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INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY AND DATA RELATED RESEARCH

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Rapid advances in Information Technologies (IT) in recent decades have had a huge impact on numerous facets of everyday life and have created tremendous opportunities for economic, technological and social gains at a global scale. In particular, the advances in data-science, block-chain technology and optimization techniques are becoming the driving force behind many changes in both technology and business. Emergence of new technologies has caused widespread expansion of the internet of things. At the same time problems related to cyber security, security of communications, as well as the security in the cloud are becoming important 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 now also used for solving some of the most pressing problems our society is facing today, such as climate change and environmental issues.

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

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Vladimir Reković, PhD – *CERN, Particle Physics Researcher*

Miroslav Popović, PhD – *Singidunum University,Serbia and UC Berkeley, California*

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COMPUTER SCIENCE, COMPUTATIONAL METHODS, ALGORITHMS AND ARTIFICIAL INTELLIGENCE SESSION

PREDICTION OF CORRECT READINGS OF CAR ENGINE MASS AIR FLOW SENSORS

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Abstract:

Let us suppose a situation in which it is necessary to check the car before going on a journey, a situation in which breakdowns appear but also mysteriously disappear, a situation where solving problems with the vehicle is only possible by looking at the data obtained by reading sensors, routine vehicle checking (insight into data irregularity), "real-time" monitoring of car condition…

The main goal of this paper is the early detection of erroneous readings of vehicle airflow systems in real time and constant monitoring of the subject vehicle, by coupling and using trained models based on machine learning tools of artificial intelligence and using "Infinity" device.

Keywords:

Can-*bus*, Automotive, Mass air flow sensor, Linear regression, Random forest

INTRODUCTION

As a result of climate change and the greenhouse effect, the Environmental Protection Agency (EPA) [1] and California Air Resources Board (CARB) [2] were authorized by the government to apply protocols that monitor the exhaust gas emissions from car manufacturers. During a car's lifetime, the owner is obliged to maintain the emission of exhaust gases in the prescribed parameters, while the manufacturers are obliged to provide the necessary infrastructure which gives an insight into the emission of harmful gases into the atmosphere.

Electronic monitoring and diagnostic operation of internal combustion engines, cars and light trucks was introduced in the late 1970s, and already in the early 1980s the OBD (On-Board Diagnostics) system designed to inspect the compliance with EPA and CARB emission control standards started to be applied. Over the following years, the diagnostic systems became increasingly sophisticated, so in the mid-1990s, the OBD standard received its upgrade called the OBDII standard. This new standard provides almost complete insight of car exhaust emissions, but also monitors other systems such as chassis parts, accessories, electronic vehicle slip system, etc.

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By implementing the OBDII standard, and in order to control the operation of all car systems and subsystems, the automotive industry had the obligation to introduce standardization, protocols according to which computers communicate with each other, without the need to introduce a master host as a control point in the exchange of information.

The auto industry that was obliged to implement the OBDII standard, inspired "Robert Bosch GmbH" to begin developing CAN protocol in 1983. It was officially introduced in 1986 at the conference of the Society of Automotive Engineers (SAE) [3] and as early as 1991, CAN protocol started to be implemented in Mercedes cars.

Shortly afterward, the acceptance of this protocol became wide spread, in other words, all car manufacturers were obliged to implement CAN protocol with part of OBDII standard [4] which are associated with control of car exhaust emission.

The CAN protocol is specific in that every unit sends data with a single header to the network, and when an end node computer needs it, it uses it by intercept the information from the CAN-*bus* network.

This research uses the data collected from the CAN-bus car network for the purpose of predicting incorrect readings of mass air flow sensors, by coupling and using trained models, machine learning tools of artificial intelligence, with the help of the "Infinity" device.

2. OVERVIEW OF TEST CYCLE TOPOLOGY

The proposed cycle as we can see at Figure 1, is based on the idea of training the data obtained from the vehicle in a relatively short interval while the vehicle engine is idling, by gradually increasing and decreasing the engine speed. A piece of hardware was developed for this research which, connected to the diagnostic port of the car, performs the basic purpose of collecting and sending data to a remote server, as well as predicting, by regression model of real-time machine learning, the values of mass air flow sensor which is described in further bellow in this paper.
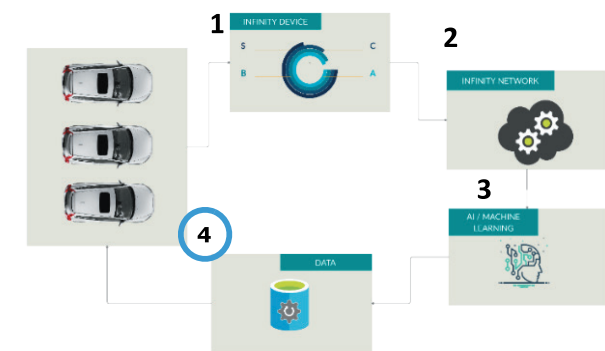
Figure 1. Topology of MAF sensor test cycle

3. NATURE OF DATA STRUCTURE

The CAN protocol [5], although standardized, did not offer a significant opportunity for an enthusiastic researcher to gain an insight into it, because each manufacturer interpreted and implemented the CAN protocol in its own way. This created an absurd situation that the standardized protocol was not standard. The problem was that the headers in sending messages through the car network were not unique to each make, type and model of a particular vehicle manufacturer.

This situation presented an opportunity to the world regulatory body for pollution control to bring under control air pollution caused by cars, and the epilogue of the introduction of standards is an obligation for all manufacturers in the automotive industry to implement standardized protocol headers for exhaust gas purification.

The standard information request headers, On-Board Diagnostics Parameter IDs (OBDII PIDs), which provide insight into a car's air purification system, have opened up the possibility of standardizing at least a small segment the CAN protocol and enable the development of various applications that are not related to exhaust gas control but use standard request headers (hereinafter: PID) [Figure 2].
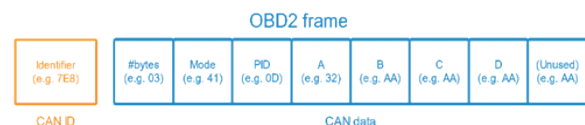
Figure 2. CAN-bus message header structure (PID)

The data analyzed in this paper were obtained from the CAN-*bus* network, utilizing several standardized PIDs that were used to predict faulty, incorrect readings of the vehicle engine Mass Air Flow sensor (MAF) [Figure 3].

4. DATASET STRUCTURE

The CAN-*bus* network is "noisy", while the maximum flow is 500 Kb/s, and all car sensors, actuators and computers constantly send information about their status, condition and values. Sensor values that are by their nature linear are discretized and as such sent to the network. The end nodes (computers) in a vehicle have access to all the data and only those that are essential and necessary for operation are prioritized and "extracted" as information.

The data status that the Engine Control Unit (hereinafter: ECU) "extracted" from the CAN-*bus* network was used to generate a dataset [6], in order to predict the correct operation of the MAF sensor. The generated dataset has the information structured of three independent variables obtained from the ECU, specifically from the sensors:

- *RPM - Revolutions Per Minute sensor*
- *MAP - Manifold Absolute Pressure sensor*
- *FGP - Fuel Gauge Pressure sensor*

The values of the selected prediction attribute, the dependent variable, are obtained from the Mass Air Flow sensor [Figure 3], and the measured values are mapped into the amount of air "sucked" into the car engine. In short, this sensor is of prime importance for the proper operation of an engine, since the data obtained from this sensor are used by the central ECU to correct the amount of injected fuel and thus enable coordinated engine operation.

Figure 3. Mass Air Flow sensor (MAF)

The combination of independent attributes (RPM, MAP, FGP) and dependent variable (MAF), can be clearly seen in the correlation matrix in Figure 4. and Figure 5.
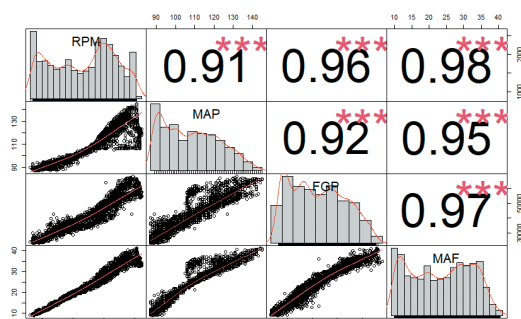
Figure 4. Correlation matrix of dependent variables (RPM, MAP, FGP) and independent variable (MAF)
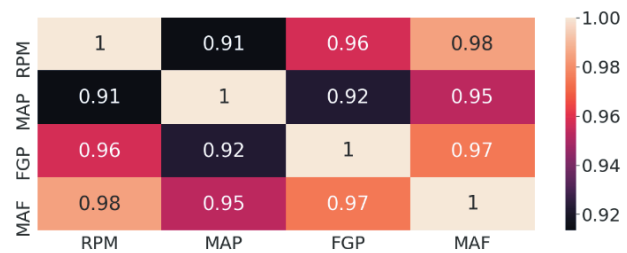
Figure 5. Correlation matrix of dependent variables (RPM, MAP, FRGP) and independent variable (MAF)

5. CHOICE OF MACHINE LEARNING METHOD

The problem of machine learning is of regression type with data that are linearly related. It should be noted that the training data set is not large since a small number of samples is sufficient for the proposed method. For that reason, a ten-minute training on a good condition vehicle can be considered sufficient for future prediction of incorrect MAF sensor readings. The data on which the training and evaluation were performed in this paper contain 2.759 samples obtained from the CAN-*bus* network. Machine learning of time series regression rules can be viewed as an interpretation of recognizing the dependence of independent attributes in the collected data. Inductive learning based on the obtained examples, after the application of machine learning methods, maps the time sequences into a prediction attribute which further predicts and checks the future input values of the MAF sensor.

Considering the linear connection of dependent attributes, this paper uses and evaluates the following regression methods of machine learning, which are:

- *Simple Linear Regression (SLR)*
- *Multiple Linear Regression (MLR)*
- *Random Forest (RF)*

6. SIMPLE LINEAR REGRESSION (*SLR*)

The general form of SLR model, according to [7], can be represented as:

$$Y_i = \beta_0 + \beta_1 x_i + \varepsilon_i \qquad i = 1, 2, ..., N$$

where Y_i is the dependent variable, x_i is the value of the independent attribute, β_0, β_1 is the unknown constant (regression parameters), N is the size of the basic set of attributes.

The best candidate of the independent attribute of SLR was obtained by looking at the correlation matrix in Table 1. The strongest correlation of MAF are RPM sensor readings.

	RPM	MAP	FGP	MAF
RPM	1.000000	0.913430	0.957484	**0.984641**
MAP	0.913430	1.000000	0.922442	0.953109
FGP	0.957484	0.922442	1.000000	0.974711
MAF	**0.984641**	0.953109	0.974711	1.000000

Table 1. Correlation matrix RPM, MAP, FGP, MAF dependence of SLR attributes

A graphical representation of the linearity of the RPM and MAF sensors can be seen in Figure 6 and Figure 7.
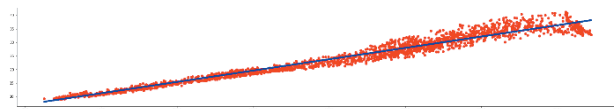
Figure 6. RPM and MAF attribute linearity (training set)
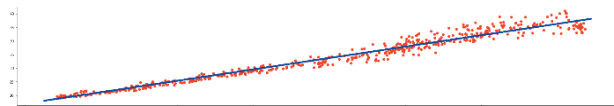
Figure 7. RPM and MAF attribute linearity (test set)

6.1. SIMPLE LINEAR REGRESSION - EVALUATION OF THE OBTAINED RESULTS

After applying OLS and statistical methods of error measurement, the following results were obtained on the test set [Figure 8]:

```
                        OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.971
Model:                            OLS   Adj. R-squared:                  0.970
Method:                 Least Squares   F-statistic:                 1.811e+04
Date:                Tue, 25 May 2021   Prob (F-statistic):               0.00
Time:                        20:25:25   Log-Likelihood:                -1033.9
No. Observations:                 552   AIC:                             2072.
Df Residuals:                     550   BIC:                             2080.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.0412      0.183     -0.224      0.822      -0.401       0.319
x1             1.0014      0.007    134.583      0.000       0.987       1.016
==============================================================================
Omnibus:                       30.209   Durbin-Watson:                   2.119
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               50.143
Skew:                           0.393   Prob(JB):                     1.29e-11
Kurtosis:                       4.249   Cond. No.                         67.4
==============================================================================
```

Figure 8. OLS evaluation of learned Linear Regression model (test set)

- Mean Squared Error = **2.48**
- Root Mean Squared Error = **1.57**
- Mean Absolute Error = **1.15**
- R-squared (R^2) = **0.971**
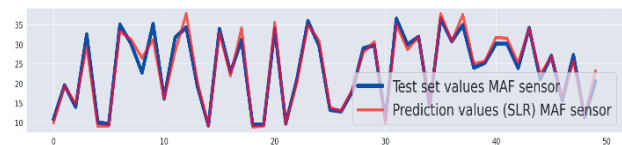
Figure 9. Comparative representation of predictive and test results (SLR)

7. MULTIPLE LINEAR REGRESSION (MLR)

The general form of the MLR predictor, , according to [8], can be represented as:

$$Y_i = \beta_0 + \beta_1 x_{i,1} + ... + \beta_1 x_{p-1} x_{i,p-1} + \varepsilon_i$$
$$i = 1, 2, ..., N$$

where $x_{i,1}$ represents the i-th value of the k-th predictor for $i = 1, ..., n$.

MLR takes several independent attributes, which can be seen in the correlation matrix done over the dataset in Table 2:

	RPM	MAP	FGP	MAF
RPM	1.000000	0.913430	0.957484	**0.984641**
MAP	0.913430	1.000000	0.922442	**0.953109**
FGP	0.957484	0.922442	1.000000	**0.974711**
MAF	**0.984641**	**0.953109**	**0.974711**	1.000000

Table 2. Correlation matrix RPM, MAP, FRGP, MAF

7.1. MULTIPLE LINEAR REGRESSION - EVALUATION OF THE OBTAINED RESULTS

After applying OLS and statistical methods of error measurement, the following results were obtained [Figure 10]:

```
                    OLS Regression Results
==============================================================================
Dep. Variable:                    y   R-squared:                       0.991
Model:                          OLS   Adj. R-squared:                  0.991
Method:               Least Squares   F-statistic:                 6.137e+04
Date:              Tue, 25 May 2021   Prob (F-statistic):               0.00
Time:                      15:38:11   Log-Likelihood:                -702.93
No. Observations:               552   AIC:                             1410.
Df Residuals:                   550   BIC:                             1418.
Df Model:                         1
Covariance Type:          nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.0015      0.100      0.015      0.988      -0.194       0.197
x1             1.0003      0.004    247.727      0.000       0.992       1.008
==============================================================================
Omnibus:                        7.446   Durbin-Watson:                   2.044
Prob(Omnibus):                  0.024   Jarque-Bera (JB):                7.591
Skew:                           0.232   Prob(JB):                       0.0225
Kurtosis:                       3.340   Cond. No.                         66.7
==============================================================================
```

Figure 10. OLS evaluation of learned multiple linear regression model (test set)

- Mean Squared Error = **0.75**
- Root Mean Squared Error = **0.86**
- Mean Absolute Error = **0.67**
- R-squared (R^2) = **0.991**

A graphical representation comparing predictive and test values can be seen in Figure 11.
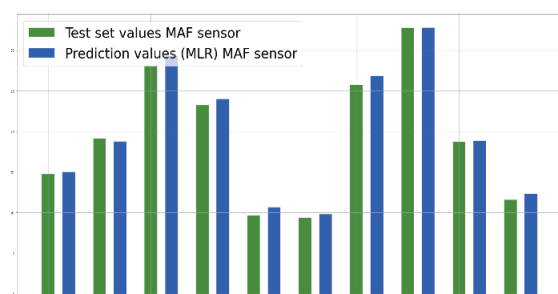
Figure 11. Comparative representation of predictive and test results (MLR)

8. RANDOM FOREST ENSEMBLES (RF)

The RF method of machine learning [9] is implemented in this paper from the Scikit-learn library, which in its implementation uses Gini Importance, which can be presented in its basic form of a binary tree as:

$$ni_j = w_j C_j - w_{left(j)} C_{left(j)} - w_{right(j)} C_{right(j)}$$

Where ni_j is the importance of node j, w_j is the weight number of samples that reached node j, C_j is the noise value of point j, $left(j)$ is the left point of the child in the branches of the tree, $right(j)$ is the right point of the child in the branches of the tree.

As with the MLR method of machine learning, RPM, MAP, FGP independent attributes were taken into account as input learning parameters of the RF model. The correlation matrix of the coupling can be seen in Table 2.

The parameters of the RF regressor that were taken into account in the training set are:

- *bootstrap = True*
- *n_estimators = 100*

8.1. RANDOM FOREST ENSEMBLE – EVALUATION OF THE OBTAINED RESULTS

After applying OLS and statistical methods of error measurement, the following results were obtained [Figure 12]:

```
                    OLS Regression Results
==============================================================================
Dep. Variable:                    y   R-squared:                       0.994
Model:                          OLS   Adj. R-squared:                  0.994
Method:               Least Squares   F-statistic:                 8.581e+04
Date:              Tue, 25 May 2021   Prob (F-statistic):               0.00
Time:                      23:22:32   Log-Likelihood:                -611.09
No. Observations:               552   AIC:                             1226.
Df Residuals:                   550   BIC:                             1235.
Df Model:                         1
Covariance Type:          nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -0.0306      0.084     -0.363      0.717      -0.196       0.135
x1             1.0008      0.003    292.939      0.000       0.994       1.007
==============================================================================
Omnibus:                      165.522   Durbin-Watson:                   1.919
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             1192.348
Skew:                           1.116   Prob(JB):                    1.22e-259
Kurtosis:                       9.845   Cond. No.                         66.8
==============================================================================
```

Figure 12. OLS evaluation of learned Random Forest model (test set)

- Mean Squared Error (test set) = **0.53**
- Root Mean Squared Error (test set) = **0.73**
- Mean Absolute Error (test set) = **0.52**
- R-squared (R^2) = **0.994**

A graphical representation comparing predictive and test values can be seen in Figure 13.
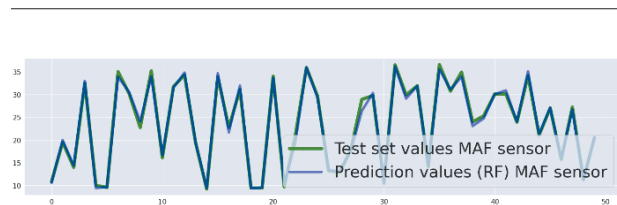
Figure 13. Comparative representation of RF model predictive and test results

9. CONCLUDING REMARKS

The main goal of the paper is to check the correctness of the MAF sensor reading in a car by applying machine learning tools over time samples obtained from the CAN-*bus* network of vehicles.

The paper presents a situation when the methods of simple linear regression take into account only one correlation attribute, namely the reading of the engine speed sensor (RPM), while other evaluations of the learned models of machine learning show the results obtained over test sets.

Since the nature of the data is linearly dependent, the application of multiple linear regression usually gives better results than simple linear regression while the best results are obtained by Random Forest ensembles learning methods. The simplicity and speed of implementation of the methods presented in the paper, as well as the size of the training set over which the evaluation models were performed, are acceptable for performing operations on minimal computing resources.

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Computer Science, Computational Methods, Algorithms and
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COMPUTER SCIENCE, COMPUTATIONAL METHODS, ALGORITHMS AND ARTIFICIAL INTELLIGENCE SESSION

CHOOSING THE BEST SHOPPING CENTER USING THE MULTI-CRITERIA DECISION METHODS

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Abstract:

This paper discusses the problem of choosing the shopping center which is the most suitable for doing shopping. In modern life circumstances, people constantly have less time available for activities such as shopping, especially in big cities, which gives the great deal of importance to this problem. Considering the fact that there is a large number of shopping centers, as well as many criteria which can directly influence the choice of the place where to go shopping, the problem is becoming more complex, so its solution requires using multi-criteria decision-making methods.

This paper explains two methods used for solving of the considered decision problem: the AHP and the PROMETHEE method. Both of these methods have a strong mathematical background, but also include personal opinion of the decision maker. This implies that the choice of the best shopping center is made considering both objective and subjective factors and is closely linked to the specific decision maker. The differences and similarities in the ranking lists obtained by applying the methods mentioned above, indicate that the results of multi-criteria analysis should be understood as a recommendation, whereas the final decision is still to be made by the deciding person. In order to perform multi-criteria analysis and apply its methods, software developed for that purpose were used.

Keywords:

Multi-criteria decision, Alternatives, AHP method, PROMETHEE method, Shopping.

INTRODUCTION

The complexity of the decision problem primarily depends on the nature of the decision-making system in which decision making is to be performed. Different circumstances and various limitations which exist in the system directly influence the choice of one of the possible alternatives. In the decision-making process, there is often a confrontation between wishes and real needs of the decision maker, on one side, and the available resources, on the other side. What is typical for these resources, is that they are always limited (by type or quantity). Also, when making a decision, several important parameters that characterize each decision should be taken into consideration and those are: the importance of the

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decision, the time needed for its making, the costs and the level of complexity.

The decision-making process includes four basic phases: identifying and defining the problem, creating a model, finding solution and implementing solution.

The poblem formulation implies getting an overall picture of the problem (orientation period), after which the components of the problem have to be defined, such as necessary skills the decision maker should have, as well as the decision criteria. Creating a model requires defining a set of possible alternatives, which are to be chosen from. Finding solution, or in other words - choosing the optimal alternative, can be carried out analytically, numerically or by simulation. The last step is the implementation phase, in which the solution obtained in the previous phase is applied to a specific problem.

2. MULTI-CRITERIA DECISION ANALYSIS

In many real-world situations [1], [2], in order to achieve the best possible decision, a large number of factors (criteria) needs to be taken into account, so that the decision could be relevant. The criteria can be mutually independent (for example, color and speed) or dependent (age and work experience) and sometimes even mutually opposed, which means that the fulfillment of one criterion can negatively affect the fulfillment of another criterion (price and quantity). Some of the criteria can be expressed quantitatively (weight), while some are described qualitatively (communicativeness). The criteria are usually not equally important to the decision maker, so criteria are often assigned priorities. In such conditions, decision making, which is now seen as multi-criteria decision making, means finding a compromise solution. The purpose of compromise solution is to achieve balance between the criteria, whereas, at the same time, it takes into account the preferences of the decision maker.

The multi-criteria decision-making process begins with the analysis of the problem and the identification of a set of criteria relevant for the decision making. In the beginning of the process, a set of possible alternatives that represent potential solutions to the problem, is also to be identified. Afterwards, an evaluation table is created, which contains values of all criteria for all of the alternatives. Using the evaluation table, the next step is to apply some of the existing multi-criteria decision-making methods (mainly with software support)

and obtain the final result: a ranking list of alternatives, from which can be easily seen which alternative is seen as the best.

In this paper, the process described above is illustrated in the example of choosing the best shopping center, using two multi-criteria decision-making methods, the AHP method and the PROMETHEE method, which will be presented in continuation.

3. THE AHP METHOD

AHP (*Analytical Hierarchy Process*, T.L.Saaty [3]) is one of the best-known methods of multi-criteria decision making. It is used in different fields for solving complex and unstructured decision-making problems, when multiple criteria are present [4]. The application of the method starts with structuring the problem, so that hierarchical structure of elements is formed (see Figure 1). The goal, which should be achieved as a result of successful decision making, is placed at the top of the hierarchy. The criteria, deriving from the goal, are to be found at the next level. If a particular decision problem requires, the criteria can be divided into sub-criteria, which are then located at the lower level. In a similar way, sub-criteria can be decomposed into further criteria levels. At the bottom of the hierarchical model, all the available alternatives are placed. Each of these alternatives is seen as the one that potentially meets the defined criteria, and in that way, the overall goal as well.
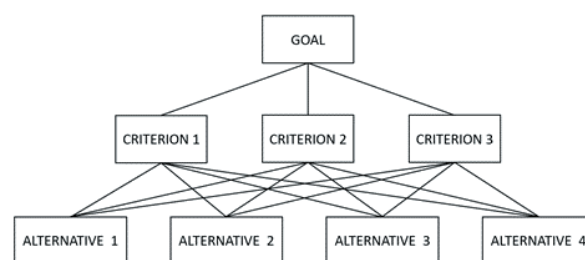
Figure 1 - Hierarchical structure of the problem.

In the second step, the elements in the hierarchy are assigned either numerical or descriptive values, based on which they will be compared. The AHP method consists of parwise comparison of elements at the same hierarchy level, with respect to the common element at the upper level.

The comparison is performed successively, starting from the first level. Firstly, criteria are compared in pairs, comparing each criterion with another one, whereby these pairs are evaluated with reference to the goal. The procedure is then repeated at each level of the hierarchy and is concluded with the parwise comparison of alternatives, which are to be found at the bottom of the hierarchy. When comparing pairs of elements, a scale of relative importance is to be used, typically Saaty's scale of relative importance. Therefore, when two elements E_i i E_j are being compared, the importance, that is the priority of one element over another is to be established and, according to the scale applied, the numerical parameter a_{ij} is to be determined. After all pairs have been evaluated, an *nxn* matrix *A* is assembled, where n represents the number of elements at the specific hierarchy level. The elements of the matrix *A* have the properties given in Equation 1:

$$\forall i = 1,...,n, \forall j = 1,...,n : a_{ij} > 0$$
$$\forall i = j : a_{ij} = 1$$
$$\forall i = 1,...,n, \forall j = 1,...,n : a_{ij} = a_{ji}^{-1}$$

Equation 1 – Definition of matrix A.

The next step is to calculate the relative weights of the elements (criteria, sub-criteria or alternatives) in relation to the higher-level element. To achieve that, each parameter a_{ij} of the matrix $\mathcal{A}$ has to be represented as the quotient of the local weights of the elements, that is $a_{ij} = w_i/w_j$. Using this matrix form, the normalized elements weight vector $w = \{w_1, w_2,...w_n\}^{T}$ is to be determined by means of one of the following methods: the additive normalization, the eigenvalue/eigenvector method, the logarithmic least squares method, etc.

In the end, the vector w should be multiplied by the weight coefficient of the higher-level element, with respect to which the comparison was done. This procedure is repeated in sequence, going from higher to lower levels of the hierarchy, until the lowest level with alternatives is reached. The final result, a composite normalized vector for the complete hierarchy, is obtained by multiplying the local weight vectors of each hierarchy level. By means of the composite vector, it is possible to determine the relative priority of alternatives against the goal, which results in their ranking and the choice of the best alternative.

3.1. THE SUPERDECISIONS SOFTWARE

For the purpose of quicker and more efficient application of the previously described decision method, multiple software tools which implement AHP method have been developed. In this paper, the *SuperDecisions* softver [5] was used, created by Saaty, the author of the method.

SuperDecisions software allows the following procedures:

- generating a hierarchical structure of the problem
- pairwise comparison of elements in a hierarchy (by means of matrix or graphically)
- calculation of relative weights of elements
- determination of the ranking of alternatives
- conducting sensitivity analysis which questionates how the change of input data would influence the ranking of alternatives

4. THE PROMETHEE METHOD

PROMETHEE (*Preference Ranking Organization Method for Enrichment Evaluation*, J.Brans [6]) represents a family of six methods that serve for ranking of alternatives, based on multiple criteria. These methods have wide application in different fields (medicine [7], chemistry, banking, etc.), primarily due to their mathematical background, ease of use and the stability of the results achieved by means of them.

The basis of the PROMETHEE method consists in pairwise comparison of available alternatives. The choice of the best alternative doesn't only depend on a set of established criteria and alternatives given, it is moreover influenced by personal beliefs and preferences of the decision maker. Therefore, the solution of a concrete decision problem can't be seen as the best in general, but only as the best according to a specific decision maker.

Let the following multi-criteria problem be given $\max\{k_1(a), k_2(a), \ldots, k_p(a) \mid a \in A\}$, where A represents a finite set of available alternatives which are to be ranked, whereas $k_1,...,k_p$ are previously defined criteria. The values of each criterion against each alternative are stored in the evaluation table (see Table 1).

Option	k_1	k_2	...	k_j	...	k_p
a_1	$k_1(a_1)$	$k_2(a_1)$	...	$k_j(a_1)$	...	$k_p(a_1)$
a_2	$k_1(a_2)$	$k_2(a_2)$	...	$kj(a_2)$	...	$k_p(a_2)$
...	...	...	...	...	...	...
a_i	$k_1(a_i)$	$k_2(a_i)$	...	$k_j(a_i)$	...	$k_p(a_i)$
...	...	...	...	...	...	...
a_q	$k_1(a_q)$	$k_2(a_q)$	...	$k_j(a_q)$	...	$k_p(a_q)$

Table 1 - Evaluation table.

On the basis of the evaluation table, the comparison of each pair of alternatives is carried out against each of the criteria. The result of comparing two alternatives a_m i a_n against the criterion k_j is given as the preference function $P_j(a_m,a_n)$, whose values are falling to the interval from one to zero [0,1]. The value 0 shows the indifference between alternatives, while the value 1 indicates the strong preference of the first alternative over the other one. The six preference functions (Usual, U-Shape, V-Shape, Level, Linear and Gaussian) are defined by the author of the method, which show how the value of the preference function depends on the difference $d_j(a_m,a_n)$ = $k_j(a_m)$-$k_j(a_n)$.

The decision maker, according to his affinities, assigns one of the preference functions to each criterion. Given that the result of comparison of two alternatives (a_m i a_n) against a criterion (k_j) is the value $P_j(a_m,a_n)$, the relation of two alternatives with respect to all criteria can be described by the preference index IP defined by Equation 2, where w_j are the relative weights belonging to criteria.

$$IP\left(a_m,a_n\right) = \sum_{j=1}^{p} w_j P_j\left(a_m,a_n\right)$$

Equation 2 – Preference index calculation.

The preference indices are calculated for every pair of alternatives and both values $IP(a_m,a_n)$ and $IP(a_n,a_m)$ have to be defined. They are then used for either partial (PROMETHEE I) or complete (PROMETHEE II) ranking of alternatives. Therefore, based on the preference indices, three preference flows are calculated as it is given in Equation 3: (1) the positive (outgoing) preference flow $T^+(a)$, (2) the negative (incoming) preference flow $T^-(a)$, and (3) the net preference flow $T(a)$.

$$T^+\left(a\right) = \frac{1}{p-1}\sum_{x \neq} IP\left(a,x\right) \quad (1)$$

$$T^-\left(a\right) = \frac{1}{p-1}\sum_{x \neq} IP\left(a,x\right) \quad (2)$$

$$T\left(a\right) = T^+\left(a\right) - T^-\left(a\right) \quad (3)$$

Equation 3 – Preference flows.

The positive or outgoing flow indicates how the alternative a is prefered to all the other alternatives. On the other hand, the negative or incoming flow shows the degree of domination of other alternatives over the alternative a. In other words, the positive flow reflects the overall strength, while the negative flow expresses the overall weakness of the alternative. The higher the positive flow, the better the alternative. When it comes to negative flow, the alternative is better with its negative flow being lower. In conslusion, the net preference flow can be seen as the relevant parameter for the complete ranking of alternatives, which means that the alternative choosen as the best will be the one with the highest net flow.

4.1. THE *VISUAL PROMETHEE* SOFTWARE

In this paper, *Visual PROMETHEE* software [8] has been used for method application. The software was approved by the author of the method and it enables creating a scenario in which the decision maker defines alternatives, criteria and preference functions, based on which alternatives are rated and ranked partially or completely.

The software offers different ways of vizualization of results: PROMETHEE Diamond (two-dimenzional representation in form of angled plane which combines both partial and complete ranking), PROMETHEE Network (a net of nodes in which incomparable alternatives are easy to detect), PROMETHEE Rainbow (shows the final ranking, including contribution of each criterion), GAIA (graphical representation of alternatives and criteria on the GAIA plane, pointing out their mutual relations).

In addition to this, the software also contains a useful tool called *Walking Weights,* that allows to analyze how the change of criteria weights affects the final ranking of alternatives. In this way, it is possible to determine the intervals in which criteria weights could vary, without causing changes in the ranking of alternatives.

5. CASE STUDY

The multi-criteria decision-making methods described in this paper (AHP and PROMETHEE) have been applied to the problem of choosing the most appropriate shopping center (SC), which is the best for doing shopping or other leisure activities that shopping centers usually offer. The interest for this problem has to do with the fact that life has become fast in modern times, which results in the lack of free time in general, as well as in the lack of time for going shopping. That is why the help with choosing a particular place (shopping center), would be very welcome for an average person.

At the time of writing this paper, the following six shopping centers were considered to be the most visited in Belgrade and therefore choosen as alternatives, based on which the decision making was conducted:

a_1 Delta City

a_2 Ušće Shopping Center

a_3 Stadion Shopping Center

a_4 Big Fashion Shopping Center

a_5 Rajićeva Shopping Center

a_6 Ada Mall

The shopping centers will be compared with respect to the following five criteria:

k_1 The retail area

k_2 The car parking options

k_{21} The number of parking spots

k_{22} The parking fee

k_3 Nearby public transportation options (total number of public tansportation lines)

k_4 The location (the distance from the city center)

k_5 The average attendance

k_{51} The attendance on Wednesdays

k_{52} The attendance on Saturdays

As can be seen, the second and the fifth criterion are divided into two sub-criteria. The average attendance includes two sub-criteria as well, which is important because there is a significant difference when it comes to number of visitors on weekdays (in this case, on Wednesday) and on the weekend (on Saturday).

