 \\ best\left(x_j\right) + MOP \times \left(\left(UB_j - LB_j\right) \times \mu + LB_j\right), r_3 \geq 0.5 \end{cases}$$

Equation 4 - Math operations governing the exploitation

With C_{Iter} representing the current agent of the i-th iteration, $x_{i,j}$(CIter) being the jth position of the ith agent, best(x_j) standing in for the current optimal solution. The upper and lower bounds are denoted by UB_j, LB_j respectively. With μ again representing a control parameter used to adjust the search method.

The exact operation used for exploitation is determined by the value MOA function, and conditions r1 are a random value. When the third conditional $r_3 < 0.5$ the subtraction is applied, however, if $r_3 \geq 0.5$ then the addition is used.

With both stages in mind, the full pseudo-code for the AOA can be seen in Listing 1.

4. EXPERIMENTAL SETUP AND RESULTS

To provide valid comparative results, this research relies on the publicly available CSDMC2010 SMAP dataset for performance evaluation. The dataset is comprised of 4327 emails, with 1378 (31.85%) being spam, and 2949 (68.15%) valid emails. With 82148 distinct terms available in the provided dataset. However, the dataset is imbalanced with an evaluated factor of 2.14, as well as sparse with a percentage of 90.48% with a total feature vector size of 1000.

For this research independent implementations of both the ABC algorithm and the AOA have been done, to provide valid groups for result comparison. Due to the metaheuristic nature of swarm intelligence, testing and result representation are adequately adjusted, with multiple repeating independent runs taking place during testing, and results showing statistical results of multiple iterations. Additionally, various parameter settings were tested in search of optimal performance, as shown in Table 1 by the limit parameter having both values

of 100 and 200, as well as the SN showing numbers of agents in a given population.

Of note, is that better performance is generally observed when using a limit of 200, as such the results in Table 2 use a limit value of 200.

According to the attained results, the overall performance of the LR model trained with the AOA optimizer is fairly similar to that of LR trained with the ABC algorithm, when considering best results, with appropriate limit and MR values, for the same size population in both algorithms.

With a smaller experimental features size of 500, the ABC algorithm performs slightly better with a smaller population of 40 and 60, while the AOA outperforms it with a population of 80. However, with a feature space of 1000 and a population of 80, the results are virtually identical. Additionally, it is worth noting that the ABC poses a slight advantage over the AOA, as it poses a larger number of adjustable parameters including MR and limit, these allow for a more detailed adaptation to the presented problem.

```
Initialize parameters α, μ.
Initialize random agent positions (Agents: i=1, ..., N .)
while (C_Iter < M_Iter) do
    Evaluate agent fitness (F F)
    Determine fittest agent obtained so far
    Refresh the value of MOA according to Eq. (1).
    Refresh value of MOP according to Eq. (3).
    for (i=1 to Solutions) do
        for ( j=1 to Positions) do
            Generate random values between 0 and 1 for  r 1, r 2, and r 3
            if r 1 > MOA then
                Enter the exploration phase
                if r 2 >0.5 then--
                    (1) Apply the Division math operator (D " ÷ ").
                    Update ith agents positions according to rule one in Eq. (2).
                else
                    (2) Apply the Multiplication math operator (M " × ").
                    Update ith agents positions according to rule two in Eq. (2).
                end if
            else
                Enter the exploitation phase
                if r 3 > 0.5 then
                    (1) Apply the Subtraction math operator (S " - ").
                    Update ith agents positions according to rule one in Eq. (4).
                else
                    (2) Apply the Addition math operator (A " + ").
                    Update ith agents positions according to rule two in Eq. (4).
                end if
            end if
        end for
    end for
    C Iter=C Iter+1
end while
Return the best agent (x).
```

Listing 1 – Pseudocode for the arithmetic optimization algorithm.

SN	MR	Limit	Feature vector size = 500					Feature vector size = 1000				
			Best	Worst	Median	Mean	Std.	Best	Worst	Median	Mean	Std.
40	0.05	100	98.18%	97.81%	98.03%	98.04%	0.11	98.57%	98.18%	98.39%	98.38%	0.09
		200	98.32%	97.78%	98.03%	98.01%	0.12	98.66%	98.22%	98.45%	98.44%	0.10
	0.08	100	98.16%	97.86%	97.99%	98.01%	0.07	98.64%	98.15%	98.30%	98.33%	0.11
		200	98.18%	97.81%	98.03%	98.03%	0.09	98.48%	98.11%	98.34%	98.34%	0.11
	0.1	100	98.18%	97.74%	97.93%	97.93%	0.11	98.51%	98.04%	98.27%	98.25%	0.13
		200	98.16%	97.77%	97.94%	97.96%	0.10	98.55%	98.02%	98.24%	98.24%	0.12
	0.2	100	98.06%	97.46%	97.75%	97.75%	0.14	98.36%	97.76%	98.04%	98.03%	0.14
		200	98.01%	97.63%	97.75%	97.77%	0.10	98.32%	97.72%	98.06%	98.03%	0.16
60	0.05	100	98.34%	97.95%	98.09%	98.11%	0.10	98.63%	98.25%	98.45%	98.41%	0.10
		200	98.20%	97.93%	98.10%	98.07%	0.07	98.71%	98.25%	98.45%	98.42%	0.11
	0.08	100	98.22%	97.83%	98.07%	98.05%	0.10	98.55%	98.13%	98.41%	98.39%	0.11
		200	98.25%	97.90%	98.06%	98.08%	0.08	98.60%	98.18%	98.37%	98.36%	0.09
	0.1	100	98.18%	97.81%	97.99%	98.02%	0.10	98.54%	98.15%	98.31%	98.32%	0.11
		200	98.25%	97.86%	98.05%	98.05%	0.11	98.56%	98.11%	98.32%	98.35%	0.12
	0.2	100	98.16%	97.57%	97.85%	97.83%	0.14	98.36%	97.81%	98.11%	98.12%	0.15
		200	98.10%	97.46%	97.82%	97.81%	0.15	98.36%	97.65%	98.12%	98.11%	0.15
80	0.05	100	98.18%	97.76%	98.03%	98.06%	0.09	98.57%	98.20%	98.33%	98.36%	0.09
		200	98.18%	97.88%	98.02%	98.02%	0.08	98.48%	98.11%	98.35%	98.34%	0.09
	0.08	100	98.23%	97.81%	98.03%	98.01%	0.11	98.54%	98.15%	98.38%	98.35%	0.11
		200	98.23%	97.71%	98.04%	98.02%	0.12	98.54%	98.11%	98.39%	98.33%	0.11
	0.1	100	98.29%	97.83%	98.04%	98.03%	0.13	98.53%	98.18%	98.34%	98.34%	0.09
		200	98.22%	97.86%	97.99%	97.97%	0.10	98.53%	98.13%	98.31%	98.33%	0.11
	0.2	100	98.06%	97.54%	97.83%	97.84%	0.15	98.34%	97.86%	98.10%	98.08%	0.11
		200	98.06%	97.66%	97.88%	97.89%	0.11	98.34%	97.74%	98.07%	98.05%	0.14

Table 1 - ABC trained LR classification statistics for the CSDMC2010 dataset

All testing done in this research has been done with population sizes of forty, sixty, and eighty for each algorithm

SN	Limit	Feature vector size = 500					Feature vector size = 1000				
		Best	Worst	Median	Mean	Std.	Best	Worst	Median	Mean	Std.
40	98.45%	97.45%	97.66%	97.71%	0.13	98.52%	98.15%	98.31%	98.33%	0.10	0.09
60	98.19%	97.76%	98.03%	98.11%	0.14	98.61%	98.18%	98.35%	98.39%	0.12	0.11
80	98.26%	97.92%	98.05%	98.13%	0.12	98.54%	98.12%	98.32%	98.32%	0.11	0.11

Table 2 - AOA trained LR classification statistics for the CSDMC2010 dataset

Based on the conducted experiments, it can be deduced that the AOA is perfectly acceptable for addressing the problem of spam filtering, matching the performance of the ABC algorithm, which has been shown to outperform traditional classification methods. Making the AOA a suitable choice for application in advanced spam prevention systems.

5. CONCLUSION

In conclusion, this work presents the first-ever application of the AOA algorithm to the problem of spam filtration found in the literature. The algorithm has been independently implemented and tested on a real-world CSDMC2010 SMAP dataset, and the resulting performance was evaluated in comparison to another popular independently implemented metaheuristic algorithm, the ABC algorithm. Both metaheuristics present similarly admirable results in independent implementations and have similar overall performance when evaluated, however, the AOA algorithm shows great potential for addressing and resolving this kind of challenge. Accordingly, future work will focus on modifying and improving the basic AOA algorithm in hopes of improving overall performance, additionally, applications of the algorithm to similarly difficult challenges will be carried out.

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ARTIFICIAL INTELLIGENCE APPLICATIONS IN HUMAN RESOURCE MANAGEMENT

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Abstract:

The accelerated development of artificial intelligence (AI), especially the increasing application of machine learning (ML) algorithms in the field of human resource management (HRM), has led to significant changes in the HRM industry. Existing AI applications help HRM professionals in their daily activities and provide essential support for the overall business. The aim of this paper is to review some cutting-edge AI applications in HRM function with attention to the IBM talent management life cycle model.

Keywords:

Human Resource Management, Artificial Intelligence, Machine Learning, Talent Management Life Cycle.

INTRODUCTION

Applications of artificial intelligence (AI) in everyday life and work are no longer part of the distant future but the current reality. Machine learning (ML) algorithms already work extensively on the Internet, analysing big data and providing knowledge of user preferences to predict their future behaviours [1].

Furthermore, AI encompasses various areas, such as robotics, natural language processing (NLP), ML algorithms, computer vision, expert systems and others [2]. Since most of these elements (e.g. NLP. ML algorithms, etc) are nowadays harnessed and integrated in one robotic system, the broader term the system of artificial intelligence is being used [3].

Human capital is a vital resource in contemporary organization and the only asset that organization cannot legally possess [4]. Utilizing human capital requires not only the administrative function (i.e. employee records, attendance, vacations, sick leave, regulation of legal issues, etc.) but also knowledge of psychology (e.g. to recognize job saturation, the appropriate position for the employee, etc.), leadership skills and other so-called hard and soft skills [5].

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With the advent of artificial intelligence applications, human resources are gaining a new dimension, where the traditional is slowly moving to an intelligent (cognitive) approach.

2. ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING ALGORITHMS

Artificial Intelligence is a field of computing that deals with the development of machine intelligence, i.e. the systems that mimic the cognitive functions of the human mind with the goal of learning, understanding, adapting, predicting and functioning independently [6]. Cognition means conscious mental activity or the process of acquiring knowledge and understanding through thoughts, experiences and senses. It includes cognitive processes such as learning, memory, judgment, evaluation, problem-solving and decision making, from the existing knowledge to generate new ones [7].

One of the key fields of AI is machine learning. This represents a collection of algorithms and techniques that allow smart applications to learn and improve from experience without being explicitly programmed. Instead of coding, it is only necessary to apply some of the algorithms over a dataset and it will make its logic, such as finding correlations between data [8]. When it comes to the algorithm itself, it renders the structure of some mathematical model computed by programming language and implemented within certain application. Application is deemed 'smart' because algorithm(s) are able to resolve some problems without human involvement, for example, predicting future behaviour, recognizing the potential threats, learning from experience, etc [9].

The term machine learning means that machines are developed to act like humans. For example, if we want a machine to recognize some object, we provide datasets where specific features are stored and labelled. These data are processed by specific algorithms, that make their own logic of learning, which creates the model of learning. Usually, we chose the algorithm that recognises objects with high accuracy that can be implemented within a given application. For example, an algorithm called Convolutional Neural Network is able to recognise human emotions with 98% of confidence [10].

All these algorithms can be classified into three groups as described by in Figure 1 [11]:

- Supervised learning algorithms, applied to labelled datasets in order to predict the output from the input data.
- Unsupervised learning algorithms, applied to datasets that cannot be labelled (e.g. stock market shares), to learn the inherent structure from the input data.
- Reinforcement learning algorithms, applied to no-predefined data, learn based on their mistakes, similar to when a person plays a game and avoids the mistakes he has made, in order to win or move to the next level.

Figure 1 - Machine Learning algorithms [12]

3. ARTIFICIAL INTELLIGENCE APPLICATIONS IN HUMAN RESOURCE

The HRM sector is facing number of significant challenges today. The influence of the gig economy, cognitive computing, and especially virus pandemic, are changing existing business models, workforce demographics, patterns of work, socio-economic conditions, user experiences, creating new jobs, while simultaneously replacing old ones with robots or intelligent applications [9].

Currently, HRM is moving away from the usual human resources practices and is developing in the direction of automation, enhanced intelligence, robotics and artificial intelligence. These trends completely re-examine the entire HRM process in contemporary businesses. In addition, the integration of AI into human resources practices enables better analysis, prediction, and diagnosis to improve the overall decision making [13]. According to the Oracle and Future Workplace report [14], more than 50% of employees use some form of AI in their business, and more than 60% are optimistic and grateful having robotic co-workers, they can trust more than their managers [14].

According to research by the IBM Smarter Workforce Institute, the application of AI in HRM will solve business challenges, attract and develop new skills, improve worker experiences, provide analytical decision support, and enable more efficient allocation and use of HRM budget [13].

Artificial intelligence can be applied in a number of HRM areas including attraction, candidate recruitment, engagement, learning, rewarding, career management, retention and HRM support. In this paper, the IBM talent management life cycle is reviewed as a framework for presenting applications of AI technologies in HRM, because IBM is rendered a leading talent-centric and AI-powered organization [15]. IBM's HRM team, together with their client services experts, have developed these AI solutions including IBM Watson Candidate Assistant, IBM Watson Recruitment, IBM Watson Career Coach, Your Learning, and number of others, depict in Figure 2.

3.1. PHASE 1. ATTRACT: IMPROVING THE CANDIDATE'S EXPERIENCE

During this phase, AI can be used to identify high-quality candidates, even before they even thought of applying for the job. The aim of this phase is to gather as many potential candidates as possible who have the necessary skills for a certain position, and to encourage them to apply for a certain job by providing all the relevant information about the company, position, environment, advantages and other benefits [13].

One example is the use of specialized chatbots. Chatbots send messages at regular intervals, to intrigue and encourage candidates to ask questions about work and organization.

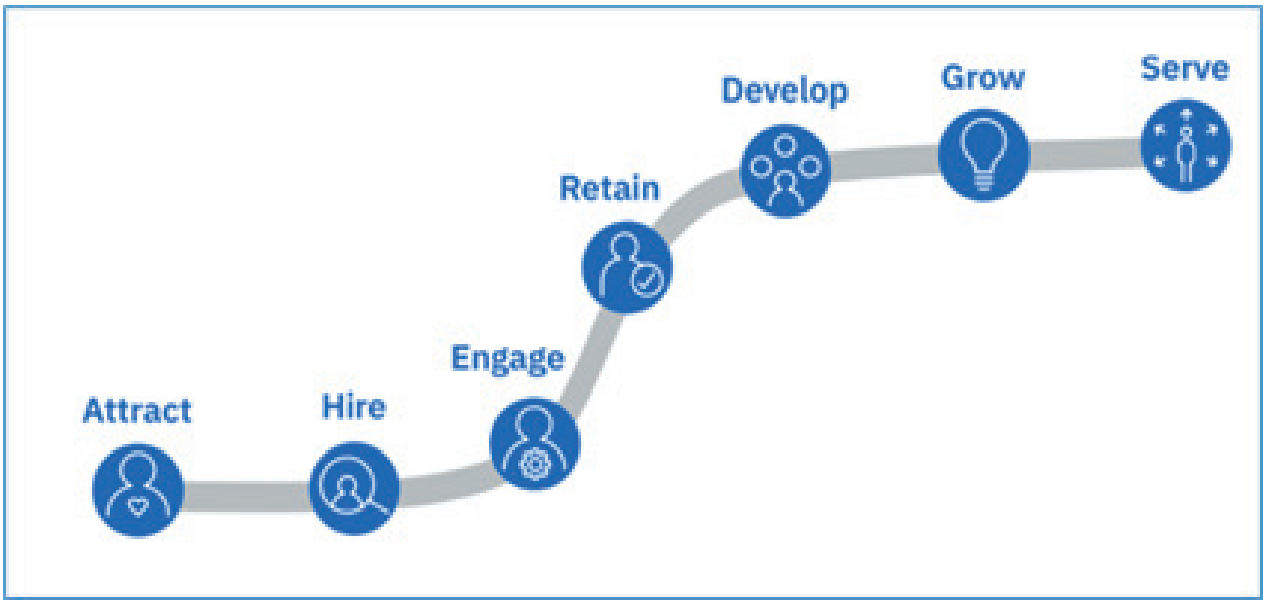

Figure 2 - IBM Talent Management Life Cycle [13]

Also, this technology speeds up the research process about the company, its reputation, analyses the comments of current or former employees on various forums, matches the candidate(s) skills with specific requirements in certain positions, creates a system of recommendations based on the candidate(s) biography, etc. According to expert advice, the list of high-ranking chatbots in 2020 includes XOR, Arya, Olivia, and number of others [16].

XOR recruitment software combines the latest advances in AI, machine learning and chatbot technology [17]. The software uses 100 languages with its algorithm, and is set up to turn a potential candidate into an employee . Recruitment chat, Arya, developed by Leoforce company [18], identifies top talents, comparing skills and building the relationship with the right candidate(s). The major strength of this chatbot is that during the conversation, it can fully see and understand the dilemmas and needs of the candidate(s).

Olivia chatbot, developed by Paradox company [19], is on the HRM market since the 1990s,. It allows quick attraction of candidates by creating a personalized experience, collecting basic personal information (i.e. name, email, phone, previous positions or applications for the job), automatically scheduling interviews, managing recommendations, etc.

3.2. PHASE 2. HIRE: ENABLING PROPER STAFFING

The job of a recruiter is time-consuming, especially when there are multiple open positions with a load of documents from the candidates that need to be reviewed and their compatibility matched with job requirements.

In this phase, machine learning algorithms are used to analyse and sort jobs according to the priority, match candidate(s) skills, predict their future performance based on data collected during the job application process, and other [20]. Current AI applications used in this phase enable automatic reading of job application forms (CV, cover letter), testimonials, and other candidate(s) documents, and load, analyse and match these data with vacant position(s) within the HRM system.

In addition, AI referral analysis applications help identify relevant people inside or outside the company who have the best recommendations from own employees [21]. By reviewing current employee's work performance and analysing their recommendations, AI applications can sort the list of employees by significance based of their work track records and recommendations.

Many AI applications are available on the market. Talkpush is the chatbot that automates the hiring process, and is currently used by companies some Fortune 500 companies, such as Amazon, Walmart, McDonald's. Furthermore, IBM's Watson Recruitment (IWR) uses AI to gather labour market information and candidate(s) previous experiences in order to predict future work performance [22].

3.3. PHASE 3. ENGAGE: INCREASING EMPLOYEE MOTIVATION

AI applications are also used to analyse employee engagement and inform the management [23]. By analysing the data that employees enter daily, it is possible to predict their fatigue, job saturation, burnout, and other possible risks [24]. Furthermore, it predicts the employees' potential, their expectations, improvements, intention to change jobs, etc. Based on analysis of this data, personalized schedules are made and more productive conversations are held with employees to improve their experience, work performance and retain talented workers [25].

Engage at IBM assess social media content within the IBM itself, to identify key employee issues [13]. This AI application analyses unstructured data from annual reports, received recognitions and awards, comments of employees, etc., in order to motivate and better engage employees [26]. For example, when someone is praised by their team, the app notifies the manager to share the news with other employees, or post it on social media.

AI alert systems provide notifications to managers about their team members [27]. For example, if employee has been in the team for a long time, achieved certain competencies and is ready for promotion, the manager is noticed [8]. Similarly, a manager can also receive notification of employees who have a greater propensity to leave the company. In that case, manager can react quickly and propose preventive measures to further motivate employee(s) and get them back on track [28]. One of the ML algorithms often used for this type of analysis is Naive Bayes (based upon Bayes' probability theorem). The algorithm analyse and identify key characteristics of employees who have left the company and match it among the existing employees, assuming they may leave the organization in the foreseeable future if the management does not take any action [3].

AI applications that additionally influence the motivation of employees are chatbots that lead to an informal conversation with employees, follow their feelings, take

preventive and appropriate measures, answer everyday questions regarding, vacations, sick leave, workers' rights, etc [29]. Since these chatbots are available to employees on daily basis, they are better acquainted to the employee than HR staff. For example, some questions that chatbot regularly ask are: "Are you bothered or frustrated by something", "What do you want to achieve during the day" [13]. In conclusion, these applications are of great help in preventing employee dissatisfaction on time and thus resolving some organizational issues.

3.4. PHASE 4. RETAIN: SMARTER COMPENSATION PLANNING

Decision on how to compensate employees requires careful consideration and analysis of many factors. In addition to work performance, compensable factors include the current market price of a particular skill, how demanding the skills are, what the need for that skill is, and whether it is better to reward strong work performance as the base salary or to include bonus scheme. The advent of AI applications to support the compensation system has significantly reduced the time for the preparation of compensation plans and consequently reduced the possibility of bias in the compensation process. One AI application available in the market is the Beqom compensation management application [30].

3.5. PHASE 5. DEVELOP: PERSONALIZED LEARNING AND TESTING

AI applications on employee learning and development are designed to accelerate the acquisition of skills both by employees and organizations as a whole. By making learning available when and where it is needed, AI helps to acquire the strategic skills of the organization.

The company should know what skills employees possess and at what level of expertise. With built-in AI algorithms, the system will automatically detect skills level of an employee and create personalized, agile and adaptive learning programs to meet the individual needs. Concurrently, employees' feedback on business is considered. Analysis of learning history is assessed as an indicator of each employee propensity to learn, which becomes just as important as a employee's current skills, as the lifespan of skills naturally continues to decline over time.

Bernard [31] stated that AI applications for learning and development enable: a) Personalized learning path depending on learning style, role at work, existing plan for developing skills and future goals while proactively directs towards the missing skills, b) Assigning tasks and engaging in projects that are based on employee skills, c) Pairing learning content based on the individual needs of employees, d) Learning chatbots that are accessible to employees as additional support, e)Adaptive testing, etc.

3.6. PHASE 6. GROW: CAREER DEVELOPMENT

Career Coaching is a powerful way to create a more meaningful work experience for employees and can lead to high motivation and engagement, higher productivity, as well as improved overall job performance [32]. It is usually time-intensive , expensive and has generally been reserved for employees who either perform poorly or for individuals who represent great potential for the company [33].

IBM [32] has developed the Watson Career Coach (WCC) which enables the following:

- Personal career counselling: answers the FAQ about career and provides guidelines that are tailored to the career aspirations of the individual;
- Explores future career opportunities: advising employees on new job opportunities that match their skills, interests and desired career path;
- Move towards a career path: helping employees to map the path of their career by showing them what, in a given role, they will do next;
- Discovers new learning opportunities: preparing employees for their future growth and development, offering them learning opportunities that match their desired career paths.

3.7. PHASE 7. SERVE: 24/7 INTERACTION WITH EMPLOYEES

AI application most frequently used in HRM are chatbots [34]. They must be available for 24/7 in real-time, and deliver customized support and interventions through brief conversations with employees [35]. However, the most significant advent in nowadays AI applications is the ability of chatbots to constantly learn from employees' feedback and thus improve their responses over time [26].

4. CONCLUSION

This paper presents the existing AI applications in HRM that are used today by all the sizes of businesses. Large companies already implemented HRM systems, such as SAP, Microsoft, SalesForce, and many others [9]. For a number of small and medium-sized enterprises, these HRM systems are quite expensive so they usually use smaller web AI applications. These AI applications are more agile and cheaper, while developed using modern technologies, but they can only cover some parts of the HRM business and are generally not integrated with other business functions within the company.

HRM information systems today are mainly divided into "Operational" that support everyday human resources operations and "Analytical" that provide help in decision making processes. Whatever is the capability of current HRM information systems, they implement modern technologies such as AI, Big Data, IoT and others.

Although AI is currently mostly used for repetitive administrative jobs, it is slowly utilized in jobs that require determination and expertise, especially when it comes to making business decisions about certain issues [36]. However, considering the HRM role and business objectives, it is expected that future AI applications will require a multidisciplinary approach in the areas of administration, psychology, management, etc.

Many people are worried that AI systems may completely replace humans and reshape the nature of labour and market itself. However, there are comforting voices that in the future AI will very much depend on human skills. Some of these skills (so-called 5C) regarded as a crucial differentiators of people versus machines in the future, are listed by Eubanks [25] – these are: Creativity, Curiosity, Collaboration, Compassion and Critical thinking.

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STUDENT SESSION

CYBER SECURITY AND DOMAIN NAME SYSTEMS DEPLOY AND PROTECT NETWORK WITH DNS SINKHOLE BLACKHOLE

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Abstract:

DNS is a protocol within the standards for how computers exchange data on the Internet, known as TCP/IP protocol suite. A DNS server, also called a name server, handles a massive database, which maps domain names to IP addresses. The Domain Name System (DNS) [1] is central to the operation of modern networks, translating human-readable domain names into machine-usable Internet Protocol (IP) addresses. DNS makes navigating to a website, sending an email, or making a secure shell connection more accessible and is a crucial component of the Internet's resilience. As with many Internet protocols, DNS is one of them which not withstand abuse from wrong actions intent on causing harm. “Protective DNS” [2] is different from earlier security-related changes to DNS. It is a security service – not a protocol – that analyses DNS queries and takes action to mitigate threats, leveraging the existing DNS protocol and architecture.

Keywords:

DNS, Protective DNS, DNS Sinkhole, protection from Ads.

INTRODUCTION

The domain name system is indisputably one of the most important and overlooked parts of the Internet. Since it is difficult to memorise many IP addresses, which are strings of numbers, DNS came into existence. Domain name system (DNS) manages a considerable database mapping IP address against domain names. DNS takes the URLs we enter in our web browsers as input, finds the IP addresses of the web servers hosting those sites, and returns those IP addresses [3].

Phishing is the attempt to obtain confidential information such as usernames, passwords, and details of credit and debit cards, often for malicious reasons, by tricking the user. There are some approaches to prevent phishing. DNS sinkhole is one among them. DNS sinkhole, also called blackhole DNS, is used to spoof DNS servers to prevent resolving hostnames of specified URLs. A sinkhole is a way of redirecting malicious Internet traffic so that it can be captured and analysed by security analysts. That can be done by configuring the DNS forwarder to return a false IP address to a particular URL.

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DNS sinkhole can restrict access to specific sites that violate corporate policies, including abusive social networking content. In DNS sinkhole, we create two lists called whitelist and blacklist. Malicious URLs can be collected from already known servers through the open-source sites providing malicious IP details. The known malicious URLs will be placed on a blacklist, whereas the whitelist contains essential URLs. The URLs present on a blacklist can never be accessed. The URLs present in the whitelist are safe for sure. DNS sinkhole verifies the input DNS query with the elements present in the whitelist. If the system query finds a match on the list, the user will have full access to the IP address. Otherwise, it verifies with those present on the blacklist, and the user gets information that access is forbidden [4].

When a new domain is on the blacklist, the domain ultimately falls under the control of the sinkhole administrator. After this, it is no longer possible to access the original host. The blacklists must be updated constantly by the administrators of the DNS sinkhole. Open-source lists of known adware sites, malware sites, and information from other sources can combine with organisation-specific information from DNS resource record queries from affected clients' analysis of malware found on compromised clients. The mentioned information can add to the blacklist of a sinkhole. The DNS sinkhole can also control some domains that are not malicious or fraudulent but contravene the policies. DNS sinkhole can be a part of security [5].

2. WHERE IS THE PROBLEM?

It is the age of bots. Botnet traffic is increasing daily, exploiting computer systems through various infection vectors and establishing command and control channels for sale or lease to the highest bidder. Attacks are seen as a form of cybercrime and other illegal activities. Security analysts and administrators must respond daily to malware that forces users to unknowingly download suspicious files from websites that they have no reason to access. Available applications that are dangerous must also be blocked. The following figure shows that botnet activity has been increasing day by day.

It is the duty of security analysts and anti-malware engineers to control and prevent bots and other unwanted traffic. DNS sinkhole can play a significant role in preventing access to known malware sites as a part of security [6].

3. DOMAIN CLASSIFICATION

A core capability of Protective DNS is the ability to categorise domain names based on threat intelligence. Protective DNS services typically leverage known malicious domains' open source, commercial, and governmental information feeds. These feeds enable coverage of domain names found at numerous points of the network exploitation lifecycle. Some solutions may also detect novel malicious domains based on pattern recognition. The types of domains typically addressed by a Protective DNS system include the following:

- Phishing: Sites known to host applications that maliciously collect personal or organisational information, including credential harvesting scams. Protective DNS can protect users from accidentally connecting to a potentially malicious link [7].
- Malware distribution sites are known to serve malicious content or used by threat actors to command-and-control malware. For example, these may include sites hosting malicious JavaScript® files or domains that host advertisements that collect information for undesired profiling. Protective DNS can block and alert on known malicious connection attempts.
- Advanced malware – including some botnets – depends on communicating with command and control (C2) infrastructure. Cyber threat actors use domain generation algorithms (DGAs) for malware to circumvent static blocking – either by domain name or IP – through programmatically generating domain names according to a preset speed. Protective DNS can offer protection from malware DGAs by analysing every domain's textual attribute and tagging those associated with known DGA attributes, such as high entropy.
- Content filtering: Sites whose content is in specific categories against an organisation's access policies. Although an ancillary benefit to malware protection, Protective DNS can use a categorisation of various domains' use cases (e.g., "gambling") and warn or block on those that are a risk for a given environment [8].

4. RESPONSE TO DNS AND FUNCTIONALITIES

The DNS sinkhole bypasses the DNS request and provides the response configured by the DNS sinkhole administrator. It does not allow the domain to resolve requests by its authoritative owner. Instead, the DNS sinkhole intercepts the DNS request and responds with an authoritative answer configured by the organisation.

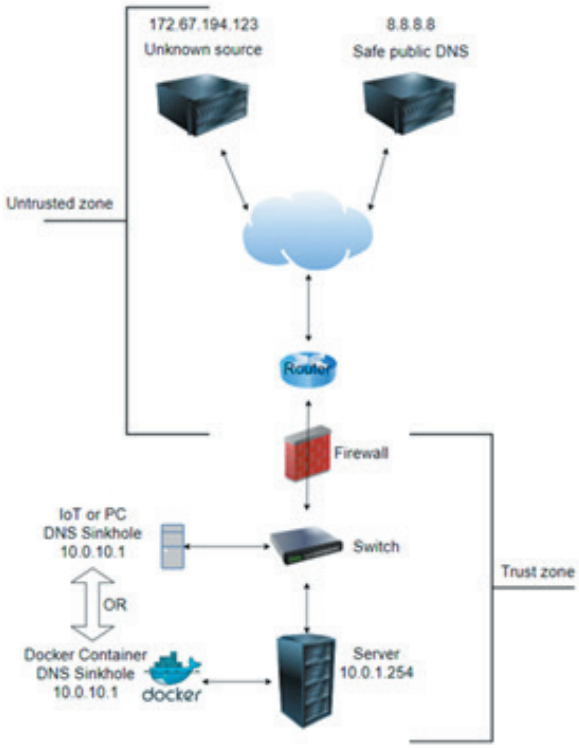

Figure 1 - An example workflow of a sinkhole on the primary network

With the basic sinkhole functionality, the malware on the infected machine attempts to initiate a connection to a system hosted on a URL with a known malicious domain configured in the DNS sinkhole. However, the request does not pass to the malicious URL. Instead, all DNS requests from the client redirect to the sinkhole, which is the localhost IP address. The client cannot contact the malicious site, and the command-and-control connection with the botnet can not establish the connection. The botmaster will be unaware that the compromise has occurred.

After this step, the preparation, detection, and partial containment are finished. Containment is partial because the compromised computer may still attempt to attack internal computers.

Therefore, the corresponding teams should carry out additional analysis and eradication steps.

1. DNS sinkhole workflow: The client hosts on the server, and sinkhole IP addresses must be in different zones, so sessions pass through the firewall. The sinkhole IP address does not have to be an active host, just an unused IP address.
2. DNS sinkhole setup overview (IoT or Docker): For demonstration, we will use popular PiHole DNS Sinkhole as Network-wide ad blocking and block in-app advertisements, improving network performance and, in the end, coming with complete monitor statistics with API for extending stats.

For this configuration, the process is used Raspberry Pi Zero W with a microSD memory card of 8GB size, USB to UDP connection, and another experiment was with Docker container on the server, VM with double CPU core and 8GB size of RAM and the exact size of HDD [9].

5. INSTALLATION, CONFIGURATION, AND TESTING NETWORK

5.1. FIRST TEST CONFIGURATION:

For that matter, Raspberry Pi Zero, or any other Raspberry Pi model, needs an operating system before running any software or application. While there are different ways to go about this, we recommend using Raspberry Pi Imager. The Imager is an easy-to-use utility that lets conveniently flash an image onto a microSD card. In advanced settings, it is essential to set up an SSH connection with the user and password for, and if not using LAN connection, in the same settings, configure a Wi-Fi connection.

Plug-in microSD card either using an adapter or a card reader to the computer. Now, in Imager, choose which OS to install which memory card and then Write to start flashing OS on the memory card.

When the flashing process finishes, remove the microSD card, and plug it into Raspberry Pi Zero. Raspberry Pi Zero should now boot up. Start Putty and connect to Raspberry Pi by SSH connection. Default login credentials in the terminal window are - username: pi; password: raspberry.

Lastly, we need to assign a static IP (Internet Protocol) address to the Raspberry Pi to prevent your router from assigning a new IP address to the Pi every time it connects. To do this, first, get the static IP address currently assigned to Raspberry Pi Zero. The easiest way to do this is to type in arp -a in the terminal window, which presents the interface, the IP address, and the MAC address of Pi. Alternatively, head to the router's configuration page to view these details.

And hit Enter\return. The above command may seem odd to some — piping curl to bash — if we are doing it over HTTPS and aware of the source installing the software, we should be fine. Using that command makes the installation procedure efficient and quick.

The Pi-hole installer should start now, and all we have to do from hereon is follow the on-screen instructions. We need to particularly pay attention to a few screens for static IP, upstream DNS provider, and ad-services blacklist. For static IP, make sure it matches the one we added to the configuration file, and for upstream DNS, select the DNS service we prefer (Google, Cloudflare, AdGuard).