The values for each criterion/sub-criterion for every alternative are given in Table 2. The number of parking spots (k_{21}) is expressed in hundreds, while the parking fee (k_{22}) is given in din/h, with the fact that the alternatives a_1 i a_2 have no parking fee during the first three

hours, whereas the alternative a_5 includes free parking during the first 30 minutes. The criterion k_3 refers to the total number of public transportation lines by which the shopping center can be reached. Furthermore, the attendance (k_5) shows the number of shopping center visitors in the period from 5pm to 8pm, considering location-based check-ins suggested by Google. This criterion is assigned values from 1 to 4, with 4 expressing the biggest attendance and 1 indicating the smallest number of visitors.

SC	k_1 ($10^3 \, m^2$)	k_2		k_3	k_4 (km)	k_5	
		k_{21}	k_{22}			k_{51}	k_{52}
a_1	30	11	100	10	5.8	3	4
a_2	50	13	100	22	2.9	3	4
a_3	28	0.8	-	4	7.7	3	4
a_4	32	8	-	10	4	2	4
a_5	15.3	4.5	100	9	1	3	4
a_6	34	10	-	21	6.2	2	4

Table 2 - The values of criteria for all alternatives.

5.1. APPLICATION OF THE AHP METHOD

In order to conduct the multi-criteria decision analysis using the AHP method, the hierarchical structure of the problem was created according to the criteria definition given in Table 2 by means of *SuperDecisions* software.

Afterwards, the alternatives are pairwise compared with respect to a higher-level element, starting from the first level, at which criteria are to be found. If a criterion is diveded into sub-criteria, the comparison of the alternatives (which are at the bottom level) is done against the sub-criteria. If there are no sub-criteria, alternatives are compared with reference to the criteria given. With the aim of comparing the elements, Saaty's nine-point scale was used.

The comparison results were placed in the pairwise comparison matrix. For example, in case of comparing the given alternatives with respect to the number of parking spots, the matrix will have the form shown in Table 3.

k_{21}	a_1	a_2	a_3	a_4	a_5	a_6	Priority
a_1	1	1/4	5	5	7	3	0.238
a_2	4	1	6	6	9	5	0.470
a_3	1/5	1/6	1	1	5	1/4	0.061
a_4	1/5	1/6	1	1	5	1/4	0.061
a_5	1/7	1/9	1/5	1/5	1	1/7	0.023
a_6	1/3	1/5	4	4	7	1	0.147

Table 3 – The comparison of alternatives with respect to the number of parking spots.

Based on all pairwise comparison matrices, the *SuperDecisions* software generated the ranking of the alternatives as shown in Figure 2.
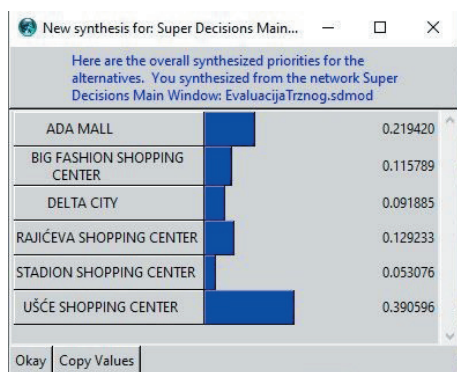
Figure 2 - The ranking of alternatives using the AHP method.

5.2. APPLICATION OF THE PROMETHEE METHOD

The application of the PROMETHEE method to the considered decision problem using *Visual PROMETHEE* software starts with defining the scenario and its parameters that is the input data related to alternatives and criteria given in Table 2.

Compared with the AHP method, the criteria are now organized in a different way. Namely, the criteria are classified considering some of their common features. The groups of criteria can then be grouped into clusters. In this particular example, the sub-criteria defined in the hierarchy can be seen as criteria, which are then grouped, depending on their nature.

Firstly, it was defined whether a particular criterion has to be minimazed or maximazed. If a criterion is quantitative, it was expressed in a suitable unit of measurement.

In order to rate criteria, appropriate evaluation scales were defined for qualitative criteria (*yes/no*, 5-point scale and 4-point scale, depending on specific criterion).

The weights of the criteria are the same as the ones calculated by means of the AHP method. For each criterion, a preference function was defined using the appropriate tool available in *Visual PROMETHEE* software (the decision maker fills out a questionnare based on which their affinities are determined).

The alternatives were grouped into two categories depending on whether the shopping center was opened in the last five years or earlier.

Using the data entered by decision maker, the software calculates the partial ranking of alternatives (PROMETHEE I method), which shows that SC Ušće has the highest positive and the smallest negative flow, so it is certainly the best alternative. It can be noticed that there are two pairs of alternatives which are incomparable.

Figure 3 shows the complete ranking of alternatives (PROMETHEE II method), in which the obtained ranking is based on the net flow.

$$\forall i = 1,...,n, \forall j = 1,...,n : a_{ij} > 0$$
$$\forall i = j : a_{ij} = 1$$
$$\forall i = 1,...,n, \forall j = 1,...,n : a_{ij} = a_{ji}^{-1}$$
$$IP(a_m, a_n) = \sum_{j=1}^{p} w_j P_j(a_m, a_n)$$
$$T^+(a) = \frac{1}{p-1} \sum_{x \neq} IP(a, x)$$
$$T^-(a) = \frac{1}{p-1} \sum_{x \neq} IP(a, x)$$
$$T(a) = T^+(a) - T^-(a)$$

Figure 3 - The complete ranking using the PROMETHEE II method.

6. CONCLUSION

From the ranking results obtained by the application of the AHP and the PROMETHEE decision-making methods, it can be seen that the alternative SC Ušće is the best in both cases, followed by Ada Mall, whereas there are slight differences in the ranking of other alternatives. The main reason for that is the fact that personal beliefs, foresights and experiences of the decision maker are differently modelated in each of these two methods. Therefore, it would be possible to obtain different rankings even if the same method would be applied by two decision makers (for example, in case of PROMETHEE method, based on the affinities of the decision makers, two different scenarios could be defined, including different preference functions). What can be concluded is that each decision could be seen as good enough, provided that it uses the algorithm of multiple criteria decision making. Certain requirements and opinions of the specific decision maker are also a crucial part of making a potentially good decision

In order to make the best possible decision, these two methods can be interconnected, so that each of them can use other method's results [9]. For example, in this paper the weights of the entities were determined by applying the AHP method, which were then used for ranking of alternatives by means of PROMETHEE method. The use of available programs simplifies the entire decision-making process, since the results are generated straight away.

One of the biggest advantages of both methods is the possibility to perform a sensitivity analysis, which shows how changes in importance of criteria influence the ranking of alternatives.

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CURRENT ASPECTS OF USING ARTIFICIAL INTELLIGENCE IN DIGITAL GAMES AND COMPUTER GRAPHICS CONTENT CONTROL

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Abstract:

The extraordinary size and influence of gaming industry on contemporary (digital) markets creates a vast pool of resources (material and abstract) that is constantly refilled and used in order to make modern digital games of all kinds and genres as attractive and performant as possible. A key component of almost every complex digital game that is developed today is its artificial intelligence module. Due to the variety of problems that can be and are solved by using artificial intelligence in digital games its functionality is practically essential.

The paper describes the application of artificial intelligence methods, its implementation in the content generation process, as well as modelling the gameplay. The game design directly conditions the complexity and performance of artificial intelligence module. It should be noted that the digital games that so far used mode advanced artificial intelligence techniques had variable success, which implies that this area of application still needs to be fully defined, and that the future technological/software progress will further determine the level of freedom that game designers will have in their creativity.

Keywords:

Digital Games, Computer Graphics, Artificial Intelligence.

INTRODUCTION

The field of artificial intelligence is rapidly evolving for the benefit of various industries and applications. The creation of interconnected and intraconnected machines, devices and software is enabled by using multidisciplinary and interdisciplinary approaches in the fields of mathematics, computer science, technology, psychology, art, linguistics, etc. When we carefully observe the fantastic world of digital games as one of the highest software abstractions or entities, it is natural that the question of managing and controlling this incredibly complex digital environment must come in order. Interestingly, even though they are incredibly complex, digital games bear probably the least risk to human life and wellbeing in real-world application of all IT industry fields, if you exclude the possibility of one developing digital game addiction, of course.

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The importance and potential of digital games industry have been recognised for the last half century, as the IT gradually entered everyday human lives and gaming became primary leisure human activity today.

Digital games are important application of artificial intelligence today, and presents an excellent platform for implementing adaptive intelligent agents. As a base, machine learning can naturally make digital games more interesting and reduce the production cost.

The rest of the paper is organized as follows. The Section 2 focuses on the typical applications of artificial intelligence in digital games. Subsequentially, the novel algorithmic approaches that are used in contemporary digital gameplay design are described in brief following the application of artificial intelligence in procedural content creation and player modelling. Section 3 gives concluding remarks on the topic.

2. THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN DIGITAL GAMES

The historical development of digital games greatly correlates with the development of artificial intelligence and neural networks. For a long time, artificial intelligence managed gameplay agents combined with learning components was the primary approach in this symbiosis [1]. Early research mainly focused on more traditional game concepts with simple rules but great complexity in solving, such as Chess (e.g., IBM Deep Blue [2]). During the late 20th century (e.g., 80's), another alternate use of artificial intelligence emerged – procedural content creation. One of the first famous examples of successful implementation in the field of home PC gaming market was the Elite, a space simulation game that used artificial intelligence for creating vast simulated universes with their unique star systems and planets without the need for manual static design which greatly reduced the memory requirements [3]. This was extremely important at the time when home computers were scarce and very limited in processing power, memory and storage space. Even though computers are nowadays digital data powerhouses, previous application modality is still being used extensively. Existing procedural content generation methods, such as search-based, solver-based, rule-based and grammar-based methods have been applied to various content types such as levels, maps, character models, and textures [4]. For the last two decades, artificial intelligence started being used in analysing gameplay characteristics and modelling player profiles.

As the global gaming market exploded thanks to the internet (among other factors) it became very important for game designers to appeal very diverse audience, in age, interests, culture, language, financial background, digital literacy, religion, etc. Nowadays, practically every successful commercial game continuously collects gameplay data and analyses it with the support of artificial intelligence agents [5][6], and even consumer electronics manufacturers started providing artificial intelligence-based metrics to (semi) professional players, e.g., HP OMEN Command Center (Fig. 1).
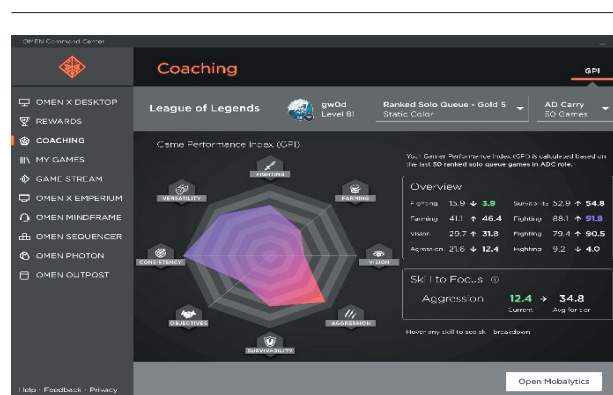
Figure 1 – AI coach in HP OMEN Command Center

2.1. KEY GAMEPLAY AI ALGORITHMS

When we talk about modern digital games, finite state machines, behavior trees, and utility-based artificial intelligence are authorship methods that traditionally dominated the control of non-player characters (NPCs) [7]. Finite state machine (FSM) and the hierarchical finite state machine (HFSM) variant were mostly used in NPC control and decision-making processes a decade ago.

Contrary to supervised learning where agent is provided with the action as a response to various states (e.g., human labelled data was provided for the algorithm to learn patterns), Reinforcement Learning agent interacts with the environment and usually learns to perform through rewards. Maybe the biggest challenge in successful applying reinforcement learning is balancing short- and long-run high rewards, i.e., exploit vs explore [8]. Still, random trial and error is a key component and the method by which agent must begin leaning to receive a reward. Unlike other machine learning techniques, reinforcement learning is not limited to (human) labelled data. Still, it should be noted that the examples of successful implementation of reinforcement

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learning in commercial games are extremely scarce (e.g., Black & White) as It demands extensive data manipulation and customization.

By combining reinforcement learning and deep neural networks researchers created algorithm that can learn directly from sensory streams – Deep Reinforcement Learning [9]. Images, videos and sounds can all present a valid high-dimensional input that the algorithm can use without pre-processing. Deep reinforcement learning algorithm is often used in modern games (e.g., StarCraft, MOBA, Dota2, Minecraft) [10]. Even though the algorithm is one of the most promising, some challenges for its wider implementation in digital games such as balancing between exploration and exploitation, low sample efficiency, problems with generalization, multi-agent learning, etc., still need to be addressed.

Deep Learning is a broad term but when we talk about digital games the idea is to progressively learn high-level features through layers of nonlinear processing. Efficient fast GPUs and affordable video memory enabled DL methods to surpass image and speech recognition applications towards even more complex cases, such as automatically learning player models that are used for fast artificial playtesting of new levels during game development [11] (Fig. 2). Recent advances in deep learning have been additionally accelerated because of the increased interest by a variety of different companies such as Facebook, Google/Alphabet, Microsoft and Amazon, which heavily invest in its development [12].
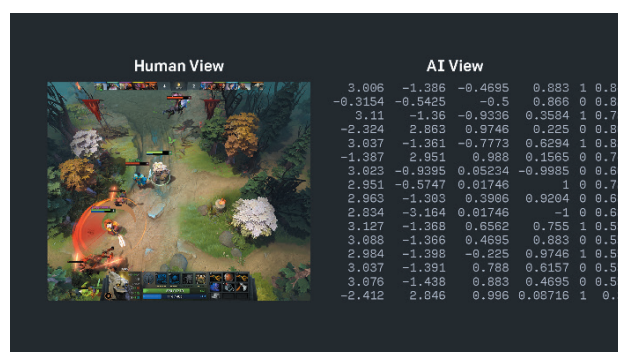
Figure 2 – OpenAI Five playing Dota2

Contrary to the traditional alpha/beta game development sequence, Monte Carlo Tree Search algorithm uses controlled explore & exploit of previously obtained knowledge and often fully randomized playouts.

This algorithm can be applied to large trees but cannot guarantee optimal solution. Win/Loose information is propagated up to the tree root and every node holds an estimate of the win ratio so the search can be directed. One of the most successful implementations of the Monte Carlo Tree Search algorithm is controlling opponent human-like behaviour in fighting games [13][14][15].

When traditional methods of optimization stalls or cannot be applied because of the lack of numeric objective values Evolutionary Algorithms comes to light. The idea is to do parallel search by concurrently improving means of populations of various candidate solutions. This flexibility enabled evolutionary algorithm often outperforming deep learning machines playing digital games. As it currently stands, evolutionary algorithm will be in the focus of great number of researches for its further application in digital game design and production in near future.

2.2. PROCEDURAL CONTENT CREATION

Using artificial intelligence in digital game procedural content creation increases its replayability by offering players new experience every time they play.

For example, Civilization series (Fig. 3), World of Warcraft: Shadowlands, Microsoft Flight Simulator, Minecraft, etc., all use procedural content generation methods as part of their core gameplay engine which enable player exploring practically unlimited varieties of digital gameplay environments and the creation of extremely large game worlds even on devices with relatively modest memory capacity, such as low-spec computers and smartphones.

Figure 3 – Civilization VI uses procedural content creation method for world map customization

One interesting and very applicable filed of using procedural content creation approach is in training deep reinforcement learning artificial intelligence agents. As a matter a fact, using deep reinforcement learning in playing digital games has one crucial flaw – if the environment that agent trained on is not exactly the same as in the actual game – the method overfits. By using procedural content creation in their training, agent performance became significantly more general [16].

2.3. GAME ANALYTICS AND PLAYER MODELLING

Game analytics is currently the main use case of artificial intelligence in digital games industry. In addition to previously mentioned learning to play and content creation, game analytics is crucial in collecting data about the player while in the game and then ad hoc updating the game so for instance the difficulty level could be automatically adjusted accordingly or user interface could be streamlined [17].

Another important application of artificial intelligence in adaptive gameplay paradigm is player modelling. Modelling can be executed via supervised (e.g., training a neural network on recorded human gameplay) or unsupervised learning. The combination of procedural content creation and player modelling allows the algorithms to automatically generate unique content in accordance to player desired experience [18]. This approach is called Experience-Driven Procedural Content Generation.

A decade ago, focus of many researchers was the human-like behaviour of NPCs, and with the new interest in human-AI collaboration it is likely that it will be in the spotlight again.

Debugging and playtesting during game design and production is another field of artificial intelligence application that shown some encouraging results. Balancing game mechanics is crucial to the gameplay quality and the success of game in general, and is still under-researched area that may be exploited.

3. CONCLUSION

As digital game development companies and studios are more and more collaborating with academic research institutions, latest innovations in artificial intelligence will surely find their commercial application quickly. Procedural content creation and deep reinforcement learning are already a part of some of the biggest gaming franchises, so their further development and implementation is secured. Near future will probably bring into play a combination of some machine learning techniques and procedural content creation [19], such as Generative and Adversarial Networks. This will enable players further personalisation of their game avatars in a level so far unprecedented and realistic.

Future applications of artificial intelligence in digital games will probably lead to better collaboration between various agents, better automated playtesting and natural language processing to the extent that at some point there will be free-form direct communication between players and NPCs.

In conclusion, the desire to apply more artificial intelligence algorithms to complex digital games is clear, but the real-life implementation has many obstacles. Starting with having very little control over the deep learning methods actual performance to hardware limitations when experimenting with parallel computation. It is obvious that only a limited portion of academic research in the field of artificial intelligence is actually applicable when we observe digital game industry.

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AUTOMATED COMPLIANCE SYSTEM FOR SERVICE ORGANIZATIONS

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Abstract:

Cloud-based applications are becoming an increasingly important component for many enterprises. For customers' data to remain confidential and secure, service organizations must adhere to security and privacy best practices, applicable laws, and regulations. There has been some effort to develop uniform standards for cloud security, but most service organizations need to apply with a combination of security and privacy regulations and standards. For early-stage technology companies, this mission can be even more challenging since they are oriented towards product development and have limited resources to invest in the compliance of security, availability, confidentiality, integrity, and privacy.

These risks have led to uncertainty among Software-as-a-Service ('SaaS' customers about what measures they should require from their IT vendors and whether those measures will be in line with their policies and commitments to their customers. The rapidly evolving cloud utilization of corporations migrated to the cloud, or new technology companies (start-ups) has led to a security audit examination report. The report developed from the accounting audit, based on global accounting audit methodology and the COSO framework examined by technology auditors.

This paper integrated a study case of a Service Organization's security audit in the field of financial payment.

An automated compliance system has been proposed that could assist both Service Organizations and Service Auditors to ease the audit process and make it more efficient and effective, compromise lack of expertise, save employees' time, decrease human errors, and eliminate non-compliance issues by automation, integrations, machine learning, and pre-designed workflows.

Keywords:

Cloud computing, information security, IT audit, compliance, ISMS.

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INTRODUCTION

1.1. CLOUD STRUCTURE AND SERVICES THAT CLOUD PROVIDES

Cloud computing is an application-based software infrastructure that stores, process and manage data on a remote server (data centre), which can be accessed through the Internet to the backend by the Cloud Provider or the application by the end-user client that uses the results.

Cloud providers offer a broad set of global cloud-based products, including computing power, databases, storage, networking, analytics, management tools, and more.

In a cloud computing architecture, objects are organized into the components and subcomponents that form cloud computing. These include a client-side platform, a server-side platform, a cloud-based delivery mechanism, and a network.

Consequently, the cloud computing architecture consists of these components.

1.2. SERVICES THAT THE SERVICE ORGANIZATIONS OFFERS TO END-USERS

The software-as-a-service model allows applications to be delivered via the Internet. The software can be accessed via the Internet instead of being installed and maintained, freeing organizations from complex software and hardware management. Almost every industry can benefit from SaaS implementation. Service Organizations provide a variety of services, including:

- Managed Security: Security Information and Event Management (SIEM), anti-malware, network configuration scanning, source code vulnerability analysis, Identity, access management, and incident management.

- Organizational Systems: recruitment human resource management, change management system, vendor risk management, customer relationship management, and sales analysis.

- Financial services: transaction processing, payment processing, purchasing, peer lending, payroll management, financial compliance, VAT reclaim, Tax refund, and Insurance on-demand.

- Healthcare: remote diagnosis, medical surgery video analysis, visual aid, blood diagnostics, and more.

1.3. DEFINED SECURITY REQUIREMENTS

Management remains responsible for risk arising from Service Organizations to regulators, boards of directors, shareholders, and customers. A service organization's internal environment is controlled by its management, responsible for setting the controls.

For assessment, prioritization, administration, and mitigation of the risks associated with service organization systems and processes, enterprises request information periodically on the design, operation, and effectiveness of controls across the platform.

To strengthen their risk assessment procedure, companies may request Service Organization to comply with specific standards based on their geographic location, industry, technology, and internal policy.

For example, while European enterprises request compliance with ISO/IEC 27001 framework, United States enterprises request compliance with the AICPA SOC 2 framework. Therefore, the security requirements are subjected to the framework the company has been asked to comply with by their customers.

1.4. DEFINED SYSTEM MODEL CLOUD PROVIDER – END-USER

Companies of all sizes, types, geographies and industries use cloud services for various use cases, including customer-centric web applications, disaster recovery, backups, virtual desktops, software development, testing, and big data analytics. Service locations, data centers, or hardware platforms and the operating systems on which applications do not matter much to end-users.

The main advantages of cloud computing are (1) agility, (2) resilience, (3) reliability, and (4) fault tolerance. There are three methods of cloud computing [1]:

1. Infrastructure as a Service (IaaS) - virtual hardware resources which provide access to computers (physically or virtual machines), network capabilities, and storage space. This is managed by the Cloud Provider, including secure design, physical access, surveillance and detection, monitoring and logging, infrastructure maintenance, device management, business continuity, and disaster recovery;

2. Platform as a Service (PaaS) – Procurement of IT resources, software maintenance, capacity planning, OS patch management. It allows Service Organization not to have to manage basic infrastructure and focus on application management. They provide customers with services built on their infrastructure;

3. Software as a Service (SaaS) – A complete cloud-based product or platform maintained, managed, and operated by a Service Organization, also called 'end-user application.' It allows the end-user (customer) to focus on its core services and outsource supportive or internal IT applications.

Compliance and security are the joint responsibility of the Cloud Provider and the Service Organization. The Cloud Provider manages the elements and addresses

them from the Physical Security of the objects (i.e., data center) to the host operating system and virtualization layer in which the service operates. The nature of the shared responsibility also gives Service Organizations increased control and flexibility over their assets. This division of duties can be considered the security of the cloud (Cloud Provider) instead of the security in the cloud (Service Organization).

2. SECURITY OF THE MODEL

The risks and threats for the global IT enterprise environment are dynamically and constantly evolving, as threat actors discover new vulnerabilities and advanced methods of exploiting them. There is no need to set up a large office, expensive equipment, and qualified staff. All required is a computer, Internet connection, and time devoted to learning cyber hacking techniques. The threat actor can act from any country globally and can compromise any enterprise in any country. State-sponsored actors are highly knowledgeable, have access to sophisticated resources, and are heavily funded. Other threat actors are activist groups that generally do not want to steal money or trade secrets but want to expose the observed "wrongdoings" of large enterprises or promote their reputation. The internal threat actor is another threat that needs to be considered; these are disloyal, frustrated, or negligent employees that can use their access privileges and position for fraud, scams, or stealing of confidential information. As risk is defined as a vulnerability meeting threat [2], enterprises should identify risks and reduce them to an acceptable level.

Service Organizations have to deal with these threats by defining the organization and regulations they need to comply with, performing baseline assessments based on a chosen security framework, identifying gaps, assigning organizational responsibilities and timelines to monitor and remediate internal control, and leveraging external audits incorporate change management triggers.

2.1. INFORMATION SECURITY STRATEGY

Information security strategy requires a top-down approach, management commitment, and a direct link to the business goals [3]. For protection to be adequate, it must deal with complete administrative, operational, and technical controls related to people, procedures, technology, and data. To ensure proper governance, a set of organizational standards should be developed to

provide accepted defined limits for the minimum-security baseline required for different aspects.

Strategy implementation must be implemented through an Information Security program that includes approved policies and standards by stakeholders. In short, the information protection program must consist of elements such as:

- Assignment of roles and responsibilities;
- Periodic risk assessments and impact analysis;
- Information assets must be identified and classified; controls must be appropriate, efficient, and adequate;
- Integrate security into all processes in the organization;
- Monitor security elements;
- Access management methods that ensure proper authentication of identities and access permissions for information users;
- Meaningful metrics;
- Instructions on information security obligations for all employees, including management and board members;
- Training for the functioning of security processes, as needed;
- Develop and test business continuity plans for outages or disasters.

The basic information security program will utilize a combination of technological, procedural, and administrative controls (e.g., Physical Security, Environmental Security) to protect information assets, background checks, onboarding / offboarding employee, identity access management, IDS / IPS, firewall, cryptography, anti-virus, penetration test, vulnerability scan) as well as automated and manual controls. In addition, these controls should specify a reduction of potential consequences to an acceptable level set and approved by senior management that addresses both vulnerabilities and threats.

2.2. MUTUAL RESPONSIBILITY

Traditionally, enterprises were responsible for all aspects of security, including applications, physical servers, user controls, and physical perimeter security. The Cloud Service Provider (CSP) offers relief to Service Organizations by taking on a portion of many operational duties, including security. The shared responsibility model [4] clearly defines ownership of protection

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between the Cloud Provider and Service Organization; each retains complete ownership over assets, processes, and functions. Service Organizations can secure their environments more easily by collaborating with a CSP and sharing security responsibilities. The responsibility for cloud security, data protection, and privacy lies with both customers and cloud service providers.

Responsibility	On-Premises	SaaS	PaaS	IaaS
Data Governance	C	C	C	C
Endpoint Protection	C	C	C	C
User Access Management	C	C	C	C
Identity Infrastructure	C	C CSP	C	C
Application	C	CSP	C	C
Network Control	C	CSP	C	C
OS Security	C	CSP	CSP	C
Host	C	CSP	CSP	CSP
Network	C	CSP	CSP	CSP
Data Centre	C	CSP	CSP	CSP

Table 1 - Mapping responsibility for data security requirements to cloud service models
C= Client; CSP = Cloud Service Provider

2.3. SECURITY STANDARDS

Defines requirements for the formulation, implementation, management, and improvement of the information security management system (ISMS) [5]. The objective of a standard is to assist companies in Securing their information resources and keeping risk low. Enterprises that meet the requirements of a standard may decide to be certified by a certification body (depending on the standard and industry) upon completing an audit performed by a certified auditor of an approved certification body.

There are dozens of comprehensive security standards available, and enterprises choose those that work for their business needs based on customers' requests, laws, and regulations, creating a competitive edge or the strategic security decision of the management. A few well-known security standards are the following:

- ISO/IEC 27001 - an international standard that deals with the management of information security management systems. A joint effort by ISO and IEC was responsible for the publication of the standard [6];

- NIST - The National Institute of Standards and Technology [7] in the USA formed several frameworks, including SP 800-53 and the Cybersecurity framework. Despite being a federal law, it is also widely applied in state and local governments and private organizations. Federal and state government agencies must follow it. Many private organizations, too, use NIST SP 800-53 as their security controls framework.

- Cloud Security Alliance (CSA)- The CSA [8] is a global organization working to identify and improve cloud security standards. Through its educational programs, research, events, and products, the CSA leverage the subject matter expertise of industry professionals, associations, governments, companies, and individual members to deliver cloud security-specific information. A cloud control framework was developed by the CSA, known as the Cloud Controls Matrix.

- SOC 2 Type II - Formed by the American Institute for Certified Public Accountants (AICPA) and utilizing the COSO framework [9], a Service Organization Control (SOC) 2 is an internal control examination of the outsourcing of services performed by an organization. SOC 2 provides valuable information that can be used to assess the risks associated with outsourced services. This audit function inspects the system regarding security, availability, confidentiality, processing integrity, and privacy.

3. IMPLEMENTATION

The SOC 2 Type II examination is used to assess the effectiveness of controls in a service organization. The controls are designed and mapped based on the AICPA COSO framework by the Service Organization. The Trust Service Principles (TSP) is divided into five principles: Security, availability, confidentiality, processing integrity, and privacy. When assessing the design and operational effectiveness by at least one of the principals, the TSP Service Organization may be used.

An organization's internal control system may be at risk for failure because of the following factors:

1. Identify the nature of the enterprise's activities;
2. A company's operating environment;
3. Information that the enterprise generates uses, and stores;

4. Contracts signed between an organization and its customers and third parties;

5. Responsibilities related to the management and maintenance of enterprise systems and processes;

6. Technology, connection methods, and delivery channels used to serve customers;

7. Service Organizations can utilize third-party resources that have access to the Service Network and data to provide elements to the Service Network;

8. Changes from the following: system operations, data processing, management governance, supported by the functions, regulatory and legal requirements that Service Organizations should adhere to;

9. Introduction of new services, products, or technologies.

Service Organizations address these risks by implementing control mechanisms that, if effective, give reasonable assurance of the attainment of the objectives. For each TSC, the framework also presents areas of focus based on experience and judgment to be utilized in real-world situations.

A key component of COSO's Internal Control-Integrated Framework is the emphasis placed on the points of focus that are intended to represent important aspects of the criteria.

A Service Organization's management can use these focus areas to design, implement, and operate controls for security, availability, confidentiality, processing integrity, and privacy.

Additionally, management and auditors can use the focus points to determine whether the controls are adequate in design and operation to achieve the Service Organization's control objectives.

3.1. DESCRIPTION

The Case study focuses on SOC 2 Type II examinations. A Service Organization's effectiveness of the design and operating of controls contained in its management's system description document relative to security, availability, and confidentiality during a given period for achieving its goals based on the criteria in a SOC 2 Type II. A SOC 2 Type II engagement includes an auditor's opinion about the design and operating effectiveness of controls implemented in Service Organizations. These documents also provide detailed information on the

audited systems and controls and the results of those tests. An organization's software, procedures, and data are created, implemented, and managed by employees to achieve company goals and meeting management's specific needs.

System segments can be classified into five categories:

1. Infrastructure - IT environment that consists of physical and virtual resources managed by Service Organization to provide services. The physical environment, related structures, information technology, and hardware are all considered.

2. Software - Applications supporting the operating systems, middleware, and utilities of the infrastructure; Databases used, external-facing web-based applications, and proprietary applications;

3. People - Personnel who organize, provide guidance, develop, operate, secure, and use a system;

4. Data - The data types used by the system, including transaction streams, files, databases, tables, and anything else the system produced or processed;

5. Procedures - Procedures for providing services, including appropriate procedures for initiating, authorizing, performing, delivering, and preparing reports and other information.

3.2. CASE STUDY

The case study is based on an insurance platform that provides rating, quoting, binding, policy issuance, premium billing, and reporting. Since the industry in which the company operates is heavily regulated. Since the company offers insurance and fixed insurance platforms for insurance agencies in the US, some customers require them to show substantial compliance with global security standards.

Companies are required to comply with different regulations, laws, and standards. This requirement is based on several factors, including geographical location, industry-oriented standard (i.e., healthcare, payments, Etc.), data stored & processed, service commitments to customers, and management decisions. First, a company will need to identify with which regulations and laws it needs to comply. For example, if a company controls or processes the personally identifiable information ('PII') of EU citizens, the company needs to comply with the GDPR. On another example, if a company wishes to have business activities in the United States, there is a high probability that its prospective customer will condition their contract according to the SOC2

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Type II examination. Some countries' regulations refer to security goals, while others specify detailed implementations in their regulations. Some nations simply establish security goals, while others require risk management [10]—the combination of all the above supporting the decisions with the compliance strategy.

Therefore, compliance with the regulatory framework is based on the sole judge on the board of directors and based on local and international regulations, global standards requested from customers, including industry-oriented certifications/audits and contractual commitments.

The selected Service Auditor was EY, who examined the accompanying description of the assurance Service Organization's platform according to the COSO criteria for describing the service organization system for Security, Availability, and Confidentiality and by the EY Audit methodology [11].

Under this requirement, the Auditor's plan and audit must achieve reasonable assurance about whether (1) the description was presented according to the criteria to describe the official organization, and (2) the controls described effectively met the applicable TSCs during the audit period. This technical judgment is based upon several factors, such as the likelihood of material misstatements or fraud and the quality, timing, and extent of the methods selected. The Auditor believed the evidence he collected was sufficient and appropriate to make a positive conclusion on the attestation.

In the Readiness Assessment process, system components were categorized into five categories: Hardware, Software, People, Procedure, and Data.

In the audit attestation process, the entity provided information to determine whether its controls were adequate. Auditors developed controls testing plans, timing, and scope based on the characteristics of control environments and sufficient tests.

4. CONCLUSION

The thesis suggests a novel approach that supports the development of automated, utilizing artificial intelligence, robotic process automation, and integrations.

A holistic methodology will oversee a range of administrative, procedural, and technical controls and provide continuous monitoring of the effectiveness of the controls.

Further developments in the context of information security and compliance audits will be seen soon. The current state of information security audits is managed periodically and population-based on samples, while it will transform for extensive data analysis of all tested cases.

The automated compliance solution will generate policies and procedures based on several gap analysis questionnaires assign to the relevant business unit owner to build a customized control list based on the COSO framework used by the AICPA. Integrations with suitable organizational systems will scan the environment to validate if gaps were remediated.

Once the controls were designed and implemented in the organization, the automated compliance system will continuously monitor those controls and trigger alerts, tasks, and user reports on issues that arise in non-compliance. These issues will be seen and addressed promptly, supporting governance information security management, laws and regulations, and audit programs of the organization.