In addition to the above screens, we must also carefully attend to the screens that ask for web admin interface installation and web server installation. Likewise, we can select to log queries and set privacy mode depending on preference on the screens that follow. If we set Pi-hole on a home network, we can enable both options. However, it is necessary to select an option in an office setting sensibly.

Finally, once the installation is complete, we are presented with a screen that contains all the necessary settings for our Pi-hole. Note these settings or take a snapshot as we will need them later [10].

Once have the IP address, enter the following command in the terminal:

```
sudo nano /etc/dhcpcd.conf
```

Furthermore, enter/modify the following details:

```
[hostname]interface eth0
static ip_address=[IP address with subnet mask]
static routers=[router gateway address]
static domain_name_servers=[router DNS or other preferred DNS server]
```

Alternatively, a Static IP address we can be set up by a MAC address on the DHCP server. The only thing needed is to make an Address reservation by MAC address.

We are now on to the final step in the process, which is to install Pi-hole on the Raspberry Pi. For this, enter the following command in the terminal window:

```
curl -SSL <https://install.pi-hole.net> | bash
```

5.2. SECOND TEST CONFIGURATION

How to set up pi-hole and Docker?
Open a terminal and Start Docker

```
sudo systemctl start docker
```

Enter the command to download PiHole from docker hub:

```
sudo docker pull PiHole/PiHole
```

Change the DNS to something else like google:

```
set DNS 8.8.8.8
```

Open a File

```
sudo nano /etc/resolv.conf
```

Furthermore, copy/paste the below code:

```
version: "3"
services:
  PiHole:
    container_name: PiHole
    image: PiHole/PiHole:latest
    ports:
      - "53:53/tcp"
      - "53:53/udp"
      - "67:67/udp"
      - "80:80/tcp"
      - "443:443/tcp"
    volumes:
       - './etc-PiHole/:/etc/PiHole/'
       - './etc-dnsmasq.d/:/etc/dnsmasq.d/'
    dns:
      - 127.0.0.1
      - 1.1.1.1
    cap_add:
      - NET_ADMIN
    restart: unless-stopped
```

Run the compose file to launch PiHole:

```
sudo docker-compose up -d
```

Move inside PiHole container:

```
sudo docker exec -it PiHole bash
```

Change PiHole password:

```
PiHole -a -p
exit
```

5.3. HOW TO USE PI-HOLE?

With Pi-hole running on the local network, all we must do to use it and block ads is configure the DNS. There are two ways to do this: we can either make Pi-hole's IP the default DNS of the entire network or point all devices to this IP address to route their traffic.

The former approach requires changing the DNS client for the network from the router's settings, while the latter only requires changing the DNS server on each device from their Wi-Fi settings. Now use the PiHole as DNS instead of any other:

Go to the DNS setting in Windows…

Settings –> Network and Internet –> Ethernet (if we want to connect to ethernet) or Wi-Fi (if your laptop connected to Wi-Fi) –> change adapter options –>right click on Wi-Fi or ethernet and go to properties –> select IPv4 –> properties –> change the DNS to the IP of PiHole.

Select IPv4 –> Change the DNS from obtaining DNS automatically to Use following DNS server and write the IP the box. In second write any DNS like 8.8.8.8

6. CONCLUSION

To summarise, deception as an intelligent sinkhole in the organisation is easy to configure and yields much information about the adversaries' activities. We can gather intelligence and information about the attacker's goals and learn how to detect and prevent current and future attacks.

DNS always was seen as an attacker's target. The concept of Protective DNS came that it is critical to leverage DNS to protect our network from threats. DNS sinkhole technique is the best method for defending from malware.

The sinkhole is OS and protocol-independent, which we can configure as a shield and real-time reporting notification system to improve our response. A complete analysis of logs in the DNS sinkhole helps us research threats in the network deeply.

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STUDENT SESSION

DIGITAL FORENSICS ARTIFACTS OF THE MICROSOFT PHOTOS APPLICATION IN WINDOWS 10

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Abstract:
Modern operating systems come equipped with software designed to improve user experience and offer a user-friendly environment while maintaining seamless integration and constant operation times, even when tackling demanding tasks. Applications generate extensive operation logs to aid the diagnostics and maintenance processes. Modern software often relies on the mechanism for cashing and storing additional data that can later be used to access requested resources faster, improving performance. These behaviors often lead to the creation of software artifacts in the form of logs, temporary files, and databases. These artifacts become crucial sources of information in forensic investigations. This paper analyses a set of artifacts created by the Microsoft Photos application that is the default photo viewer and editor in the Windows 10 operating system. Conducted research indicates that a large amount of potentially useful information is created during normal software operation. These fragments can be located and analyzed in files located in system directories. Further exploration reveals a set of valid digital forensic assets. These consist of user action logs, facial recognition identification results, optical character recognition strings acquired from images, metadata, information on devices used to capture the photo, and other information sources.

Keywords:
Digital forensics, Database forensics, Software artifact forensics, Microsoft Photos, Windows 10.

INTRODUCTION

The field of Digital Forensics (DF) has evolved from various forms of abstruse tradecrafts into a staple of modern investigation, examination, and data analysis [1]. Numerous DF tools and approaches are utilized to aid in countless cases daily, and many investigators rely on results acquired using these tools, often without even realizing it [2]. Coupled with these tools, a set of best practices has slowly emerged for tackling specific situations. However, each investigation can pose new challenges and investigators often need to make decisions concerning which actions are best to take on a case-by-case basis [3]. Having a thorough understanding of systems and, in turn, potential sources of digital evidence is a crucial skill through every investigation. Nevertheless, the systems that may find

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themselves in front of an investigator keep changing and evolving, as do methods of avoiding detection and obfuscating the evidence. The search for novel sources of digital evidence becomes an ever more crucial component of DF research.

Investigations relying on DF often center around gathering digital evidence from scattered digital forensic artifacts. An equivalent to real word forensic evidence, these artifacts are often left behind unintentionally or unknowingly and often invisible to users. An experienced investigator can gather and analyze artifacts generated by user actions or background processes, to reconstruct incidents and provide valid evidence aiding the investigation. Artifacts can take many forms, filesystem fragments, log files, shell bags, SQL databases (DB) are just some common, noteworthy examples [4]. However, with the ever-increasing size of storage media, the issue of finding artifacts becomes overshadowed by the number of artifacts presented. This in turn manifests as a problem of insufficient time for analysis. Knowing where to look for the right kind of artifact that can serve as evidence in a case is becoming an ever more pivotal ability.

Microsoft's popular operating system (OS) Microsoft Windows, often simply called Windows comprises several graphical OS groups. The most popular of which, at the time of writing, is a version of Windows NT named Windows 10. It remains a dominant competitor in the home and business markets, and as such is probably the most common type of OS seen in DF investigations. A default installation of this OS provides a user with several useful software packs included. These assist the user in common computational tasks, such as word processing, image manipulation, music reproduction, web browsing, and many other functionalities. Many users rely on these default applications through their everyday use. As such, data generated by these applications can present a promising resource when searching for artifacts to guide DF investigations.

A notable example available on almost all machines running Windows 10 is the Microsoft Photos application. Due to the practical integration, as well as user familiarity with the application, few users go out of their way to replace this default software with an alternative. However, the increased random-access memory (RAM) and processor usage, in comparison to other contemporary applications suggest additional functionality present in the application unknown to the ordinary user. A deeper look into the internal structures and files of this application suggests many such background processes being carried out on images. These include location classification, optical character recognition (OCR), and even facial recognition. Additionally, the application maintains logs of user actions, image metadata, and information about the devices used to capture images accessed by the application. In this research paper, the focus is on artifacts generated by this application, as well as their practical applications in digital investigations.

In summary, the main contributions of the conducted research are:

- Presenting the locations, formats, and types of forensic artifacts created by the default Photos application of the Windows 10 operating system
- Demonstrating how user interactions affect artifact generation
- Proposing methods for effective artifact acquisition and analysis
- Exhibiting the forensic significance and user privacy implications of the created artifacts

The remainder of this paper is structured according to the following. Section 2 examines research papers that cover similar topics and gives a summary of the inspiration behind this paper. Section 3 gives an in-depth view of the functions behind the Photos application system. Section 4 covers tools utilized in this study, as well as an extensive examination of the artifacts that can be found inside the application, their significance in forensic investigations. This is followed by a practical example. Finally, a conclusion and future work is given in Section 5.

2. PRELIMINARIES AND RELATED WORKS

When discussing digital investigations, it is impossible not to mention the tools and techniques used when attaining evidence. Many such tools exist, often not constructed to be used in investigations such as disk image creation tools and search tools. Specially designed tools do exist, they are usually custom-built, proprietary, and difficult or expensive to acquire. A well-known open-source alternative used when conducting this research is Autopsy. A DF platform that is equipped with tools found in commercial forensic tools and available free of charge. An additional advantage of this tool is that it allows customization and inclusion of custom community-made modules that extend on the base functionality of the software. With all this in mind, Autopsy offers an excellent set of tools regarding artifact search, as well as DB analysis. It has been used by many researchers in similar DF studies on various applications [5] [6].

In addition to the standard tooling provided in the Autopsy software package, a supplementary open-source software specializing in SQLite. A DB Browser for SQLite is used to better demonstrate database structures and relations in a visually more appealing manner.

Modern OSs offer sleek user interfaces and smooth operating times. However in this process, many artifacts are generated, some of which are valuable when conducting DF investigations. In the case of this research, the Windows 10 OS offers a wealth of artifacts, as a side product of normal software functionality [4]. These artifacts result from operations designed to benefit users and programmers alike. Depending on the nature of the investigation the appropriate approach may vary, data recovery may require additional steps. Sometimes simply proving possession of certain information can lead investigations in the right direction. Filesystems, registries, event logs, and executable files all need to be considered as sources when locating evidence [7]. Mechanisms for prefetching files allow for a smoother user experience by improving response times. This process also generates files that can indicate that a specific program was executed. These files prove an asset when considering anti-forensic tools possibly brought into play by the user [8] [9]. In addition, the Windows Registry, a binary hierarchal DB can provide details on user configurations. It also records user-specific information to better the user experience, essentially providing a record of user-system interaction activities [6].

As open-source relation, DB SQLite provides a relation DB management system (DBMS) often used by developers due to ease of use, accessibility, simple integration, and comparatively small footprint. In contrast to other such DBMS, SQLite does not constitute a client-server model, instead, the system is embedded into the end software. It is strongly favored by web browsers, phone application developers across all platforms, but is also found in many desktop applications, and is amongst the most popular DBMS [10]. Microsoft's version of SQLite Is quartet by Microsoft, and Microsoft frameworks provide SQLite support to assist developers. By architectural design, the entire DB can be contained inside a single file, and atomic commits allow for increased DB integrity. However, this leads to the creation of rollback journals that essentially record transactions before their execution [11]. This paper will not focus on these behaviors, since despite these settings being the default, they can be altered or disabled, making rollback journals an unreliable source. SQLite is considered a good choice for caching and storing data because of its smaller sizes and administration-less capabilities. It is precisely these data caching behaviors that lead to the generation of a plethora of forensic artifacts [12] [13].

With all this in mind, data stored inside an SQLite DB is easily acquirable. The only requirements are a DB browser and the DB itself. Just with these an investigator can query any data values currently stored in the DB. By default, SQLite will not delete records, instead simply marking them as deleted, so the possibility of recovering additional information on deleted files persists [14].

With costs of development and distribution decreasing, as well as the increasing popularity of social media, user-installed applications are becoming a convenient focus when searching for new forensic artifact sources. Third-party software often focuses on cross-functionality, accessibility, and ease of use hence often generating many artifacts. Due to user convenience and familiarity with these applications, communications over such platforms have become exceedingly common. With the rapidly changing landscape and alleged increased message security through encryption or obfuscation, in addition to the often-international nature of data traffic, gathering evidence is becoming somewhat challenging. This has led to illicit activities often taking place over these communication channels as opposed to more established, better regulated, and monitored traditional methods for communication. Investigators often need to rely on the evidence available on the user side rather than information provided by service providers outside jurisdictions. Due to these factors combined, various forensic artifacts of popular communication applications have been analyzed and well documented. However, relying on the user-installed application as a source of evidence can prove unreliable, as these applications tend to drastically vary on a case-by-case basis. A more pragmatic approach involves focusing on applications most likely to be available. This makes default OS applications particularly attractive in terms of research, and some such software has already been undergoing analysis [15]. To the best of the authors' knowledge no such research has yet been conducted on the specific application, Microsoft's Photos, covered in this work.

3. THE MICROSOFT PHOTOS APPLICATION SYSTEM

Introduced in 2012 along with Windows 8, as a successor to the Windows Photo Viewer, the Microsoft Photos application comes preinstalled on machines running the Windows 10 operating system. It is set as the default image viewing tool. It is also available on the windows store for installation under a freemium license. It allows for image viewing, organization, raster editing and is, at user discretion, capable of uploading images directly onto social media platforms, such as Twitter, Facebook, Instagram, and others.

Additional capabilities include photo editing, with functions such as cropping and rotating, color correction, regulating image noise, adjusting red-eye artifacts as well as touching up spots and blemishes. This process created a proxy image during editing, and the changes are only stored upon saving the new image. This allows users to compare edited images to the original, and revert changes. These actions also result in the creation of forensics artifacts in the application SQLite DB, that can be leveraged in digital investigations concerning fraud.

In the default configuration, the Photos application organizes digital images sorting images according to dates. Images can additionally be arranged into albums, which can be either user-created or automatically generated. To accomplish this the application runs background processes to attain metadata and classify images accordingly. Residual artifacts of these results are stored inside an SQLite DB that will be covered in more detail in the following section.

4. ARTIFACTS IN THE PHOTOS APPLICATION

This study covers easily accessible software data, generated by the everyday functioning of the Microsoft Photos application. No alterations to the application or the OS have been made unless explicitly stated otherwise.

4.1. LOCATIONS AND FILES OF INTEREST

Locations of files and directories of notes in the conducted research are given in Table 1: Notable file directories. The directories shown assume a default installation, on the C:\ drive, values for %VERSION% varies according to the installed version, and the variable %USERNAME% depends on the account username.

4.2. THE MEDIADB.V1 SQLITE DB

The primary focus of this research, and proposed source of forensic data, the MediaDb.v1 file is an SQLite DB file. While access to the DB file requires an administrative password, the database itself is unencrypted, making it easily accessible for investigators.

The DB itself has an extensive structure consisting at the time of writing of a total of 128 tables. The database contains extensive data on user actions, access logs, directories containing images, image formats, hash tables, image analysis results, location data, OCR, facial recognition features, and classifications. This research will only cover in detail data considered most interesting and relevant to forensic investigations, while the remaining data will only be presented as a summary.

The material covered includes:

- Data concerning user actions, application execution, image alterations, printing, user searches, and image sharing
- Image geographic location data
- Information concerning devices used for image capture
- OCR data extracted from images, and the generated data's when usability concerning personal documents
- Facial recognition data

Name	Path
Microsoft.Photos	C:\Program Files\WindowsApps\Microsoft.Windows.Photos_%VERSION%_x64__8wekyb3d8bbwe\
Settings	C:\Users\N3cr0\AppData\Local\Packages\Microsoft.Windows.Photos_8wekyb3d8bbwe\Settings\
MedaiDB.v1	C:\Users\%USERNAME%\AppData\Local\Packages\Microsoft.Windows.Photos_8wekyb3d8bbwe\LocalState\

Table 1: Notable file directories

Additionally, it is worth noting that, by default, the data contained in the DB remains after images have been removed, and as such persists after file deletion or encryption. As this DB is often overlooked by file shredding applications, and users obfuscating their actions, it can prove a valuable source of evidence in investigations where data was destroyed. Using the data generated by the Photos application and permanently stored in this database could play a valuable role as a sort of pseudo recovery. It could become a source of valid evidence where none would be available.

In this research, a practical example of a database has been extracted from a researcher's computer using well-known forensic practices and methods. An image of the machine was created using tools available in Windows 10. Following this, the image was loaded into Autopsy, and the database was extracted from the appropriate source. SQLite browser is then used to explore and document findings. This procedure is repeated several times, to document how user behavior and setting influence artifact generation on a system.

The database primarily contains information on accessed file locations, folders used to store images, such as the photos and downloads folder as well as additional user-created folders. The purpose of this is to help the application quickly locate images when presenting them to the user. These tables are updated and indexed every time a user relies on the search functionality of the application. New folders are added, and image locations updated. However, as previously stated, deleted images are not removed from the table.

These simple indexing directories can help investigators locate images, and possibly narrow down the search when looking for illicit content. Image access times are also contained in these tables, so finding recently accessed files is trivialized.

4.2.1. User action data

Extensive data on user actions is maintained inside the DB. This includes data on software launches, entry points, as well as timestamps of when the events have taken place. Data is kept on searches performed by the user, including search box text used in the search, numbers of results recovered, and timestamps of these actions are saved. Additional actions logged are user views and slide shows, data in these tables cover entry points, and timestamps. Print and share events are also tracked similarly. Share events including the data on the targeted platform of distribution, as well as a column storing data on whether the shared attempt was successful. The table labeled sqlite_sequence contains the total numbers of specific actions users have taken, in terms of views, prints, slideshows, etc.

Data in these tables is significant, as it provides definitive logs tying user access to images. In cases where the distribution of illicit material is deemed relevant, print, and share events could help investigators determine when and if reproduction and distribution have taken place. Search results and camera device data can be used to track down image origin points even when images are no longer directly available.