The system will automatically aggregate the appropriate evidence to a dedicated dashboard mapped to the relevant control objectives, test procedure, and framework. Alerts will be sent directly to the organization's alerting tool upon system identification. This functionality will reduce the time spent gathering evidence for external audits and is used as a communication tool for cooperation between the Service Organization's internal stakeholders and the Service Organization and external Service Auditor.

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NATURE-INSPIRED APPROACHES IN SOFTWARE TESTING OPTIMIZATION

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Abstract:

Software development is considered to be a fast growing industry that drives numerous modern world domains forward. At the same time, software testing and quality assurance, that is equally important branch of software industry, resides in the shadows, far away from the spotlights. The goal of the software testing is to detect defects in the software and ensure that it has sufficient quality prior to the release.

The main objective of the software testing can be defined as finding the minimal test suite that is still efficient enough to maintain the certain software quality. Since the process of test cases generation performs a search for an optimal test suite in a huge search space, and keeping in mind that the swarm intelligence metaheuristics have already proven to be efficient optimizers in other domains, it makes sense to apply swarm intelligence algorithms to the process of test cases generation as well. By utilizing this approach, it could be also possible to reduce the cost required for testing. This paper provides a survey of recent applications of swarm intelligence algorithms in the domain of software testing.

Keywords:

Cloud computing, information security, IT audit, compliance, ISMS.

INTRODUCTION

Software testing is a crucial activity that is often the decisive factor that determines if a software project will succeed or fail. The defects can be very expensive, especially if they were found late in the software development process. In this case, the process of debugging and fixing is costly, as the defect have probably propagated through multiple phases of the development, and affected other parts of software, documentation etc. Even worse, if defects haven't been found during testing process, they will typically be found by end-users in production, which will lead to financial loss, low customer satisfaction, poor reputation etc. Not to mention possible human casualties (medical applications or autonomous car software), substantial loss of client's data and money (banking applications)

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or leakage of client's private data such as documents, contacts, photos, call list and location (mobile applications).

Additionally, modern applications are complex, and the task to perform appropriate testing implies knowledge and mastery of different testing approaches. Most of the traditional testing techniques were introduced for simple procedural programs. However, the tester must apply different approaches to test object oriented software [1] or web applications [2].

Web applications are challenge on their own, as they are typically built in several different programming languages. Frontend is typically built with HTML, CSS and JavaScript, and it communicates with the backend through AJAX. Backend, on the other hand, can be built with either PHP, Node.JS, ASP .NET C#, or Java (JSP or Spring, for example). Finally, there is also the data persistence level, built with MySQL, Oracle, MongoDB or MSSQL. The options are numerous, and all parts are required to be tested thoroughly.

Besides the goals to find bugs in the software and ensuring that the software behaviour is correct according to the specification, software testing can be performed with a goal to build confidence in the application as well. The absence of critical defects will generally speaking increase the confidence in the software. However, one must be cautious as the actual absence of defects doesn't necessarily mean that the software is bug-free. One of the core principles of testing is that exhaustive testing is not possible for any non-trivial application, as the number of all possible combinations of input values is too large to be tested in a reasonable amount of time. In other words, the absence of defects just shows that the utilized test suite was not able to detect any bug. Therefore, the most important thing in software testing is to create a test suite that will cover all the functionalities of the application, with a special attention to the functionalities that are the most visible to the end-users (the functionalities that the users of the system will frequently use) and the use case scenarios (how the users will use the system).

According to the most estimations, software testing takes more than 50% of both the time and the cost of the software development process. This means that the test cases generation process is crucial, and if done properly, it can save the time and the cost of the entire project. Nature-inspired metaheuristics are proven to be exceptional optimizers in variety of other application domains, and it makes sense to assume that they can be applied in software testing as well, with a goal to optimize the test cases generation, and consequently to reduce

the overall time and the cost of the complete project. This paper presents a survey of recent applications of the swarm intelligence and evolutionary algorithms in the software testing process optimization. The remainder of this paper is structured in the following way. Section 2 introduces the nature-inspired algorithms and gives the survey of the most important methods and their applications in various practical domains. Section 3 gives an overview of the practical implementations of the nature-inspired algorithms in the software testing domain. Finally, section 4 suggest the possible future work in this domain and concludes the paper.

2. SURVEY OF NATURE-INSPIRED APPROACHES

NP-hard challenges play a vital role in the modern computer science and have a significant practical importance in a large number of application domains, such as machine learning, wireless sensor networks and cloud systems. The common basis for all NP-hard problems is that it is not possible to solve them by applying the traditional deterministic approaches in an acceptable time-frame. They require another, stochastic approach, if the problem is to be solved in a reasonable time.

Metaheuristics methods belong to the group of stochastic algorithms. Their main purpose is to obtain the satisfactory solution to the problem (solution that is sufficiently good, but not imperatively the best one) in a predictable and reasonable time-frame [3]. The survey of the recently published works indicate that metaheuristics approaches have been used to solve a wide variety of different practical NP-hard challenges. One famous and important family of metaheuristics approaches are the nature-inspired algorithms. Nature-inspired metaheuristics can be roughly separated into two distinct sub-families: evolutionary algorithms (EA) and the swarm intelligence (SI) metaheuristics, respectively.

The EA methods are inspired by the natural selection and the premise that only the fittest individuals in a given population will survive. The fittest units are then chosen for breeding, and generating the offspring for the following generation that will inherit the favourable characteristics from the predecessors. After certain amount of iterations, the algorithm will produce the generation of the fittest units (solutions). The most famous representative of this group of algorithms is the genetic algorithm (GA) [4]. It was successfully applied in wide range of the practical NP-hard challenges, such as the load-balancing problem in the cloud-based

systems [5], machine learning based Covid-19 prediction [6], design of the convolutional neural networks [7] and many others.

The latter family of the nature-inspired approaches, SI metaheuristics, was motivated by the behavior demonstrated by the groups of relatively simple animals, such as fireflies, bats, ants, moths, etc. Those simple animals can self-organize, show high level of coordination and perform complex actions when they form large groups (swarms). This particular feature of the swarms was the main source of inspiration for all SI algorithms [8]. Particle swarm optimization (PSO) was one of the earliest SI algorithms, and was proposed by Kennedy and Eberhart in 1995 [9]. It was inspired by the behavior demonstrated by the flocks of birds. Since its introduction, it was used to solve a variety of real-life problems, like cloud task scheduling [10]. Besides PSO, one more famous representative of the SI metaheuristics is the artificial bee colony (ABC) algorithm, inspired by the behavior of the honey bees in a hive, and introduced by Karaboga in 2007 [11]. ABC has also been used to solve a large number of different problems in various domains, for instance the portfolio problem as stated in [12]. Other famous SI approaches include the bat algorithm (BA) [13], firefly algorithm (FA) [14], and monarch butterfly optimization (MBO) [15] to name the few. Besides the mentioned metaheuristics approaches, there are dozens of other algorithms belonging to the SI family, with new approaches emerging every day.

Nature inspired approaches have recently been intensively used to address a wide spectrum of different NP-hard problems from a large number of application domains. SI metaheuristics were applied in the domain of the wireless sensor networks to solve the sensor node localization problem [16], prolonging the network lifetime [17], [18] and maximizing the network energy efficiency [19]. Another field where the SI metaheuristics have obtained respectable results is the cloud computing. SI was used to optimize the task scheduling by minimizing the overall time required to execute all tasks and the overall cost [20] [21] [22]. In the domain of machine learning, SI was utilized to design the convolutional neural networks [23], feed-forward neural network training [24] etc. Nature inspired metaheuristics also show very promising results in time-series prediction, the feature that was used to predict the Covid-19 cases [6] [25]. Finally, the SI approach was used to design a convolutional neural network that performs the classification task of the MRI images of the glioma tumor [26].

3. NATURE-INSPIRED APPROACH IN SOFTWARE TESTING

As discussed in the introduction, generating test cases and creating the appropriate test suite is crucial for the success of the project. The deficiencies in the testing process can be very costly and they will inevitably lead to defects occurring in the production. There are two contradictory requirements for a good test set. The first requirement is that it must be detailed enough to test all the important scenarios and paths through the program. However, the second requirement demands that the cost and time needed for testing are minimized as much as possible. It is clear that if we try to add more tests to the suite, we will increase the time and the cost of test execution. Vice versa, if we try to reduce the number of test cases with a goal to save time and money, it could result in the test suite which is not detailed enough and which will miss some defects.

Scientists in the software testing domain around the world have turned their attention to the artificial intelligence and nature-inspired approaches with a goal to address the test cases generation problem. As expected, the most popular nature-inspired metaheuristics were applied to this problem. The very first approach was to use GA to generate unit test cases automatically with a goal to obtain high code coverage. This approach is known as evolutionary structural testing (EST), and it was introduced all the way back in 1996 [27], and was later refined in 2006 [28]. EST has established to be efficient and successful for various academic test object instances, and also for some industrial projects. The main principle of EST is as follows: it is impossible to perform exhaustive testing, as the amount of time needed to test all the possible combinations of input values would be too long and impractical. Therefore, a subset of input data that is relevant must be selected. The term "relevant" here depends of the selected coverage criteria. Coverage criteria for the white box approaches are based on the control flow graph – CFG. For example, if a generated test set executes all the statements in the software component, it fulfills the statement coverage criterion. However, most of the industrial software must fulfill more strict criteria such as branch/decision coverage (all branches/decision outcomes in the CFG of the software component being tested must be exercised) or path coverage (all the independent paths through the CFG must be covered), which affects what is considered to be the "relevant" test set. The EST considers the test cases generation as the optimization problem that needs

to be solved by using the search method, for instance, the GA. After selecting the test coverage criterion, the code is divided in the individual test goals which will be optimized separately. The fitness function is defined by utilizing the two distance metric: approximation level and branch distance, respectively. The former is related to the CFG of the software component that is being tested. More precisely, it correlates to the amount of critical branches, positioned between the problem and the target nodes in the graph. Here, the target node is the structure in the code that needs to be covered, while the problem node is the code structure where the program execution is diverging through a branch that will make reaching the target not possible. The latter, branch distance metric, corresponds to the condition found in the problem node. It serves to describe how close the condition has been evaluated to deliver the boolean result that was required to reach the target.

The original EST approach with GA implementation has been compared to the PSO implementation in [29]. The authors noted that since the PSO is easy to implement, efficient, and has the ability to converge fast to the optimal parts of the search space, it could also enhance the EST as well. They implemented both algorithms, and selected the branch coverage as the code coverage criterion. Furthermore, they considered each branch as an individual testing goal that needs to be optimized. They conducted the simulations over a total of 25 test object instances with different levels of complexity that have been created for the purpose of the experiment. The obtained results have proven that the PSO – based approach outperformed the GA in about 2/3 of the observed test instances. The authors concluded that the GA converges slightly faster if the functions are simple (in terms of parameters passed by), while the PSO drastically outperformed the GA in case of complex functions that have a large search space (mixed parameters, such as boolean, integer and/or double that are passed by when invoking the function). The final remarks of the paper indicate that the PSO is competitive with GA, and in cases of complex functions, it clearly outperforms the GA.

Paper [30] proposes the GA and PSO approach to the process of the test cases generation, by identifying the paths in software that are susceptible to defects. The proposed approach was named HGPSTA (hybrid genetic particle swarm technique algorithm), and it combines the individual advantages of GA and PSO. The authors have utilized the EST, that is used to generate the test cases automatically. EST considers this task as an optimization problem.

The GA has been hybridized with PSO with a goal to enhance the efficiency of the process. The GA utilizes three operators, namely selection, crossover and mutation. The GA hybridized with PSO uses enhancement operator, that is utilized to improve the units in the same generation. After calculation of the fitness value of all solutions of the population, the best half of solutions are noted. The algorithm then applies the PSO directly to improve the individual solutions. Crossover operator includes only the improved solutions, and the authors applied the roulette wheel scheme for the selecting process.

The proposed HGPSTA method was applied to the fitness function that utilizes the data flow testing coverage criteria, and tested on the seven classic programming problems. The HGPSTA was compared to the basic GA and basic PSO. Published results suggested that the HGPSTA approach was able to achieve 100% data flow coverage in less rounds than the basic GA and PSO algorithms, resulting in a smaller number of required test cases.

Another hybrid approach was proposed in [31], where the authors hybridized the GA with ACO, and named the approach hybrid ant colony genetic algorithm (HACGA). Their approach was based on the fault matrix, with 15 different defect and 15 test cases, with the assumption that every test case exposes at least one defect. The problem was further formulated as choosing the subset of the matrix's rows that covers each column (containing defects) at least once. The collection of test cases is chosen by the ACO search, and then refined by the GA. The conducted experiments included comparison with plain ACO and GA approaches as well. The proposed HACGA outperformed both GA and ACO in this particular test setup.

ACO – based approach was utilized as well in [32] with a goal to generate test data to cover the prime paths in the software. Prime paths in this context are the basic paths (no repetitions), and loops are tested just with 0 and 1 passes through the loop. Path coverage is considered to be the most strict criteria among white box techniques, as the 100% path coverage implies 100% decision coverage and 100% statement coverage as well. Therefore, covering the paths can discover defects that other techniques are not able to. The authors have tested their approach on seven benchmark programs with known bugs, and compared it to PSO and GA approaches. The obtained results suggested that ACO method outperforms the GA both in terms of coverage and efficiency. When compared to the PSO, authors noted that ACO obtains better test coverage than PSO, however, it is less efficient than PSO.

4. CONCLUSION

In this paper, we have performed a survey of nature-inspired metaheuristics that found their use in optimization of the software testing process. The hardest task in the software testing is the test cases generation process. The success of a software development project largely depends on it – if the test set is not adequate, it can lead to the complete failure of the project after the deployment. On the other hand, having a test set that has a large number of test cases is not efficient both in terms of the time and the cost required for the testing.

Nature-inspired metaheuristics have proven to be efficient optimizers. From the performed survey, it can be noted that there were several attempts to optimize the test generation by applying famous algorithms, including GA, PSO and ACO. The common goal for all mentioned approaches is that they try to generate test set that will increase the code coverage according to the selected criterion (statement, decision or path coverage), while decreasing the amount of test cases. It can be seen from the presented approaches that other researchers mostly play safe, by choosing and applying the traditional, famous algorithms. This leaves a lot of open space for applying modern, state-of-the-art metaheuristics (for example BA, FA or MBO), either in original, or their hybridized and/or improved versions to the same problem, with a reasonable chance to improve the test cases generation process even further.

Future research will focus on implementing one of the more recent metaheuristics to the software testing problem, and validating it against the traditional approaches such as GA and PSO executed on the same problem instance.

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COMPUTATIONAL METHODS APPLICATION FOR FINDING THE OPTIMAL TRANSPORTATION COSTS

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Abstract:

Computational methods are, among other things, widely used in operational research. Operational research is a complex interdisciplinary field that deals with the problems of decision-making in real conditions, considering all the factors that affect the problem directly or indirectly, in order to find the best, i.e. optimal solution. As there is a growing need for continuous process improvement, there is a growing presence of operational research methods for various real-life problems.

The transportation problem is one of the segments of research within operational research. It aims to determine the optimal program of distribution of a certain type of commodity from sources (points of origin) to destinations. The sources are the places where the commodity leaves (the warehouse), while the destinations are the ending points to which the commodity should be transported (in our case - the store). As a criterion for optimizing the transportation of goods, the request for minimizing the total transportation costs is most often taken. In the case of transportation problem, the objective function expresses the total transportation costs, while the limiting conditions are determined by the supply of individual sources (warehouses), i.e. the demand of individual destinations (stores).

This paper discusses the possibility of applying operational research methods in the service sector. The aim of the research part of the paper is to find the optimal solution for real data of a given problem, simulating different conditions and constraints. An experimental analysis was performed for the problem of warehouse operations, and the goal was to minimize the costs of transporting goods. Two different methods were applied in order to determine the optimal solution. Based on the obtained results and their analysis, conclusions were made as to whether the problem was solved.

Keywords:

operational research, methods, optimal solution, service sector.

INTRODUCTION

Among the mathematical methods which optimize control processes, the most developed is the method of linear programming (LP). This method determines the maximum / minimum of the linear objective function, which depends on several variables, provided that these variables are non-negative and that they satisfy linear constraints in the form of equations or inequalities [1].

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A special case of the general linear programming task is the transportation problem. The formulation of the transportation task is given as follows:

There are m warehouses that offer certain goods in quantities a_1, a_2,…,a_m and n stores that demand these goods in quantities b_1, b_2,…,b_n. The assumption is that the sum of the warehouses' offers is equal to the sum of stores' demand:

$$a_1 + a_2 + ... + a_m = b_1 + b_2 + ... + b_n$$

The numbers c_{ij} are given, which indicate the prices of transporting a unit of goods from the i-th warehouse to the j-th store.

Such numbers are to be found $x_{ij} \geq 0$ where x_{ij} indicates the quantity of goods to be transported from the i-th warehouse to the j-th store so that the total transportation costs are minimal [2].

2. MATHEMATICAL DEFINITION OF THE TRANSPORTATION PROBLEM

The optimal transportation plan means the plan of transportation of goods from the warehouse to a certain store, which minimizes the total price of transportation. There are several phases in finding a solution to this problem.

2.1. PROBLEM FORMULATION

The transportation problem has a very wide application. The possibility of minimizing the total transportation costs is what is most often sought when it comes to the transportation problem. The starting point is the assumption that the amount of resources to be transported is specified and homogeneous.

The transportation problem requires finding the most rational way of supplying multiple destinations (stores) from several sources (warehouses), while the transportation costs should be minimal [3].

The transportation problem determines the optimal plan for the transportation of one type of goods if the following is known:

1. The number of warehouses (dispatch centres or production centres), from which the transportation of goods should be organized;

2. The number of stores (receiving stations or consumer centres) to which the goods are to be delivered;

3. The quantity of goods in warehouses;

4. The quantity of goods demanded by each store; and

5. The price of transport per unit of goods from each warehouse to each store.

Solving this problem can be divided into three phases:

1. Determining Initial Basic Feasible Solution (IBFS);

2. Evaluating optimality of the obtained solution; and

3. Change of plan.

2.2. MATHEMATICAL MODEL BUILDING

- Defining a mathematical programming task = mathematical program (linear or nonlinear);

- Defining the objectivel function (objective function is the objective that is to be achieved by the functioning of the system):

$$z = f_{max/min}(x_1, x_2, ..., x_n)$$

or this function may consist of multiple criterion functions, the so-called multicriteria optimization;

- Constraint conditions = mathematical relations between variables x_j that depend on technological requirements, available resources, workspace, etc. [4].

2.3. DETERMINING THE SOLUTION TO THE PROBLEM

› Determining the optimal solution = determining the values of the variables $x_1, x_2, ... x_n$ that satisfy the constraint conditions and for which the objective function has a maximum or a minimum (depending on what is required in the problem formulation). The optimal solution can be reached analytically for simpler problems (application of mathematical operations such as algebra, differential and integral calculus) and by numerical procedures, where iterative procedures from the assumed initial solution lead to the optimal solution;

› Sensitivity Analysis Solution = the optimal solution for the selected parameter values is determined and then it is determined how it changes with the changes of parameters [5].

3. PROBLEM FORMULATION AND SOLVING

Among the tasks of linear programming, a special place is occupied by the transportation problem, due to the characteristic formulation of its mathematical model, which allows significant simplifications in the process of finding the optimal solution [6].

Identification and correct definition of the problem is the initial and relatively most complex phase in the process of obtaining a solution. Unambiguous rules and unique algorithms for problem formulation do not always exist. This phase is characterized by the fact that the experience and creation of the problem analyst should be fully expressed.

When solving the transportation problem, the objective should be defined first, i.e. it should be determined which problem the decision maker wants to solve by using the solution of this problem. Formulation of objectives, which are solved by modeling, must be in accordance with the set time and financial constraints. The objectives should neither be too specific in terms of their context, because the justification of investing in the development of the model can be questioned, nor should they be too general, because solving all possible problems in the considered system by using a single model is not fesible.

Bearing all this in mind, especially the problem which is to be solved, the aim of this paper is to formulate a mathematical model of the transportation problem, where the function of the objective is to minimize transportation costs, i.e. to first determine the initial basic solution and then the optimal solution.

The formulation of a mathematical model implies defining the objective function and constraints. The objective function is to determine the minimum transportation costs, and the constraints are defined by the quantities in the warehouses and the needs of the stores [7].

When solving the problem, we will use several methods to determine the optimal solution, and thus determine which of the methods used provides the lowest price of transporting goods, i.e. the method that provides the best optimal solution.

4. EXPERIMENTAL ANALYSIS

We will observe the problem on the model of four warehouses marked with I_1, I_2, I_3 i I_4 which have quantities of a product of 26, 23, 29 and 12t respectively. Transportation costs per unit are given in Table 1.

	O_1	O_2	O_3	O_4	O_5	a_i
I_1	5	12	1	4	13	36
I_2	7	8	14	6	5	23
I_3	15	4	2	7	9	29
I_4	6	11	5	16	3	12
b_j	13	24	15	21	27	100

Table 1 – Transportation cost per unit

The transportation plan should be determined so that the total cost of transporting 100t of product is minimal.

The defined problem represents a special form of transportation problem which is solved in two phases:

› The first phase - finding the initial basic solution;

› The second phase - finding the optimal solution.

Prior to finding the initial basic solution, it must be determined whether the transportation problem is "balanced" or "unbalanced". A balanced transportation problem arises due to the ideal balance of supply and demand, i.e. if the quantity of product offered (in our case, the quantity in the warehouse) is equal to the quantity of product demanded (quantity of goods in the store). An unbalanced transportation problem is the disproportion in supply and demand.

Determining the type of transportation problem is done by comparing the sum of the total quantity of goods in the warehouse and the sum of the total quantity of goods demanded by the stores. In our case, it was determined that this is a balanced transportation problem, which is proven by:

$$\Sigma a_i = \Sigma b_j = 100 \ t$$

Upon determining the type of transportation problem, we approach the solution thereof [8].

4.1. METHODS FOR DETERMINING THE INITIAL BASIC SOLUTION

Several methods have been used to determine the initial basic solution [9].

1. Upper Left Corner or North-West Corner Method (Dantzig's method).

   In its calculation, this method does not consider the value of c_{ij} i.e. unit price, so it is considered the simplest but also the most inefficient method for determining the initial allowable solution of the problem.

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In this method, the calculation is started from the North-West corner (top left corner) from requirement b_1 in the table and it is compared with the available quantities a_1. There can be three cases:

› If $b_1 < a_1$, then b_1 value is assigned to x_{11} and proceeds to cell x_{12}, i.e. proceeds horizontally.

› If $b_1 = a_1$ then b_1 value is assigned to x_{11} and proceeds to cell x_{22}, i.e. proceeds diagonally.

› If $b_1 > a_1$ then a_1 value is assigned to x_{11} and proceeds to cell x_{21}, i.e. proceeds vertically.

By using this method, we find that the transportation cost is T_{min} = 870 monetary units.

2. Least Cost Method (least unit price method)

This method starts from the cost table and the cell with the lowest cost coefficient is sought; once the cell is found, the largest possible quantity of products allowed by the warehouse or the store is distributed into that cell.

By using this method, we find that the transportation cost is T_{min} = 429 monetary units.

3. The method of the largest difference of the smallest coefficients (Vogel's Approximation Method -VAM)

In this method, we start from the unit costs table, and then for each row and column of that table, the difference between the two smallest elements in the column or row is determined. These differences are entered in an additional column or row. The procedure for allocating costs is as follows: the largest difference between these minimum elements is sought, and then the lowest cost coefficient is sought in that column or row, and the maximum possible quantity of goods to be transported is allocated there. The procedure is repeated until the needs of warehouses and stores are met. By using this method, we find that the transportation cost is T_{min} = 392 monetary units.

4.2. METHODS FOR FINDING OPTIMAL SOLUTION

The methods listed below were used for finding the solution to our problem [10] [11].

1. STEPPING STONE METHOD (jumping from stone to stone method)

This is a rather simple method which is particularly suitable if the number of warehouses and stores is not large. Basically, this method is iterative. The first step is to find a basic solution, and then iterations get better and better solutions from it. Iterations are repeated until the optimal solution is obtained.

The starting table is the table that was obtained by one of the methods for finding the solution. We do the procedure of finding variations for each unoccupied cell $\delta_{ij} = \sum c_{ij}$.

The optimality condition is that every $\delta_{ij} > 0$.

Relative costs are obtained by "jumping from stone to stone", i.e. by alternating addition and subtraction of unit costs, so that the procedure starts from the cell for which the relative cost is calculated, then continues clockwise onto the occupied cells, depending on the path.

By using this method, we find that the transportation cost is T_{min} = 392 monetary units.

2. Method of Distribution (MODI)

This method also finds the optimal solution based on the previously obtained basic solution using some of the previously mentioned methods. Relative costs are calculated according to the formula:

$$X_{ij} = c_{ij} - (u_i - v_j)$$

where:

› c_{ij} – unit costs;

› u_i i v_j – coefficients for each basic solution of the values obtained from the formula

$$c_{ij} = u_i + v_j$$

over the occupied cell.

When all the related relative costs in the unoccupied cells in the transportation matrix are positive, the basic solution, which is also the optimal, is obtained.

This method results in minimal transportation costs T_{min} = 392 monetary units.

5. CONCLUSION

In this paper, we have dealt with a transportation problem that can be applied in any activity. Here we observed the model applicable in the service sector through the transportation of goods from the warehouses to the stores. Given that there is a certain physical distance between the warehouses and the stores, certain costs arise during the distribution and transportation

of goods. These costs can, among other things, significantly affect the final price of the product. If the transportation costs are high, the price of the product itself will be higher. The transportation problem can be very successfully formulated and solved by using the linear programming model, if the basic requirement for optimizing the transportation of goods is to minimize the total transportation costs.

By modifying the method, a solution to practical problems can be reached. One method of problem solving is almost never enough. Methods and mathematical problems combine with each other to create a new method.

Based on the comparative analysis of data obtained using the methods listed in this paper, we conclude that the costs obtained using the North-West Corner method are the highest, and amount to 870 monetary units, while transportation costs obtained using the VAM method (Vogel method) are closest to the optimal solution and amount to 392 monetary units. Unlike the method of determining the initial basic solution, where we obtained different results by applying different methods, by using any of the methods to find the optimal solution we get the same value of the transportation price. Furthermore, one can notice that the transportation costs obtained by the methods for finding the optimal solution coincide with the transportation costs obtained by the VAM method (Vogel method), which actually means that these costs cannot be further reduced, i.e. that the lowest possible transportation price is obtained.

Based on the methodology presented in this paper, it can be concluded that it is rather complex to standardize the methodology of solving a problem by observing the service sector. The activities in this sector are inherently different, hence the successful implementation of one method in one activity will not ensure the successful implementation of that same method in another activity.

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COST EFFICIENT MULTI-SOURCE ENERGY MIXING FOR RENEWABLE ENERGY MICROGRIDS USING HYBRID ABC-PSO ALGORITHM

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Abstract:

Energy management systems can provide a variety of features and services to prosumers. One of its most important functions is to determine cost-effective energy mixing rates by evaluating the unit price and power of energy resources. This study mainly proposes a hybrid optimization based on two heuristic algorithms: Artificial Bee Colony (ABC) and Particle Swarm Optimization (PSO) algorithms. A hybrid ABC-PSO algorithm has been applied to solve the energy efficient multi-source energy mixing problem in Matlab. The proposed algorithm has been tested in the simulation of an energy management system including a grid, solar panel, wind turbine, and storage unit. The results show that the proposed algorithm responds appropriately to meet the hourly changing demand of the consumer in cases of energy production fluctuations in renewable energy sources and dynamic electricity price tariff implementation of the grid. This method can provide cost efficiency by maintaining the energy balance of consumers in smart grids. The algorithm has a simple structure, thus the method provides a solution for low-cost energy management applications in the microgrid.

Keywords:

Smart grid, hybrid ABC-PSO algorithm, cost efficient energy mixing, microgrid.

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INTRODUCTION

Global warming, limited energy resources, increasing dependence on energy require modernization of conventional grid architecture, innovative solutions and technologies [1]. In this context, the energy industry is transitioning to a new era called "smart energy". Energy will become more sustainable, reliable and green by using information and communication technology in the near future. On the other hand, the smart energy system is a cost effective system that incorporates renewable energy sources into the process. Smart grid, demand response, microgrid, smart home are the main concepts in this field [2]. The negative effects of traditional fossil fuels on the environment and the public awareness of developments in renewable energy technology have increased the interest in microgrids [3]. Microgrids can be described as small, local distribution systems containing micro resources such as solar panels, wind turbines, storage systems, micro turbines, fuel cells [1].

Renewable energy sources have an intermittent generation due to their nature. This situation considerably fluctuates the demands of the consumers [4]. The microgrid allows users to decide on setting the time and amount of consumption [2]. Generally, demand-side management in microgrids can be carried out using a smart optimization process [5].

The use of renewable energy sources in the energy systems of buildings has a significant impact [6]. The total energy consumption of buildings corresponds to 40% of the world's energy consumption. It is thought that in the close future, buildings will be able to produce their consumed energy. This means zero energy buildings. Since fossil fuels are unsustainable, the idea of using renewable energy in smart homes has generated great interest from the public. With the advance of home energy management systems (HEMS) in smart grids, users have the opportunity to actively participate in demand-side management (DSM). Through the smart home energy management system, users can optimize their electricity consumption and improve their comfort levels [7]. Figure 1 shows five technical functional diagrams of energy efficiency in smart homes [8].
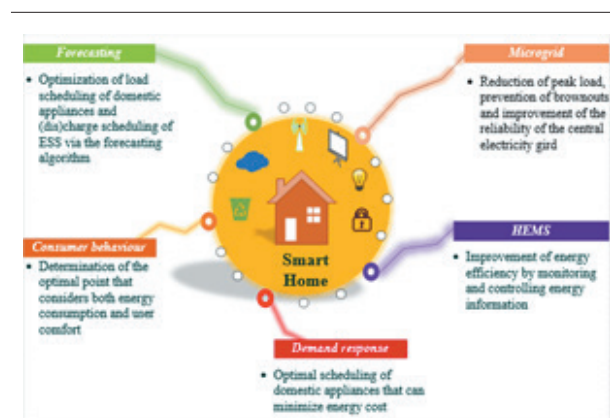

Figure 1 - Conceptual diagram of energy efficiency in smart homes [8].

Smart consumers are the end user members of the future smart grid and play a key role in the supply-demand balance [9]. With the active participation of consumers in demand management, the use of information and communication technology devices has become widespread in-home applications [10]. In the near future, it will be possible to optimize electricity consumption, meet supply constraints and minimize costs in smart homes with energy management systems. At the same time, it is usual to predict that the continuity of the desired comfort level for the users will be facilitated by

energy management systems [11]. Automatic Home Energy Management System (AHEMS) with appropriate algorithms in a smart home should allow optimization of the existing energy system (grid, loads, local generation and storage unit) at time-varying tariffs. In this context, algorithms in the core of AHEMS allow flexible use of some end-user loads. Thus, it contributes to taking advantage of higher levels of renewable energy generation and lowering the energy bills of consumers [12]. Data collected from smart measurement systems and meteorology can be updated by artificial intelligence techniques and machine learning algorithms to regulate the relationships between various variables such as energy consumption, radiation, temperature, time, and battery charge state [13]. Representation of artificial intelligence as "Energy Intelligence" on the subjects of cost, efficiency and energy monitoring is a guide for users [14].

There are various algorithms in the literature such as artificial bee colony (ABC), particle swarm optimization (PSO), genetic algorithm, random search algorithm, differential evolution. Among these solution approaches, ABC [15] and PSO [16,17] are the most common techniques used to solve optimization problems [18]. Although the ABC algorithm has an effective discovery capability, it has weak exploitation capability. PSO has a good utilization ability. However, when the population or particle falls to the local minimum, the PSO has no ability to get out of the local minimum level. Therefore, PSO is not sufficient for the exploration of the search space [19]. Most of the time, a hybrid optimization method combining two or more methodologies is proposed to increase the convergence time of the optimization process [20]. This hybrid optimization process is carried out by improving PSO's weak discovery ability and ABC's weak exploitation ability [21].

This study proposes a hybrid optimization based on two heuristic algorithms: ABC and PSO. The hybrid ABC-PSO algorithm has been applied in Matlab to solve the energy efficient multi-source energy mixing problem. The proposed algorithm has been tested in a simulation of an energy management system including grid, solar panel, wind turbine and battery. The results show that the proposed algorithm responds appropriately to meet the hourly changing demand of the consumer. The production fluctuations of renewable energy resources and the dynamic electricity price tariff of the grid were taken into account in this process. This method can provide cost efficiency by maintaining the energy balance of consumers in smart grids. The structural simplicity of the method provides a solution for low cost, smart and local energy management applications.

2. METHODOLOGY

2.1. THE PROBLEM OF ENERGY MIXING IN MICROGRIDS INCLUDING RENEWABLE ENERGY SOURCES

The architectural structure of the microgrid energy management system consists of renewable energy sources, grid, battery, loads, smart algorithm and energy mixing components as shown in Figure 2.
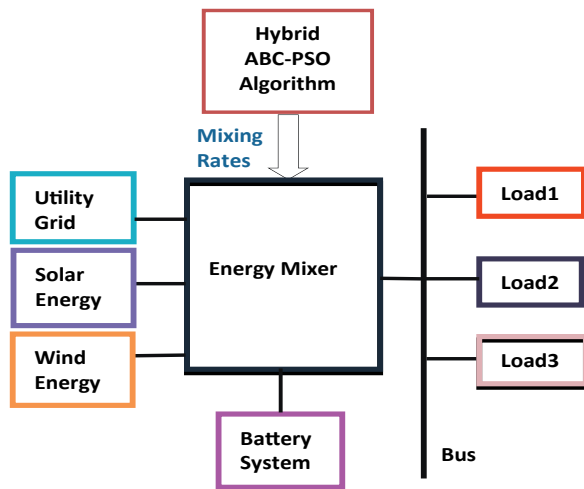

Figure 2 - The architectural structure of the optimal microgrid management system [22].