4.2.2. Image geographic location data

Image metadata is, when available, also processed, and the country, region, and district of where the photo was taken are all recorded. Additionally, regardless of metadata availability, the images are processed and classified, and appropriate tags are applied during processing. At the time of writing the Tag Variant table, responsible for storing all the possible classifications of images, consists of 500 entities. These include airplane, celebration, child, document, drawing, car, vehicle, night, newborn, nature, landmark. While the full list includes far too many entries to list here, the reader is encouraged to explore the DB at their own accord for further details.

It is abundantly clear how these automatically applied classification tags can help narrow down investigator search areas when looking for sources of evidence. As previously stated, when images are deleted or encrypted, the information contained in these tables can offer clues as to the original contents. The classifications the application performs are quite extensive and can prove an asset to any investigation.

4.2.3. Image capture device data

Tables CameraModel and CameraManufacturer contain data on the make and model of devices used to capture images accessed by the application. This extends to mobile phones, and device manufacturers and exact models can be recovered from these tables. Useful when tracking the origin of images.

4.2.4. OCR data

During the image search and indexing process, OCR is performed on images, they are assigned a text tag and resulting strings of text are stored inside the DB. This makes images searchable by the text they contain, also leading to the formation of very useful forensic artifacts. Entries of interpreted text taken from images are created in the DB and associated with the image. This in turn means that despite possible images of documents being deleted, removed, or encrypted, their contents remain stored in the DB.

The performance of the OCR algorithm varies. The main limitation is poor performance when processing foreign languages and writing systems. However, it is reasonably good when processing printed English text and performed consistently well when handling printed digits. In the conducted, presented in following sections, tests most information present on publicly available samples of user ID cards and driver licenses were fully recoverable from the DB. This kind of approach can prove fruitful in cases concerning identity theft, fraud, or any cases dealing with access to sensitive documents of any kind. This is a major cause for concern when considering privacy and security. Recently more services are requiring registration using images of valid government-issued documents. It is worth considering that data on the images processed by the default image viewing application will persist after the files are removed from the machine.

4.2.5. Facial Recognition data

Unlike the other findings presented in this paper, facial recognition is not enabled by default and needs to be user enabled. However, when facial recognition is enabled, a plethora of information is generated and stored. Once enabled, like the other processes mentioned here, facial recognition is carried out in the background. Face features are extracted. Faces are also classified according to expression and position. In addition to this, faces are associated with persons in the DB, and the probability of each face belonging to each person is calculated. Should a person be confirmed by a user when classifying photos, their name and, when available email, are stored in the DB. The application keeps track of the number of occurrences of each person available in the dataset.

Using data available on faces and persons can prove an asset in investigations. This data can be used to prove association or possession of images containing certain faces. However, with this feature not enabled by default, facial recognition data is not as reliable of a source as the other sources listed in this work.

4.3. A PRACTICAL EXAMPLE

For a practical demonstration, a total of 5 publicly available examples of personal documents, namely driver's licenses were taken from public sources and loaded into the photos application. After a few minutes of software use, browsing images, indexing and processing were completed in the background, the database is again loaded into appropriate software, and analysis is repeated.

The results attained from OCR varied based on image composition and quality. They were nevertheless sufficient to demonstrate that it is possible to fully recover personal information from data generated by the photos application. Names, dates of birth, identification numbers, expiration dates, and other data visible on the documents were later fully recovered from DB tables. Additionally, facial recognition ID can be matched if additional photos of persons are available. Examples of the attained results can be seen in Figure 1: Personal document samples and OCR artifacts recovered from them. The documents used were acquired from official government websites [16] [17] respectively. These are sample documents meant to mirror legitimate documents while not compromising individual private information. Below the images that were used in this example are the OCR items recovered from the database. As shown, ID numbers, names, dates of birth, date issues, and expiration dates were all recoverable from the OCR artifacts.

The procedure was also repeated on an example of a local document, a government-issued ID card. Results attained from OCP were less impressive, due to language barriers. However, digit data was fully recovered as well as facial recognition data.

Additional tests were performed where Face IDs were able to be matched between images on the ID cards, and images of the individual taken at a different time. These gave consistent promising results. However, due to the sensitive nature of the data presented in these documents results are not practically shown.

Figure 1- Personal document samples, and OCR artifacts recovered from them

5. CONCLUSION

As anti-forensic and encryption tools become exceedingly common, investigators need to continuously strive to improve on and look for new sources of evidence often overlooked by end-users. In cases where large amounts of files are available and need to be processed quickly, the information on user actions taken on files provided by these sources can point investigators in the right direction, conserving resources and precious time. In cases where images were changed or removed, evidence of these actions can be gathered from temporary and DB files created by the internal mechanisms of the Photos applications. In investigations dealing with removed or encrypted images, additional data and information are contained in them. This data bay takes the form of OCR results, and facial recognition IDs can be recovered from a DB that maintains this information in the default configuration even after the files have been encrypted or removed. The conducted research presented in this paper takes a DF approach to examine the Microsoft Photos application. To the best of the authors' knowledge, it is the first academic work addressing forensic artifacts generated by the Microsoft Photos application on a Windows 10 OS. Proposals are made on how and where these artifacts can be located, and their forensic significance is additionally elaborated on. Furthermore, the approach utilizes open-source tools, demonstrating that this kind of investigation can be carried out without overly specialized and often inaccessible, expensive tools and reasonable computational resources.

In future works, we aim to extend methodologies applied in this paper, looking at other available applications that may provide valid evidence often overlooked by tools attempting to obfuscate it. Also, we may introduce tools that streamline the process of data acquisition, further reducing investigation requirements in terms of time and resources.

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STUDENT SESSION

GENDER INEQUALITY PRESENT IN THE GAMING COMMUNITY

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Abstract:
The aim of this paper is to explore gender inequality present in the gaming community. The paper is split into three major topics. We will take a closer look at the position of women in gaming as a hobby, gaming as a professional career and gaming development. In the first part, where we focus on women who game as a hobby, we will explore the general atmosphere in gaming and how women fit in it. A separate section here will be devoted to strategies women implement in order to protect themselves. In the second part we will look at the professional gaming scene, and discuss the position of women as professional players. In this section we will also take a closer look at the streaming platform Twitch.tv and explore the position of women who have a career in streaming. In the third part we will discuss the position of women in the gaming development industry.

Keywords:
Women, gaming, discrimination, sexism, harassment.

INTRODUCTION

The issue of gender inequality is present in all aspects of life everywhere in the world. We cannot deny the fact that, through the ages, women have won some rights for themselves and have elevated their position in the society. But what has been done is simply not enough, and true equality between genders still does not exist. Women still face discrimination, just in different, more hidden ways.

Mary writes about the fact that just because women made important changes in their lives in the past hundred years, that does not mean those changes can be called progress. She notes that the fewest changes have been made in the workplace where women are still highly discriminated against. [1]

The workplace is ripe with gender inequality. Regardless of their profession, women face discrimination in the workplace, but in some professions, discrimination is more prevalent. Cecilia talks about this in her book in which she elaborates that there are professions which are considered primarily male and female. And this segregation is closely tied to the cultural understanding of gender roles. [2]

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If a woman works in a profession considered male, she will be discriminated against and considered an intruder. One such profession is the IT industry, which is closely tied to the gaming industry. When it comes to the gaming community, it has been considered male territory since its very existence. If we imagine a developer or a gamer, we will most likely imagine a man. Regardless of whether we are talking about gaming as a hobby or gaming as a career, the first image that will appear in our minds is that of a man.

Despite the fact that women have always been involved in gaming, and in the recent years their involvement has become more visible, the stereotype of a gamer being exclusively a man is still unbreakable. It does not take a lot of research to conclude that the gaming community is a world created by men for other men. The majority of gaming developers are men, and they are the leaders of gaming companies. In professional esports women are almost non-existent. Even though women are very much interested in the gaming world, to this day they struggle to be included.

When it comes to gaming as a hobby, the situation is not any better. The belief that women are not interested in gaming is unfounded and completely false. But still, there is this widely accepted belief that women are simply not interested in gaming. It is understood that women have other, gentler, interests. Despite the fact that research shows that women are interested in gaming, the stereotype that women do not belong in gaming remains steadfast.

Gaming is a very problematic area for women and leaves much to be desired. The gaming community is infested with abuse, sexual harassment and misogyny. The aim of this paper is to uncover all of these issues and present the problems women have to deal with daily if they are a part of this community.

2. WOMEN AND GAMING AS A HOBBY

In its early years gaming was considered a peculiar hobby which usually attracted young men. But in the present, gaming has developed into one of the largest and most profitable industries on the market. Nowadays gaming has become a universal hobby. Technology has also advanced greatly and now gaming is available on various devices, including mobile phones, making gaming more accessible for a variety of people. Despite this fact, gaming is still considered male territory. The gaming community has isolated itself and stubbornly refuses to accept that the times have changed and now gaming is for everyone. We are still fighting this outdated notion that gaming belongs on PC's and consoles and only to men.

Alison and Tamara point this out in their article and say that video game marketing is still solely focused on young, white, heterosexual men. They point out that this makes it so video game content is tailored exclusively to their tastes and it leaves little room for considering what women would like to see in video games. [3]

This atmosphere creates a "digital citizenship" where only certain people have the right to participate and be a part of the community. In this context digital citizenship means a person's capability to be a part of the gaming community freely, without being disturbed by others or afraid of harassment and retaliation. Currently, women do not have that status, despite the fact that research proves that women make 41% of the gaming community. [4]

It is no longer possible to deny the fact that women are a part of the gaming community. But since the existence of women in this community is still undesirable, new ways have been invented to exclude women. Thus, the definition of a "true" gamer has been created. Namely, there is a stereotype that women are casual gamers, who like only certain video game genres. They usually game on their mobile phones and play puzzles, word games, or dress-up games. Thus, women are not true gamers. On the other hand, men are considered hardcore, true gamers. They play difficult PC and console video games which require a lot of skill, time and dedication to perfect. Genres typically assigned to men are first person shooters, RPGs (role playing games) and MOBAs (massive online battle arenas).

This segregation between hardcore and casual gamers clearly shows the discomfort of the gaming community to accept women into its ranks as equals. Since their presence in the gaming community can no longer be denied, they somehow must be made inferior. Research shows that women are present in all genres of gaming, on all devices. [4] But despite this fact, this stereotype is widely accepted.

In the last couple of years, it has also become increasingly difficult to deny the presence of women in PC or console video games, especially male dominated genres like MOBA's and first person shooters. Just how women have been delegated the role of casual gamers who like easy video games, another mechanism designed to make women inferior has been set in place. When it comes to first person shooters and MOBA's, it is widely accepted that women only play support heroes. That is a class

type in video games, whose primary purpose is to stay behind the team, heal and take care of teammates. This class is wrongly considered the easiest class to play and women are always delegated to it. It is considered that women can't play damage or tank heroes, because they require a lot of skill, which women do not possess. If a woman is discovered in a match not playing a support, she will be immediately called out and told to go back to "her role". When women game together with men, it is automatically assumed that they will fill the role of the support. It is also assumed that women only play female characters who look pretty, and that they are more interested in customizing the character's appearance than gameplay. A good example comes from the multi-player video game *Overwatch*. It is assumed that women only know how to play a female support hero called Mercy, with an angelic appearance and kind nature.

When a woman claims to be a gamer, the first reaction she will get is disbelief. She will be told that it is a weird hobby for a woman to have. This disbelief will become even greater if a woman says that she is interested in PC or console video games and not in mobile phone video games. It will get even worse if she likes genres typically considered exclusively male, like first person shooters or MOBA's. Regardless of whether a woman says she likes single-player or multi-player video games, she will be met with confusion and deprecation. The only difference is that when playing single-player video games players are alone and thus protected from direct abuse, and while playing multi-player video games the atmosphere is very hostile. That is to say, women will always be considered intruders in gaming, and with multi-player video games, especially certain genres, comes the added bonus of direct abuse.

When it comes to the general atmosphere in gaming, sexism, stereotypes, sexual harassment and misogyny are widespread and normalized. There is a myriad of stereotypes women have to face. The most prevalent stereotype is that women are bad gamers. Women simply do not know how to game, and no matter how hard they try, they will never be as good as men. If women play together with men in a team, it is assumed they will be the weakest player. Everyone hates losing, that is no secret, but losing from a man, while irritating, is considered normal, but losing from a woman is considered an embarrassment. This stems directly from the belief that women are inferior to men and are naturally bad gamers, so losing from them means that you are worse than a woman, and there is no greater shame than that.

Women are also accused of having secret motives for gaming. Namely, if women game, they do not do it because they truly like it. As Bròna and Rhi say in their paper, two secret motives are usually tied to their interest in gaming. The first motive is that women are actually searching for a romantic partner, so they use gaming since they know a lot of men like to game. The second one is that women want to appear special as opposed to other women. Researchers cite male respondents in their paper who said: "Some girls have a need to state how different they are from other girls [...] as if that somehow makes them superior, some try to latch on to 'guy stuff' because they've noticed that typical female stuff is trivialized". Another respondent said: "It seems outrageous that female gamers like to game just because it's fun! Surely it must be for an alternative reason?" [5]

Women are in a very unfavorable position because they can either keep quiet and take the abuse or speak up and be shut down. Women who speak up are told to become more resilient. They get the explanation that gaming is very competitive and emotions get high, so it is normal for people to become toxic and abusive. If they refuse to accept abuse as normal, they are told that they are too emotional. Instead of attacking the abuser and shutting him down, the spotlight is brought onto the victim and she is told to accept being abused.

Sexism and various stereotypes discussed above are not the only problems women have to deal with. Oftentimes women deal with open hostility and misogyny. Apart from sexist comments telling them to "get back into the kitchen", women are exposed to blatant misogyny. They are primarily attacked for their appearance. They are told that they must be ugly and disgusting seeing how they sit and game alone in their room like losers. It is interesting to note how the first thing the abusers focus on is the women's physical appearance. The fact that they do not know how the victim looks like is unimportant, what matters is that they assume that a woman's most important feature is her looks. Women have been historically considered sexual objects, whose defining function is to look beautiful and keep quiet. Sadly, this fact remains unchanged to this day. If an abuser was to insult a man, he would not go after his appearance, but his skills.

Just because abuse is done online does not mean it hurts any less. And those who abuse online, most certainly do so in real life too, since it is in their character. And if they do not behave abusively in real life, the sole reason they are deterred is the fear of consequences. Thus, it is a very dangerous practice to normalize abu-

sive behavior. Abusers must not be given free rein to do as they like, they must be sanctioned.

One way to explain the ever more abusive communication online is that it alienates people. It is easy to forget that you are talking to another human being while staring at a computer screen. Thus, it becomes easy to dehumanize the other person, which in turn creates brutality.

2.1. WOMEN'S STRATEGIES FOR DEFENDING THEMSELVES FROM ONLINE ABUSE

Since the atmosphere in the gaming community is very hostile towards women, they have adapted certain strategies in order to shield themselves from the abuse. The most widely used tactic is to hide their gender when playing multi-player video games. When playing video games that have voice communication, which is usually available in fast-paced video games which require quick reaction times, women don't use the microphone. They know that as soon as they speak, and everyone in the lobby hears that they are women, abusive will follow. So, they give excuses such as: "my microphone broke" or "I'm sick and can't talk". There are a lot of testimonies from women who say that before their teammates knew their gender they behaved normally. As soon as they spoke and revealed their gender, the attitude of their teammates would change in an instant. Normal men who laughed and joked only a second ago would become cruel. They would immediately start sexually harassing them, insulting their appearance and behavior and mocking their gameplay. They would often mock their voices, comparing them to little boys. If they decided to defend themselves, they soon realized that it was a losing battle. They would be told that they are too emotional and that they cannot take a joke. Or, they would be told that they should feel flattered that they are getting so much attention. Oftentimes, when men realize they have a woman on their team, they start blaming her for everything that goes wrong in the match. If they lose, it is her fault. It is also possible that they will throw the match on purpose and blame it on the woman, saying that she provoked them.

Apart from hiding their voice, women are also reluctant to use gamer tags that they want, if the desired gamer tag is feminine. So, they usually use gender neutral gamer tags. Women who have feminine gamer tags get abused even more, since they reveal their gender upfront.

Other, drastic measures are also implemented. Some women decide to quit gaming altogether or transition solely to single-player video games where they cannot be abused by anyone. Women who transition to single-player video games become invisible, and thus contribute to the stereotype that women do not exist in gaming. Women who stay in multi-player video games limit themselves to playing only with friends, thus they can't create new friendships. [6]

Amanda also points out that many women cope with online abuse by drastically changing their character. Since they do not want to quit online gaming, they must adapt. Women report becoming aggressive, impudent and sarcastic. When abusers see their violent nature, they leave them alone, since harassing them becomes too much work. [6]

Refusing to use the voice chat, changing gamer tags, quitting gaming, limiting themselves to playing only with friends and drastic, forced changes of character are catastrophic consequences brought about by the hostile atmosphere in the gaming community towards women. These strategies and their necessity clearly show that something is very wrong with this community.

The current situation in the gaming community drastically limits women, and prevents them from behaving normally. They are seen as intruders and treated as such. Women are denied the opportunity to behave naturally. Instead, each day is a warzone.

It is important to mention that such abusers are a minority. The majority of men behave normally. But despite this fact, witnesses of such abuse do not speak up and defend the victim. Thus, abusers know they can say and do whatever they want, which makes their abuse more brutal. The silence of others makes them feel justified in their actions.

Research conducted by Benjamin et al. shows that while women make 40% of the gaming community, only 14.4% of women called themselves gamers, as opposed to 85.6% of men. Women are reluctant to identify themselves as gamers since they know how unwelcome they are. [7]

Niklas and Hampus researched the video game *Overwatch*, and clearly showed the extent of gender-based violence and its consequences. They found that 81.40% of women were abused because of their gender, as opposed to 27.60% of men. Additionally, 72.5% of women felt the need to hide their gender, as opposed to 0.9% of men who expressed this same need. It is important to mention that men get abused too, just not for their gender, but their gameplay. 94.60% of men and 80.40%

of women reported being abused because of their skills. 90.9% of all respondents said that abuse was a major problem. [8]

The results of their research are dire, showing that women primarily get abused due to their gender as well as their gameplay, and men primarily get abused due to their gameplay. Despite the fact that almost the entire community of *Overwatch* recognizes how extreme the problem with abuse is, nothing has been done to change this.

3. WOMEN AS PROFESSIONAL ESPORTS PLAYERS

As we have seen in the previous parts, the gaming community is quite hostile to women in general. Especially in multi-player video games where they are directly exposed to violence and even more so if they play certain video game genres. Since women are generally considered not to belong in these genres, it is very hard for them to become a part of the communities in those video games. For women who would want to become professional esports players, and thus become visible to the public eye, the situation is much worse.

Esports has developed tremendously in the past couple of years. It has amassed millions of fans, and has become a successful business which attracts many talented young players. The issue here is that women are, for the most part, completely excluded from this scene. Becoming a professional esports player is very hard. For women it is even harder due to their gender. In traditional sports, men are considered superior due to their greater physical strength, but in esports, where physical prowess means nothing, women are still considered inferior to men.

Women are a minority among professional esports players. Top leagues, teams, tournaments and positions are reserved solely for men. It is not that women do not want to become professional esports players, it is that teams, for the most part, d not want to hire them. They are excluded solely because they are women.

It is a long and difficult road to become a professional esports player. It takes a lot of talent, dedication, effort and time. Honing this skill to perfection, like any other, is life's work. With the increasing popularity of esports, the influx of new players wishing to make a name for themselves is greater than ever. For a talented player considering this career, attending tournaments and getting recruiters to notice them is the first step. The problem for women is that recruiters do not objectively look at their performance in game, but will immediately eliminate them based on their gender. That is why women talented enough to become professionals often report avoiding such events and giving up on pursuing this career altogether.

In their research done on 511 women, only 69 (13.5%) reported considering professional gaming as a viable career. When asked why they gave up on this career, women reported that they knew the hostility that awaited them, and they were unwilling to surround themselves which such abuse and discrimination. They didn't want to torture themselves with such a hard life and instead chose other, more welcoming careers. Another important reason they stated was that they believed that they were not good enough to become professional esports players. One respondent stated that she did not want to torture herself to create a steel façade in order to deal with men attacking her. [9]

As for the women who responded that they considered this a viable career path, they discussed many issues they predicted would await them. The first issue mentioned was the atmosphere of constantly having to prove your worth just because you were a woman. They would constantly feel pressured to prove that they were good enough to be there. The spotlight would always be on them, every single mistake they made would reflect badly on the entire gender, and they would feel like they failed other women. They did not like the fact that their gender defined them to such an extent and that they could not escape from it. They would never be just gamers, they would always be women first, gamers second. [9]

As Simone De Beauvoir says: "If I want to define myself, I first have to say, "I am a woman"; all other assertions will arise from this basic truth. A man never begins by positing himself as an individual of a certain sex: that he is a man is obvious". [10]

When asking the general public why women were so underrepresented in gaming, the researchers met with two interesting answers. The first answer was that women's biology limited them, made them bad at gaming and inferior to men. The second answer was that cultural reasons and the general atmosphere in the society were to blame. Women were largely considered to be weak, gentle and lacking a competitive streak. Respondents said that women were not aggressive, had slower reflexes and bad spatial orientation. Women were created to be caretakers and they did not possess the drive to defeat enemies. [9]

Research done on 16,821 *League of Legends* players showed that women had the same potential as men to perfect their video gaming skills. The only difference was the players' self-assessment. Namely, when describing themselves, women were very self-critical of their skills, saying there were not good enough, as opposed to men who were extremely confident in their skills and boasted about their talents. The main reason women were less skilled that men was because they played less. Women who spent the same amount of time gaming as men had equal skills. [9]

The amount of time women spend gaming is directly linked to their status within the gaming community. They are largely considered bad gamers who are inferior to men and they are constantly sexually harassed and abused. This makes women very self-critical and unsure of their skills. So, the amount of time they dedicate to gaming decreases. These results clearly show that women's biology does not limit them and make them bad gamers, but society does. They are socially excluded from gaming, abused into believing they are unskilled and unsuitable for gaming. This makes women give up from this career and retreat since they do not see a different solution and society has not done anything to integrate them.

Taking all of this information into account, it can be concluded that women are extremely discriminated against, their gender being the primary factor that serves as their downfall.

3.1. WOMEN ON THE STREAMING PLATFORM *TWITCH.TV*

Another viable career option for gamers is streaming. Playing video games for a mass audience and having that as your primary source of income is a dream come true for many people. Much like with professional esports it is a long and difficult road. Streaming has become increasingly popular in the last couple of years, and making a name for yourself in a sea of creators is harder than ever.

As with other categories previously discussed, women have a much harder time becoming respected streamers than men. There is a big difference in the way female and male streamers are treated. If a woman becomes a successful streamer, it will always be attributed to her appearance. For a man, his success is always attributed to his talents.

In his research, Jonathan concludes that fewer women than men are streamers, they are less popular and have fewer active viewers. Women are exposed to a lot of sexism, sexual harassment and misogyny, and only women suffer comments directed to their appearance. In his research he equally visited channels of female and male streamers and found 207 female streams and 1 male stream where the streamer was insulted based on their appearance. Additionally, searching for sexism 852 female streams where infested with sexist comments and sexual harassment, as opposed to only 7 male streams. [11]

The stereotype that women are bad gamers especially comes into the light while streaming. If female streamers are also very talented gamers, they will constantly face disbelief about their skills. Viewers will wonder if they are cheating, or if their boyfriends are playing in the shadows while they are on the camera. [11]

These results confirm that female bodies are viewed as sexual objects, and are subject to constant evaluation. Since the only important feature of a woman is her appearance and everything else is negligible, this is the first thing that will be insulted. To the abusers, it goes without saying that women are untalented for gaming. Of course, they will mention that she is a bad gamer too, but first and foremost they must let her know that she is ugly, meaning she has no value. Men on the other hand, are abused solely for their gameplay, their appearance never being a part of the insult. Because for men, it goes without saying that their primary value is their intelligence and not their appearance.

4. WOMEN IN THE GAMING DEVELOPMENT INDUSTRY

When it comes to women who exist behind the scenes, as a part of the gaming industry, the situation is also problematic. In the USA, 18% of IT graduates are women and they make 29% of the IT job market. Despite this, only 4% of gaming developers are women. Research shows that men are more likely to get hired as gaming developers and get assigned leading positions. For women, it's a question if they will get hired by a gaming company at all, and getting leading positions is virtually impossible. [12]

Amanda says that "women were viewed by supervisors as less promotable than the men because the performance of the women was less likely to be attributed to ability and effort, and more likely to be viewed as emanating from help and luck". [12]

Women are also subject to different standards than men. When it comes to their appearance no matter how women dress, they will be criticized. Women who dress feminine, wear heel and skirts are accused of using their appearance and charm in order to reap special benefits. And those who dress conservatively and wear oversized clothes in order to hide their bodies and prevent being seen as sexual objects are accused of being unsightly and unkempt. Women reported situations at company hosted parties where people automatically assumed that they were someone's arm candy. They had to repeatedly explain that they attended the party because they were gaming developers too. The companies are also more lenient towards men and their behavior. Men are allowed to joke and laugh more at work and be generally less serious, it is also tolerated for them to get drunk at company parties. But for women it is expected that they must remain serious, dedicated and graceful at all times. [12]

Double standards follow women everyone in the workspace. Behavior which is rewarded in men is criticized in women. So, if a woman is outspoken, ambitious, has ideas and pushes for their realization in meetings, she will be called aggressive, impudent, emotional and hysterical. If a man behaves in a such a way he will be praised as a motivated, hardworking employee who exhibits outstanding leadership qualities. Women are regularly silenced in meetings and their ideas ignored.

Women are sabotaged right from the start. When they apply for IT colleges and show interest in engineering even professors doubt their intentions. One woman reported that during her first day at college the professor openly asked her if she entered the wrong classroom since software engineers were there and she probably lost her way. Another woman reported that her professor openly asked her if she were a man hater and if she came to their department to stir trouble. Some women even reported incidents at interviews, where the recruiters openly told them that they would not hire them because they were not looking for female developers. [12]

5. CONCLUSION

The main goal of this paper is a detailed analysis of the position of women inside the gaming community. Regardless of whether women game as a hobby, as a professional career, streaming included, or if they are working in the gaming industry, women are exposed to sexism, sexual harassment and misogyny. The gaming community is filled with stereotypes. Women's skills are constantly doubted. Due to the amount of gender-based violence women are exposed to, they resort to hiding their gender in gaming or quitting altogether. In esports women are heavily underrepresented, and completely missing in professional leagues of many video games. Women who aspire to become esports professionals are heavily discriminated against and their gender makes it almost impossible for them to pursue this career. In the gaming industry, women are underrepresented as gaming developers and have a very hard time securing jobs in gaming companies. If they do secure a job, it's a low-level position and they are discriminated against. They are also faced with a myriad of double standards.

Women are equally capable of learning and excelling in gaming as men, but they are limited by "environmental factors of male dominance and external factors of sexual harassment". [13]

The main problem is the atmosphere of the gaming community and its open hostility towards women, alongside a myriad of stereotypes women are exposed to which are designed to make them seem inferior. The only way this problem can be solved is if the gaming community actively starts working on including women into its ranks and sanctioning abusers who target them.

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STUDENT SESSION

PLANT CLASSIFICATION USING FIREFLY ALGORITHM AND SUPPORT VECTOR MACHINE

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Abstract:

The importance of plants for survival of all living beings as well as the humans' agricultural needs is great as the identification and classification have a key role for their use. Plants are recognized by leaf, flower, or fruit and linked to their suitable cluster. Classification methods are used to isolate and select traits that help identify plants. An automated approach aims to help farmers grow crops easier and better. Computer vision technologies have attracted significant interest in precision agriculture in recent years. This research proposed an approach based on swarm intelligence algorithms and support vector machines to extract features and classify plant images. The nature-inspired firefly algorithm models mating patterns of fireflies, and adapts them to optimization problems for which it excels at resolving. Combined with support vector machines methods, that are often used for solving classification problems with great accuracy, this work proposes a novel approach used to handle plant identification.

Keywords:

SVM, firefly algorithm, plant classification, swarm intelligence, optimization.

INTRODUCTION

Plants play an important and significant role in human life, ecosystem and agriculture. As plants are of great importance for the survival of live, it is a serious task to nurture and cultivate plant. With the advancement of technology and the use of advanced algorithms and proper identification we can help agriculture making decisions such as spraying appropriate fertilizers, irrigation system, and weeding. To address these challenges, the complex, multivariate and unpredictable agricultural ecosystems need to be better understood by monitoring, measuring, and analyzing continuously various physical aspects and phenomena. Images constitute, in many cases, a complete picture of the agricultural environments and could address a variety of challenges. Imaging analysis is an important research area in the agricultural domain and intelligent data analysis techniques are being used for image in various agricultural applications.

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Identification of plants based on leaf image involves feature extraction, classification as well as optimization. In this paper the authors use the firefly algorithm FA for comparison with other algorithms and present the best solution for the use of plants in agriculture.

The process of plant identification includes feature extraction, optimization, and classification. Generally, feature extraction is performed by speed-up robust features (SURF) [1], scale-invariant feature transform (SIFT) [2] among many other approaches. The feature optimization phase is an important step where an individual can deploy an algorithm to select the best feasible set of features. Researches have applied whale optimization algorithm (WOA) [3], bat algorithm (BAT) [4], differential evolution (DE) [5], salp swarm algorithm (SSA) [6], sine cosine algorithm (SCA) [7], and many other swarms and evolutionary algorithms for solving this combinatorial optimization problem. Most of the recent research in the domain of plant identification used artificial neural network (ANN) and support vector machine (SVM) [8], and deep residual networks [9] have been proposed for optimization. This work proposes a novel approach based around SVM [10] as well as a swarm intelligence (SI) algorithm, FA, in an attempt to address classification in an efficient manner.

2. RELATED WORKS AND BACKGROUND

2.1. SUPPORT VECTOR MACHINE

A support vector machine [11] is a computer algorithm that learns by example to assign labels to object. SVMs are becoming popular in a wide variety of biological applications. Because of their relative simplicity and flexibility for addressing a range of classification problems, SVMs distinctively afford balanced predictive performance, even in studies here sample sizes may be limited.

SVM, because of its property of convex optimization, is best suited for finding the global minimum. With the radial basis function being its kernel, it is beneficial for both linearly and nonlinearly separable data and is thus predominantly used in plants recognition. SVM is used to address a binary pattern classification problem.

When we notice a binary classification problem, with a total of l training samples (x_i,y_i), $I = 1,2\ldots, l$; When x_i is part of the first category $yi = 1$, accordingly $y_i = -1$ should x_i be part of the second category. With this in mind a hyperplane dividing these samples across the two categories is defined according to Eq. (1)

$$\omega^T x+b=0 \tag{1}$$

with ω being the coefficient vector normal to the dividing plane and b representing the origins bias. The linear SVM finds the optimal separating margin by solving the following optimization task according to Eq. (2)

$$\begin{aligned} &Min\left\{\frac{1}{2}|\omega|^2+C\sum_{i=1}^{l}\varepsilon_i\right. \\ &s.t.,\gamma_i\left(\omega^T x_i+b\right)\geq 1-\varepsilon_i \quad I=1,2,\ldots,l \end{aligned} \tag{2}$$

The minimum problem can be reduced by using the Lagrangian multiplier α_i, giving us Eq. (3)

$$\begin{aligned} &Max\left(\sum_{i=1}^{l}a_i-\frac{1}{2}\sum_{i,j=1}^{l}a_i,a_j\gamma_i\gamma_j x_i x_j\right) \\ &s.t.,\sum_{i=1}^{l}a_i\gamma_i=0;\;\; a_i\geq 0 \end{aligned} \tag{3}$$

The equation can now be solved using the quadratic programming techniques with best values of a begin $a*=\left[a_1^*,a_2^*,\ldots,a_l^8\right]$, and optimal values of w and b being ω^* and b^* respectfully in Eq. (4)

$$\begin{aligned} \omega^* &= \sum_{i=1}^{l}a_i^* x_i\gamma_i \\ b^* &= -\frac{1}{2}\omega^*\left(x_r+x_s\right) \end{aligned} \tag{4}$$

where x_r and x_s represent a support vector pair of two classes. Finally, a linear discriminant function is attained according to Eq. (5)

$$f(x)=sgn\left(\sum_{i=1}^{l}a_i^*\gamma_i\left(x_i x\right)+b\right) \tag{5}$$

The widely used kernel function is the radial basis function (RBF), because of its accurate and reliable performance. This research makes use of the RBF shown in Eq. (6)

$$K\left(x,x_i\right)=exp\left(-\gamma\left\|x-x_i\right\|^2\right) \tag{6}$$

The γ is the predetermined smoothness parameter that controls the width of the RBF kernel.

2.2. SWARM INTELLIGENCE

Swarm intelligence is the discipline that deals with natural and artificial systems composed of many individuals that coordinate using decentralized control and self-organization. Focus is on the collective behaviors that result from the local interactions of the individuals with each other and with their environment. Examples of systems studied by swarm intelligence are colonies of ants and termites, schools of fish, flocks of birds, herds of land animals.

Some human artifacts also fall into the domain of swarm intelligence, notably some multi-robot systems, and also certain computer programs that are written to tackle optimization and data analysis problems. This is one of the computational intelligence techniques which are used to solve a complex problem. SI involves the collective study of the individual's behavior of population interacts with one another locally. Especially for biological systems nature often act as an inspiration. Simple rules are followed by agents and no centralized control structure exists in order to predict the behavior of individual agents.

Biologists and natural scientists have been studying the behavior of social insects due to their efficiency in solving complex problems such as finding the shortest path between their nests and food source or organizing their nests. In spite of the fact that these insects are unsophisticated individually, they make wonders as a swarm by interacting with each other and their environment. In the last two decades, the behaviors of various swarms that are used in finding prey or mating are simulated into a numerical optimization technique. Some of the popular SI algorithms included Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), and Ant Colony Optimization (ACO). Swarm intelligence can be described by considering five fundamental principles:

1. Proximate principle: The population should be able to carry out simple space and time computation.
2. Quality principle: The population should be able to respond to quality factors in the environment.
3. Diverse response principle: The population should not commit its activity excessively narrow channels.
4. Stability principle: The population should not change its mode of behavior every time with the environment change.
5. Adaptability change: The population should be able to change its behavior made when it is worth the computational price.