In the authors' previous studies, random search optimization (RSO) [22] and particle swarm optimization (PSO) algorithms [16] were applied to find cost-effective optimal energy mixing ratios according to the power levels and unit energy costs of renewable energy sources. In this study, the hybrid ABC-PSO algorithm was applied to solve the energy efficient multi-source energy mixing problem. The determination of energy mixture rates was carried out in Matlab. Suppose that the energies of solar panels, wind turbines, battery and grid are combined at mixing rates expressed as α_s for solar, α_w for wind, α_b for the battery system, and α_g for grid. In this case, the total energy sent from sources to grid loads can be expressed as follows [22]:

$$E_T = \alpha_s E_s + \alpha_w E_w + \alpha_b E_b + \alpha_g E_g$$

Equation 1 - Total energy from sources.

In here, E_s, E_w, E_b, E_g represent instantaneous energies from the sun, wind, battery and grid, respectively. Considering the unit energy costs of c_s for the solar system, c_w for the wind system, c_b for the battery system and c_g

for the grid, the cost function to be used in optimization for energy efficient, cost effective mixing of resources can be written as follows [22]:

$$F = \alpha_s c_s E_s + \alpha_w c_w E_w + \alpha_b c_b E_b + \alpha_g c_g E_g$$

Equation 2 - Cost function.

Let consider that the mixing rate coefficients are updated at every Δt time interval by the hybrid ABC-PSO optimization algorithm. Thus, the cost function minimized by using the average output power of the sources in Δt time intervals can be written as [16],

$$F(\alpha) = \alpha_s c_s P_s \Delta t + \alpha_w c_w P_w \Delta t + \alpha_b c_b P_b \Delta t + \alpha_g c_g P_g \Delta t$$

Equation 3 - Minimized cost function.

where P_s, P_w and P_b express the average output power of the solar, wind and battery system, respectively and P_g shows the average power drawn from the grid. Also, the mixing rate vector for the microgrid is shown as $\alpha = [\alpha_s \, \alpha_w \, \alpha_b \, \alpha_g]$. It is important to balance energy production (E_T) and energy demand (E_D) in the microgrid. Energy supply and demand balance status in the microgrid can be written as [16],

$$\gamma P_D = P_T = \alpha_s P_s + \alpha_w P_w + \alpha_b P_b + \alpha_g P_g$$

Equation 4 - Energy balance status.

where P_T and P_D indicate the total average output power of the sources and the total demand power, respectively. The case of $\gamma > 1$ provides a virtual demand to reduce energy shortage by allowing some over-production. Equation 5 can be written to determine the energy balance error [16].

$$E_h = P_D \Delta t - P_T \Delta t$$

Equation 5 - Energy balance error.

Considering the energy balance boundary condition expressed in Equation 4, the mixing ratio of the grid can be calculated with the following equation [16]:

$$\alpha_g = (\gamma P_D - \alpha_s P_s - \alpha_w P_w - \alpha_b P_b)/P_g$$

Equation 6 - Mixing ratio of the grid.

$\alpha_g \leq 0$ condition indicates the island-mode operation of the microgrid. According to α_g value, the cost function has been calculated as Equation 7 to determine the working status of the system in islanded mode and to maintain the working status of grid-connected [16]:

$$F(a) = \begin{cases} a_s c_s P_s \Delta t + a_w c_w P_w \Delta t + a_b c_b P_b \Delta t \\ \quad + a_g c_g P_g \Delta t \, a_g > 0 \\ \qquad\qquad\qquad F_h a_g \leq 0 \end{cases}$$

Equation 7 – Calculated cost function.

where F_h means high cost value to avoid the islanded mode operation of the microgrid. Therefore, the hybrid ABC-PSO algorithm does not allow the system to run in islanded mode [16].

2.2. APPLICATION OF HYBRID ABC-PSO ALGORITHM FOR ENERGY MIXING RATE OPTIMIZATION

Discovery and utilization capabilities of population-based algorithms are among the main features of these algorithms. The discovery searches unknown regions to find the global optimum, while utilization tries to apply knowledge of previous solutions to find better solutions.

To achieve the best result, discovery and utilization abilities should be balanced. However, researches show that ABC algorithm performs good discovery and weak utilization in the solution search process [23]. PSO has good utilization ability. On the other hand, when the population or particle drops to the local minimum, the PSO cannot get out of the local minimum level. In addition, the PSO is not sufficient for the discovery of the search space [19]. In order to take advantage of these two algorithms and eliminate their disadvantages, a hybrid global optimization approach called ABC-PSO can be used [24].
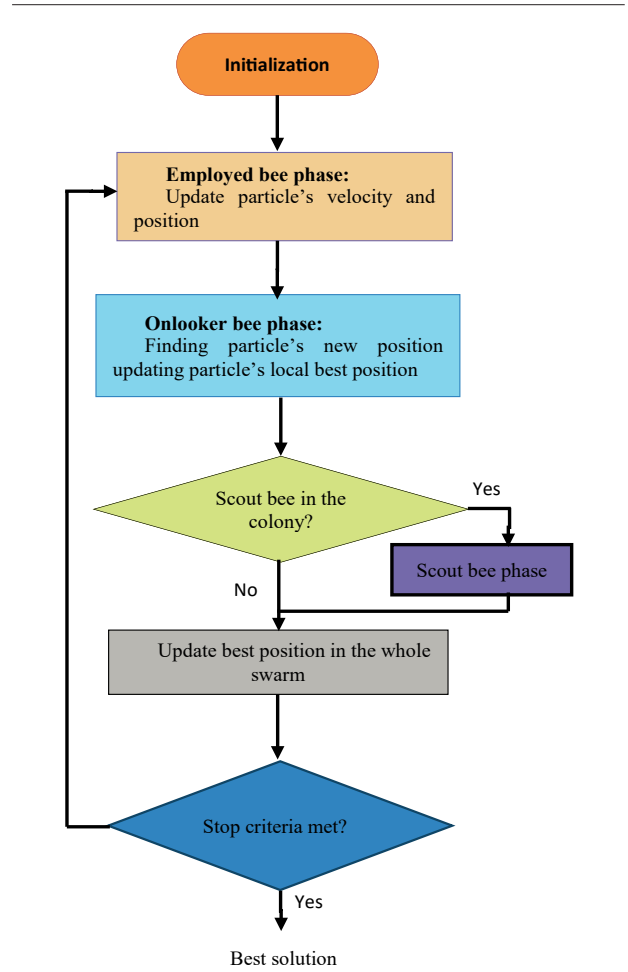
Figure 3 - Flow chart of the proposed algorithm[24].

Figure 3 shows the flow chart of the proposed optimization algorithm. In this algorithm, three phases of ABC are used. For the employed bee phase, PSO's method and speed of finding new food sources are used. After the location of the new food source is updated, the best available position is determined using Equation 8 [24].

$$Pbest_i^{t+1} = \begin{cases} Pbest_i^t, if \; f\left(Pbest_i^t\right) \leq f\left(X_i^{t+1}\right) \\ X_i^{t+1}, if \left(Pbest_i^t\right) > f\left(X_i^{t+1}\right) \end{cases}$$

Equation 8 - Best available position.

At the onlooker bee phase determined by the employed bee, onlooker bees will find and memorize a new food source location based on the knowledge of the best food source location visited by the employed bee. This operation is performed according to Equation 9 [24].

$$X_{ij} = \begin{cases} Pbest_{ij} & , if \ j \neq m \\ Pbest_{im} + \varnothing_{im}\left(Pbest_{im} - Pbest_{km}\right), if \ j = m \end{cases}$$

Equation 9 - Food source location.

where m∈[1,D] is chosen randomly, $k \neq j$ and $\varnothing_{im}$ are random numbers generated between -1 and 1. The scout bee phase is similar as in the ABC algorithm [24].

In order to carry out the energy mixing rates to the energy mixer block, the normalization should be performed to satisfy $\alpha_s + \alpha_w + \alpha_b + \alpha_g = 1$ condition. Equation 10 is used for this process.

$$\tilde{a}_x = \frac{a_x}{\sum_{i=\{s,w,b,g\}}^{4} a_i}, \ x = \{s,w,b,g\}$$

Equation 10 - Normalization of mixing rates.

3. SIMULATION STUDY FOR ENERGY MANAGEMENT IN MICROGRIDS INCLUDING RENEWABLE ENERGY RESOURCES

In this section, a simulation study was carried out to perform the hybrid ABC-PSO algorithm for cost-effective renewable energy mixing in a home energy management system shown in Figure 4. The simulation model consists of four energy systems: solar, wind, battery with an output power of 1 kW and electricity grid with power limitation of 2 kW [16].
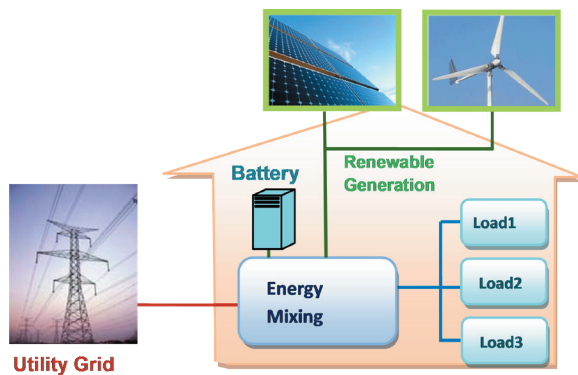
Figure 4 - Simulation model for cost effective energy management in the microgrid [16].

In the simulation study, hourly generation profiles of solar and wind energy systems shown in Figure 5 were used.

The average demand profile shown in Figure 6 was used for the demand profile of the home considered as a microgrid.
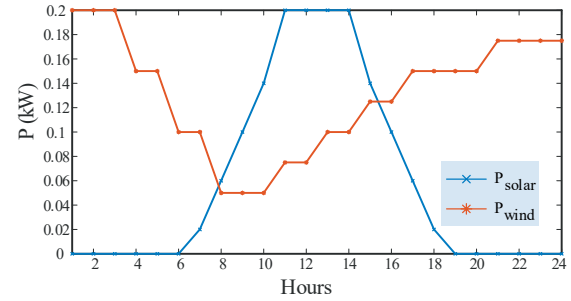
Figure 5 - Production profile of the solar and wind energy systems [16].
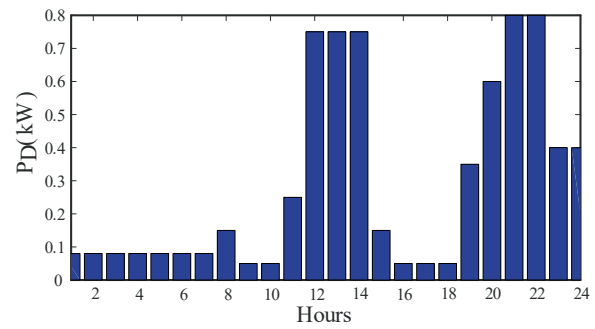
Figure 6 - Average demand profile of the home.

It is accepted that the energy unit costs of the solar, wind and storage system used in the simulation and the energy unit price of the grid applied in the dynamic tariff are determined as in Figure 7 [16].
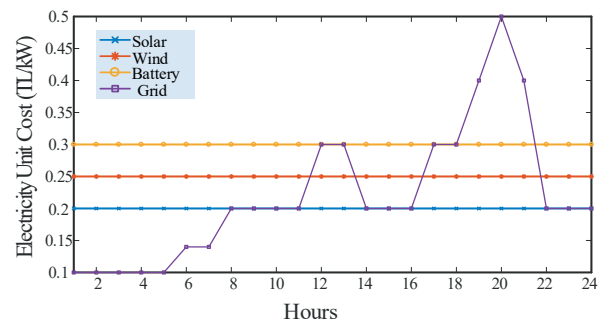
Figure 7 - Pricing profile of energy resources.

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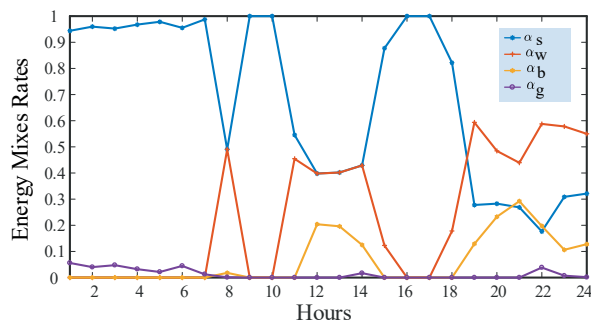
Figure 8 shows the hourly calculated mixing rates of the energy sources by the hybrid ABC-PSO algorithm.

The energy balance error given in Figure 9 shows that the proposed algorithm within the scope of the production fluctuations of solar and wind energy sources and the dynamic energy price tariff of the grid can maintain the supply-demand balance. Figure 10 shows the hourly changes of the energy efficient cost function. It is seen from this figure that the hybrid ABC-PSO algorithm achieves better results than ABC. It can be said that this is achieved by combining ABC and PSO algorithms.
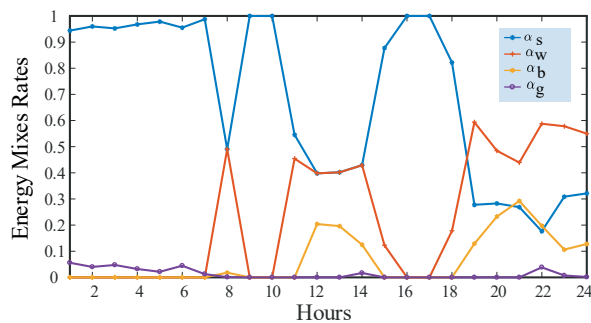
Figure 8 - Energy mixing rates determined by the proposed hybrid ABC-PSO algorithm.
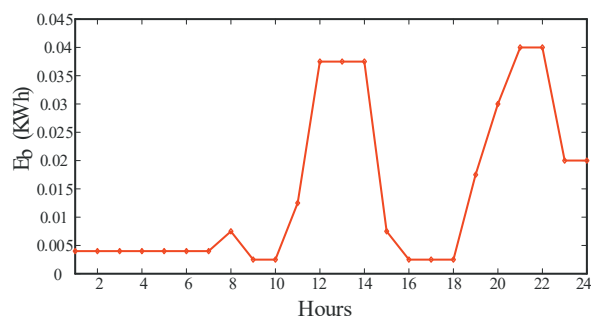
Figure 9 - Energy balance error of microgrid.
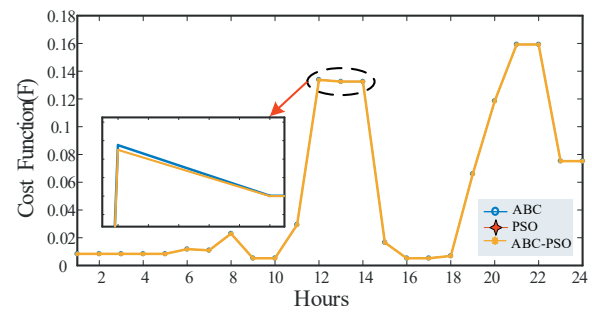
Figure 10 - Hourly change of cost function.

4. CONCLUSION

This paper demonstrates the use of the hybrid ABC-PSO algorithm to solve the energy efficient, cost-effective multisource energy mixing problem in microgrids containing renewable energy sources. Our numerical analyzes show that the proposed hybrid ABC-PSO algorithm responds appropriately to meet the hourly changing demand of the consumer in case of power generation fluctuations in renewable energy sources and dynamic electricity price tariffs in the grid. By preserving the energy balance and without affecting the life comfort of the users, the cost efficiency can be achieved through the optimization algorithm by taking into account the dynamic electricity tariffs.

The method has a simple algorithm; therefore, it offers a solution opportunity for low cost, smart and local energy management applications.

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COMPUTER SCIENCE, COMPUTATIONAL METHODS, ALGORITHMS AND ARTIFICIAL INTELLIGENCE SESSION

A SINGULAR WORKFLOW FOR 3D SURFACE RECONSTRUCTION OF HEAVILY NOISY POINT CLOUDS

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Abstract:

Surface reconstruction from low quality point clouds represents a common problem in most standard algorithms created for this purpose. Point clouds acquired using specialized devices, such as 3D scanners, or as outputs from structure from motion algorithms are usually flawed in that they contain a significant amount of noise and outliers, making the surface reconstruction process difficult, resulting in low quality surface estimation. The quality of the reconstructed mesh is directly proportional to the quality of the point cloud itself. This paper proposes a workflow for creating 3D surfaces from unstructured point clouds. The workflow takes an unstructured point cloud as input and, through four phases, automatically cleans up the point cloud data and creates a watertight surface reconstruction of the point cloud, all in a single, end-to-end workflow.

Keywords:

Surface Reconstruction, Point Cloud, Outlier Removal.

INTRODUCTION

Raw point cloud data acquired using specialized devices such as LiDAR sensors or as structural outputs from motion algorithms that use RGB images and depth data along with feature matching, usually contain a large amount of noise and outliers. Point clouds in such a state cannot be easily reconstructed into a 3D mesh, but rather must first undergo a process of data cleaning. As such, the process of generating the 3D mesh from a raw point cloud can be separated into two distinct phases, the first phase being clean-up and the second phase being the reconstruction itself.

The amount of data clean-up must be carefully constructed in order to preserve as many features and details as possible, while removing as much noise as possible. The subject of de-noising has been extensively studied and adapted for different surface types, object shapes and other parameters [1]. There is no single method that prevails above all others. Every method has applications in certain use cases. Unfortunately identifying the best method for a particular point cloud is usually experimental in nature.

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Similar to noise removal, the subject of surface reconstruction from 3D point clouds is not a new area of research. As such, there are many algorithms to choose from when performing surface reconstruction, each with their own pros and cons [2].

The choice of algorithm is invaluable in getting satisfactory results, due to the fact that each algorithm handles specific drawbacks of non-perfect point clouds in different ways.

2. RELATED WORK

As mentioned in the introduction, both phases of the reconstruction process have been extensively researched. We will briefly review the methods that influenced and motivated our work below.

The removal of outliers has many approaches. Sun et al. [3] proposed a method for removing outliers that utilized L0 minimization, thus creating sparser outputs and retaining sharp features and surfaces, thus eliminating an recurring issue of oversmoothing in outlier removal and surface reconstruction. However, sparse outputs will not retain as many surface details as dense outputs would. A different approach is using neighbouring points in a point cloud to detect clusters. These approaches are usually slow in computation, where the speed is dependant on the complexity of the data. Sankaranarayanan et al. [4] described an algorithm that improved the computational speed in using neighbourhoods of points in outlier removal. Ning et al. [5] removed noise from point clouds by analyzing categories of outliers identified in the cloud itself. Due to using the local density of points for detecting outliers, this method is not suitable for point clouds where dense clusters of outliers exist. Yuan et al. [6] developed a novel method called spatial neighbourhood connected region labelling, which is used for data clustering in the point clouds. The method was tested on both synthethic and real world point cloud data. The points are classified into clusters which are then used for identifying cluster outliers as well as sparse outliers. Li et al. [7] extracted the nearest neighbouring points before the search began, thus removing repetition with the Euclidean distance calculation that is required, and saving time and resources. Reconstruction of point clouds usually relied on standardized, tried and tested algorithms, such as [8] and [9]. These algorithms are heavily dependent on the input and as such the quality of their output is directly affected by the outlier removal. With the development of machine learning, approaches that utilize more complex

workflows for surface reconstruction have begun to appear. Hanocka et al. [10] uses a deep neural network to deform an initial mesh to encapsulate the input point cloud, thus ensuring the shape of the object does not lose the actual point cloud shape. The authors demonstrated the robustness of the algorithm on point clouds of non-trivial shapes that vary in density and quality, showing that the algorithm outperformed multiple standard algorithms such as [8]. Ladicky et al. [11] propose a surface reconstruction method that utilizes regression forests, using predictions that depend on the local context. The training of the network was done on synthetic data, which represents the biggest problem of the pipeline itself, due to the difficulty of generating quality noisy point cloud data that mimics realistic scenarios. That, in itself, represents the biggest issue that the neural network approaches have - the quality of data acquisition. Dill et al. [12] presents a generative model that progressively deforms a uniform sphere mesh until it approximates the input point cloud. The limitations of this approach are its limitations to objects with a similar topology as well as failure to preserve the finer detail.

3. PROPOSED METHOD

Our solution combines the process of outlier removal with the process of surface reconstruction to create watertight 3D meshes. The point cloud data used to showcase the workflow is deliberately of a lower quality, with a large amount of internal and external noise [Figure 1]. The process of creating the 3D surface reconstruction of this point cloud consists of four phases.

In the first phase, initial outliers are identified and removed from the input point cloud. Only the most extreme outliers are removed in the first phase. Initially the centre of mass of the point cloud is calculated, after which the points that are located furthest away from the centre are identified as the initial candidates for removal. A k-nearest neighbour is implemented to detect a neighbouring area around the point. Once the area is selected, the number of points inside the area are counted. If the number of points is lower than the threshold value, the points are identified as outliers and removed from the point cloud [Figure 1]. The threshold is variable and depends on the distance of the point from the centre of mass of the point cloud.
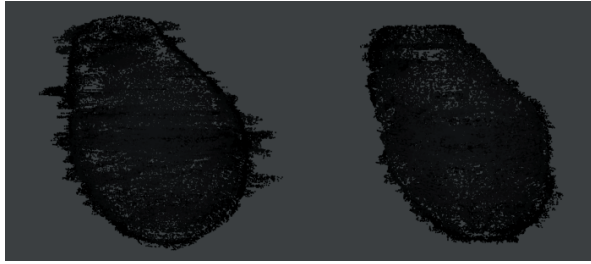
Figure 1 – Noisy input point cloud (left);
after initial noise removal (right)

Figure 3 – Convex Hull initial topology (left);
Convex Hull after re-meshing (right)

After the removal of the most extreme noise in the point cloud, a rough approximation that envelopes the entire point cloud is generated. The approximation is generated using the Convex Hull approach. Once this initial mesh is calculated, both the mesh and the point cloud are loaded into the same environment [Figure 2]. Due to the fact that the Convex Hull does not take cavities into account when generating the mesh, the initial mesh needs to be deformed in order to follow the shape of the original point cloud. In order to do so, the initial mesh is projected directly onto the surface of the point cloud. However, a Convex Hull mesh is not prone to quality deformation. To alleviate this, a re-meshing of the Convex Hull is performed. The purpose of this step is to create an evenly distributed face topology that will allow the mesh to deform uniformly across the entire object [Figure 3]. Once this step is complete, the projection of the mesh may be done. The main attribute of the mesh that dictates how much the mesh can deform is the amount of polygons that it consists of. In this step, the number of polygons is not increased as the purpose is not to go into minute details, but to create a more precise shape that follows the contours of the point cloud [Figure 4].

In the third phase, the rough estimated mesh is used to identify the points near the contour of the object that still represent noise and reduce the number of surface details that can be reconstructed. Both the rough estimation and the point cloud are again loaded into the same environment, where now there should be no points that are outside the mesh. The mesh is then scaled by a miniscule amount iteratively, and the number of points that are exposed with each scaling iteration are counted. A threshold is defined as a percentage of the density of the point cloud itself. For each iteration, if the number of exposed points is under the defined threshold, the points are identified as noise and removed from the point cloud. Once the number of exposed points reaches the threshold, the process is halted, and a new point cloud is defined [Figure 5].
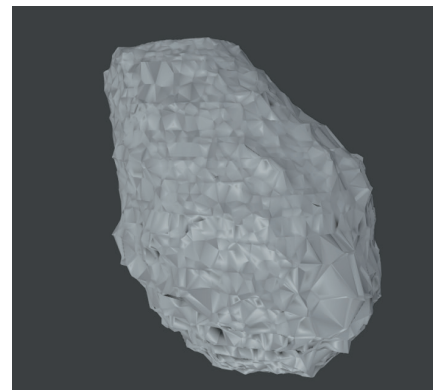
Figure 4 – Rough shape estimation of the point cloud

Figure 2 – Convex Hull (left) ;
Convex Hull with point cloud (right)

Figure 5 – Point cloud after the second round of noise removal

Once the final point cloud is created, the process from the second phase is repeated albeit with some modifications. The Convex Hull of the point cloud is calculated again, and the meshing process is repeated again. This time, however, the resulting mesh is subdivided into a more dense mesh i.e. a mesh that contains a higher number of polygons and as such can be deformed to reconstruct more of the finer details. Again, the resulting subdivided mesh is projected onto the point cloud [Figure 6]. The more cavities the point cloud contains, the higher the subdivision level should be. After this step, the mesh is finalized and ready for use. A smoothing of the surface can be implemented if necessary, but was not included in our solution.
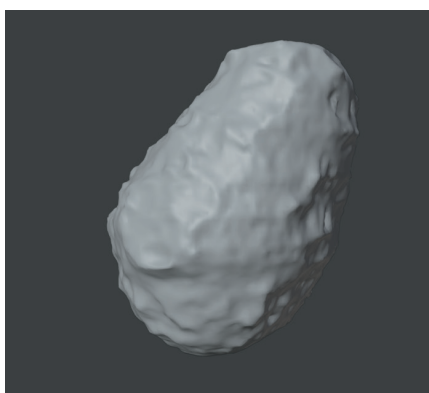
Figure 6 – Final version of the surface reconstruction

4. RESULTS

The resulting mesh is compared with standard approaches for reconstruction. To test out the quality of the reconstruction, the input point cloud in all of the reconstruction algorithms is the final version of the point cloud from the workflow, the use of which ensures uniform conditions that will only focus on the reconstruction process.

In [Figure 7] the results of the reconstruction are shown. It is clearly visible that the standard algorithms did not deal with the varying density of the point cloud well, creating large gaps in the surface, and small cavities where there should be none. Outlier and noise removal will only go so far in improving the quality of the point cloud. In some cases, as it is the case here, the point cloud will have parts of the surface missing. Combined with the internal noise that is present, this could create an illusion of gaps and cavities that should not be present. The workflow presented in this paper deals with all of the mentioned issues, and creates an accurate representation of the point cloud in question.
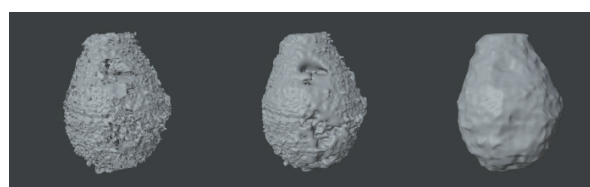
Figure 7 – Marching cubes (left);
Poisson surface reconstructon (middle);
our workflow (right)

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COMPUTER SCIENCE, COMPUTATIONAL METHODS, ALGORITHMS AND ARTIFICIAL INTELLIGENCE SESSION

SIMULATION AS A TOOL IN CONSTRUCTION MANAGEMENT

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Abstract:

Advances in technology and modern systems have enabled a major shift in the presentation of reality in a virtual way. The representation of a real system using a model enables various experiments, analyzes and studies. In this paper, a general overview of modelling and simulation is given. Through a brief description of methods and techniques, a special review of the simulation in construction management is given. Processes and phenomena in construction are mostly of stochastic character, so it is very convenient to apply simulation for their computer representation. Also, the cyclicity of most processes in construction, as well as their dynamics provides a suitable basis for the application of simulation. Simulation is often used to solve various problems in construction management, as: optimization, predicting, allocation of resources, solving transportation problems, supply chains, selection of machinery, etc. Simulation methods are described and an overview of the software most commonly used in construction management is given.

Keywords:

Modelling, Simulation, Construction management, Simulation software.

INTRODUCTION

Advances in technology and modern systems provide a number of possibilities and create an environment that enables the visualization and creation of virtual reality. Modelling and simulation make up a series of creation activities model of a real system and its computer simulation. For more than four decades, modelling and simulation have been in use in various fields of science and technology. It is practically an essential and inseparable part of all scientific fields, for example, in the management of organizations and business systems, engineering, military industry, medicine, computer science, biology, education, but increasingly also in the social sciences. Modelling methods have been perfected with the development of applied mathematics, mathematical statistics, operational research, experimental and computer methods. The accelerating advances in technology, computing, and science have enabled a major shift in the representation of reality in a virtual way for an ever-increasing range of systems.

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The representation of a real system using a model enables various experiments, analyzes and studies. Simulation modelling is one of the leading modern methods of computer-aided modelling. It is in fact an abstract representation of a real system, valid only for strictly defined experimental conditions. This method enables the description, understanding and quantitative analysis of complex dynamic systems in different areas: production, transport, economics, mass service, computing, etc. In this paper, a general overview of modelling and simulation and a special review of the simulation in construction management are given.

2. MODELLING AND SIMULATION IN CONSTRUCTION MANAGEMENT

Processes and phenomena in construction are mostly of stochastic character, so it is very convenient to apply simulation modelling for their computer representation. Also, the cyclicity of most processes in construction, as well as their dynamics provides a suitable basis for the application of simulation. The methodology in modelling, as shown on Figure 1, is based on a closed cycle.
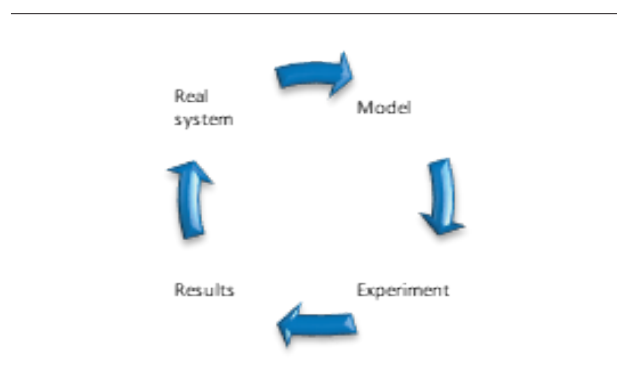
Figure 1 – Research methodology in modelling process.

Simulation is often used to solve various problems in construction management, as: optimization, predicting, allocation of resources, solving transportation problems, supply chains, selection of machinery, etc.

Simulation plays an integral role in a futuristic vision of automated project planning and control of computer modelling system for construction [1]. Many works and methods applied for the development of simulation models are based on one of the first CYCLONE simulations recommended by Halpin [2].

Simulation models are models that are related to dynamic systems, i.e. systems that change over time. Typical examples of these systems are: queues, production processes, storage, transport, etc.

AbouRizk *et all* presented an overview of three simulation implementations: for an earthmoving contractor (namely dynamic process interaction), an aggregate producer (continuous time-dependent) and a general contractor (static simulation) [3].

The complexity and uncertain nature of construction projects require simulation for analyzing and planning these projects. On the other hand, Genetic algorithm (GA) can be used to optimize the cost and time of a project [4] [5] [6] [7].

To improve the performance of construction operations, [8] simulation has been used to predict productivity. The Agent-Based Modelling (ABM) as an effective tool for predicting the effects of congestion on labour productivity in construction projects presented in [9]. Predicting productivity of concreting process [10] and project duration [11] presented using simulation.

In paper [12] has been proposed production processes optimization and implemented in the metallurgical enterprise information system.

Building Information Modeling (BIM) is a new approach to the application of simulations in construction. It helps architects, engineers and constructors to visualize what is to be built in simulated environment and to identify potential design, construction or operational issues [13] [14] [15].

Modern modelling is inconceivable without the use of computers that, along with various methods and software tools, provide a good space for creating complex models and working efficiently with them. Computer simulation is the performance of experiments on a model of a real system, over a period of time, which is performed on a computer (Figure 2).
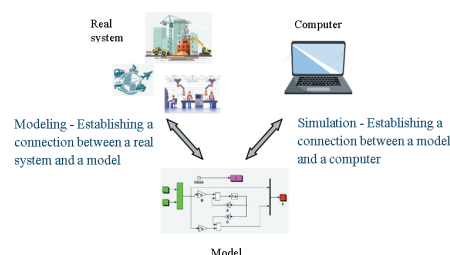
Figure 2 – Modelling and computer simulation.

The speed of modern computers and the development of many programming languages and methods enable greater and easier application of simulation. Graphical representation of the system being modelled (e.g. presentation of the production process) and animation of the system through 2D and 3D views during simulation experiments allows easier evaluation of the logic and dynamics of simulation models and easier monitoring of model development over time.

There is a large number of ready-made software that is very widely used in the creation of simulations in construction management. Some of the software is:

- MATLAB & Simulink - a programming environment for algorithm development, data analysis, visualization, and numerical computation. That is a programming platform designed specifically for engineers and scientists to analyze and design systems and products that transform our world;

- AnyLogic - is the only simulation tool that supports Discrete Event, Agent Based, and System Dynamics Simulation;

- FlexSim - is a powerful tool for modelling, analyzing, visualizing, and optimizing any process - from manufacturing to supply chains;

- Arena - Simulation solution that assists businesses with 3D modelling, design analysis, dynamic modelling, and more;

- SimcadPro - Simulation software with interactive 2D/3D modelling. Support for Discrete Event, Continuous Flow, and Smart Agents;

- VenSim - Leading System Dynamics & simulation solution for building high quality models of complex systems;

- Enterprise Dynamic - is a simulation software platform to design and implement simulation solutions in Industry, Logistics & Transport, etc.

Many have ready-made libraries specializing in displaying individual processes. They enable visualization and animation through 2D and 3D views. They use different programming languages as: Matlab, C ++, Fortran, Python, JAVA methods, etc.

3. DEVELOPMENT ALGORITHM OF SIMULATION

The life cycle of the simulation is a series of steps that describe the individual phases of problem solving. The number of phases and the order of their execution depend on the specific situation. The basic phases of the simulation process are shown in Figure 3.

Defining the aim of the research describes problem to be solved. System identification describes system components, interaction of components, mode of operation, connections with the environment, formal presentation of the system. Collection and measurement of relevant system data, analysis of these data (selection of distributions of independent random variables, evaluation of the values of distribution parameters). Creating a conceptual model that adequately describes the system and allows solving a given problem. Making simulation software by choosing a programming language or package and creating a simulation program by writing a program or automatically generating a program based on a conceptual model. Simulation program verification is testing the simulation program according to the simulation model settings. If the verification of the program did not give satisfactory results, a return to step 5 is required. Evaluation of the simulation model implies examination of whether the simulation model adequately represents the actual system by analyzing the results. If the evaluation of the model is not successful, it is necessary to return to point 4 and make changes to the model. Planning of simulation experiments and their execution means planning and execution according to the adopted plan in order to enable fulfillment of the study goal. Analysis of the results of the experiments - during the analysis of the results, it may be necessary to supplement phase 8, i.e. to perform additional experiments. Conclusions and recommendations are at the end of simulation.
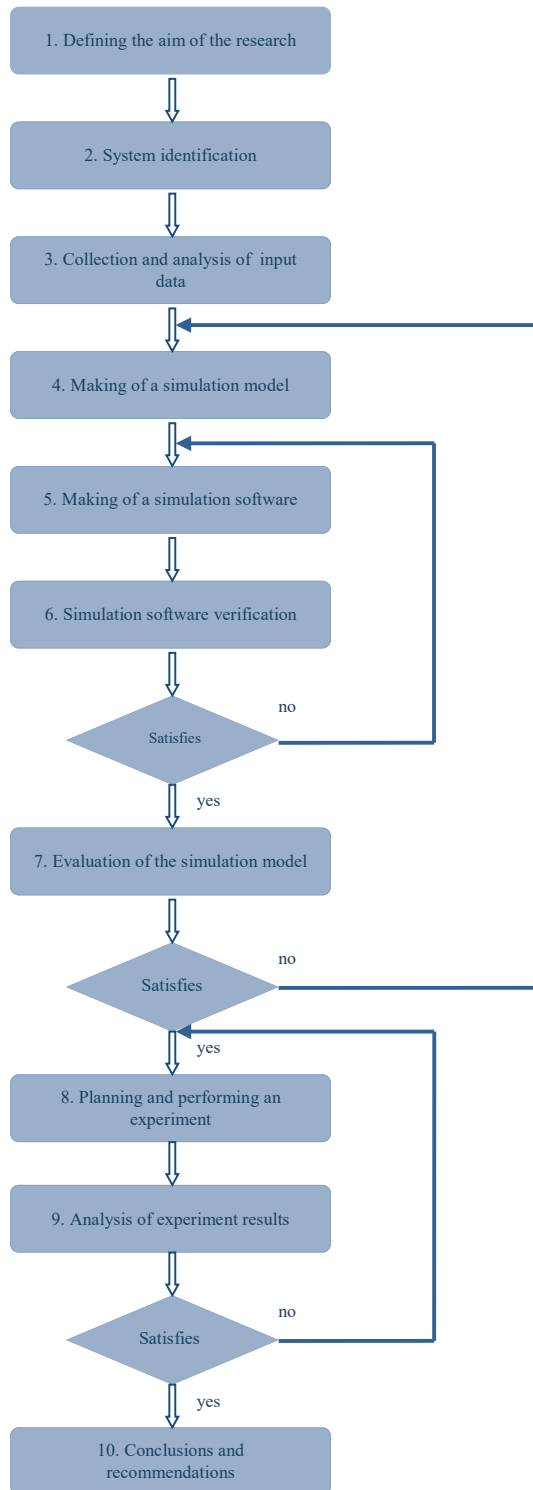
Figure 3 – Development process of simulation.

4. TYPES AND METHODS OF SIMULATION

Depending on how to solve the problem and consider the environment, there are 4 basic types of simulation: Monte Carlo, Discrete Event, Continuous and Mixed Simulation.

4.1. MONTE CARLO SIMULATION

The Monte Carlo simulation depicts stochastic processes, in which time does not play a role. It is also referred to as the method of repeated attempts and is a static type of simulation in which the creation of samples from the distribution of random variables is used in problem solving.

In construction management, Monte Carlo simulation applied to predict potential delays prior to the start of the construction project [16]. A Fuzzy Monte Carlo Simulation (FMCS) framework for risk analysis of construction projects [17] has been used successfully.

4.2. DISCRETE EVENT SIMULATION

Discrete Event Simulation (DES) is a method of simulation modelling of systems in which state changes occur discontinuously in time, i.e. only at certain times in time. Systems modelled in this way are dynamic and almost regularly stochastic.

The model is executed in steps, where the next state of the system depends on the current state and the current influence of the environment. The simulation describes each discrete event, moving from one event to another, resulting in a shift (increment) of the simulation time. One of the key elements in the development of discrete event simulation is the time shift mechanism. Two basic mechanisms are used: time shift for constant increment and time shift to the next event as shown in Figure 4.
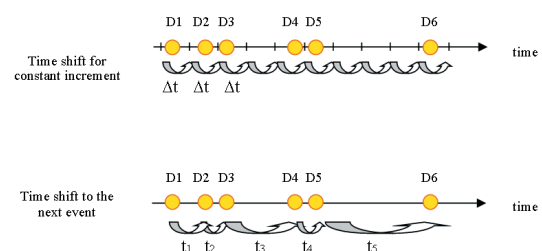
Figure 4 – Mechanisms of time shift in discrete even simulation.

The shift of time for constant increment implies a change of time in the simulation model so that the same increment Δt is always added. After each time shift, i.e. updating the value of the simulation clock, it is examined whether some events should have occurred

in the previous time interval. If so, then these events are planned for the end of the interval. This time shift has a disadvantage because moving the event to the end of the time interval introduces an error into the simulation. Events that are not simultaneous in this approach are displayed as simultaneous, and then the order of their execution is determined (which may differ from the actual order). By decreasing the time increment, these errors are reduced, but the time spent on performing the simulation is increased, as well as the number of time intervals in which there are no events.

Shifting the time to the next event means moving the simulation clock to the time in which the first or more subsequent event will occur. If events are set to run at the same time, they will be executed in series as shown in Figure 5.
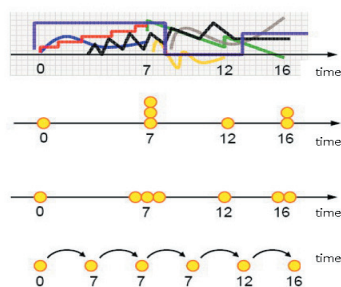
Figure 5 – Execution of simultaneous events.

The simulation ends when there are no more events or when some predefined condition for the end of the simulation is met. In this way, an error in the execution time of the event is avoided and at the same time intervals in which there are no events are skipped. This principle is more complex but also more efficient, so all key simulation languages use this mechanism. Figure 6 is shown order of execution of events.
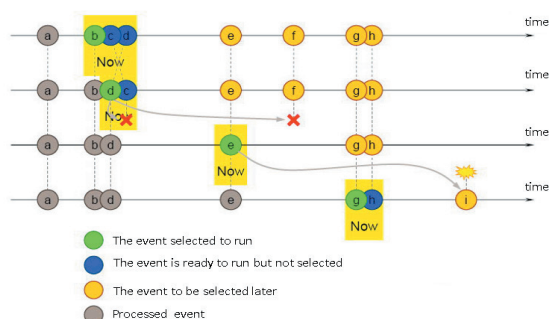
Figure 6 – Order of events execution.

An optimization methodology that integrates discrete-event simulation (DES) with a heuristic algorithm is developed to optimize dynamic resource allocation for construction scheduling [18]. A new simplified discrete-event simulation approach (SDESA) is presented through extracting the constructive features from the existing event/activity-based simulation methods [19]. Supply chain operations by looking at the logistics function of construction material suppliers a discrete event simulation approach to assess the impact of demand fluctuations on two crucial logistics performance measures; lead time and cost efficiency are presented in [20].

4.3. CONTINUOUS SIMULATION

Continuous simulation is used for dynamic problems in which state variables change continuously over time. Continuous simulation uses equations that describe the system in the form of change intensity. System dynamics is a methodology of research, modelling and simulation of complex dynamical systems. Feedback systems are a basic type of system that is modelled by system dynamics. Feedback models are most commonly used to model engineering, biological, social, and economic systems.

A dynamic simulation model is developed using system dynamics for supplying ready mixed concrete (RMC) [21]. Paper [22] presents a system dynamics computer model to evaluate alternative type of recycling centre under different policy and economy environments.

4.4. MIXED SIMULATION

Combined simulation, applies the simulation of discrete events to a single continuous model. In some types of systems, continuous simulation, as well as simulation of discrete events, cannot fully describe the mode of operation of the system. These are those systems that contain processes that run continuously and events that lead to discontinuities in the behaviour of the system. In order to model and simulate such systems, a mixed simulation has been developed that allows the integration of continuous and discrete system elements.

Discussion about the deficiencies of two traditional simulation methods – System Dynamics (SD) and discrete Event Simulation (DES) – for simulation of construction projects which can be compensated by implementing hybrid SD–DES model are presented in [23]. Research [24] argues about a hybrid SD-DES approach to model labour productivity considering the effects of

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both the context and operational level factors. The developed methodology integrates DES and SD to utilize their respective advantages in simulating construction operations [25].

5. CONCLUSION

The increasingly rapid progress of technology, technology and science, provides the opportunity to develop increasingly complex and comprehensive methods and techniques that are successfully applied in various fields of science. In construction management, computer simulation is widely used to solve various problems, as optimization, allocation of resources, prediction of project duration, cost, productivity, supply chain management, construction site problems, etc. Simulation has a number of advantages, such as controlled experimentation, animation, multiple uses, solving complex problems, etc. Each of the described methods is used in construction management, but most of all the method is discrete event as well as mixed simulation through the hybrid approach DES-SD. A huge amount of software for simulation have a large help to build simulation for concretely problem.

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CREATING SMART HEALTH SERVICES USING NLP TECHNIQUES

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Abstract:

The rapid growth of the urban population and the development of information and communication technologies have led to the creation of a new concept - a smart city. The smart city uses information and communication technologies to improve the quality of life of its citizens. One of its most important components is smart health. Also, heaps of textual data are created every day, in medical information systems, then there are the government documents, and citizens' comments, reviews, etc. This paper examines the possibility of using text mining techniques and natural language processing to create smart health services. Three services intended for these purposes have been proposed, designed, and implemented: a service for answering patients' questions, an information board for visualizing data about an epidemic, and automatic processing of questionnaires and psychological tests.

Keywords:

Smart Health Services, Natural Language Processing, Text Mining.

INTRODUCTION

The constant progress of information and communication technologies (ICT) has enabled their application in almost all segments of individuals' lives to provide many services which make life easier for citizens. Modern technological infrastructure (Internet, smartphones with built-in sensors, smart devices in the household) is available today to most of the population. Techniques for processing large amounts of data, collective intelligence, and increasing the number of inhabitants in urban areas enabled the creation of a smart city, which is efficient in terms of energy consumption, transport, administration, learning, economic development, and other aspects [1]. It is based on Big Data [2] and IoT technologies [3]. Within the smart city, there are smart transport, smart agriculture, smart administration, smart education, smart healthcare, etc. Smart health uses ICT technologies to create services which contribute to the facilitation of medical procedures and better health of the population [4].

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The difference between e-health and smart health is in the flow of data. For example, creating electronic reports using the medical information system is an example of e-health, but enabling communication with doctors, and dashboard with analysis based on data in medical information systems (where the data flow is from citizens to smart city, and from smart city to citizens), are examples of using smart health.

Large amounts of data are collected daily, in medical information systems, then there are documents related to the medical domain (instructions for medicines, various forums containing instructions of experts, etc.).

Some information from patients can be collected using crowdsourcing (the technique of acquiring knowledge through the voluntary participation of users) [5]. EHRs [6] are electronic medical records created and stored in medical information systems and contain information about the patient's examination. They contain structural fields, such as name, identification number, date of examination, location of the institution where the examination was performed, diagnosis code, name of the diagnosis, but also contain a non-structural part consisting of physician observations that cannot be expressed through structural fields, physician notes, diagnoses, laboratory results, therapies, etc. The documents also contain textual data, as the free-answer questions in the questionnaires for patients. Unstructured data must be organized and structured in a way that allows their analysis. This requires sophisticated statistical and linguistic techniques. This process is usually associated with the artificial intelligence (AI) technique called natural language processing (NLP), which allows the system to understand the meaning of data in human language. The goal of NLP is to read, decipher, understand, and find meaning in natural language. Most NLP techniques rely on machine learning to infer the meaning of data in natural languages [7].

The research question of this paper is whether and how NLP techniques can be used to create smart health services. The motivation for this research is the creation of smart health services based on NLP which would be useful for patients and citizens in a smart city. For the realization of this research, the method of description was applied to the existing smart health services based on NLP techniques. Three services are proposed and using the modeling method and use case diagrams are shown. Details of the implementation and a screenshot of the demo systems that implement these services are given.

The paper is organized as follows. The second section presents the application of NLP techniques for medical purposes through related research. This is followed by a proposal and a description of NPL-based health services, and the implementation of the service is given. In the end, the conclusion and directions of further research are given.

2. RELATED WORK

This section presents research and examples of the use of tools based on NLP techniques for improving health. One of the ways to use the processing of textual data entered by users is the detection of depression [8].

The most popular medical text marking systems are CTAKES and CLAMP systems [9] [10]. The identification of medical terms in texts written by patients, using crowdsourcing, is presented in [11]. One approach to correcting errors in the free text of medical reports is presented [12].

3. SMART SERVICES BASED ON NLP TECHNIQUES

This section describes services based on NLP. The source of data for the implementation of these services are documents written in natural languages, citizens' answers obtained by crowdsourcing and EHRs from medical information systems. The service whose input data are documents is used to answer patients' questions. The service whose input data are the answers of citizens obtained by filling out questionnaires is the automatic processing of psychological tests. The service that processes the data entered in the EHRs displays data on the state of the epidemic. Use case diagrams, a description of the services, and finally presentations of their implementation are given.

3.1. ANSWERING THE PATIENTS' QUESTIONS

The smart health service for automatic answering of questions and search of medical documents should provide the user to enter a question and get an answer based on the similarity with the sentences in medical documents entered in the system by experts. The capabilities of this service are shown by the use case diagram used in Figure 1.
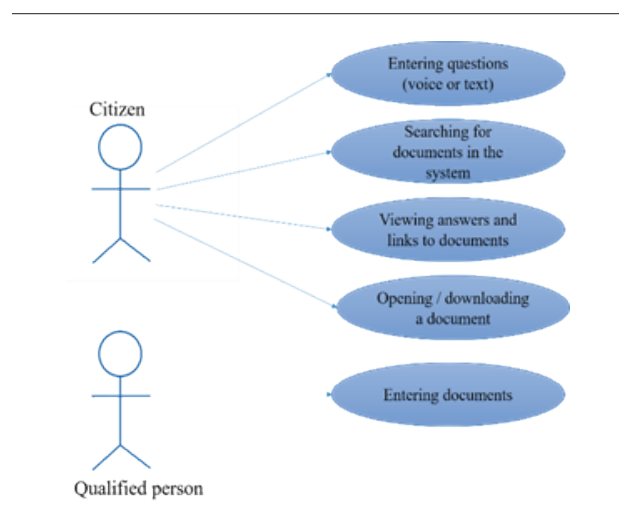
Figure 1. Use case diagram for the service for the automatic answering of citizens' questions

This service should help the citizen to get an answer to his question quickly at any time. There are three types of content in the system: questions, formal documents, and expert answers. Questions and documents are grouped based on keywords. When the user asks a new question, its similarity with the questions and documents in the selected group is considered. Preparation of documents for processing, normalization, extraction of keywords, the grouping of the documents and questions as well as finding the answer to the question are NLP techniques necessary for the realization of this service [13].

Figure 2. The realization of service for answering patient's questions

Figure 2 shows the realization of the client part of the document search service, i.e., answering citizens' questions.

The question can be entered directly from the keyboard or by voice, where the voice is recognized and converted to text, using the *Speech to Text API* [14], for automatic speech recognition in Serbian. It is also possible to click on one of the most frequently asked questions, and search for it. The result is a document containing an answer to a question.

On the server-side, an expert can enter a document in *pdf, txt, doc,* and *docx* format, after which the documents are normalized and stored in the database in a searchable form. When entering a document, the keywords for the document are automatically extracted, however, they can also be entered by the expert who enters the document, to further enrich the metadata.

3.2. AUTOMATIC PROCESSING OF QUESTIONARIES

Psychological tests often limit the respondent by offering him the possibility of choosing some of the offered options without entering a free answer because it is complicated for analysis. For the realization of the service for automatic processing of questionnaires and psychological tests, it is necessary to collect information about the mental state, as well as about specific reactions to appropriate stressful situations.

The questions are expressed in the form of standardized psychological tests as well as fields for describing a stressful situation. The frequency of similar stressful situations, as well as evoked feelings in comparison with the results obtained from psychological tests, can more clearly indicate the existence or non-existence of a corresponding psychological problem. A person best describes his mental state in his mother tongue, so the analysis of these tests is adapted to people who speak Serbian. The complexity of processing texts in the Serbian language is an additional challenge. This service can be applied to various types of questionnaires. As an example, a psychological test is given intended to provide support to women during pregnancy and the postpartum period who may have some specific psychological problems. The use case diagram of the service is given in Figure 3 and its realization in Figure 4. The text data that users enter is in a format that is not suitable for direct processing and needs to be processed using NLP techniques to be machine-readable. Descriptions of stressful situations are compared with those in the database, to obtain the results of the questionnaire. To compare descriptions as word vectors, their pre-processing and normalization are required [5].
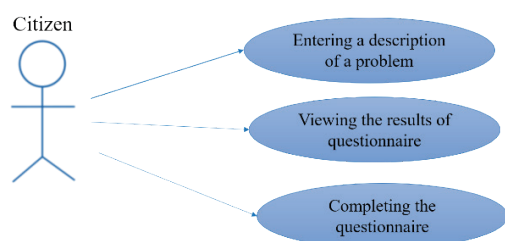
Figure 3. Use case diagram for the service for automatic processing of questionnaires

Psihološki testovi

Figure 4. The realization of service for automatic processing of psychological tests

3.3. DASHBOARDS WITH INFORMATION ABOUT AN EPIDEMIC

At the time of an epidemic, people need to have information about the situation in their place from verified sources, to act following it. The lack of such information can lead to the spread of news from non-objective sources, unscrupulous behavior of citizens, but also the spread of panic. Epidemic control is one of the topics in the field of smart health within smart cities. Based on the reports that are stored daily in medical information systems, various information on the epidemiological situation in cities can be extracted. Examples of realization are given based on EHRs from Health Centre Nis, from the period of the measles epidemic. The service is designed to work in real-time, directly takes data from EHRs, and provides many details, such as the prevalence of the virus by age structure, health facilities, and an overview of the number of infected in the appropriate time interval [15] [16] [17]. This service enables two functionalities based on NLP techniques (Figure 5):

a) Report on the most common symptoms. Using this report, the citizen would be more informed about the disease and could recognize the symptoms and in that case, contact a doctor. This report is created based on data obtained by entering in an unstructured field for physician comments from EHRs. With adequate processing of this text, frequently occurred symptoms can be extracted and shown on the diagram (Figure 6).

b) Questionnaire on the patient's current health condition (symptom presence/absence) to check whether to report to the medical station for treatment or not.
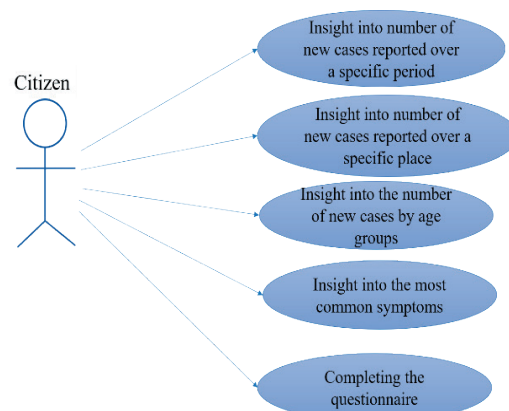
Figure 5. Use case diagram for the service for visualization of the epidemic data
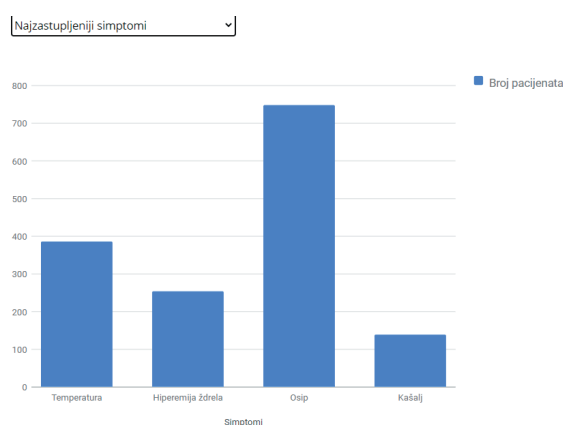
Figure 6. The realization of service with information about epidemy

4. CONCLUSION

A lot of textual data is created daily in medical information systems, and NLP techniques can be applied to gain new knowledge that will be used to create smart health services. Three use cases of NLP-based smart health services for each input type of text data (document, EHRs, and patient's responses) are presented. In further research, we will improve these and create new services that use NLP methods, such as finding and correcting errors when entering a non-structural part in the EHRs.

5. ACKNOWLEDGEMENTS

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COMPUTER SCIENCE, COMPUTATIONAL METHODS, ALGORITHMS AND ARTIFICIAL INTELLIGENCE SESSION

RANK-BASED SELF-ADAPTIVE INERTIA WEIGHT SCHEME TO ENHANCE THE PERFORMANCE OF NOVEL BINARY PARTICLE SWARM OPTIMIZATION

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Abstract:

Inertia weight is a significant parameter of the particle swarm optimization (PSO) algorithm. Its controllers the search capabilities of PSO and provides a balance between exploration and exploitation. There are a plethora of studies on inertia weight variants of continuous PSO (CPSO). However, a few numbers of studies have been presented for binary PSO (BPSO). In existing BPSO variants, despite different positions of particles, every individual is treated equally by ignoring the dispersion of particles in the search space. To deal with each particle according to its fitness value, we have proposed a Rank-based Self-adaptive Inertia Weight to enhance the performance of the Novel BPSO (NBPSO). The proposed algorithm controls the movement of particles by defining the ranks of each particle based on their fitness. The performance of the proposed algorithm is evaluated on four benchmark test functions. The experimental results show that the proposed method performs better than the compared algorithms in terms of convergence speed.

Keywords:

PSO, fitness rank, self-adaptive, inertia weight, convergence speed.

INTRODUCTION

The continuous particle swarm optimization (CPSO) [1] is a nature-inspired algorithm proposed by Kennedy and Eberhart in 1995. The algorithm is motivated by the social behavior of bird's flock and fish schooling. Its quick convergence, simple implementation, and non-complex computations have made it a widely accepted algorithm to solve many real-world optimization problems. This basic version of CPSO is utilized for the real number spaces and continuous problems [2].

To address binary optimization problems, Kennedy and Eberhart developed the Binary PSO (BPSO) in 1997 [3]. In BPSO each particle changes its position by either selecting 0 or 1. To enhance the performance of BPSO, several improved variants have been proposed. Khanesar et al. [2] proposed the NBPSO by presenting a new definition of velocity vector that is the rate of changing particle bits. The NBPSO also addressed the issue of selecting a proper value of inertia weights introduced in [4].

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Inertia weight provides the balance between exploration and exploitation capabilities of CPSO [5]. In literature, various inertia weight schemes have been presented. These schemes are classified into three classes [6]. First is a constant [4] or random inertia weight [7], in which the value of inertia weight is constant or random.

The second class is time-varying inertia weight, in which the value of inertia weight changes in every iteration step. These include linearly decreasing inertia weight [8, 9], non-linearly decreasing inertia weight [10], and Chaotic inertia weight [11]. The third class is adaptive inertia weight, which uses feedback parameters to set the value of inertia weight and monitor the algorithm's state. This class includes adaptive inertia weight [12], dynamic adaptive inertia weight [7], and rank-based inertia weight [13].

In this paper, we have proposed a rank-based self-adaptive inertia weight scheme to enhance the performance of NBPSO [2]. In the proposed scheme, an adaptive inertia weight strategy [13, 14] is incorporated to enhance the convergence speed. The velocity of each particle is directly controlled by their fitness such that the particle with high fitness gets the high rank and the particle with low fitness gets the lower rank. The movement of each particle is controlled directly by its fitness so that the particle with a low rank moves with high velocity. The proposed RIW-NBPSO enhanced the performance of NBPSO in terms of convergence speed.

The paper is structured as follows: Section II includes a Binary PSO and its variants. Section III presents the Novel BPSO. The proposed algorithm is presented in IV and in section V simulation results are presented. Finally, the paper is concluded in section VI.

2. THE BINARY PSO (BPSO) AND ITS VARIANTS

In contrast with CPSO, each particle in BPSO is represented with a bit string. A particle decides to pick a value of either 0 or 1. The particle updates the position by shifting values between 0 and 1. A particle's velocity is the probability change of taking 0 or 1, so the velocity of a particle must be bounded within the range [0, 1]. The sigmoid transfer function (sig) is used to represent and bound all the real number velocities within the range of [0 1] as:

$$v_{ik} = sig\left(v_{ik}(t)\right) = \frac{1}{1 + e^{-vik(t)}} \qquad (1)$$

Based on the above $sig(v_{ik}(t))$, the new position will be computed as:

$$x_{ik}(t+1) = \begin{cases} 1, if\ rand_{ik} < sg\left(v_{ik}(t+1)\right) \\ 0, otherwise \end{cases} \qquad (2)$$

where $rand_{ik}$ is a random number between [0, 1]. In standard BPSO velocity update is based on the following rule:

$$v_{ik} = wv_{ik} + c_1 r_{1_k}\left(p_{ik} - x_{ik}\right) + c_2 r_{2_k}\left(g_k - x_{ik}\right) \qquad (3)$$

where w is the inertia weight: $0 < w < 1$. p_{ik} is the kth bit of ith particle's personal best and gk is the kth bit of the best particle among all of the particles (global best position). c1 and c2 are the acceleration coefficients such that c1, c2 > 0, r1k, and r2k are random uniform distributions within 0 and 1.

Several BPSO variants have been proposed to achieve better performance in solving various problems. Beheshti et al. [15] improved BPSO to Memetic BPSO (MBPSO) depends on the hybridization of global and local topologies in PSO. Chaung et al. [16] proposed a Chaotic BPSO (CBPSO) by embedded chaotic maps in BPSO to solve feature selection problems. Khanesar et al. [2] proposed Novel BPSO by representing a new definition of the velocity vector and also addressed the issue of selecting a value of inertia weight in existing BPSO. A quantum computing-inspired BPSO (QBPSO) was proposed by Jeong et al. [17] that addressed the premature convergence of original BPSO and applied it in unit commitment problems for power systems. A modification was made by Afshinmanesh et al. [18] in BPSO based on the negative selection in the Artificial Immune system. Liao et al. [19] extended the basic discrete PSO to solve flow shop scheduling problems by redefining the particles and their velocities. An improved BPSO was proposed by El-Maleh et al. [20] that overcome the drawbacks of the original BPSO and solved the issues of state assignment in sequential circuit synthesis targeting area optimization. Wei and Jing [21] presented a Novel BPSO to solve the heliotype inference problem. A new modified BPSO for solving knap-sack problems [22] is proposed. A new probability function is inserted that maintains the diversity of the swarm. A modification of BPSO was presented by Vieira et al. [23] to predict mortality of septic patients using SVM. A modification was made by Yang et al. [24] in which different transfer functions were used along with a new procedure to update position to search for best task allocation solution for wireless sensor network. Lin et al. [25] proposed a

high-utility item-set mining (HUIM-BPSO) by using BPSO to find HUI efficiently. In [26], the theoretical as well as empirical analysis of effect of inertia weight strategies on the performance of BPSO have been presented. In [14], the value of acceleration coefficients was modified base on the fitness of each particle to improve the convergence speed. Ji et al [28] proposed an effective approach named Improved BPSO to address the formulated problems in feature selection and improve its accuracy. Too et al [29] presented a new co-evolution BPSO by utilizing different inertia weight strategies to solve feature selection problems. Mafarja et al [30] proposed a feature selection approach by using BPSO with a time-varying inertia weight strategy to reduce the processing time.

3. THE NOVEL BPSO

A Novel BPSO (NBPSO) [2] was proposed to address the difficulties of standard BPSO and also solved the issues of selecting a proper value of inertia weight. In NBPSO personal best position *pbest* and global best position *gbest* are updated the same as the standard BPSO equations. The definition of velocity is different in this novel version. Two velocity vectors V0 and V1 were introduced for each particle such that V0 holds a chance of a particle's bits to change to 0, while V1 holds a chance of particle's bits to change to 1. V0 and V1 are computed as:

$$V_{ik}^{1} = wv_{ik}^{1} + q_{1}^{1} + q_{2}^{2} \qquad (4)$$

$$V_{ik}^{0} = wv_{ik}^{0} + q_{1}^{0} + q_{2}^{0} \qquad (5)$$

w is the inertia weight and q1, q0 are temporary values. If k_{th} bit in gbest and *pbest* is zero, V_{ik}^{0} will grow and the chance of changing to one will be decreased to zero. And if the kth bit in *gbest* is one, V_{ik}^{1} will be increased and V_{ik}^{0} will decrease. Based on the above description, the following rules are elicited:

If $P_{ibest}^{k} = 1$ then $g_{ik,1}^{1} = c1r1$ and $g_{ik,1}^{0} = -c2r2$

If $P_{ibest}^{k} = 0$ then $g_{ik,1}^{0} = c1r1$ and $g_{ik,1}^{1} = -c2r2$

If $P_{gbest}^{k} = 1$ then $g_{ik,2}^{1} = c2r2$ and $g_{ik,2}^{0} = -c2r2$

If $P_{gbest}^{k} = 0$ then $g_{ik,2}^{0} = c2r2$ and $g_{ik,2}^{1} = -c2r2$

where r1 and r2 are random variables within (0, 1) and are updated after each iteration. c1 and c2 are the acceleration coefficients. After V^{0} and V^{1} are updated, the velocity of change is computed as:

$$V_{c} = \begin{cases} V^{1}, if \ x = 0 \\ V^{0}, if \ x = 1 \end{cases} \qquad (6)$$

Normalization is performed using a sigmoid function in equation (1). The next position of the particle is computed as:

$$x_{ik}(t+1) = \begin{cases} x_{ik}(t), if \ r_{ik} < V_{ik}^{'} \\ x_{ik}(t), if \ r_{ik} < V_{ik}^{'} \end{cases} \qquad (7)$$

The performance of NBPSO was compared with other versions of binary PSO. Experiments were performed on four test functions.

4. THE PROPOSED ALGORITHM

To improve the performance of NBPSO, we have proposed a RIW-NBPSO algorithm. Instead of a fixed value for inertia weight in NBPSO, an adaptive inertia weight strategy based on fitness rank is introduced. The proposed algorithm works the same as the NBPSO. The velocity vectors are evaluated using equation (3) where the value of w is computed as in equation (8). In the proposed algorithm fitness of each particle is computed. All particles are then sorted based on their fitness. Then rank is assigned to every particle for their corresponding fitness. In RIW-NBPSO a particle with a high fitness value gets the first rank and the value of w for this particle will be minimum which speeds up the convergence rate, while a particle with a low fitness value, gets the lowest rank, and w for this particle will be maximum which improves search abilities so the particle with low fitness can move with the high velocity. This improves the convergence speed.

$$w_{1} = w_{min} + \left(\frac{w_{max} - w_{min}}{Population(n)} \right) \cdot FR_{i} \qquad (8)$$

where FR_{i} is the fitness rank of each particle. w_{min} is 0.4 and w_{max} is 0.9. As an important parameter of CPSO, it is important to set a proper value of inertia weight. This parameter highly affects the performance of the algorithm [23]. In the proposed RIW-NBPSO the employment of adaptive w has served well and better than NBPSO in terms of fast convergence.

I. The population is initialized with random positions of particles within the hypercube (particles are selected randomly from binary values 0, 1).

II. Compute the fitness for an individual particle by using its current position.

III. Find the personal best position of each particle by comparing every particle's fitness to its best fitness. Set the current place as the best place if

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fitness at the current place is better than its best place.

IV. Find the global best position from all the particles by comparing the individual's fitness to its best fitness within the population. Set the current position as the best position if the fitness at the current place is better than its best place.

V. Sort and rank all the particles with respect to their fitness.

VI. Calculate the inertia weight for each particle using equation (8), so that the movement of each particle is commanded by its fitness.