3. PROPOSED METHOD

3.1. ORIGINAL FIREFLY ALGORITHM

The firefly algorithm [12] [13] [14] is a swarm intelligence-based algorithm and has been shown to be effective in solving nonlinear optimization problems, especially multimodal problems where the objective landscape can have many maxima or minima. There are two important issues regarding the firefly algorithm, namely, the variation of light intensity and the formulation of attractiveness. Yang simplifies the attractiveness of a firefly by determining its brightness which in turn is associated with the encoded objective function. The attractiveness is proportional to the brightness. Three basic rules are established for this algorithm:

1. The fireflies are unisex, and each firefly can be attracted to the other firefly.
2. The attractiveness and brightness are proportional, and their values decrease as their distance increases. For a couple of fireflies, the firefly with less brightness moves toward the other firefly; if they both have the same brightness, then their movement will be random.
3. The brightness of a firefly is obtained by the objective function.

The movement of a firefly i is attracted to another, more brighter firefly j is determined by Eq. (7)

$$x_i^{t+1} = x_i^t + \beta_0 e^{-\gamma r 2ij}\left(x_i - x_j\right) + a\varepsilon_i \tag{7}$$

Where $\beta_0 e^{-\gamma r^2}(x_i - x_j)$ is due to the attraction of the firefly x_j and $\alpha\varepsilon_i$ a randomization parameter; so if β_0=0 then it turns out to be a simple random movement.

The attractiveness, which is its brightness, I of firefly i on the firefly j is based on the degree of the brightness of the firefly i and the distance r_{ij} between the firefly i and the firefly j as in Eq. (8)

$$I(r) = \frac{I_s}{r^2} \tag{8}$$

Suppose there are n fireflies and x_i corresponds to the solution for firefly i. The brightness oh the firefly i, is associated with the objective function $f(x_i)$. The brightness I of a firefly is chosen to reveal its recent position of its fitness value or objective function $f(x)$ as in Eq. (9)

$$I_i = f\left(x_i\right) \tag{9}$$

The less bright firefly is attracted and moved to the brighter one; and each firefly has a certain attractiveness value β. However, the attractiveness value β is relative based on the distance between fireflies. The attractiveness function of the firefly is shown in Eq. (10)

$$\beta(r) = \beta_0 e^{-\gamma r^2} \tag{10}$$

Where is β_0 is the attractiveness at the distance r=0, and the second term is due to the attraction.

The algorithm compares the attractiveness of the new firefly position with old one. If the new position produces higher attractiveness value, the firefly is moved

to the new position. Otherwise, the firefly will remain in the current position. The termination criterion of the FA is based on an arbitrary predefined number of iterations or predefined fitness value. The brightness firefly moves randomly based in Eq. (11)

$$x_i(t+1) = x_i(t) + a\varepsilon_i \quad (11)$$

4. RESEARCH FINDINGS AND ANALYSIS

4.1. DATASET DESCRIPTION

The dataset is used to research and compare the design of the model and testing is procured by Plant Village and Kaggle, the party in order to best compare previous results. This dataset contains over 10000 images, in four subcategories which are called apple, cherry, pepper, and tomato. From each category are used 200 images for training and testing this model. This dataset is used to measure the performance of the proposed method in terms of the accuracy of classification of each class using a leaf image dataset. In order to train the model 70% of available data is used, while the 30% has been utilized for testing.

4.2. PLANT LEAF IMAGE CLASSIFICATION METRICS AND RESULTS

The proposed method has been compared with the methods used for testing and obtaining results with other methods applied for the same problem. In this experiment we used methods SCA, SSA, DE, WOA, and BAT algorithms, original FA was also implemented and validated [15]. Each class has the same number of sets of images to compare with these algorithms. The comparisons can be in seen Table 1. The results are measured by calculating the F1 score, precision, recall, and accuracy.

The best results for the classification of plants will be obtained by using the SVM method with a radial base core (RBF) function, and this core was used in experiments. To validate proposed method, dataset that consists of healthy plants leaves images are used. All images are retrieved from the repository that consists of 61,486 images of healthy and plant leaves with 39 different classes of diseases.

By further analysis, it can be stated that among original metaheuristics, FA, WOA and SCA perform similarly establishing average results, while SSA, BA and DE show worst results.

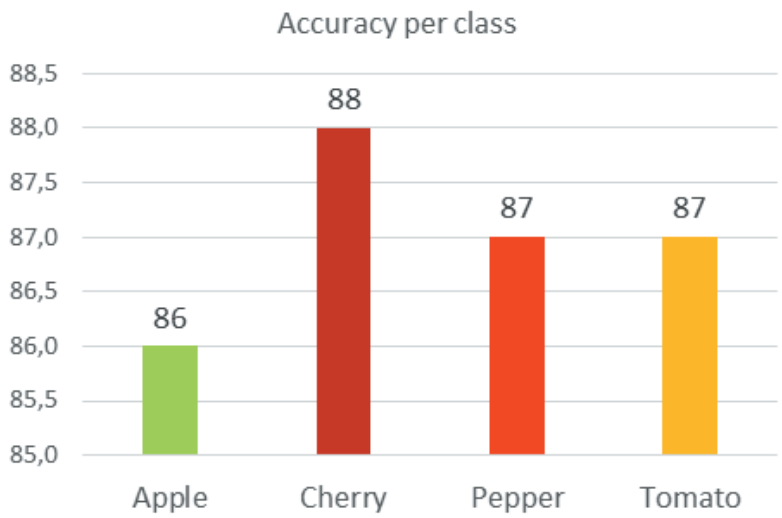

Figure 1 - Accuracy of FA per tested classes.

Algorithm	Accuracy	Plant Leaf Class	n Truth	Precision	Recall	F-measure	Acc. per. class
BAT	69.58%	Apple	125	0.70	0.63	0.66	0.84
		Cherry	134	0.73	0.67	0.70	0.86
		Pepper	156	0.62	0.78	0.69	0.83
		Tomato	142	0.76	0.71	0.73	0.87
DE	65.13%	Apple	98	0.61	0.49	0.54	0.80
		Cherry	136	0.74	0.68	0.70	0.86
		Pepper	132	0.52	0.66	0.58	0.76
		Tomato	155	0.78	0.78	0.78	0.89
SCA	76.41%	Apple	144	0.76	0.72	0.74	0.88
		Cherry	137	0.83	0.69	0.75	0.89
		Pepper	169	0.73	0.85	0.78	0.88
		Tomato	161	0.77	0.81	0.79	0.89
SSA	71.64%	Apple	134	0.72	0.67	0.69	0.85
		Cherry	122	0.75	0.61	0.67	0.85
		Pepper	163	0.67	0.82	0.73	0.85
		Tomato	154	0.74	0.77	0.76	0.87
WOA	75.01%	Apple	148	0.73	0.74	0.73	0.87
		Cherry	151	0.78	0.76	0.79	0.88
		Pepper	158	0.74	0.79	0.76	0.87
		Tomato	143	0.76	0.72	0.74	0.87
MWOA	79.03%	Apple	162	0.73	0.81	0.77	0.88
		Cherry	151	0.87	0.76	0.80	0.91
		Pepper	170	0.73	0.85	0.79	0.89
		Tomato	145	0.84	0.73	0.78	0.90
FA	74.32%	Apple	151	0.72	0.76	0.74	0.86
		Cherry	144	0.78	0.72	0.75	0.88
		Pepper	154	0.73	0.77	0.75	0.87
		Tomato	145	0.75	0.73	0.73	0.87

Table 1 - Performance comparisons of the proposed method and other algorithm

5. CONCLUSION

Using a plant leaf image dataset, this study presents a new plant classification method. This research showcases the best plant classification technique and methods based on FA algorithm. Converging towards the plants with high economic importance ten different plants have been selected for this study. The support vector machine is used for the classification of the leaves. FA is very efficient and can outperform other conventional algorithms based on statistical performances measured using standard stochastic test functions. FA algorithm works based on global communications among the fireflies. The results are evaluated by the obtained accuracy on the utilized plant datasets. The suggested FA-SVM method obtained the best recall, precision, F1 score, and ultimately the overall accuracy of 81.68%, surpassing other algorithms used for comparison, namely BAT, DE, SCA, SSA, WOA and MWOA metaheuristics.

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STUDENT SESSION

SDN APPROACH IN DEVELOPMENT IOT ENVIRONMENTS

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Abstract:

SDN and IoT are two growing technologies that have been the focus of researchers around the world in recent years. Modern access to the network offered by SDN and the growing number of IoT devices shows that the integration of these two technologies as well as their adaptation to each other can significantly improve the interoperability of the whole environment. IoT security issues can also be bridged by the idea of integrating modern firewall or IDS/IPS solutions through an SDN controller or as an independent entity within an SDN environment. The paper aims to show the work done so far on the implementation of SDN in the IoT environment as well as to provide overview for further development of SDN in the IoT communication service.

Keywords:

SDN, IoT, Integration, Programability, Security.

INTRODUCTION

SDN stands for Software Defined Network created by Martin Cassado in 2005 [1]. SDN is a different approach to network management that allows dynamic, programmability and efficient network configuration, all in order to improve network performance and monitoring, thus making the network more of a cloud-computing component than a component of traditional computer systems.

Despite the fact that traditional networking devices are evolving, the disadvantages of the traditional approach are the impossibility of massive scalability, multi-tenant networking, as well as virtualization. This further implies the difficulty of proper configuration, the difficulty of adding new functionalities (upgrades) as well as the difficulty in finding potential errors on the system (it is necessary to analyze all devices in the network).

A new approach to computer networks - SDN, provides a new workspace in which network engineers can automatically and fully dynamically manage and control a large number of network devices, services, different topologies and even packages using a higher programming language and APIs. The needs of SDN are virtualization and orchestration. Virtualization because there is no need to worry about where the logic of the network is really physically located, how big it is and how it is organized.

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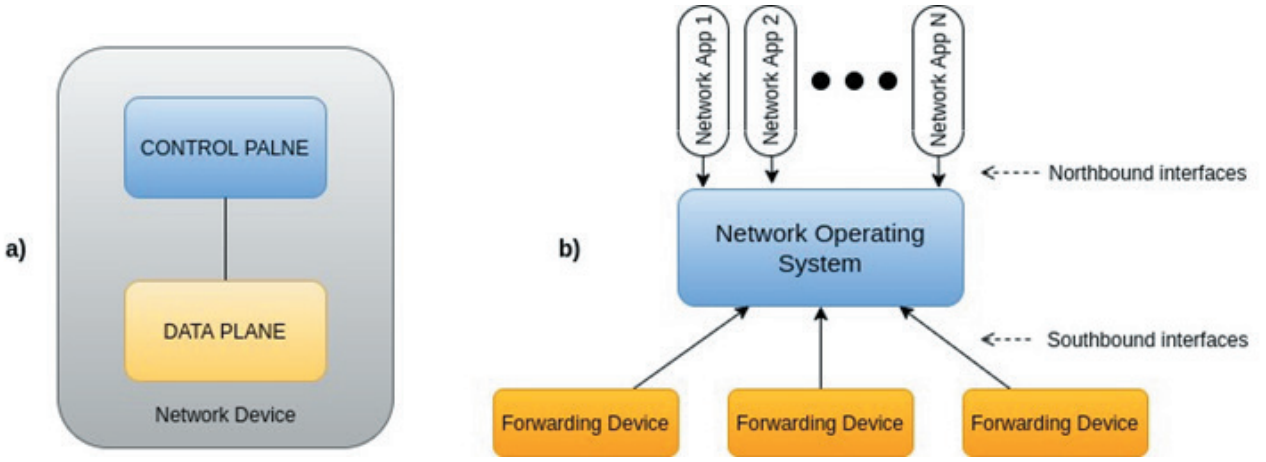

Figure 1 - a) Traditional network model, b) SDN network model

Orchestration means the control and management of a large number of devices through a single command. On the other hand, the Internet of Things, together with SDN, is presented as one very important development technology that seeks to connect different objects via the Internet. By implementing SDN in the IoT network, centralized control of IoT devices such as sensors, actuators, RFID tags, etc. is achieved. The main purpose of integrating SDN into IoT is to organize streams using SDN controllers which further reduces human activity on the network.

Some benefits of SDN and IOT integration are implementing intelligent routing decisions, simplification of information collection, analysis and decision making, visibility of network resources which include network management simplification based on user, device and application specific requrements or implementing intelligent traffic pattern analysis and coorinated decisions. The main feature of the SDN network model is the separation of Control and Data Plane, which allows independent development of each individual. A comparative view of models are given in Figure 1.

2. AN OVERVIEW OF CURRENT SDN SOLUTIONS

Many professional and scientific communities have been involved in the development of SDN, as well as many manufacturers of network devices. The course of development of open source SDN solutions constantly follows the development of SDN solutions of vendor companies. One of the major differences is the technology of creating SDN controllers and components that join the controllers, while from the aspect of network application development the situation is completely identical, both communities offer a well-defined API, thus providing independent access to the system in relation to the programming language.

2.1. OPENSOURCE SOLUTIONS

ONOS - Open Network Operating System is a java-based SDN solution that is being actively developed by the ONF community. ONOS network operating system, framed by a software controller implemented in next-generation SDN/NFV environments. It has been developed to satisfy the flexibility in creating and implementing dynamic network services with a simple programmable interface. ONOS supports pre-configuration and real-time network configuration, eliminating the need to run routing and switching control protocols within network devices [2].

OpenDayLight is a modular open platform for configuring and automating networks of any size and distribution. ODL is a part of LF networking that aims to develop the Open Networking ecosystem. It is designed as a general-purpose platform for delivering a wide range of network services. ODL provides all the benefits of SDN and NFV providers, research institutions and organizations such as smart cities or metropolitan areas. Its SDN controller is called OpenDayLight Phosphorus [3].

Open vSwitch is a multi-layer switch licensed under the Apache 2.0 license. It is designed to enable massive network automation through programmable interfaces, supporting both standard management interfaces and protocols such as NetFlow, sFlow, LACP, 802.1ag, etc. In fact, it is designed to support the distribution of network services across multiple physical servers, similar to VMware VDS or Cisco Nexus 1000v series switches [4].

Ryu is a component-based software-defined network

framework. Ryu delivers software components with a well-defined API, which facilitates the development of network management and network applications. Ryu supports various protocols for managing network devices such as OpenFlow, NetConf, OF-config, etc. Unlike ONOS and ODL, Ryu is a python-based SDN solution [5].

2.2. VENDOR SOLUTIONS

Cisco ACI (Cisco Application Centric Infrastructure) is an SDN solution from Cisco, the world's leading network equipment manufacturer. This solution works with the APIC (Application Policy Infrastructure Controller) software controller and Nexus 9000 switches. What characterizes the Cisco ACI is a much higher throughput, 5 times less latency compared to competing technology, 2 times faster data backup, supports micro-segmentation thus providing a higher level of security. In addition to full automation, it also offers a unique management console [6].

When it comes to Data Centers, VMware currently offers a leading SDN solution related to Data Center technology. NSX is basically an overlay network technology and can work with any hardware switch. NSX offers a wide range of network functionalities in virtualized form, which means that it is possible to create a large number of Overlay networks, Virtual routers, Edge gates, Switches, Firewalls, Load Balancers, VPNs, etc., without the use of additional hardware. VMware offered NSX in two variants: NSX-V and NSX-T, where NSX-V is exclusively for vSphere hypervisors, while NSX-T supports most modern infrastructures such as OpenStack, KVM, Kubernetes, AWS, etc. [7].

One of the world's telecommunications companies is Nokia, which offers the Nuage Networks Virtualized Services Platform (VSP) SDN solution based on its own Virtualized Services Container (VSC) as well as two other key elements: Virtualized Services Directory (VSD) and Virtual Routing and Switching (VRS). Like other vendors, Nokia Nauge Networks provides a full range of products optimized for Data Center, Cloud and SDN operations [8].

3. OVERVIEW OF RELATED RESEARCH AREAS – INTEGRATION OF SDN INTO THE IOT ENVIRONMENT

The starting point for this paper was a publication that thoroughly described the application of SDN and virtual technologies and their integration into the IoT environment [9]. The idea of the authors was to systematize all the knowledge related to the support of SDN in the IoT environment, from physical computer network to wireless and mobile sensor networks. The authors conclude that the advantages of SDN are numerous, especially when it comes to sensitive and mission-critical IoT applications that require a certain level of security. What determines all scientific papers is what they deal with SDN and its integration into the IoT. The following subsections provide some topics on which there is a large amount of research.

3.1. NETWORK MANAGEMENT EFFICIENCY

Research shows the potential inefficiencies of traditional network technology when it comes to the large number of IoT devices on the network. In general, they analyzed the implementation of SDN in production networks, after which they came to the conclusion that SDN is one of the good ways to improve the management of the entire network infrastructure [10].

Based on results in Table 6 [11] it is shown that the SDN-based framework in relation to tables that handle environments such as network management protocols for IoT low power networks Cloud-based frameworks, Semantic-based frameworks and machine learning based frameworks in advantage by the following parameters Scalability, Fault tolerance, Energy efficient, QoS, Security.

What is specific of SDN-based frameworks in according to the IoT with traditional networks, is the flexible topology which is changeable. So if the traditional gateway breaks down, the networks can not continue to work by adjusting themselves. But in the introduced SDN, the network can reconfigure according to the change of environment [12].

SDN-based frameworks for IoT networks management have been proposed in order to centralize network management operations on a central entity and so, reduce computational operations on IoT devices

3.2. SECURITY

Due to the weaker processing power of IoT devices, a large number of papers have been published on the topic of researching the security aspect of the IoT environment. Some security risks of SDN integration into the IoT environment have been defined and provide a distributed control plan solution as one of the effective solutions to protect the network, both from external attacks and from internal attacks [13].

Authors of the paper "Security improvement in IoT based on Software Defined Networking (SDN)" [14] in the service of improving security, and due to the fact that not all IoT sensors can be SDN eligible, introduces the term IoT agents and IoT controllers who need to connect SDN-incompatible resources with IoT devices that they did.

The paper "An approach to adding a simple interface as a security gateway architecture for IoT device" [15] provides an interface that deliver security to the IoT environment without overloading end IoT resources, and this solution provides security that is compatible with remote Internet services.

The popularity of SDN and IoT technologies, as well as their mutual integration, is growing, which indicates the commitment of the scientific and professional community to provide new directions for the development of these technologies [16].

4. POSSIBILITY OF IMPROVING RESULTS IN IOT RESEARCH

Based on the previously shown research, there is no doubt that SDN completely provides a new approach in the development of IoT environment, which enhances research in various areas such as improving security aspects, performance measuring, development of network applications, etc. This paper aims to provide an overview of some directions in which the development and improvement of the IoT environment in line with SDN potentials can take place.

IoT devices as well as IoT network are applied on the southbound interface of SDN architecture. According to the Figure 2, IoT device can be connected directly to the SDN Controller or using a Forwarding device. Depending on the network topology but also the specific requirements of IoT communication, SDN can be configured to meet all needs in order to provide network services through network applications that are applied to the northbound interface [17].

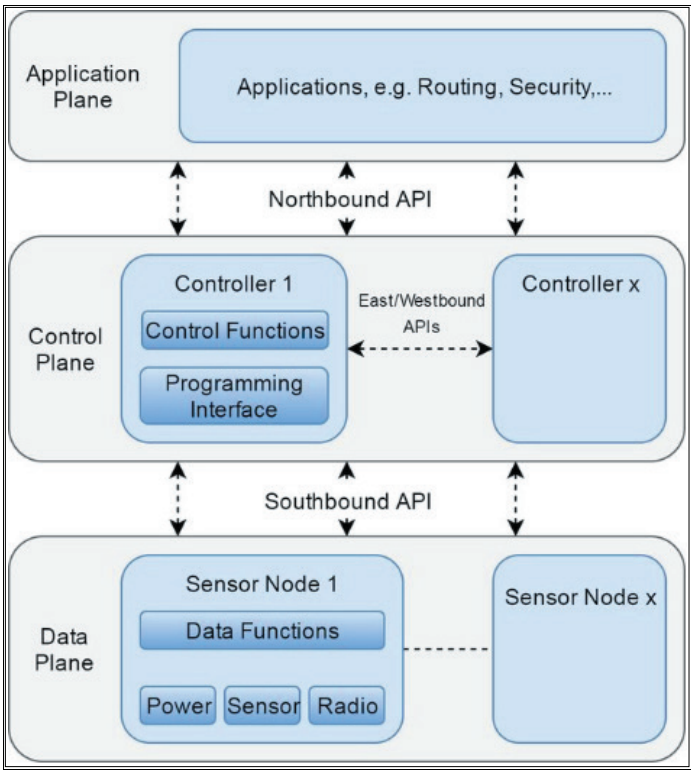

Figure 2 - SDN model adapted to IoT environment

4.1. PROGRAMMABILITY

Compared to traditional networks, SDN can be programmed at all levels: Data Plane, Control Plane and at the level of network applications [18]. Many network models are analyzed on "bottom-up" principle, starting from the physical to the application level. Within the Infra project, the Open Network Foundation community has developed the P4 - Programming Protocol-independent Packet Processors is an open source, domain-specific programming language for network devices, specifying how data plane devices (switches, routers, NICs, filters, etc.) process packets [19]. XDP (eXpress Data Path) is designed for users who want programmability as well as performance. XDP allows users to write a C-like packet processing program and loads into the device driver's receiving queue. It is more performance compared to P4 and adapted to the new upcoming 6G networks, but has a less intuitive programming language as show in paper work [20]. The difference between the two technologies is quite significant, with XDP clearly in favour. If there is a plan to implement light forwarding devices that can be part of the IoT environment then this fact should be taken into consideration. The conclusion that can be drawn from this part is that it is possible to create and form flow tables on devices operating at the Data Plane level, using one of these two programming languages to meet the specific need with a detailed flow of data and all in order to provide communications between two or more IoT entities. One of possible forwarding device block diagram with flow tables and IoT sensors are given in Figure 3.

The SDN Controller serves as an aid to dynamically populate forwarding tables with precisely defined rules. Also, development of SDN Control Plane, ie. SDN Controller, means the development of a service for distributed management of forwarding devices, a service for accepting network applications, but also a service for clustering the SDN controllers themselves. In accordance with the SDN network model, different types of OpenFlow, PCEP, etc. protocols can be developed on the southbound interface. While on the northbound side, API or REST / HTTP services are most often developed. On the controller it is possible to develop monitoring services for devices, topology, and service discovery mechanism; a path computation system; and potentially other network-centric or resource-centric information services. The conclusion that can be seen here is that the SDN controller can be considered as a network operating system that can be upgraded in accordance with the applicable rules of upgrading and currently up-to-date computer operating systems. In the IoT service, the SDN controller is considered to be the data flow editor in the IoT network. A possible but not final model of the SDN controller in the IoT environment is given in the Figure 4.

The development of network applications, given the existence of the northbound interface, should allow developers to create their own protocols without knowing the technology of SDN control and forwarding devices. This allows developers to write applications or entire app-systems in any programming language (Python, JAVA, C++, etc...) that will communicate with the SDN controller via the API/HTTP or any other northbound

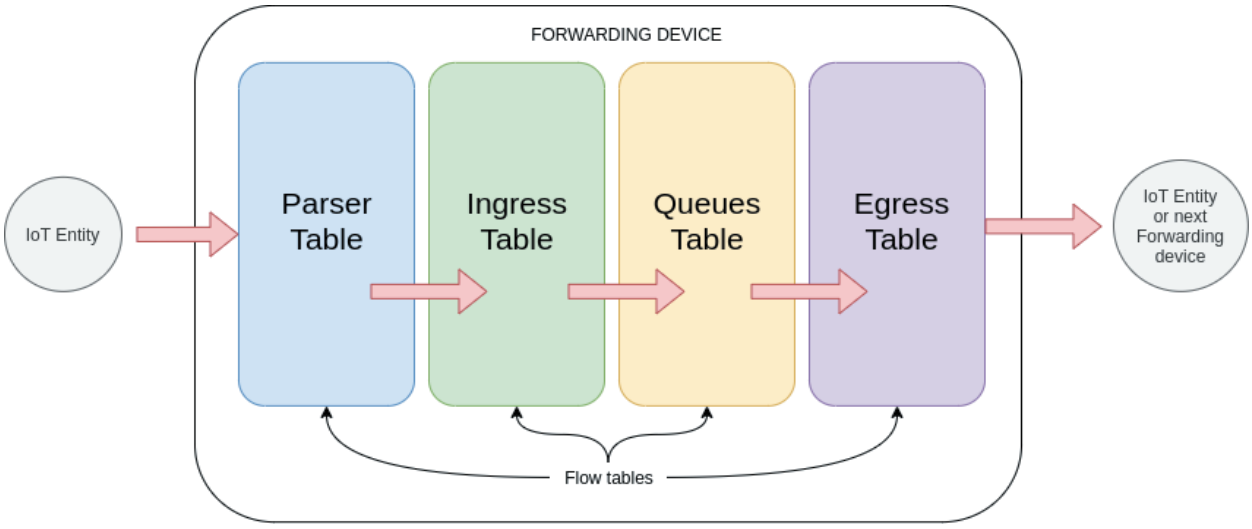

Figure 3 - Overview of Data Plane model of Forwarding device and Flow tables with position of IoT entities

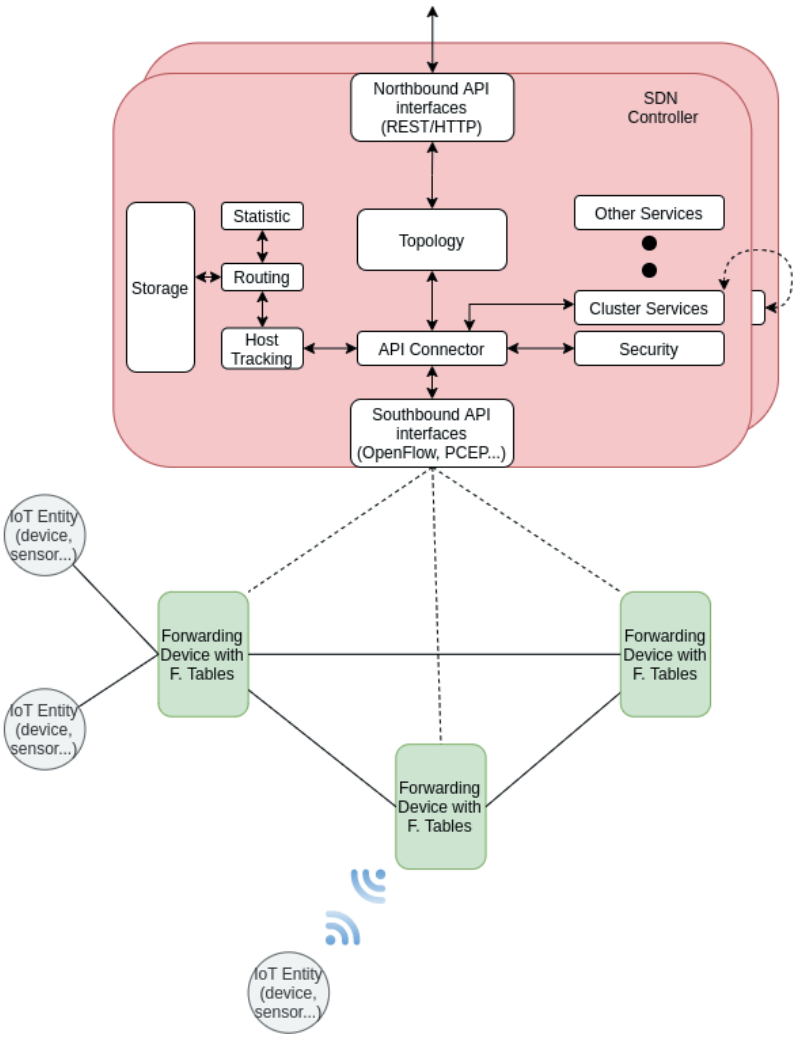

Figure 4 - Overview of SDN Controller block model for IoT environment

interfaces that are developed for specific communication. There are a lot SDN applications that can bi associated to IoT environment including monitoring and measurement, security, cloud, big data, wireless etc.. [21]. Therefore, researchers are given the opportunity to, using any programming language, independently develop potential algorithms that will solve current problems that occur in IoT environments.

This subsection more closely determines the position of the IoT entity in relation to SDN components, shows the direction of development of each layer of the SDN model and how it is possible to improve communication between SDN entities and the rest of the network.

4.2. SECURITY

Some authors have shown how it is possible to integrate a blockchain architecture to protect IoT networks whether it is a centralized or distributed network system [22][23]. This works describes how to deploy security measures, including threat prevention, data protection, and access control, and mitigate network attacks such as cache poising/ARP spoofing, DDoS/DoS attacks, and detect security threats.

Since the most SDN controllers are OpenSource, a number of firewall policies or IPS / IDS systems can be integrated with the controller itself to block or identify malicious traffic. Some authors explain that for the purposes of SDN, IDS / IPS functionality is provided through external systems, such as Suricata [24]. This allows the implementation of various security services: Firewall, network scan detection, abnormal traffic detection, intrusion detection, intrusion prevention.

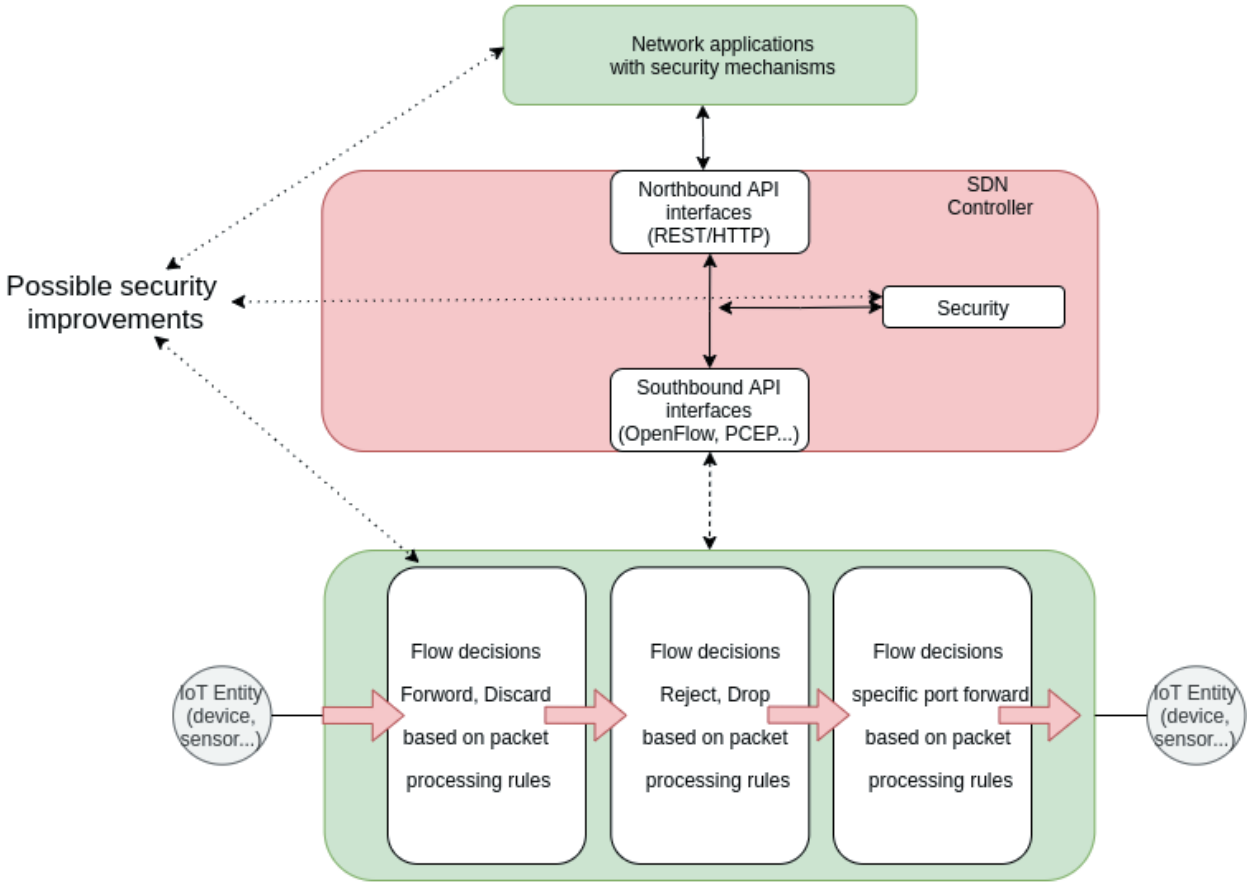

Figure 5 - Overview of possible security improvement

In accordance with the previously proven security improvements of the IoT environment, the following Figure 5 shows the directions in the development of security solutions at all levels of the SDN model or their integration with all layers of this model.

In conclusion, the fact that the SDN platform is extremely suitable for further development of security protocols in the IoT environment as well as relatively simple integration with external security solutions.

Given all the facts presented so far, it can be concluded that the SDN platform is largely suitable for the IoT environment. All the specific requirements of specific IoT communication can be realized through the development of applications at all levels of the SDN network model.

5. CONCLUSION

This paper provides an overview of current researches on the topic of IoT and SDN integration. The systematization of the material is based on the available open source SDN solutions that are most often used in research. Parameters such as network programmability and security that are important for the IoT environment were evaluated. It has been shown that in most cases the SDN architecture provides better opportunities in IoT communication, gives developers the freedom to develop their own applications, provides better control over system behavior as better security solutions. The paper also showed possible software and security points in the development of SDN architecture in service of IoT needs.

In the time to come, SDN will become a technology that will be much more responsive, fully automated and highly secure, as well as one of possible directions for improving IoT services by SDN technology.

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STUDENT SESSION

UNDERSTANDING JOB REQUIREMENTS USING NATURAL LANGUAGE PROCESSING

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Abstract:

With the rising number of remote jobs and mediums on which companies rely as funnels to attract job candidates, the number of job applications receives increases exponentially over time. Human Resource (HR) departments are becoming bottlenecks for pleasant applicant experiences because of the laboriousness of the application processing task. Increasing the size of HR departments works to a certain point but hiring more HR specialists becomes impossible from a financial and managerial standpoint. We propose a novel approach for candidate filtering based on competence matching between job ads created by companies and submitted resumes. The proposed system achieves 99.5% accuracy and relies on natural language processing techniques to extract information from both candidates' resumes and job ads. It allows companies to create their personalized automated filters using the extracted information.

Keywords:

e-administration, public administration, administrative procedures.