VII. Update the velocity of particle V^0 and V^1 according to equations (4) and (5).

VIII. Compute the velocity of change of bits according to equation (6).

IX. Generate a random variable r within range (0, 1) to move each particle to a new place according to Equation (7).

X. Go to I, repeat till the convergence.

4.1. EXPERIMENTAL SETUP & RESULTS

To evaluate the performance of RIW-NBPSO, four test functions were selected and shown in equation (9) to equation (12) for Sphere, Rosenbrock, Griewangk, and Rastrigin [27] respectively. The comparison of the improved performance of the proposed RIW-NBPSO with NBPSO and other algorithms is provided in tables. The experiments are conducted on the minimization of test functions.

$$f_{1(x)} = \sum_{i=1}^{N} x_i^2 \qquad (9)$$

$$f_{2(x)} = \sum \left(100\left(x_{i+1} - x_i^2\right)^2 + \left(x_i - 1\right)^2 \right) \qquad (10)$$

$$f_3(x) = \frac{1}{4000} \sum_{i=1}^{N} x_i^2 - \prod_{i=1}^{N} \cos\frac{x_i}{\sqrt{i}} + 1 \qquad (11)$$

$$f_4(x) = \sum_{i=1}^{N} \left(x_i^2 - 10\cos\left(2\pi x_i\right) + 10 \right) \qquad (12)$$

In the above-mentioned benchmark functions, N represents the dimensions of search space. The population size of 100 is carried out for a maximum number of iterations: 1000 within range of [-50, 50]. Real numbers are represented using 20 bits binary values. Three different dimensions are tested: 3, 5, and 10. The experimental results in Table (I-IV) show the improved performance of RIW-NBPSO in terms of fast convergence for all four test functions.

Dim	RIW-NBPSO	NBPSO [4]	BPSO [4]	BPSO [4]
3	**6.821*10-9**	6.821*10-9	0.0561	0.154
5	**1.136*10-8**	1.921*10-6	7.9578	224.404
10	**1.682*10-7**	0.112	213.606	394.706

Table 1 Results of Sphere function

Table 1- presents the experiments of the mean of the best *gbest* carried out on Sphere function. In which RIW-NBPSO outperforms the NBPSO and other algorithms for different dimensions: 3, 5, and 10 in terms of fast convergence.

Dim	RIW-NBPSO	NBPSO [4]	BPSO [4]	BPSO [4]
3	**0.031**	0.093	0.938	0.864
5	**1.366**	2.247	1406	3746.5
10	**8.724**	32.831	1.309*106	1.523*106

Table 2 Results of Rosenbrock function

Table 2- shows the experiments for the mean of best *gbest* conducted on Rosenbrock function. The improved convergence of RIW-NBPSO as compared to NBPSO and other algorithms are listed with different dimensions: 3, 5, and 10.

Dim	RIW-NBPSO	NBPSO [4]	BPSO [4]	BPSO [4]
3	**2.08*10-9**	2.08*10-9	0.1716	0.2025
5	**2.59*10-9**	7.4*10-3	0.5824	0.6574
10	**0.0230**	0.0579	1.3864	1.4333

Table 3 Results of Griewangk function

Table 3- demonstrates the results for the mean of best *gbest* on the Griewangk function. RIW-NBPSO increases the convergence speed than the NBPSO and other algorithms for different dimensions: 3, 5, and 10.

Dim	RIW-NBPSO	NBPSO [4]	BPSO [4]	BPSO [4]
3	**4.5109*10-9**	1.353*10-6	2.669	3.7127
5	**4.5109*10-9**	0.0034	25.875	51.3154
10	**4.5109*10-9**	10.392	490.	539.337

Table 4 Results of Rastrigin function

Table 4- presents the results for the mean of best *gbest* on Rastrigin function. It is cleared that RIW-NBPSO performed better than NBPSO and other algorithms for all dimensions 3, 5, and 10 in 1000 iterations.

It is cleared from Table (1-4) that the proposed RIW-NBPSO using Rank-based inertia weight significantly improved the convergence speed. The proposed scheme outperforms as compared with NBPSO and other algorithms in terms of quick convergence.

4.2. ADDITIONAL EXPERIMENTS & DISCUSSION

To validate the improved performance in terms of fast convergence of RIW-NBPSO, we have performed further experiments by reducing the number of iterations from 1000 to 500, 200, 100, and 50. When the iterations are 1000, the particles get a higher chance to search the space so for 1000 iterations our proposed RIW-NBPSO quickly converges.

We have performed experiments by reducing the iterations. When the iterations are reduced to 500 RIW-NBPSO still provided better convergence results. We further reduced the iterations to 200 to check the convergence speed of the proposed RIW-NBPSO, it gives better results here too. The number of iterations further reduced to 100 and still the particles converge quickly which shows the proposed algorithm provided better results. We then reduced the iterations to 50, RIW-NBPSO showed quick convergence. It is validated from these experiments that the proposed algorithm accelerates convergence.

Table 5- evaluated the experimental results of RIW-NBPSO on Sphere function for different iterations tested on dimensions: 3, 5, and 10. The results demonstrated that the RIW-NBPSO particles quickly converged for 1000 iterations, when the iterations are reduced to 500 the algorithm still provided a better convergence. For 200, 100 and 50 iterations algorithm performed well.

Dim	1000	500	200	100	50
3	**6.821*10-9**	6.821*10-9	6.821*10-9	6.821*10-9	6.821*10-9
5	**1.1369*10-8**	1.136*10-8	1.136*10-8	6.93*10-6	0.010
10	**1.682*10-7**	6.472*10-5	0.007	0.616	8.236

Table 5 Results of Sphere function

Table 6- showed the results on the Rosenbrock function for dimensions: 3, 5, and 10. The results demonstrated that the RIW-NBPSO particles quickly converged for 1000 iterations, when the iterations are reduced to 500 the algorithm still provided a better convergence. For 200, 100 and 50 iterations algorithm performed well.

Dim	1000	500	200	100	50
3	**0.031**	1.771	0.286	0.392	0.070
5	**1.366**	3.980	2.879	3.136	3.446
10	**8.724**	17.422	56.395	105.485	5.75*102

Table 6 Results of Rosenbrock function

Table 7- demonstrated the results on the Griewangk function for dimensions: 3, 5, and 10. The results made it clear that the RIW-NBPSO particles quickly converged for 1000 iterations, when the iterations are reduced to 500 the algorithm still provided a better convergence. For 200, 100 and 50 iterations algorithm performed well.

Dim	1000	500	200	100	50
3	**2.08*10-9**	2.086*10-9	2.086*10-9	2.086*10-9	0.0074
5	**2.59*10-9**	0.0075	0.0148	0.0300	0.0311
10	**0.0230**	0.0124	0.0160	0.1531	0.2238

Table 7 Results of Griewangk function

Table 8- presented the results on the Rastrigin function for dimensions: 3, 5, and 10. The results demonstrated that the RIW-NBPSO particles quickly converged for 1000 iterations, when the iterations are reduced to 500 the algorithm still provided a better convergence. For 200, 100 and 50 iterations algorithm performed well.

Dim	1000	500	200	100	50
3	**4.5109*10-9**	4.5109*10-7	4.5109*10-7	4.5109*10-7	4.5109*10-7
5	**4.5109*10-9**	4.5109*10-7	4.5109*10-7	4.5109*10-7	4.5109*10-7
10	**4.5109*10-9**	4.5109*10-7	4.5109*10-7	4.5109*10-7	4.5109*10-7

Table 8 Results of Rastrigin function

5. CONCLUSION

In this work, a Rank-based Self-adaptive inertia weight scheme is introduced in NBPSO to enhance its convergence speed. Unlike BPSO where all the particles with distinct positions are equally considered, the proposed RIW-NBPSO uses rank-based inertia weight that controls the movement of particles by assigning ranks to the particles based on their fitness value. The experiments are performed on four benchmark test functions to evaluate the performance of RIW-NBPSO. The findings affirmed the improved performance of the proposed RIW-NBPSO than the compared algorithms in terms of convergence speed. To validate the improved convergence speed of RIW-NBPSO, additional experiments are executed on four test functions for different iteration. The additional results demonstrated that RIW-NBPSO performed better, not just for 1000 iterations, it also performed better when the iterations are reduced from 1000 to 500, 200, 100, and 50. Hence the proposed RIW-NBPSO based on fitness rank enhances the convergence speed.

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ENVIRONMENTAL DATA SCIENCE SESSION

THE INFLUENCE OF COVID-19 LOCKDOWN ON BTEX LEVEL DISTRIBUTIONS IN BELGRADE

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Abstract:

In this study, we have used the Standard Proton Transfer Reaction Mass Spectrometer (PTR-quad-MS) for online measurements of volatile organic compounds during the three-month campaign before, during, and after the state of emergency introduced as a preventive measure to the COVID-19 pandemic. The obtained data were analyzed by using correlations with hierarchical clustering, box plots, time variations, and bivariate polar plots with correlation and slope factor analysis, to provide better insight into the behavior and sources of the analyzed pollutants. As shown, pollutant concentrations have decreased only a week after the introduction of the curfew, and the benzene concentration dynamic was shown to be different compared to toluene, ethylbenzene, and xylenes behavior pattern.

Keywords:

Air Quality, BTEX, COVID-19, Lockdown, PTR-MS.

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INTRODUCTION

In Spring 2020, the lockdown was implemented in many countries worldwide to prevent person-to-person SARS-CoV-2 virus transmission. During that period several studies have been performed in different countries to investigate the impact of prevention measures and restrictions on air quality.

The study of Jephcote et al. [1] registered a decline in monthly average traffic counts by 69%, which was reflected in the decrease of ozone, NO_2, and $PM_{2.5}$ concentrations by 7.6, 38.3, and 16.5%, respectively. However, it has been shown that traffic had a relatively modest contribution to air quality in the UK and meteorological conditions which were associated with the observed episodes of high particulate levels confirmed the importance of long-range transport and distant emission sources. The study of Mor et al. [2] aimed at investigating the relationships between 14 pollutant concentrations and meteorological factors during the four periods of lockdown, each of them lasting for 20 days, has confirmed the impact of local residential emission sources and regional atmospheric pollutant transport on local air quality.

Sari and Esen [3] used data from 61 air quality monitoring stations in 31 cities to investigate the impact of restrictions on PM_{10} and SO_2 levels. Their results have shown that mean PM_{10} and SO_2 levels were decreased by 38.7% and 33.9%, and the observed effects of restrictions of both human and industrial activities on air quality were more pronounced than the effects of meteorological conditions.

As regards volatile organic compounds (VOCs), the study of Pakkattil et al. [4] examined the impact of lockdown on ground benzene, toluene, ethylbenzene, and xylenes (BTEX) levels in various metropolitan cities and according to the results, an enormous decline of 82% in BTEX concentrations was registered. However, despite the decline in BTEX levels and reduction of the ozone-forming BTEX potential, the corresponding decline in ozone concentrations was not observed. In the study of Kerimray et al. [5], the concentrations of PM2.5, NO2, SO2, CO, and O3 were decreased by 15 to 49%, however, the levels of benzene and toluene were 2-3 times higher than those registered during the previous years.

The pandemic-related measures and lockdown represented the sort of a real-world experiment that was used in many studies to derive important information and confirm conclusions that could enhance environmental policies and interventions in the future. In Serbia, preventive measures included restricted human mobility after 5 PM, during the weekend and on public holidays, except for medical personnel. Both human and industrial activities were minimized. In this study, we have investigated the impact of the most stringent introduced measures to air quality.

2. MATERIALS AND METHODS

The measurements of VOCs and meteorological parameters were conducted in an urban area of Belgrade, Serbia (44.86° N, 20.39° E). The measurement period (2nd March-2nd June 2020) covers two weeks before the introduction of the lockdown introduced as a response to the COVID-19 pandemic, nearly two months of curfew, and almost a month after the measures were lifted. Standard Proton Transfer Reaction Mass Spectrometer (PTR-quad-MS, Ionicon Analytik, GmbH, Austria) was used for online measurements of more than 230 masses [6], [7]. Meteorological parameters were measured using the Vaisala weather station. The calibration of PTR-MS measurements was done according to Taipale and coauthors [8] by using referent gases and a liquid calibration unit (Ionicon Analytik). The obtained data were analyzed by using correlations with hierarchical clustering, box plots, time variations, and bivariate

polar plots with correlation and slope factor analysis [9]. Mobility trend reports were obtained from Google and Apple.

3. RESULTS AND DISCUSSION

Figure 1 shows BTEX concentrations and human activity change which were registered as a result of lockdown and curfew implemented for public safety and prevention of COVID-19 pandemic spread in Serbia.
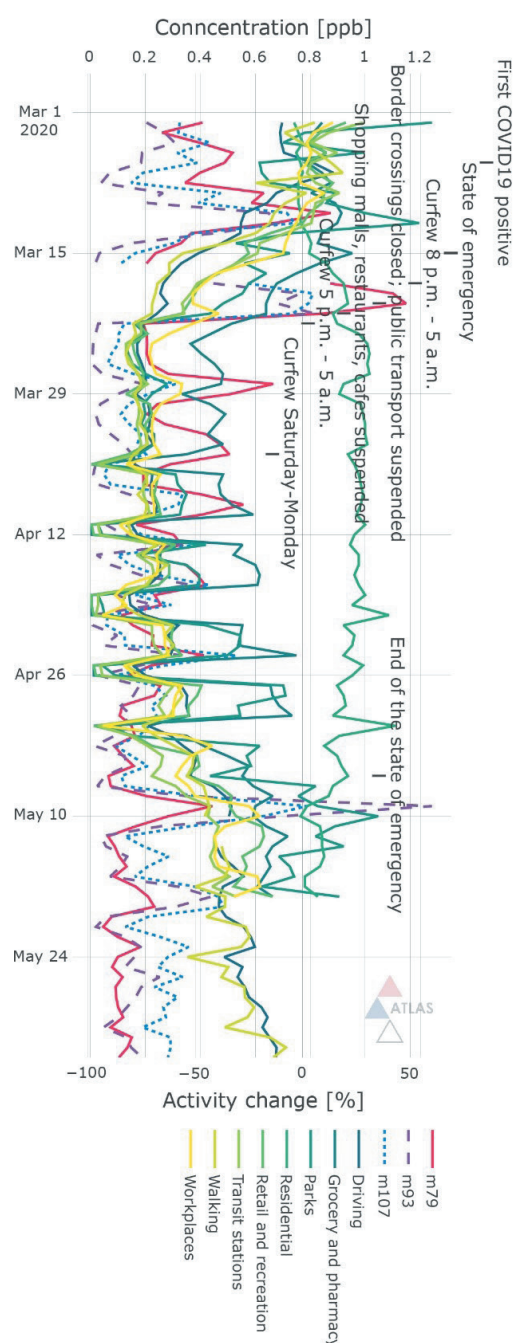
Figure 1 - BTEX concentration and human activity time series.

As can be seen, after the lockdown introduction, pollutant concentrations did not appear to reflect instant air quality change. It is worth noting that despite the abrupt cessation of human mobility and industrial activities, the beginning of the curfew period was characterized by an increase in BTEX concentrations. It cannot be excluded that the factors i.e., unfavorable meteorological conditions and the nature of the emission sources which govern the air quality in this part of the year could be responsible for the observed BTEX dynamics.

The first significant drop in BTEX concentrations was noticed a week later after the human mobility and industrial activities were minimized. The registered declines could be related to the first curfew periods that ranged, first for 9 hours (8 p.m.-5 a.m.), then 12 (5 p.m.-5 a.m.), and finally throughout all the weekend (Saturday-Monday). After several weeks of strict measures, a certain amount of human mobility was re-introduced, but BTEX levels continued to decline. The measurement campaign ended before the intensity of human activities returned to the common level.

In the period before the introduction of lockdown, the correlation analysis shows that the compounds registered at m/z 107 (ethylbenzene and total xylene) were in good correlation with compounds at protonated masses 93 (toluene) (r=0.93) and 79 (benzene) (r=0.9). This period was characterized by a good correlation between benzene and human activities such as spending time in retail and recreation (r=0.83) and transit stations (r=0.82), as well as between compounds registered at m/z 107 and activities in parks (r=0.86) (Figure 2). Among BTEX, the linear relationship was not observed only between benzene and toluene (r=0.73). During the lockdown, a strong correlation was observed between all compounds of the BTEX groups, with no significant correlations between BTEX levels and human mobility. After the lockdown, the relationships between all volatiles strengthened, but the correlations with human activities were not re-established.

Figure 3 represents the changes in mean BTEX concentrations during and after restrictions relative to the period before the state of emergency. As can be seen, the decrease in BTEX levels during the lockdown was in the range of 31 to 45%. The levels of volatiles increased after the human mobility and industrial activities were re-established, with exception of benzene which continued to decline up to 71% relative to the concentrations in the period before the pandemic. The box plot in Figure 4 also illustrates the decline in benzene concentrations with time. As shown, in the period after the lockdown,

the 7th percentile of benzene concentrations was only around 0.15 ppb. In this period, the traffic intensity showed a stable increase, reaching the level that was only 15% lower than before the measures (Figure 1), which is not accompanied by an increase in benzene concentrations. This suggests that the contribution of traffic emissions to the total benzene levels was overestimated in the previous literature.
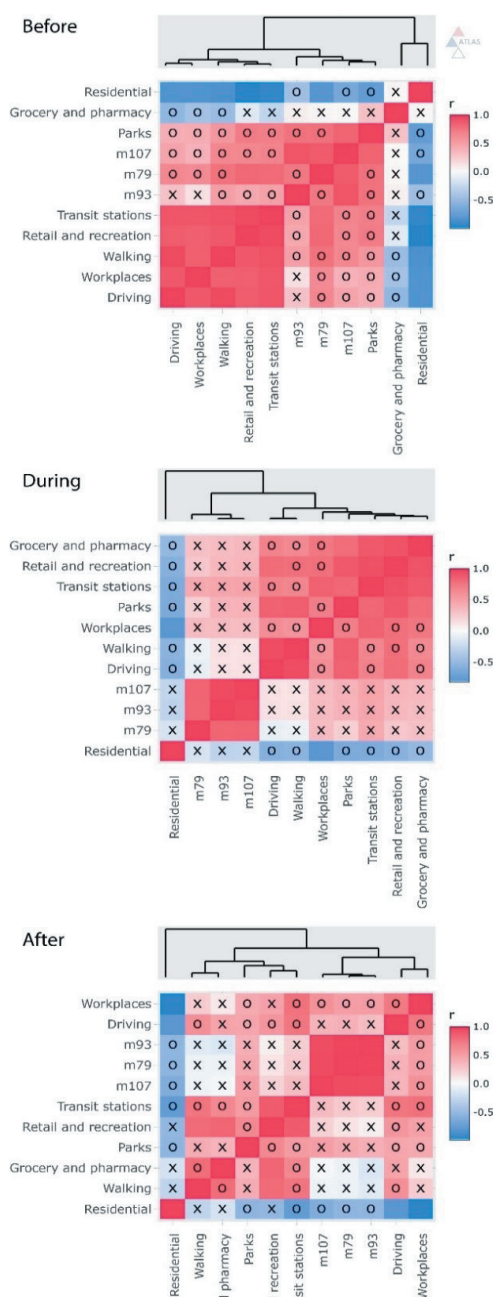
Figure 2 - Parameter value correlation matrix.

Figure 5 shows the dependence of the correlation and slope of toluene and benzene on wind parameters. The strong relationship between these compounds before restrictions indicates the dominant emission sources. The highest correlation (r=1) was recorded from all wind directions in the speed range from 1 m s-1 in the west to 8 m s-1 in the northeast from the measurement site.

The high ratio of toluene to benzene (T/B ratio > 2) suggests the existence of evaporative emissions (probably from industrial activities) being located in the north, northeast, south, and southwest.
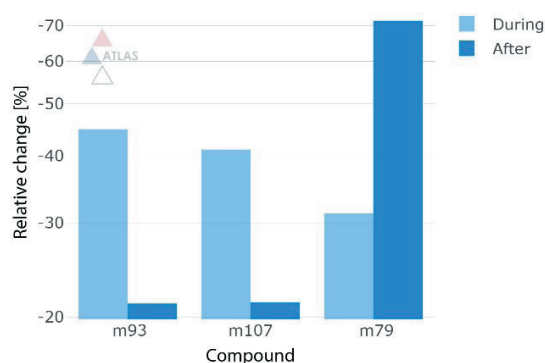
Figure 3 - Mean BTEX concentration difference during and after relative to the period before the state of emergency.

The dominance of the combustion process (T/B ratio < 2) was observed during the state of emergency, while after the lockdown period, the dominant evaporative emissions were restored, mainly in the southwest direction. This may indicate the reestablishment of the industrial activities and intense evaporations supported by higher temperatures in the period May-June.
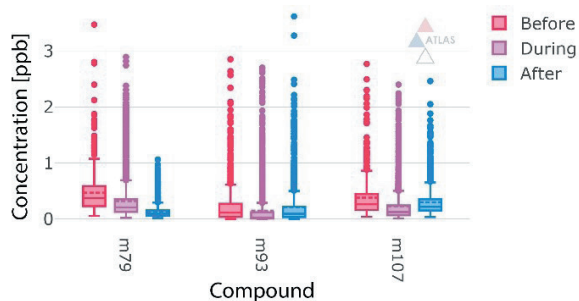
Figure 4 - BTEX box plots.

The daily and weekly variations in BTEX levels are shown in Figure 6. Daily variations (pronounced peaks early in the morning, late afternoon, and evening) indicated the expected distribution of VOC concentrations governed by meteorological parameters, photochemical processes, planetary boundary layer height evolution, and human activities in all three examined periods.

In contrast to the relatively stable daily dynamics, BTEX weekly variations changed over time. Before the lockdown, the highest BTEX levels were registered on Tuesday and Wednesday. During the lockdown, concentration peaks were displaced to Friday, while after the lockdown period, BTEX levels peaked on weekend.
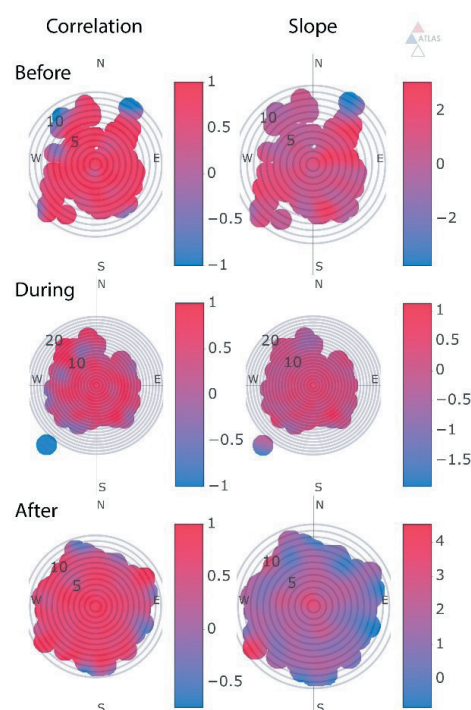
Figure 5 - Toluene and benzene correlation and slope dependency on wind parameters.

After the restrictive measures have ended, the pronounced BTEX peaks on weekends might be associated with travel, recreation activities, and staying outdoors, although based on the analysis of the time series (Figure 1), it is clear that increased human activities after the lockdown did not induce an increase in benzene concentrations, neither reestablishment of the correlations between BTEX compounds and human activity (Figure 2).
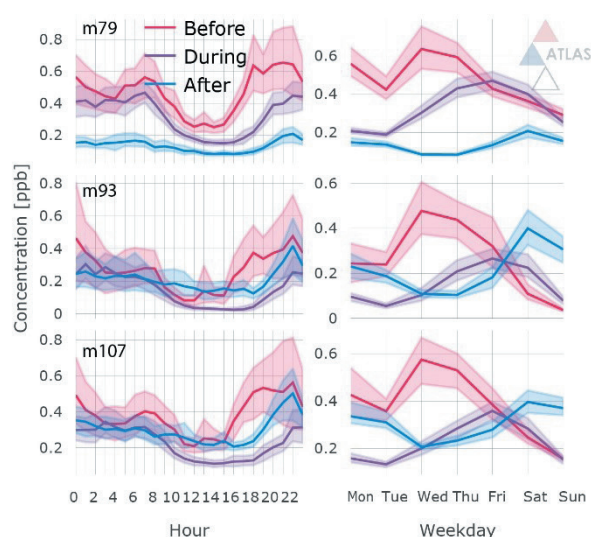
Figure 6 - BTEX diurnal and weekday variations.

As this type of analysis cannot indicate the main causes for the observed weekly variations in BTEX levels, it is necessary to approach more complex and precise analyzes.

4. CONCLUSION

While in the period before the introduction of the state of emergency and reduced human mobility, benzene and toluene levels exhibited no correlation, during and after the lockdown period strong correlations were observed between BTEX compounds, but no significant correlations between BTEX levels and human mobility were detected. An increase of human activities after the lockdown did not induce an increase in benzene concentrations, neither reestablishment of the correlations between BTEX compounds and human activities.

5. ACKNOWLEDGEMENTS

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ENVIRONMENTAL DATA SCIENCE SESSION

ECOLOGICAL RISK ASSESSMENT MODEL FOR THE „JADAR" PROJECT

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Abstract:

This paper presents a general framework for environmental risk assessment for the project "Jadar" - exploitation and processing of minerals "Jadarit". Conceptually, the paper is set up to provide insight into the applicability of a given model of environmental risk assessment.

This model is based on a scientific and proven methodology. The paper emphasizes the complexity of assessment and the need for a broad scientific approach. This environmental risk assessment is based on three potential sources of risk: mining activities, production-industrial activities and the generation of industrial waste.

As a possibility of negative impacts on the territory of the "Jadar" project, it is assumed that ecosystems, habitats and the environment would suffer consequences in general. The paper is expected to stimulate discussion and offer a proposal for solving this issue - the problem.

Keywords:

Environment, Assessment Phases, Stressor, Key points, Conceptual Model.

INTRODUCTION

The subject of this paper is the proposal of the model of environmental risk assessment, as a consequence of the realization of the project "Jadar" (hereinafter the Project).

The subject of the paper is spatially determined by the territory of the Project realization. The timing of the subject of the work includes the planned period from the beginning to the end of the Project implementation (at least 50 years). The Project envisages the construction of an underground mine, with two shafts with a diameter of about eight meters, which descend to a depth of 650 meters. The production of lithium carbonate, boric acid and sodium sulfate is planned within the Project. Lithium carbonate can be easily converted to lithium hydroxide and lithium phosphate from which batteries for electric vehicles are made [1].

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The project is expected to generate revenues for the Republic of Serbia of around 30 million per year or 300 million euros for a decade.

The aim of this paper is to assess the environmental risk as a consequence of the future realization of the Project on a scientifically based approach. The paper presents a model of the environmental risk assessment, based on a methodology that has been tested and scientifically proven. Identifying and describing sources of pollution, stressors, analyzing future effects of pollution and assessing environmental risks are requires an interdisciplinary scientific approach.

Taking into account the current state of the environment, with the growing impact of climate change, the implementation of the Project is an activity that has the potential for further deterioration of the ecological condition.

Applying the given model of ecological risk assessment would give precise answers about the potential of ecological risks in the observed area.

2. TYPES SPATIAL DETERMINATION OF THE PROJECT OF CONTENT

The Project area covers an area of 293.91 km2 and on the territory of local self-government units: - the city of Loznica - entire cadastral municipalities (CM): Runjani, Lipnica, Bradić, Brnjac, Veliko Selo, Jarebice, Draginac, Simino Brdo, Cikote, Šurice, Stupnica, Slatina, Korenita, Gornje Nedeljice, Donje Nedeljice, Grnčara and Šor; - municipality of Krupanj - entire cadastral municipalities (CM): Kostajnik, Dvorska, Brezovice, Krasava and Cerova [1].

Local self-government unit	Area of the covered part of the territory of the local self-government (km²)	%
City of Loznica	194,81	66,28
Municipality of Krupanj	99,10	33,72
Total	293,91	100

Table 1: Scope and area of the Spatial Plan area
(Source: Institute of Architecture and Urbanism of Serbia)

The spatial scope of the Project is determined by the borders of entire cadastral municipalities and is graphically shown in Figure 1. The border represents a special purpose area in a broader sense [1].
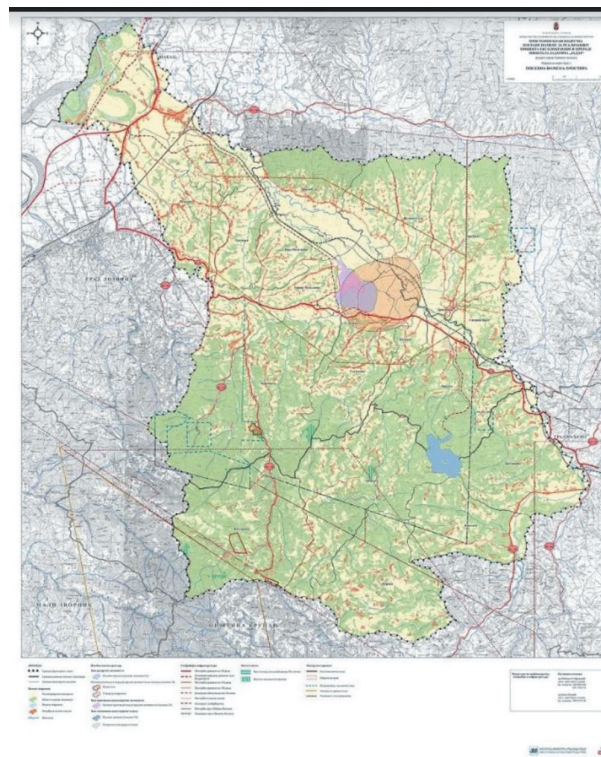
Figure 1 – The map of the Project area in the scale of R 1: 25.000 (Source: http//mgsi.gov.rs. [2]).

3. ECOLOGICAL RISK ASSESSMENT MODEL

It is assumed that the implementation of the Project there is an environmental risk of excessive pollution. This can cause environmental problems and consequences for the environment of this and wider area.

This pollution is determined by time. It can be considered from the beginning, during and after the realization of the Project.

In order to successfully address these dilemmas, it is necessary to use an adequate methodology based on science [3]. The assessment in question would use an environmental risk assessment model developed by the US Environmental Protection Agency [4]. The applied methodology of environmental risk assessment, which is internationally validated both in theoretical and practical terms, provides a good basis for its implementation in this case as well.

In that sense, the application of the given methodology of ecological risk assessment would determine the current ecological condition and the present risks with the aim of reducing them in the future. In general, environmental risk assessment can be defined in a way that it is a process of: collecting, organizing, analyzing and presenting scientific data in order to make decisions that provide protection and improvement of the ecological condition of the observed area [5]. Defined in this way, environmental risk assessment is a unique form of assessment that includes the term risk and which assumes a cause-and-effect relationship (relationship) stressor - response. The term ecological risk means the function of the probability of a given source of threat - stressor, which uses a certain potential sensitivity of an ecological system, and the corresponding response of the same to a given event. The term stressor refers to any physical, chemical or biological entity that can induce a negative reaction [6].

Environmental risk assessment of the Project implementation is a process that would be carried out in stages as follows:

- ◆ Assessment planning
- ◆ Problem formulation
  - establishing clear management goals and guidelines
  - determination of stressors
  - selection and definition of key assessment points
  - development of a conceptual model
  - development of an analysis plan
- ◆ Implementation of the Risk Analysis phase
  - evaluation of data and models for Analysis
  - characterization of exposure and environmental effects
- ◆ Implementation of the risk characterization phase
  - risk assessment
  - risk description
  - linking the obtained information with management decisions

Having in mind the complexity and scope of the model, this paper provides a general overview, with an emphasis on defining the stages of assessment and development the conceptual model. The conceptual model is one of the most important elements of the overall process and provides the basis for the whole assessment.

3.1. ASSESSMENT PLANNING

Environmental risk assessment planning must be separate from the scientific part of the assessment. [4] In this particular case, this would include:

- formation of a working group (team) for assessment,
- clearly defined goals and tasks of the management,
- defined management options in the context of achieving the set goals and
- agreement on the scope, complexity and focus of the risk assessment including the expected result and the technical and financial assistance needed to achieve the set goals.

One of the most important planning products would be to establish management goals and objectives. In this case, the main goal could be: Determining the quality of the environment during and after the implementation of the Project.

Some of the management objectives of a given assessment, which more explicitly explain possible objectives and which are grouped together in the main objective, could be:

- Determining the current state of the environment, including current quantities for individual pollutants
- Determining the state of quality of environmental elements (water, air, soil)
- Determining the state of health of plants, animals and other organisms, excluding humans.
- Establishment/implementation of measures to improve the state of the environment.

3.2. PROBLEM FORMULATION

Preliminary hypotheses are made here about what environmental effects have occurred or may occur in a given procedure [6]. This phase provides the basis for a complete environmental risk assessment of the consequences of the Project implementation.

From the collected (available) information, the following products would be prepared: defined stressors and key assessment points; conceptual model (s) developed, risk hypotheses defined and risk analysis plan defined.

Stressors should be ranked according to the potential risk for all living space resources of the Project implementation and beyond.

This would be done on the basis of professional assessment by the working group. The results of the comparative analysis could first rank the pollutants, in order to verify the assumption that they are the biggest stressors for the environment of the subject area. It would be necessary to examine each stressor separately, in order to study the intensity of their impact on the environment and to determine their current state and possible increase during the implementation of the Project.

Potential stressors could be:

- physical pollutants,
- chemical pollutants,
- pollutants in the air,
- pollutants in the soil,
- pollutants in water.

The key points of the assessment are an expression of the current values of the environment we want to preserve [6]. The key points of this assessment should be: environmentally relevant, that they are related to existing stressors and that they are related to previously adopted management objectives [4].

Potential key assessment points could be:

- health of plants, animals and other organisms,
- contamination of the space,
- % representations of diseases of organisms,
- distribution and number of organisms,
- quality of groundwater and running water and soil and
- food quality in the food chain.

According to the definition, "conceptual models are mathematical models that are composed of a small number of simple elements, and each element simulates a specific phase of the process" [5]. The conceptual model in the present case would belong to the group of complex models and could be given in the form of diagrams (Figure 2). This presentation provides a description and visual presentation of the predicted relationships between environmental entities (selected key assessment points) and the stressors to which they may be exposed. All pathways in the diagram are also risk hypotheses, because they concern certain information related to this assessment. The complexity of this conceptual model-data diagram is conditioned by the complexity of the problem: the number of stressors, the number of key points, the nature of the effects and the characteristics of the ecosystem. In the case of this assessment, it can be argued with certainty that the conceptual model would be very complex.

Risk hypotheses are proposed answers to risk assessor questions about what key point reactions will show when exposed to stressors and how that exposure will occur. Risk hypotheses are specific assumptions about the potential risk of key points. In the conceptual model, risk hypotheses represent connections and can also be used to ask questions important for research in order to assess the logical and empirical consequences, in order to create a basis for risk assessment.

Regarding the establishment of risk hypotheses, in this case they could be initiated: protection of ecological values, the impact of stressors on organisms or caused ecological effects (disease of organisms, pollution and loss of habitats, etc.). Thus, some of the hypotheses could be: that excessive pollution of the elements of the environment causes a decrease in the number of organisms.

To define and develop an analysis plan, it would be necessary to once again consider the set the risk hypotheses in order to determine the method of assessment, using available and newly arrived data. It would be the obligation of the working group to make a comparative, ie. comparative risk analysis, to help define which stressors and key assessment points should be examined.

3.3. IMPLEMENTATION PHASE OF THE RISK ANALYSIS

Risk analysis is a strategic phase in environmental risk assessment [6]. In a given case, this phase would be the most extensive and demanding of all assessment phases, both in quantitative and qualitative terms. The analysis would examine the two basic components of risk, exposure and effects, and their interrelationship [5]. Before proceeding with the realization of exposure characterization and characterization of ecological effects, it would be necessary to evaluate the available data and the defined analysis model. This model would include an assessment of possible uncertainties that accompany this phase. This would include an assessment of the possibilities and limitations of the different data types, an assessment of the modeling study, as well as an assessment of the overall uncertainty regarding the quality of the data and the set model.

After conducting assessments on available data and the projected modeling study, as well as possible uncertainties and shortcomings in the assessment process so far, the characterization of exposure and the characterization of effects would be approached as the next phases of the analysis.
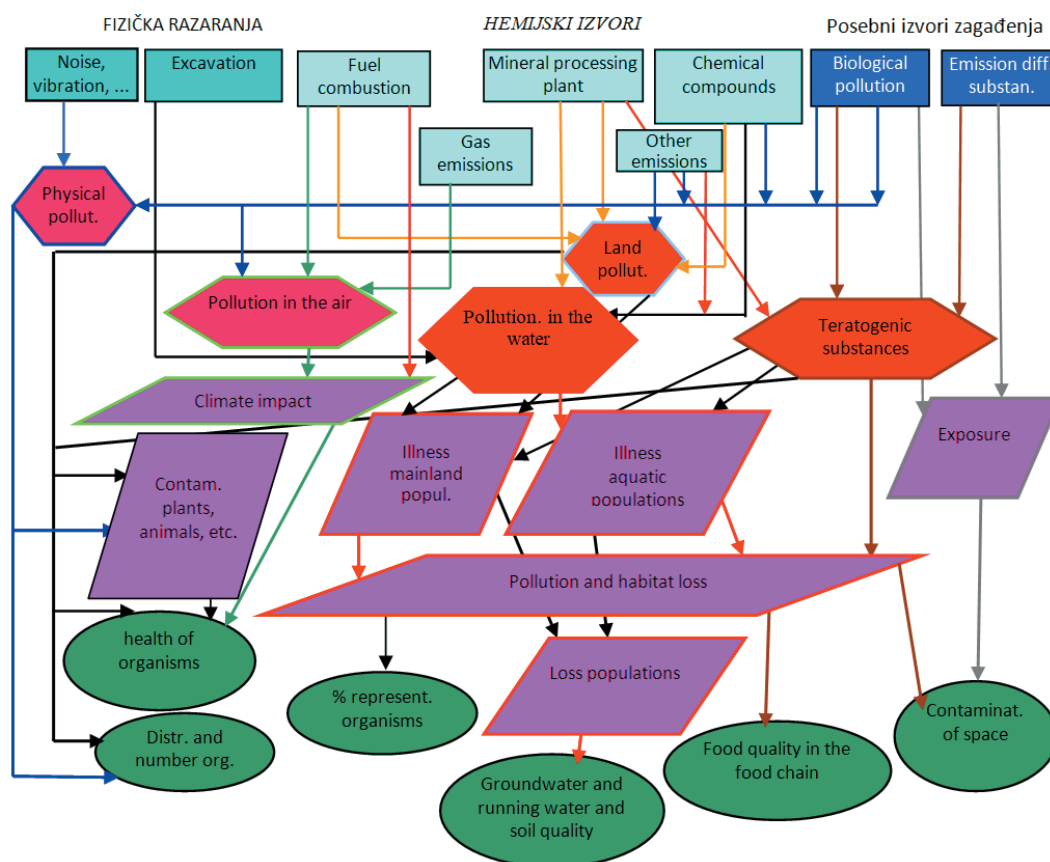
Figure 2 – Conceptual model diagram

Exposure characterization would rely on the set model of analysis. Depending on the type (character) of the assessment, adequate models are also applied (models that are universal or special models are made) [4]. In this assessment, the process would be based on exposure analysis and a description of the degree and pattern of contact or the simultaneous occurrence of defined stressors and receptors. The final product of this phase would be the so-called exposure profile [3].

Characterization of ecological effects as the next phase of analysis would include the work of an assessor who analyzes-describes the effects of the environmental response and links them to selected key assessment points. In general, characterization would begin with an assessment of data on the effects caused by a given stressor / stressors, and would continue with an analysis of the ecological response, which would assess how the extent of the effects changes with varying levels of the stressors. By this procedure, the evaluator (s) would prove that the stressors caused a certain effect, which connects the effects with the key points of the assessment and the defined the conceptual model. The conclusions would be summarized in a stressor-response profile [6].

3.4. IMPLEMENTATION OF THE RISK CHARACTERIZATION PHASE

The final phase of environmental risk assessment is risk characterization. It represents the culmination of planning, problem formulation, and analysis of predicted and observed adverse environmental effects related to defined key points [4].

The aim of the risk assessor in this case would be to gain full insight into the relationships between defined stressors, effects and key assessment points and to draw conclusions regarding exposure and damage caused by existing or projected environmental effects (environmental risk). The results of the analysis phase would be used by the assessors to develop a risk assessment of the ecological entities, primarily including the key points identified in the problem formulation. A risk description would also be given in the context of the importance of any adverse effect, as well as evidence supporting its likelihood. Finally, it would be the responsibility of the assessor to identify and summarize the uncertainties and assumptions in the risk assessment, and to report to the risk managers on the conclusions of the assessment.

The conclusions presented in the characterization of the risks from the consequences of the Project implementation should provide clear information to the risk managers in order to make the right decision related to the given problem. If the risks are not sufficiently defined and clear to make a management decision, then risk managers may decide to repeat one or more phases of the assessment. Reassessing the conceptual model (and related risk hypotheses) or conducting additional studies may improve risk assessment [6].

4. CONCLUSION

The application of the given methodology of environmental risk assessment would respond in clarifying the potential risks caused by the implementation of the Project. The methodology is clear and validated on many other similar examples, but its success and validation require both consistent application and good knowledge.

Therefore, in this case it would be necessary to apply environmental risk assessment using the established methodology with previously well prepared preparation of the selected management, with a quality selection of experts - assessors and with the adequate economic support of the client.

It is believed that an environmental risk assessment conducted in this way would be the initiator of solving many non-environmental problems that are present in the narrower and wider larger urban and industrial areas. This primarily refers to the development of economic (tourist, agricultural, economic), political and other potentials, but also to the development of society's attitude towards environmental protection. The obtained evaluation results would also be valuable data for monitoring and improving the situation, but also a good basis for further research and re-evaluation.

Given the complexity of the subject matter, and in order to better understand the research problem, this paper gives only a general approach, so that the chapters that make up the structure of the work (assessment methodologies) are treated in abbreviated form. The concretization of the paper would be checked and applied on a much broader theoretical-methodological basis.

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ENVIRONMENTAL DATA SCIENCE SESSION

ENVIRONMENTAL DATA COLLECTION AND CLASSIFICATION IN CROWD-FUNDING PLATFORMS - EVIDENCE FROM KICKSTARTER

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Abstract:

Mass use of social networks and the increasing availability of internet technologies creates a series of possibilities for raising funds for entrepreneurs. Crowdfunding is one such option, in which individuals (project creators) can share their ideas with the general public (crowd) via the dedicated Internet platforms, resulting in getting project supporters (backers). The relevance of crowdfunding platforms is thoroughly described in the contemporary academic literature. Furthermore, crowdfunding has the potential to contribute significantly to the financing of environmental ideas and projects, hence accelerating sustainability.

The purpose of this paper is to highlight some of the techniques that can be used in the analysis of data collected from CF platforms, as well as to provide an insight into tests for differences between characteristics of the project with environmental concepts. The study uses a sample of 121,437 projects from the Kickstarter platform between 2011 and 2019. A t-test was employed to determine whether the differences among environmental and non-environmental campaigns. The results show that environmental campaigns are more successful, have a higher goal, attract more funds and investors, while the Kickstarter team favourites them. Analysis showed that quantitative field studies and big data analysis can offer a deeper analysis of the main characteristics of crowdfunding campaigns.

Keywords:

Crowdfunding, Kickstarter, sustainable, bigdata.

INTRODUCTION

A series of techniques (e.g., big data, data mining, deep learning, artificial intelligence, and so on) have become the driving force of enterprise transformation in the mobile internet and social Web era [1], while crowdfunding has become an increasingly important channel for entrepreneurs to raise funds for their start-up projects [2]. Mobile phones, Internet technologies, and social networking sites have all seen rapid growth and use in the last decade.

Many financial advances, including crowdsourcing, have been enabled by technological advancements such as the growth of internet platforms and the rising number of social networks (CF). Although it is a matter of raising a relatively small amount of money, it is possible to acquire significant funds [3], in a short amount of time.

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The three basic elements of CF are dedicated Internet platforms where individuals (project creators) can share their ideas with the wider public (crowd) and get project supporters (backers). Initial forms of CF involved donations or individuals who support projects (backers) and received rewards (perks) in exchange for their support. However, more recent modifications include receiving shares of the venture or interest from the loan [4]. Many crowdfunding websites have appeared in the previous ten years. Today's, most popular are Kickstarter, Indiegogo, Patreon, GoFundME, Crowdcube and others. They gather millions of ideas and numerous potential investors. In addition to CF, the range of alternative products scopes from, financing based on future income, online loans, peer to peer loans, cryptocurrencies (Bitcoin, Ethereum, XRP, Tether and others) [5-6].

Having in mind that researchers can acquire a large quantity of data from CF platforms, several methodologies for their analysis emerged. Detailed typology of methodological approaches used in research on CF is best explained in [4].

Almost all CF platforms enable browsing options for all campaigns: up-to-date, achieved and active, successful and failed. Search tools and the growing number of CF users enables a considerable amount of data suitable for the analysis of different project characteristics. Researchers have two options for data collection: to use search algorithms or more recently to employ scraper robots that crawl CF websites and collect data on campaigns. The amount of data collected can be more than a half-million per one CF platform, depending on its size. To illustrate, according to the statistic from the official Kickstarter webpage up to June 2021 only on Kickstarter, 525,851 campaigns are launched. The range of data available for collection, defers a lot, depending on the CF platform and the campaign itself. For example, the parameters related to the campaign can include the goal of the campaign as a desired amount of funds, the percentage of goal fulfilment, the amount of pledged money, the duration of the campaign, the number of investors. Factors related to the platform include special features, such as whether the staff of the platform marks the campaign as a favourite or socially responsible. There are also campaign creator parameters the number of friends on social networks, the number of updates and comments, the number and quality of posted images and videos related to the campaign.

The retrieved data from such platforms researchers can, among others, enable employing tools for big data analysis. Nevertheless, although this is an extremely convenient way to collect data, it requires cleaning, for instance eliminating ongoing campaigns, or campaigns with too low or too high set goals.

This research aimed at pointing out to the techniques that can be applied in the analysis of data collected from CF platforms. As many studies have shown, CF has a lot of potential for contributing to environmental concepts [7] and there are big expectations for crowdfunding to accelerate sustainability [8]. Having this in mind, we classified projects with environmental characteristics and tested for differences among characteristics of the project with environmental concepts.

2. MATERIALS AND METHODS

For the purpose of this study, we used data on Kickstarter campaigns from the "Kaggle.com" open-source repository. The initial full dataset from the repository contained data on 430,938 Kickstarter campaigns in the period 2009-2019. The dataset provides essential information on crowdfunding campaigns (title of the campaign, project goal, funding goal as the amount of money a creator needs to complete the project, blurb as short description displayed under the name of the project and on the browse part of the platform page, pledged funds, as the amount of money the project raised, backers, as the number of people that have supported/invested in the project, state of the project as successful, failed, cancelled, live or suspended, country and city of origin of the campaign creator, currency, category and similar).

We applied filters to the initial dataset, before running statistical tests. Data is typically collected (crawled) in multiple iterations, with certain campaigns appearing more than once, or the program itself can enter the same campaign in the database multiple times. As we downloaded the dataset from the kaggle.com open repository, we do not know how the data was collected. Accordingly, we had to check for the double entries and eliminate them. We have performed full-data matching to confirm that entries are completely identical. If we identified such data, we eliminated them from the sample, hence such could not have contributed additionally to this research. Parallel to this we, excluded projects with a status of unknown outcomes as in [9]. We labelled these projects as cancelled or suspended. Next, we eliminated campaigns from 2011 to 2019, as there was a small number of projects. Finally, in line with [9-12], we excluded projects with too small or too big goals (with a value below $5,000 and over $500,000). This led to a final dataset of 121,437 project campaigns.

We wanted to test whether environmental campaigns have distinguished characteristics from other projects. Therefore, we formulated our main research hypothesis based on the fact that significant difference between the environmental and non-environmental campaigns exist.

In line with this, we had to identify campaigns that have environmental elements. There are few approaches to differentiate environmental projects. The simplest one is to use categories in case the platform enabled this option. Essentially, the CF platform divides projects into categories, with the environment being one of them (as used in [13]). Only a few platforms, however, have integrated environmental features in their classification. Text analysis is the next approach, which aims to find predefined words [10, 14-15]. This approach is simple to use and employable with large datasets. However, it potentially introduces a bias in the classification because it uses a dictionary of keywords arbitrarily defined by the authors [12]. Frequently, individual words can have multiple meanings. The term "green" is an example of a keyword used to classify environmental projects. In-stead, project creators can use the word green to allude to a characteristic of the campaign, referring to the colour. Certain authors use machine-learning algorithms to define automatically the dictionary of keywords used to discriminate between green and non-green campaigns [12, 16]. In this paper, we used text analysis to define projects with environmental characteristics. This way we got 2,698 campaigns in the related sample, that have environmental elements, approximately 2.2% of the total sample.

In Table 1, we have reported the descriptive statistic of the related sample used in this study. The percentage of successful projects is in line with the general statistic retrieved from Kickstarter. According to the statistic from the official Kickstarter webpage, up to June 2021, 38.82% of campaigns have successfully been financed, whereas in our sample the number of successful campaigns is less than one per cent higher. The average number of backers/investors in the campaign is 213.41. Only 166 projects have attracted more than 10,000 investors, even though the number of backers for one project can reach 87,143.

Characteristic	Total Sample	Min	Max
No. of projects	121,437	/	/
Environmental projects (%)	2,698 (2.2)	/	/
Successful projects (%)	48,186 (39.7)	/	/
Average no of backers mean (median)	213.41 (24.00)	0	87,143
Average funding goals (in 000) mean (median)	27.76 (12,000)	$5,000	$500,000
The average amount of pledged (in 000) mean (median)	19.65 (2,034.00)	$0	$13,285,226
Duration of the campaign mean (median)	34.32 (30.00	1 day	90 days
Staff Pick (%)	17,707 (14.6)	0	1
Spotlight (%)	48,186 (39.7)	0	1

Table 1 – Descriptive statistic of the related sample

The average amount of funds set as a goal ($27,757.83) is much higher than the quantity of money pledged ($19,646.56). Because we limited our sample, the funding goal ranges from $5,000 to $500,000. On the other hand, the amount of pledged funds varies from 0 (for the projects that have not collected any amount of money) up to $13,285,226. However, only three projects in the sample have pledged more than $10 million, and 206 projects more than $million.

The duration of the campaign is limited by the platform and can be from 1 to 90 days. In our sample, the average duration of the campaign is 34.32 days.

Over 14% or 17,707 campaigns were designated by Kickstarter team members as a "favourite" while they were active, measured by the indicator staff pick. Accordingly, 48,186 campaigns are marked as spotlighted allowing creators to make a home for their project on Kickstarter after they have been successfully funded.

3. RESULTS AND DISCUSSION

To test the differences among characteristics of the environmental and non-environmental campaigns, we used a t-test as an inferential statistic used to determine if there is a significant difference between the means of two groups (environmental and non-environmental campaigns), which may be related in certain features. We used the same variable as defined in the descriptive statistic, with a modification related to the values of goal and pledged funds. Due to the high skewness of the distribution data related to these values, we used the logarithm of the goal and pledged funds.

The t-test statistic shows a statistically significant difference among four major variables: the success of the project, average funding goal, average amount of pledged and staff pick.

Environmental campaigns are on average more successful than non-environment (0.414 against 0.396, p-value < 0.01). Campaign success depends on several factors, among which the most important are a well-presented and media-placed idea, the choice of platform on which it is presented, the ways and forms in which funds are raised for invested financial resources. Numerous studies point to the most important determinant of environmental campaign success. Campaign goal, length of the funding period, staff-pick, quality and complexity of the project, number of social contact and friends, comments, updates and similar factors stand out [10-12, 17-22].

In addition, creators of environmental campaign set higher goals (4.261 against 4.187, p-value < 0.01), and attract more pledged money (3.270 compared to 3.188, p-value < 0.01).

Finally, they are more often chosen as a staff pick (0.17 opposite to 0.15, p-value < 0.01), meaning that the Kickstarter team tagged it as a "favourite" while it was active.

Other variables included in the analysis are not statistically significant, but all point to higher values for the environmental campaigns. The average number of backers is slightly higher than in the non-environmental campaigns. We may argue that if the amounts pledged are higher, the number of backers would also be higher. On the other hand, we can also stipulate, that investors prefer campaigns with environmental elements, and thus these campaigns receive more attention and support.

Characteristic	Total Sample	Environmental Sample
Characteristic	Sample	Oriented towards the circular economy
No. of projects	118,739	2,698
Successful projects (%)	0.396*** (0.489)	0.414*** (0.492)
Average no of backers	213.384 (1220.883)	214.397 (833.942)
Average funding goals (log)	4.187*** (0.418)	4.261*** (0.439)
The average amount of pledged (log)	3.188*** (1.319)	3.270*** (1.296)
Duration of the campaign	34.32 (10.915)	34.30 (10.391)
Staff Pick (%)	0.15*** (0.352)	0.17*** (0.379)
Spotlight (%)	0.40 (0.489)	0.41 (0.493)

Table 2 – Comparison between two samples
Standard errors are in parentheses
*** Significance level: 0.01.

Our findings, which are based on the simple t-statistics are consistent with most of the mainstream literature. CF are a tool to foster [23] and accelerate sustainability [8], both for environmental and sustainable entrepreneurship [24]. They might be considered as an example of a business model that can help develop and scale up sustainable innovations by bringing together like-minded individuals, firms, and investors. Also, crowdfunding can be a very useful tool to achieve growth based on sustainability [25], as witnessed in Spain. Projects with environmental characteristics have higher survival rates and suggest the creation of healthy sustainability ventures through crowdfunding [26], especially for a project with general goods as the main component. Clearly, cleantech projects are an excellent example, as they deliver more than a product and accelerate the transition to a low-carbon economy [26].

To sum- up, quantitative field studies and big data analysis can offer a deeper analysis of the main characteristics of crowdfunding campaigns. In parallel, the application of classification techniques allows detailed insight into certain campaign types or phenomena,

such as the environmental component or the study of changes in the behaviour of creators and backers during a corona virus pandemic.

4. CONCLUSION

In this paper, we have investigated two issues. The first issue is related to the overview of different techniques that can be applied in the analysis of data from CF platforms, especially bearing in mind that big data can be collected from CF platforms. In addition, we wanted to present one of the methods to test the data. We have opted to test for differences among characteristics of the project with environmental concepts.

In the analysis, we used open-source data from Kaggle.com. Although previous studies also used the same set as we did, we do not have a firm knowledge that the data set is accurate. Therefore, we had to spend a lot of time cleaning up the data. This deficiency can be overcome by using custom search algorithms or scraper robots which crawls CF platforms and collect data on campaigns.

Using the data from Kickstarter, first, we classified campaigns to environmental and non-environmental using the technique of text analysis. As this method has significant drawbacks, future directions of development should include a more complex and accurate machine-learning algorithm that enables more reliable classification.

Next, we used simple t-statistic to the differences between the chosen groups. In general, we found evidence that environmental campaigns are more successful, have a higher goal and attract more funds and investors, supporting our main research hypothesis. They could be, also, considered more tailored to the Kickstarter team taste. Analysis of the characteristics of environmental projects can point to the direction for improving future campaigns in this area and may help potential crowdfunding users to design successful campaigns

This paper has several limitations. The sample used is restricted to only one CF platform, Kickstarter. New technologies enable the processing of a significantly larger amount of data, so future research directions will strive to include as many similar CF platforms as possible.

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ENVIRONMENTAL DATA SCIENCE SESSION

METEOROLOGICAL FACTORS GOVERNING PARTICULATE MATTER DISTRIBUTION IN AN URBAN ENVIRONMENT

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Abstract:

In this study, the impact of meteorological factors on PM10 concentrations in the Belgrade urban area was investigated by using eXtreme Gradient Boosting (XGBoost) and SHapley Additive exPlanations (SHAP) attribution methods. As shown, XGBoost provided reliable PM10 predictions with relative errors in the range from approx. 19% to 26% and correlation coefficients higher than 0.95. The change in emission source intensity, momentum flux intensity, lifted index, humidity, and temperature, as well as concentrations of benzene, NO, NO_x and SO_2 were the most important variables that described the PM concentration dynamics in Belgrade urban area.

Keywords:

Particulate Matter, Meteorological Factors, Machine Learning, Explainable Artificial Intelligence.

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INTRODUCTION

Suspended particulate matter refers to a complex mixture of compounds in a solid and liquid state, of organic and inorganic origin. Depending on the size, they are characterized as small/fine or $PM_{2.5}$ (with a diameter of up to 2.5 μm) and large/coarse fraction or PM_{10} (with a diameter of 2.5 μm to 10 μm). In the short run, the consequences of exposure to high concentrations of PM are irregular heartbeat and bronchial asthma exacerbation. In the long run, the adverse health effects include reduced lung capacity, increased risk of malignant diseases, increased susceptibility to systemic inflammation, as well as diabetes and its complications, exacerbation of chronical conditions, higher susceptibility to infectious viral or bacterial diseases, and increased risk of atherosclerosis and its consequences, heart attack and stroke. In addition to the impact on human health, PM has effects on the environment and other living beings. For instance, it has been widely recognized that PM contributes to the formation of acid rain, which changes the acidity of freshwater systems, reduces soil fertility, damages plant species and agricultural crops, threatens biodiversity and endangers world cultural heritage.

In this study, we used regression analysis by means of machine learning eXtreme Gradient Boosting method (XGBoost) for estimating the relationships between PM_{10} concentrations and a number of environmental parameters in Belgrade, Serbia [1]. The influence of meteorological factors on PM_{10} concentrations in the Belgrade urban area was investigated and explained by using SHapley Additive exPlanations (SHAP) attribution method [2]. The provided methodology has already been approved in several case studies [3], [4], [5].

2. MATERIALS AND METHODS

The ground-based data, including benzene, inorganic gaseous pollutants (SO_2, NO, NO_2, NO_x), were provided by the Institute of Public Health Belgrade, Serbia. Meteorological data were provided by the Global Data Assimilation System (GDAS1).

The relationships between PM_{10} and other environmental parameters were obtained by XGBoost. XGBoost is an ensemble method of supervised machine learning based on a sequential tree growing algorithm. Each decision tree aims to complement all the others and correct for residuals in the predictions made by the previous trees by iteratively reweighing the training data to improve regression performance. XGBoost uses a gradient descent algorithm to minimize loss when adding new models. The method includes many optimizations and enhancements. The dataset was split into training (80%) and validation (20%) sets. Hyperparameter tuning was implemented using a brute-force grid search and 10-fold stratified cross-validation. The best performing hyperparameter values were used for the final model.

SHapley Additive exPlanations (SHAP) is a method based on Shapley values, calculated as a measure of feature importance using a game-theory approach that provide an impact of features on individual predictions. SHAP values represent the only possible locally accurate and globally consistent feature attribution method.

In this paper, XGBoost and SHAP method implementations within the Python software environment were used.

3. RESULTS AND DISCUSSION

XGBoost provided reliable PM10 predictions with relative errors in the range from approx. 19% to 26% and correlation coefficients higher than 0.95 (Figure 1).

The best performing model with the lowest relative error and the highest correlation coefficient was obtained for the monitoring station of rural/industrial type located in Ovča.
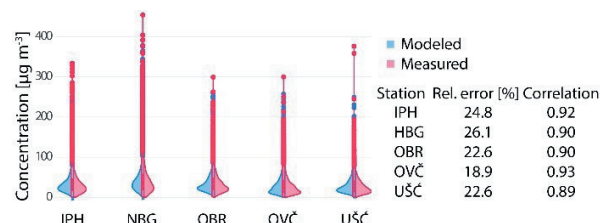
Figure 1 - XGBoost model evaluation.

On the other hand, the highest difference between modeled and measured values were detected at urban-type monitoring stations Novi Beograd and the Institute of Public Health Belgrade, both of which are exposed to traffic emissions. The modeling results were not satisfying for rural/industrial monitoring station located in Veliki Crljeni (relative error>30%, correlation coefficient<0.8), which implies that the PM10 level dynamic was mostly governed by variables other than available pollutant concentrations and meteorological parameters.

PM_{10} concentrations in Belgrade were predominantly determined by a variable that is defined as a trend of changing the intensity of emission sources (Figure 2).
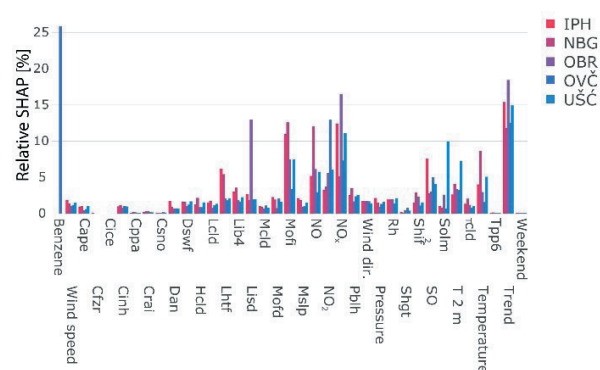
Figure 2 - Feature importance.

This variable appears to be the most important at three monitoring locations (Institute of Public Health Belgrade, Obrenovac, and Ušće), while at the stations New Belgrade and Ovča it was among the first three most significant.

Meteorological parameters including momentum flux intensity – Mofi, standard lifted index – Lisd, volumetric soil moisture content – Solm, and temperature, as well as pollutants such as benzene, NO, NO_x, and SO_2, were among the five most important variables that described the dynamics of suspended particulate matter in the territory of Belgrade area.

3.1. VOLUMETRIC SOIL MOISTURE CONTENT

In urban areas, suspended particulate matter, benzene, nitrogen oxides and SO_2 originate from common anthropogenic sources that include emissions from traffic and industrial activities, as well as the combustion of fossil fuels in thermal power plants, heating plants, and households. After the emission, the pollutants are subject to a variety of physical, chemical, and photochemical reactions. Suspended particulate matter, benzene, nitrogen oxides, and SO_2 participate in the formation of secondary atmospheric aerosols. A number of processes take place on the surface of suspended particulate matter, including gas-particles conversion, adsorption, desorption, absorption and gas dissolution, condensation of volatile compounds, as well as nucleation and coagulation. Under conditions of increased humidity in the presence of soot and inorganic oxides as catalysts (for example MgO_2 or Fe_2O_3), SO_2 will be adsorbed on the surface of suspended particulate matter to form a secondary sulfate aerosol. On the other hand, nitrogen oxides are less soluble in water compared to SO_2, so they will be less adsorbed on the surface of the particles (Figure 3). Nevertheless, in the conditions of high temperatures and intense solar activity, nitrogen oxides and volatile organic compounds such as benzene will rather participate in photochemical reactions with hydroxy, peroxy, and organic radicals in the air in which tropospheric ozone is formed.
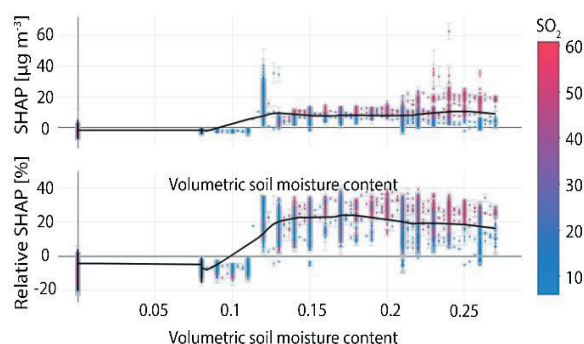
Figure 3 - PM_{10} SHAP dependency on volumetric soil moisture content and SO_2.

3.2. STANDARD LIFTED INDEX

The lifted index indicates the degree of atmospheric stability. The temperature in the atmosphere decreases with an increase in altitude, and the air that rises from the surface of the ground cools. However, when a temperature inversion occurs, air that rises to higher altitudes is warmer than the one near the ground level, which can lead to atmospheric instability. At all measuring points included in the analysis, there was a significant influence of maximum positive values of this parameter on PM_{10} concentrations (on average about 8 µg m^{-3}), which indicates that the dynamics and transformations of PM_{10} depended on atmospheric stability, Figure 4.
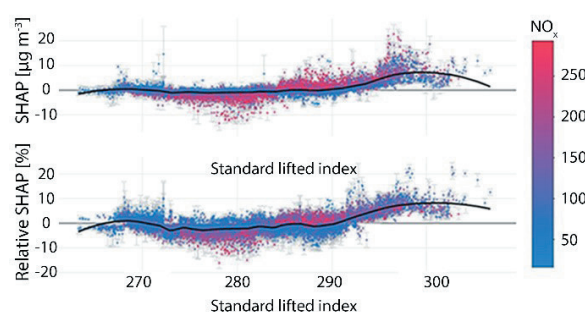
Figure 4 - PM_{10} SHAP dependency on standard lifted index and NO_x.

3.3. MOMENTUM FLUX INTENSITY

For the forecast and assessment of meteorological conditions, the momentum flux intensity is usually observed together with the wind speed. This parameter provides information important for understanding airflow in the vertical structure of the atmosphere. It can also be used to assess the stability of air mass flows in the planetary boundary layer and the occurrence of turbulent transmissions and vortices. Under stable meteorological conditions, the values of this parameter do not change significantly from the surface to the higher layers of the atmosphere and usually have lower values compared to the values measured in the case of turbulent movements. High SHAP values corresponding to increasing concentrations of suspended particulate matter up to several tens of µg m^{-3} at lower values of momentum flux intensity (<0.2) indicate a significant influence of vertical movements on the dynamics of PM_{10} and other pollutants

(NO) when they are present in high concentrations in the air (Figure 5). At all monitoring locations, a significant impact of this parameter is recorded at its lower values, which indicates that the stated relationships between pollutants are observed in conditions of stable meteorological conditions.
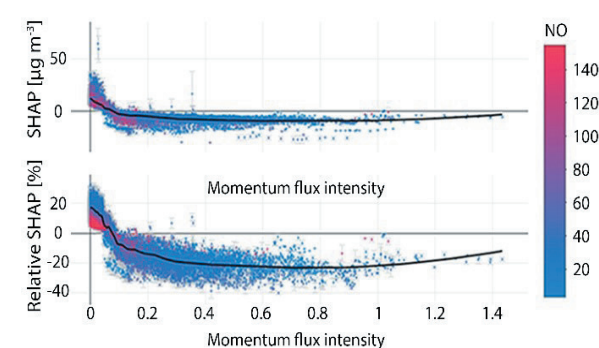
Figure 5 - PM_{10} SHAP dependency on momentum flux intensity and NO.

3.4. TEMPERATURES

The intensive combustion of fossil fuels for heating at temperatures below zero contributes to an increase in PM_{10} concentrations by an average of 10 µg m^{-3} (Figure 6). In the case of using fuels with high sulfur content, this increase can be as high as 20 µg m^{-3}. From only a few degrees above zero to about 25 °C, the effect of temperature on the suspended particulate matter is negligible, while during warmer weather, at temperatures above 25 °C, the resuspension of particles contributes to an increase in concentrations of about 4 µg m^{-3} on average.
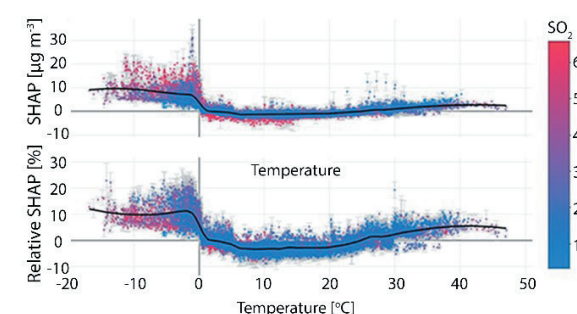
Figure 6 - PM_{10} SHAP dependency on temperature and SO_2.