INTRODUCTION

As a result of Covid 19, more and more companies rely on internet-based job boards to find qualified candidates. Each day, we can see more than ten million new job openings posted across the web, which provides fantastic opportunity and great stress for job seekers. LinkedIn, which now has more than 750 million active members worldwide, saw a sudden increase in posted job demand, yet had difficulty adjusting their job search engine with this new traffic. Currently, LinkedIn jobs show a maximum of 10.000 jobs for any given search pattern, whereas they have over 14 million active jobs. This search algorithm limitation is not an isolated problem to LinkedIn, and it results in millions of unreachable jobs for job searchers.

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The lack of a personalized search is the direct consequence of outdated technology, which produces a skewed distribution of applicants to the top searched/reached companies and their jobs. On internet job boards, human Resource departments at the most visible companies are buried in hundreds, if not thousands of applicants. Having many applicants for a company's job might sound fantastic for the company, but it is an unnecessary burden for the HR department. Most companies don't have the resources to process all submitted applications. Even if we assume they do, they are unsure how to rank applications to allocate more time to the most suitable candidates.

Artificial Intelligence has changed whole industries in the last couple of years, from creating self-driving cars to supermarkets without human workers. This shift is just beginning for the Human Resource departments and their day-to-day workflow.

Our main contributions are summarised below:

1. We demonstrate an approach to applying state-of-the-art Natural Language Models to job descriptions and create a much faster and more personalised job search and candidate filtering system.
2. We provide an open-source dataset with 100,000 carefully curated job descriptions for technical positions (each job has features extracted, such as - years of experience, degree level, degree area, and skills) and a pre-trained model for extracting relevant information from job descriptions, which will provide a starting point for new researchers in this domain and potentially grounds for downstream commercial applications.

2. OVERVIEW OF NATURAL LANGUAGE PROCESSING EFFORTS IN THE HIRING PROCESS

From the early 2000s, the recruiting procedure became a large playground for companies to explore their AI approaches to improve/automatise certain aspects of this process. The most significant problem in recruitment to this day is bias in decision-making. When a process has humans on both ends, bias is inevitable. This area was the first where companies started investing time and resources to improve this problem and make the hiring process much less stressful. Startups created automated bots for initial screening interviews, algorithms for analysis of telephone screenings, and finally, Resume/CV filtering to remove the urge of deciding with a bias towards certain candidate groups.

The HR community recognized that bias in resume filtering is a long-standing issue and initial attempts at alleviating it was based on simple key-pair matching heuristics [1]. In 2016, SAP researchers tackled this problem using machine learning [2] and showed that they could scale key-based systems by purely relying on data distributions [3].

Building on the first efforts for candidate filtering and matching, a couple of promising research directions relying on machine learning approaches to solve the constraints of key-based systems emerged. Lin et al. [4] created an ensemble model by combining XGBoost [5] with a Convolutional Neural Network (CNN) [6] to create an ensemble model and extract relevant information from job descriptions and match them with job seekers.

The ensemble approach showed promising results but did not understand the context of the given text. We recognized this problem along with an earlier French research team. Their paper [7] demonstrated a candidate matching system with open job positions by utilising the BERT model. They trained their model on a privately held dataset of 106 resumes without tackling the job description extraction part. This paper will go a step further and create our dataset, which allows us to create and train a BERT model with higher retrieval accuracy than the mentioned papers.

According to Wright [8], more than 70% of HR teams showed a positive attitude towards automatization for their jobs. While bias is to this day the first and most important problem to solve for the recruitment process, there are less impactful but still meaningful areas that provide a better quality of life for HR experts. According to the same report from 2019, many startups offer services for auto transcribing calls with candidates to those creating personalized and easy-to-use ATS systems [9]with Resume matching and search functionality built into them, such as TalentLyft [10].

3. DATASET STRUCTURE

Our focus audience for our research, and potentially a product one day, were our peer researchers, Data Scientists, and Machine Learning Engineers. To tackle this problem robustly, we first need a high-quality, up-to-date dataset. Since most of the job titles we are interested in were created and established in the past couple of years, we needed new job descriptions that recently encapsulate those titles and job-related skills created (e.g., TensorFlow, PyTorch, Fast API).

Finding a decent job description dataset is difficult, especially an updated one. We managed to find two relevant datasets ready to be reused/downloaded. The first two datasets we encountered were available for download from Kaggle Datasets [11]. The first was the UK only [12] dataset, and the second was the US only [13], which focused on the Monster website. They were created three/four years ago and did not contain any relevant jobs for our research. Even though these datasets were not used in our further work, they helped us detect a need in the research community and develop a list of features we wanted to add to our version when making it available.

Since we couldn't use any of the existing datasets, we created our system to gather the most relevant jobs around the internet. This project had two challenges that our team had to overcome - creating a reliable method for collecting raw information job descriptions from websites and automatically extracting the information we wanted from the downloaded HTML pages.

3.1. THE JOB DESCRIPTION SCRAPING SYSTEM

Every day, we can expect more than 10 million new job posts across all hiring platforms worldwide [14]. With these numbers constantly increasing, finding relevant jobs for job seekers becomes harder day-in-day-out. To tackle this growing issue, we created a fast and reliable scraping system that gathers Data Science related jobs from the most popular job boards on the internet and saves them to our database.

The first iteration of our system included only Indeed, LinkedIn Jobs, and Glassdoor - three of the biggest job boards out there. However, when Covid 19 started, we pivoted to more remote-friendly options and added TapWage, Remotive, RemoteOK, and a few smaller websites to tackle this newly recognized problem.

While building the system, there was one technology limitation to overcome - anti-scraping systems, which detect non-user behaviour and block those connections to their website. We overcame this by creating stochastic workers who try to mimic a human user while browsing a web page. Those agents make intentional mistakes, navigate randomly, and wait for a random period to create as human-like a session as possible. We used the Selenium testing framework [15] to achieve this effect.

The first version of the infrastructure had N agents in place - one for each website being scraped. Each agent would scrape in parallel and populate the database at its own pace, as demonstrated in Figure 1. This works well with a smaller load of downloaded data, but bottlenecks occur when we increase the workload for more prominent websites.

The first version worked well on a smaller scale, where website scrapes are similar in size (the number of jobs per minute), and the response time from each website to our system is similar. The complexity and first bottlenecks arise with every new website added to the system, and the number of variables that we need to handle increases exponentially.

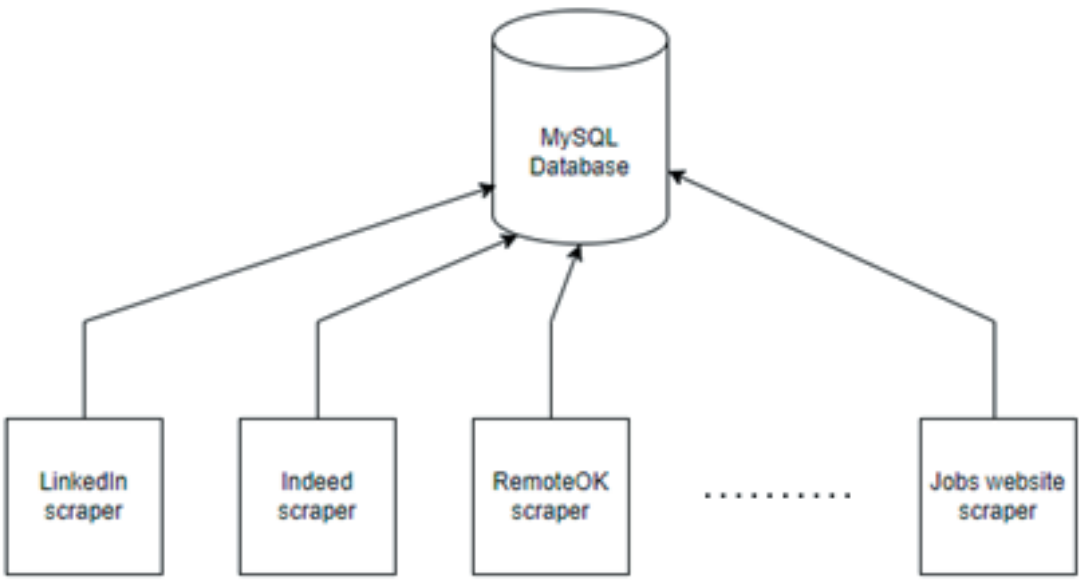

Figure 1 - The first version of the scraping system - without the central controller

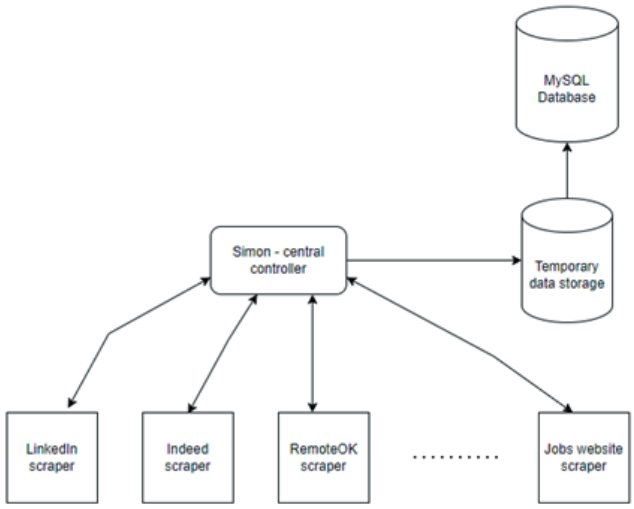

Figure 2 - Scraping system with central control unit for data syncing

To handle the database bottleneck and time variability, we added one more agent to the system called "Simon" from the popular children's game "Simon says, as seen in Figure 2. "This agent will conduct a sync between all other agents and take care of data batching, delays in data gathering between websites, and report errors directly to our Slack channel when such errors occur.

The first version of the system managed to top about 20.000 jobs per day. By adding a central authority agent (Simon), we increased this number to more than 50.000 jobs per day (~ 35 jobs added to the database per minute).

3.2. AUTO-LABELING USING REGEX

When operating at optimal capacity, our system produces about fifty to fifty-five thousand job descriptions per day. If we want to train a machine-learning algorithm on that data, we need to label it first. As our team had only two researchers, labeling all those job descriptions ourselves or paying a third-party company was not an option. We created an automated human-in-the-loop system based on regex rules to solve this challenge.

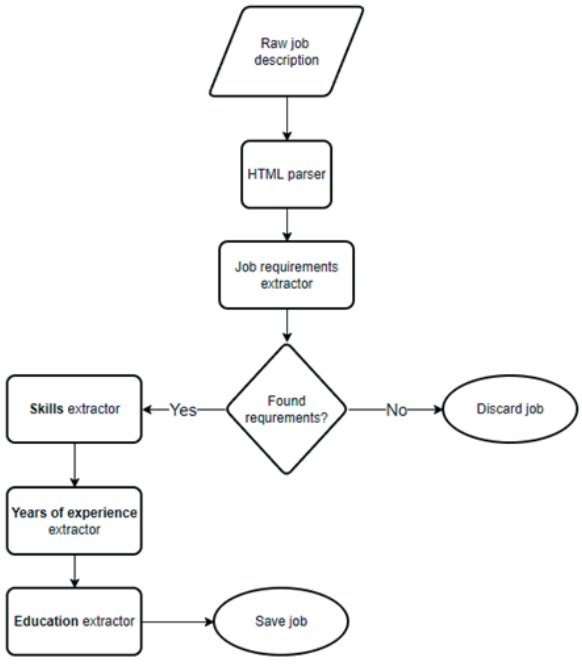

Figure 3 - Job description analyser algorithm flow

Our goal was to extract a set of job requirements for each job downloaded using an end-to-end algorithm. Here is the list of features our system searchers:

- Years of experience
- Education level (Bachelor's, Master's Ph.D.)
- Education area (e.g., Computer Science, Mathematics, Economy)
- Substitution (e.g., experience for education or education for experience)
- Soft skills (e.g., presentation, communication)
- Hard skills (e.g., Python, TensorFlow, C++, R)

We created a set of functions that check HTML structure and put the raw text through Regex [16] filters to handle each of these points, and as the output, the system produces filtered requirements for each of the classes defined in the previous paragraph.

Each filter has the same sequence of checks, with the Regex being the only difference. Here is the breakdown of how each filter processes the raw HTML:

1. Custom formatting checker approves the page or discards it
2. HTML tags filter finds a specific part of the page for job requirements
3. Job requirements are again put through a formatting checker for the second approval
4. Requirements are split into lines
5. Each line goes through a language-based classifier that determines with regex filter to apply to it
6. Regex filter is applied based on the classifier results

The system is very robust in most cases, and after several iterations, it didn't need a human-in-the-loop for additional checks. Regex checkers can capture most of the dataset and automatically label it, but they still miss it from time to time. Even though we can safely rely on the Regex version of the solution, it has its downsides. Besides its instability, it became overly complex and fast, and adding more checks required more time. The upside of the system is its memory requirement and inference speed.

4. CONCLUSION

As described in section 3.2, we built a system based on the Regex rules to extract relevant information from job descriptions. One of its drawbacks is its lack of generalization when confronted with new data points (job descriptions).

One of the main reasons for utilizing machine learning algorithms is as a solution for handling previously unseen categories of new user data, which was the main obstacle for the Regex-based system. For some rules to be detected, they had to be coded manually and added so that future data is parsed correctly. Constantly adding new rules does cover more and more edge-cases that the dataset encounters, but it also increases the complexity of the code. The main generalization issue for our task is finding the years of experience needed in a job post. The Regex system can easily recognize regular cases (e.g., 1-2 years of experience, one to two years of experience) but lacks data understanding, shown in these examples: up to two years of experience and one year in the industry, etc. When detection is context-based, the rules-based system does not perform well.

To handle context-based examples and handle the ever-rising complexity of the code, we turned this problem into a text classification issue called NER (Named Entity Recognition) [17]. In NER, we try to build a model to classify each word (or a sequence of words) into specific objects (classes). In the sentence "*I am living in London and working at DeepMind,*" - a NER model would have to recognize two distinct objects - London as a CITY/PLACE and DeepMind as an ORG (organisation). In the task of extracting relevant requirements from job descriptions, we created custom NER tags suitable for us:

Since our initial dataset was rather small, all our experiments were performed using a novel technique in Natural Language Processing called Transfer learning. We experimented with two different models, BERT [18] and its smaller version DistilBERT [19]. As the accuracy of both models was roughly the same (99.5% for BERT and 99.1% for DistilBERT), to make the final decision, we tested both models on newly scraped data. BERT performed much more accurately and showed better generalization on new data formats and job description syntaxes.

Tag name	Tag description
B-SKILL	The first word of a skill
I-SKILL	Tag for words beyond the first one (if a skill has multiple words)
B-EXPERIENCE	The first word of experience
I-EXPERIENCE	If an experience has multiple words (e.g., two or three)
B-DEGREE	The first word of a degree (e.g., Ph.D.)
B-DEGREE_MAJOR	The first word of a degree major
I-DEGREE_MAJOR	If a degree major has multiple words (e.g., Computer science)

Table 1 - NER Tags for Job Description dataset

With the trained BERT model, we solved the first problem, which is generalization of our rules to unsee data and context-based data. However, the model was still close in the number of lines of code to the original set of rules that relies on Regex only. To handle this downside, we used an open-sourced library called HuggingFace [20] that allows us to load any pre-trained language model in a single line of code. Using HuggingFace, we fine-tune the model to our dataset and deploy it in less than 100 lines of code, which officially handles the second drawback: the complexity of the code and readability.

5. CONCLUSION AND FUTURE WORK

The main objective of this paper is to demonstrate a data collection system for job descriptions and apply a machine learning model to extract relevant information from them, which can be used for better job ad personalization or creating an advanced job search engine.

This paper demonstrates an application of new NLP models called Transformers on information extraction tasks from job descriptions as a data source. We managed to get 99.5% accuracy on the NER application using the BERT model, which is not a trivial task since all categories (classes) being recognized are different. For example, skills such as TensorFlow, PyTorch, Artificial Intelligence are pure text. At the same time, years of experience can be a combination of special characters (e.g., 9 - 10), text (e.g., nine to ten), or a combination of both (e.g., zero - 1).

In our further work, we would like to extend this application to Resumes/CVs and test if we can scale the current model on different data sources with similar data distribution. Furthermore, if the Resume experiment goes well, we would like to extend our research on the matching theory between candidates and open job positions.

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ABSTRACT

ABSTRACT

EXAMINING THE SEASONAL CYCLE IN THE MEDITERRANEAN CLIMATES

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Abstract:

Our study aims at filling a gap in the knowledge and data at the regional level within a climate research framework specifically focusing on the climate change driven seasonal cycle variability in the Mediterranean type climates, with a particular focus on California. The recent seasonal cycle changes have exacerbated impacts of the seasonal droughts and floods, increasing the adverse economic and environmental impacts of already prevalent water shortages in the Mediterranean climates. Our study is intended to establish a better understanding of the causes of the climate seasonal cycle change and to provide new knowledge, data and information on the changing seasonal cycle in the Mediterranean type climates, relevant to the water-sensitive stakeholders.

We present seasonal cycle trends in the present and future climate. Our goal is threefold: (1) to gather and present a clear and comprehensive evidence of changes in the seasonality in the present climate, (2) to understand dynamics of the current and future trends and (3) to provide valuable new information and data at the national/regional level needed for developing the services for the water-sensitive stakeholders and further actionable climate research.

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