3.5. ATMOSPHERIC PRESSURE

The effect of pressure on the concentrations of suspended particulate matter is relatively small and constant (Figure 7). Somewhat stronger impact on their level dynamics is recorded in the urban atmosphere being characterized by the presence of NO_2 higher concentrations. Low-pressure conditions can contribute to a reduction in PM concentrations of up to 3 µg m^{-3}.
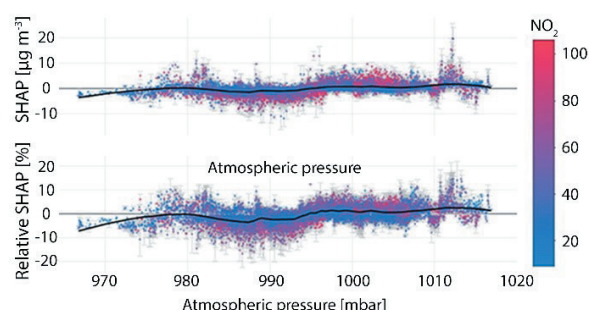
Figure 7 - PM_{10} SHAP dependency on atmospheric pressure and NO_2.

4. CONCLUSION

Based on the analysis of the dependence of suspended particulate matter concentrations on environmental factors (concentrations of SO_2, NO, NO_2, NO_x, and benzene, modeled meteorological parameters - GDAS base, trend, daily and weekend variations), the change in emission source intensity is singled out as a variable that dominantly determines the dynamics of PM_{10} concentration in Belgrade. This variable stands out as the most important one in three measuring points - Institute of Public Health Belgrade, Obrenovac, and Ušće. Also, meteorological parameters including momentum flux intensity, lifted index, humidity, and temperature, as well as concentrations of benzene, NO, NO_x, and SO_2 were among the five most important variables that described the PM concentration dynamics in Belgrade urban area.

5. ACKNOWLEDGEMENTS

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RECEPTOR ORIENTED MODELING FOR REVEALING AIR POLLUTION EMISSION SOURCES AFFECTING AN URBAN AREA

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Abstract:

In this study, we have determined PM (particulate matter) emission sources and some of the criteria air pollutant transport contribution at various locations in the Belgrade area by applying advanced receptor-oriented models, as well as the pre-processing of concentrations and air back trajectories. As shown, the monitoring locations were most directly exposed to PM emissions from the nearest surrounding. Further, the background levels and air pollution transport mostly contributed to the observed SO_2 (70%) and NO_2 levels (45%).

Keywords:

Particulate Matter, Air Pollution Transport, Receptor Oriented Models.

INTRODUCTION

Low air quality represents a particular problem in urban areas due to overpopulation, a large number of emission sources, and topographic features which prevent the dispersion of pollution. The cities, in which around 85% of global economic activity takes place, currently contain 55% of the world's population, and it is expected that two-thirds of the world's population will live in metropolitan areas by 2050. The World Health Organization estimates that the highest number of deaths related to atmospheric pollution was registered as a consequence of ischemic cardiovascular diseases, heart attacks and strokes (80%), and chronic obstructive pulmonary disease (11%), while a significantly lower number of deaths occurred as a consequence of lung cancer (6%) and acute inflammation of the lower respiratory tract in children (3%). The health effects of air pollutants vary depending on the type of pollutant, i.e., size and composition of suspended particles, the concentration of species, and the length of exposure.

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The concentrations of pollutants in the air on the territory of Belgrade area are a consequence of intensive emissions mainly from local anthropogenic sources, which can be related to the increase in population, in the number of motor vehicles, inadequate investment in the energy sector, and outdated technologies in the economic sector.

In terms of sources of pollutant emissions in the city, the following can be emphasized as significant: fossil fuel burning for energy production (heating plants, thermal power plants, boiler rooms, individual furnaces, i.e., around 300,000 individual chimneys), some industrial facilities, traffic, as well as small and medium production processes.

On the other hand, air circulation in complex topographic and meteorological conditions of the urban environment potentially leads to long retention or accumulation of pollution in certain locations, which further causes large differences in the exposure of the population in spatially close locations.

The aim of this paper is to determine emission sources of suspended particulate matter at various locations in Belgrade area by applying advanced receptor-oriented models, as well as the pre-processing of concentrations and air back trajectories.

2. MATERIALS AND METHODS

The analysis of regional transport and the assessment of pollutant emission sources was conducted by using receptor-oriented models developed within the project "Mapping of sources of toxic, mutagenic, and carcinogenic volatile organic compounds in the city of Belgrade", funded by the Green Fund of the Ministry of Environmental Protection of Serbia. The description of the methods can be found elsewhere [1].

The analysis of the contribution of regional transport was done by using the method of concentration weighted boundary layer - CWBL [2]. The method provides data on the three-dimensional distribution of pollutants based on the measured concentrations at the receptor site (measurement site), the air mass transport path and the height of the planetary boundary layer along the transport path. Based on [3], [4], [5], [6], [7], and [8], using CWBL, it is possible to estimate the regional transport of pollutants within the planetary boundary layer by determining concentrations at higher altitudes above the Earth's surface. The description of the method is presented elsewhere [2].

3. RESULTS AND DISCUSSION

Within the analysis of air quality, it is crucial to separate the different contributions to the total measured concentrations at the selected monitoring site. One way to do it is to distinguish between the contribution of emissions from local sources in the immediate vicinity of the measuring location, the contribution of regional and long-range transport, and the share of air pollution background. As can be seen in the time series of PM_{10} and SO_2 concentrations (Figure 1), narrow and high peaks are superimposed on a wider and much lower base level. The peaks probably originate from the local emission in the immediate vicinity of the measuring point, whereas the baseline level can be assumed to originate from the transported air pollution and the background.
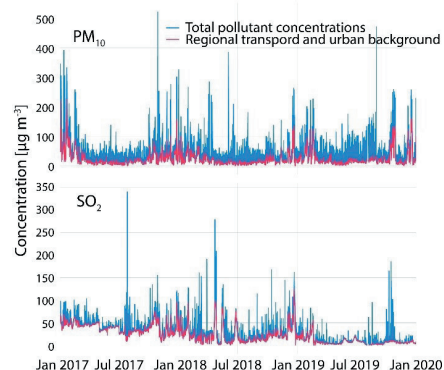
Figure 1 - An example of separating the contribution of emissions from local sources from regional transport and the background of the urban environment at the measuring point of the City Institute for Public Health Belgrade in the period from 2017 to 2019

The example shown in Figure 1 shows a different structure of PM_{10} and SO_2 concentration time series. Unlike PM_{10}, SO_2 concentrations are characterized by the less frequent occurrence of narrow peaks superimposed at the baseline level. This can be an indicator of the high contribution of background and/or regional transport to the total concentrations in the urban environment. The most important sources of SO_2 in urban areas are related to the combustion of fossil fuels for heating purposes. The position of stationary, point sources (chimneys) that are more distant and mostly distributed in a wider area without a direct impact on the monitoring station leads to the less pronounced pollutant concentration dynamics. In addition to the specificity of the emission sources, the position of the

monitoring station at the Institute for Public Health Belgrade in the canyon type street can also be the cause of high levels of urban background due to the retention and accumulation of air pollution.

The share of regional transport and background averaged at all monitoring locations of automatic monitoring (Figure 2) is the highest in the case of SO_2 when compared to all other analyzed pollutants (70%). The estimated contribution of regional transport and the background to the measured concentrations of suspended particles and nitrogen oxides is moderate and ranges from 45% to 55%. In the case of suspended particles, the existence of frequent short-term peaks in the time series (Figure 1) is an indicator of the dominance of local emission sources. The reason for this dynamics can be the direct exposure of the monitoring station to a certain type of emissions (mobile sources - traffic and transport, resuspension, and local economic activities), but also the processes of dry and wet deposition that contribute to faster removal of particles from the air. Of nitrogen oxides, it was estimated that the share of regional transport and air pollution background is the highest in the case of NO_2, which is a consequence of greater stability of the compound and therefore, the possibility of its transport over long distances, but also the formation of this compound as a secondary pollutant in the reactions of photochemical transformations in the atmosphere.
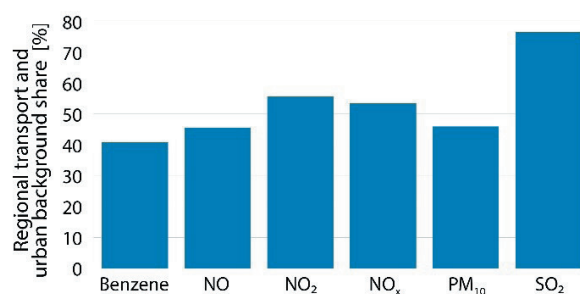
Figure 2 - The share of regional transport and the background of the urban environment with the measured concentrations of pollutants in Belgrade in the period from 2017 to 2019

By applying multireceptor-oriented models to PM10 concentrations measured at 6 automatic monitoring locations in the period from 2017 to 2019, the distribution of regional sources and sources located on the periphery

of the agglomeration, which affect air quality in central urban area was obtained (Figure 3).

Figure 3 – The distribution of regional sources of PM_{10} emissions on the territory of Belgrade and neighboring municipalities in the period from 2017 to 2019

The results of the analysis show that the area of Belgrade is exposed to the impact of regional sources of PM_{10} emissions located south, southwest, and southeast of the city, as well as slightly less impact of sources located in the areas west and east of the analyzed area. Significant emission sources in the southwestern areas on the outskirts of the agglomeration can be associated with the thermal power plant "Nikola Tesla" near Obrenovac, as well as with somewhat more distant mining basins near Veliki Crljeni. Apart from that, a source in the southeastern area that has an impact on the urban zone of Belgrade can be attributed to the Vinča city landfill, whereas several identified sources on the left bank of the Danube, outside the agglomeration, can be linked to agricultural activities in Banat. Regional sources of suspended particles whose impact is estimated to be significant, and which are located southeast at a greater distance, can be connected with "Železara Smederevo", as well as with the thermal power plant and coal mine "Kostolac". In the western region of Belgrade, along the international highway E-70, sources of slightly lower intensity have been identified, which can be attributed to traffic activities. Also, it should be taken into consideration that a large number of facilities of small economic activities (production plants, processing and storage of goods) have been built in this area in recent years, whose emissions also contribute to air pollution. Figure 3 also shows PM_{10} emission sources located south of Belgrade, which most likely represent the contribution of more remote areas, or even part of the long-distance cross-border transport route.

4. CONCLUSION

Apart from the influence of local sources, the air quality in the area of Belgrade is affected by various distant sources of emissions. The impact of strong local sources was least noticed in the case of sulfur dioxide, while monitoring locations were most directly exposed to suspended particulate emissions from the immediate environment (mobile sources - traffic and transport, resuspension, and local economic activities). On the other hand, the share of background and transport of air pollution was the highest in the case of SO_2 - 70% (combustion of fossil fuels for heating and pollutant transport from remote power plants) and NO_2 - 45% (pollutant transport and formation in photochemical atmospheric transformations).

The analysis of the contribution of regional pollutant transport to the measured PM_{10} concentrations has shown a significant impact of sources located southeast ("Železara Smederevo" and thermal power complex "Kostolac") and southwest (thermal power plants "Nikola Tesla" and mining basin "Tamnava") from Belgrade. The contribution of somewhat weaker sources located in the western area of Belgrade, can be related to traffic activities along the international highway E-70 and economic activities in its surroundings. For detailed characterization of the identified emission sources, and thus the improvement of insufficiently updated emission inventories, it is necessary to include other pollutants in the analysis and to apply the most advanced artificial intelligence methods.

5. ACKNOWLEDGEMENTS

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STRUCTURAL CHARACTERISTICS OF PARTICULATE MATTER TIME SERIES OBSERVED IN AN URBAN ENVIRONMENT

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Abstract:

In this study, we used the fractal and multifractal analysis to explore the structural characteristics of PM10 time series, among which self-similarity and invariance can be considered particularly important. The eXtreme Gradient Boosting method was used to fill in the missing data for multiscale multifractal analysis. The analysis has revealed self-similarity in PM_{10} time series with a positively correlated structure which was stable over a study period. Small fluctuations of PM_{10} levels were observed as a result of variations in local emissions and meteorological conditions. The uncoordinated and uncorrelated intervals in concentration time series were observed as a consequence of occasional pollution events in the areas dominated by industrial activities or as a consequence of the remote emission source activity when wind direction and speed were favorable.

Keywords:

Particulate Matter, Time Series Analysis, Multiscale Multifractal Analysis.

INTRODUCTION

According to the estimate from the World Health Organization, air pollution caused 4.2 million cases of premature death worldwide in the year 2015, whereas the recent estimates indicate that the mortality rate due to exposure to high levels of air pollutants is significantly higher and accounts for 8.9 million. In addition, research has indicated that in case the trend of low air quality continues and the approach to environmental issues is not fundamentally changed, the numbers could be twice as high by 2050.

Environmental science is facing many problems in achieving its mission to guarantee sustainable future in an increasingly complex and rapidly changing overpopulated world. The continuous pollution burden on the environment is dependent not only on the increasing pollutant load, but also on many known processes such as pollution transport, dispersion and deposition, atmospheric chemistry, meteorological factors, solar and cosmic radiation, topography, etc., as well as those which are not even known yet.

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The issues that prevent the environmental science to fulfil its' mission are related to (1) complexity, non linearity, interactivity, and cross-compartment interconnectivity of environmental phenomena, (2) insufficiency of data-driven knowledge, especially the knowledge derived as a result of global-scale and multi-compartment research, (3) asymmetric access to data, information, and knowledge, (4) lack of adequate infra-structures regarding environmental big data, (5) barriers and gaps to technological innovation access, (6) high pressure on human and institutional capacities regarding innovation, *etc.*

Particulate matter (PM) emitted from different both natural and anthropogenic emission sources can remain in the air for a few hours or days depending on local meteorological conditions, susceptibility to chemical and physical transformations, and factors that contribute to sedimentation and precipitation. Self-similarity and invariance are important features of pollutant concentration time-series. These structural characteristics of PM time series revealed by using fractal and multifractal analysis could be considered when assessing their behavior patterns in the present and predicting their behavior in the future [1], [2], [3], [4], [5], [6], [7]. These analyses assume that phenomena and dynamic behavior of the system do possess the property of self-similarity and that the features of the system on one scale resemble the ones on different scales [8], [9], [10].

The atmosphere of the urban environment contains up to several hundred types of particulate matter, some of which are toxic, mutagen and, carcinogen. Adequate consideration of air quality is significantly limited by relying on data on gaseous inorganic oxides, or the concentration data of only the coarse PM fraction (PM_{10}) and several of its constituents. European Union countries measure concentrations for as much as 40 pollutants, as well as numerous constituents of three PM fractions (PM_{10}, $PM_{2,5}$, and PM_1).

In this paper, we investigate the fractal behavior of PM_{10} time-series across Belgrade area by the use of multiscale multifractal analysis (MMA) with the aim to obtain a more comprehensive understanding of the particulate matter behavior and environmental fate.

2. MATERIALS AND METHODS

Analysis of the structural characteristics of PM time series (fluctuation, self-similarity, and invariance) has been performed using MMA. The analysis of the characteristic parameters of the MM-spectrum (Hurst exponent, multifractal parameter, and scale) provided information on particularities of air pollution dynamics at a given location. A detailed description of the method is to be found elsewhere [11].

Hurst exponent (H) is used to describe the self-similarity of fractal properties, i.e., time series of pollutants in the presented analysis [12], [13]. In general, if H<0.5, the correlation between the intervals in the time series is a negative one, the change that occurs in the next moment will be opposite compared to the previous one, and the system has a pronounced tendency to fluctuate. The processes characterized by H=0.5 are random, similar to Brownian motion, and there is no correlation between the increments in the time series. If 0.5<H<1.5 is valid, there is a positive correlation between the shifts in the next moment will show similar tendencies as the previous one and the time series possess the property of self-similarity. Self-similarity is more pronounced the closer H gets to 1. When H>1.5 the time series is characterized by uncoordinated and uncorrelated intervals. In addition to the Hurst exponent, a multifractal parameter with both negative and positive values can be used to assess the fractal characteristics. The higher the value of the parameter, the higher the degree of fluctuation, whereas the absence of fluctuations leads to the multifractal parameter value of 0 and represents monofractal behavior.

The eXtreme Gradient Boosting method was used to fill in the missing data for the MMA application. The study used method implementation within the Python software environment. A detailed description of the method is to be found elsewhere [14].

3. RESULTS AND DISCUSSION

Characterization of PM10 time series observed in Belgrade has been performed by using MMA. At almost all monitoring stations, the value of Hurst exponent between 0.70 and 1.5 indicates self-similar time series PM_{10} with a positively correlated structure that is stable over a long period, Figure 1.
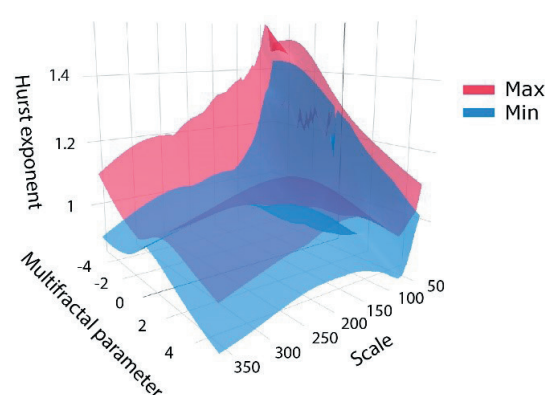
Figure 1 – PM_{10} Hurst exponent range in Belgrade 2017-2019.

Multifractal analysis of PM10 time series at monitoring stations at the Institute of Public Health of Belgrade and Obrenovac are presented in Figures 2 and 3.
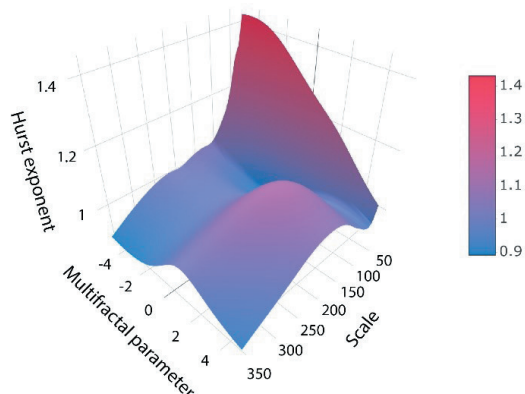
Figure 2 – Structural characteristics of time series of concentrations PM_{10} at monitoring place at the Institute of Public Health of Belgrade for the period from 2017 to 2019.

After reaching the maximums, values of Hurst exponent plummet to the value of 1 in the areas of small and large fluctuations and a time scale of up to 120 hours, thus indicating the most stable fractal nature of PM_{10} time series with a correlated structure over a prolonged period of time, i.e., the existence of the "long-term memory". This trend generally continues on scales from 150 to 350 hours with episodes of higher fluctuations (multifractal parameter = -0.5 – 1.8) for the period from 130 to 245 hours, in which the values of Hurst exponent do not exceed 1.13.

The PM10 concentration variability characterized by H values from 0.73 to 1.54 and values of multifractal parameter from -5 to 5 at the Obrenovac sampling site are shown at Figure 3. In the domain of lower fluctuations (multifractal parameter ≈-5), two peaks stand out: H>1.5 between 165 and 240 hours and H=1.3 on a time scale of up to 30 hours.
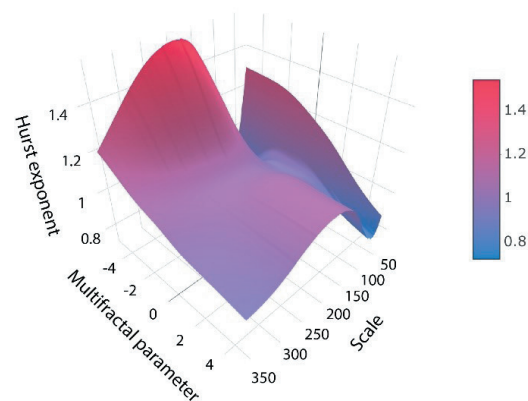
Figure 3 – Structural characteristics of time series of concentration PM_{10} at the monitoring station Obrenovac for the period from 2017 to 2019.

The time series characterized by H-values greater than 1.5 consists of uncoordinated and uncorrelated intervals which can be attributed to occasional emission intensification in the areas dominated by industrial activities or to impacts of remote emission sources when wind direction and speed were favorable. At the monitoring station Obrenovac, the most significant impacts can be attributed to emissions from the power plant "Nikola Tesla", as well as to works on construction sites of the A2 highway over the course of the observed period. Upon reaching the maximum values, steep slopes were observed in the domains of higher and lower fluctuations on the time scale of up to 350 (H up to 1.03) and 75 hours (H up to 0.72), respectively. The results indicated that the variability of PM time series decreased when the environment factors weaken and that there is a positive correlation between time intervals demonstrating similar dynamics.

4. CONCLUSION

There is an urgent need to stimulate new practices of interdisciplinary evidence-based research and innovation in which the research, design, development, deployment, and the use of advanced statistical, and numerical methods is anchored in environmental science. Further progress of environmental science and environmental pollution research will certainly depend on its integration with other scientific disciplines, among which high-performance computing seem to be of extreme significance. Moreover, the modern science requires infrastructure being data-based, efficient, real-time responsive, scalable, flexible, and robust enough to allow the understanding of the evolution of global pollution

impact and climate change in real-time and to anticipate future trends and challenges for the sake of global sustainability.

Application of MMA indicated self-similarity in PM10 time series with a positively correlated structure which was stable over a longer period of time at almost all monitoring stations. The results from AMS Institute of Public Health of Belgrade and AMS Obrenovac were taken as representative for further interpretation. At the AMS Institute of Public Health of Belgrade, the most pronounced variations were recorded in the domain of low fluctuations and on small scales of up to 45 hours. Fluctuations of PM_{10} on small scales were impacted by the intensity of local emissions and meteorological conditions governing the processes of condensation and nucleation, as well as physicochemical transformations and formation of secondary aerosols. Upon reaching the above stated maximum, a stable and positively correlated fractal nature of PM_{10} time series over a longer period of time in the domain of lower and higher fluctuations was observed.

At the Obrenovac measurement site, variability of PM concentrations in the domain of lower fluctuations was evidenced, on a scale between 165 and 240 hours. The PM time series consisted of uncoordinated and uncorrelated intervals, as a consequence of occasional pollution events in the areas dominated by industrial activities or as a consequence of the impact of remote emission sources when wind direction and speed were favorable. Also, the results indicate that variability of PM time series decreases when the impact of environment factors weakens, and that there is a positive correlation between time intervals indicating similar dynamics.

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SMART SENSOR MONITORING IN ENERGY CROP BIOMASS PRODUCTION

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Abstract:

Sustainable biomass production is recognized as a key moment in the development of the European bioeconomy. In order for the production to be truly sustainable, a holistic approach is needed for research of new technologies and methods that are at the same time economically viable, environmentally friendly and socially acceptable. The approach of smart agriculture is based on the collection and processing of large databases that serve to understand crop reactions to the current environment and enable rational production planning. This paper gives a brief overview of IT used in agriculture with a focus on monitoring the biomass of energy crops in order to indicate the current level of development and potential application in the region. Biomass development monitoring is presented through the application of Data Acquisition Sensors, Biomass indexes and Data Processing And Analysis Methods. The current level of development of these technologies enables monitoring of biomass development (primarily through the vegetation index and crop height) in real time and in the selected area. The data collected in this way are used to predict and take adequate agro-technical measures at the right time, which leads to high stable yields.

Keywords:

Biomass, smart agriculture, big data processing.

INTRODUCTION

Sustainable biomass production is recognized as a key moment in the development of the European bioeconomy [1]. In order for this production to be truly sustainable, a holistic approach is needed for research of new technologies and methods that are at the same time economically viable, environmentally friendly and socially acceptable, ie contribute to the rural development of local communities or wider regions. The yield per unit area of land is of the utmost importance. In order to achieve satisfactory yields, it is necessary to maximize the biorational use of biological resources - genetic, special and ecosystem [2]. This means that the development of biomass of different crops and their varieties should be monitored, in locations that differ in climatic and pedological characteristics and under the influence of various biological factors, and

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then appropriate biotechnical measures should be determined on that basis. It is also necessary to determine the time dimension of biomass development in order to determine the application of certain biotechnical measures (fertilization, irrigation) and the optimal harvest time.

This requires detailed monitoring of biomass development, which includes frequent field visits and extensive measurements of various biometric characteristics that determine the final yield [3,4]. This approach, in addition to requiring a cumbersome workforce, is often not able to provide all the necessary data because field monitoring is not common enough in space and time to reduce costs. In order to overcome these challenges, in recent years the approach of smart agriculture has been intensively developed, which is based on the collection and processing of large databases that serve to understand crop reactions to the current environment and enable rational production planning. New approaches relate to innovative digital technologies that enable the collection, storage and modelling of vast amounts of data [5]. This usually takes place through several steps: 1) Detection of local parameters of biomass development, 2) Identification and detection of the selected location, 3) data transfer from the field - farm to the control station and 4) decision making on the application of agrotechnical measures based on collected data, and previous experiences, and 5) activation of selected measures. For the realization of the whole process, strong cooperation of experts in the field of biology, ecology, farming and IT is necessary.

This paper gives a brief overview of IT used in agriculture with a focus on monitoring the biomass of energy crops in order to indicate the current level of development and potential application in the region.

2. BIOMASS DEVELOPMENT MONITORING

A recently published detailed review of 126 literature sources not older than 2017 related to UAS (unmanned aerial systems) indicates the relevance of research in this field [6]. UAS is a low cost, fast and non-destructive method for remote sensing testing of crop biomass development that enables non-contact monitoring by collecting data on spectral, textural and structural characteristics of fields on very wide temporal and spatial scales, and we focus on those related to farms. They consist of a platform, autopilot, mechanical steering components, sensors for navigation and data collection.

2.1. DATA ACQUISITION SENSORS

The most specific component that determines the applicability of UAS is Data Acquisition Sensors. These sensors can be classified into several groups; RGB, multispectral, and hyperspectral sensor work on the same principle. During development, crops adapt to current environmental conditions by changing the characteristics of the photosynthesis process, which is reflected in the spectrum of reflected light from the leaf surface. These changes are in the intensity of individual spectral bands, ie reflections of certain wavelengths, so based on their relationships, plants that are in some kind of environmental stress (usually lack of moisture or nutrients - primarily nitrogen) can be distinguished from plants that develop optimally. Similarly, plants that suffer from a disease can be distinguished from healthy plants. Also, during the ontogenetic development of plants, the expected spectral changes occur, which enabled the monitoring of crop phenophases using appropriate sensors.

The simplest, cheapest and least accurate are RGB sensors (which measure the intensity of only three colours (red, green and blue) in each pixel of a colour image. Low cost is the reason for their widespread use in monitoring biomass development. Multispectral sensors, unlike RGB, also track near-infrared spectral lines that are important for understanding physiological processes in the plant, but are significantly more expensive. Hyperspectral sensors provide an even more accurate panchromatic image. Their disadvantage is the high cost on the one hand and too much data which are not always necessary and their processing is extremely demanding and generally not possible using existing algorithms. Figure 1 shows the relationship between spectral characteristics and plant condition [7].
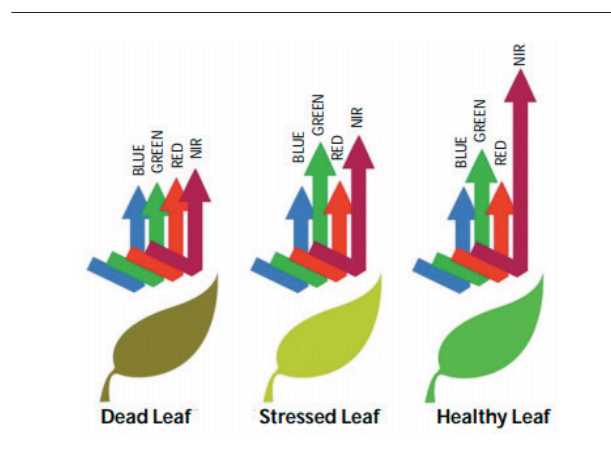
Figure 1 - Spectral characteristics of leaves in different conditions [7]
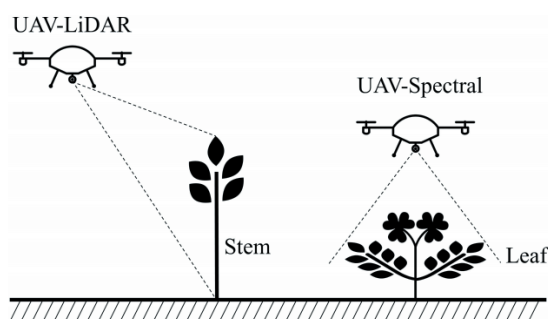
Figure 2 - Schematic illustration of the difference between LiDAR and spectral data [8]

Figure 3 - Comparison of accuracy of maize plant height extracted from digital and LiDAR data [8].

Spectral sensors are subject to interference from the environment, so they do not always provide enough necessary data. Therefore, depth sensors have been developed, primarily LiDAR (Light Detection and Ranging), which work on the principle of measuring distance by analysing the return energy of emitted laser pulses. The best results can be achieved by a wise combination and fusion of data obtained using spectral and depth sensors

2.2. BIOMASS INDEXES

The most used biomass indicators are VI (vegetation indexes) and CH (crop height) and are obtained from images or three-dimensional point clouds of crops.

VIs are used to monitor the condition of vegetation on a surface and give answers about its presence, diversity and condition. Different monitoring and calculation methods have been developed, of which the most commonly used is the normalized difference vegetation index (NDVI), which is calculated from the reflection ratio in the near infrared range and the red range, according to a simple formula. They are often combined with mage texture information.

Crop height is in a high positive correlation with the development of biomass in the vast majority of agro-energy crops, so it is a suitable parameter that is monitored using RGB sensors and multispectral sensors I LiDAR. Data are processed by various methods and inserted into prognostic models. Figure 3 shows an example of the results for the development of maize biomass obtained by applying various techniques [8]. In this case, too, due to the complexity of real situations in the field, a combination of these techniques is recommended, which must be modified in relation to each tested species.

3. DATA PROCESSING AND ANALYSIS METHODS

Sensor-generated data must be processed to be useful in biomass monitoring. Pre-preparation refers to the corrections of the images themselves and the fan data analysis is performed using Machine learning algorithms. Biomass development is a typical regression problem that can be solved by various algorithms, some of which are relatively simple and others very demanding. The most commonly used are: Support Vector Regression (SVR), Random Forest Regression (RFR), Artificial Neural Network (ANN), Multiple Regression Techniques [9]. The use of advanced algorithms such as machine learning algorithms enables the construction of highly efficient models of biomass energy crop development that use data from low cost sensor devices.

Figure 4 shows an example of a data processing diagram developed to monitor changes in the structure of canopy sorghum. Using this protocol, good agreement was obtained with the results from the field in the domain CH and VI for both examined approaches (LiDAR and RGB), but the best agreement was obtained by their combination. Although the high potential of the applied techniques in determining the state of sorghum biomass has been proven in this case as well, certain limitations in relation to the density and phenophase of crops have been observed [10].
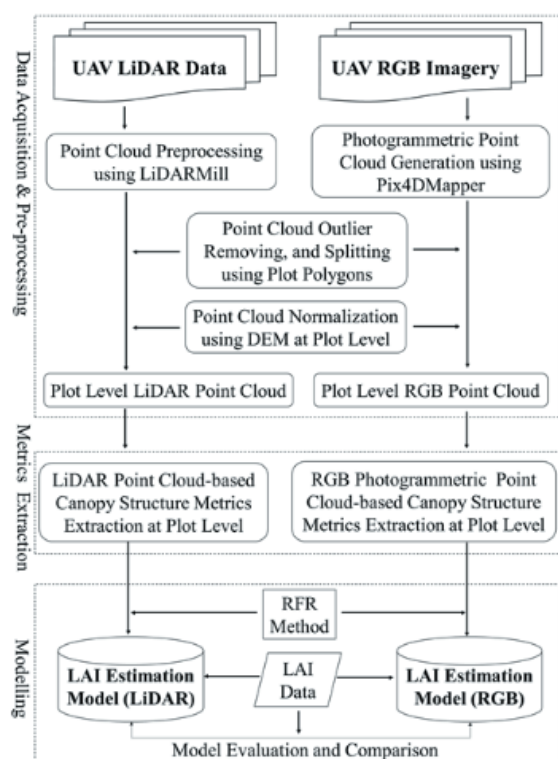
Figure 4 - Diagram of data processing and modelling for sorghum biomass [10].

biomass compared to volumetric measurement because it allows to distinguish between living and dead biomass (ie photosynthetically active and dried plants) [11]. Such models are suitable for monitoring the spatial distribution of biomass but are not sufficiently usable in relation to the time scale.

Figure 5 - Comparison of the representation of the same experimental field of sorghum by different models:
a - RGB, b - volumetric model, c - GNDVI for biomass, d - GNDVI for vegetation cover [11]

Research and development of these methods are primarily focused on application models that are rapidly appearing on the market. From a research point of view, these technologies are in the early stages of development and show many advantages but also limitations. Namely, the obtained results are often not comparable even if it is the same crop, because they appear in different formats. On the other hand, when comparing the application of the method, it is noticed that different authors recommend different combinations of Data Collection and Processing Systems, which are often contradictory.

In order to overcome such problems, intensive research is conducted through case studies and comparisons of results with the results of classical tests. Figure 5 shows an example of comparing 3 predictive models of forage crop biomass testing that differ in the level of generalization. The Green Normalized Difference Vegetation Index (GNDVI) was developed in two directions in relation to small and large values of fresh and dry mass of the biomass sample of forage crops and in relation to the vegetation cover cluster. All three models allow fine spatial resolution. In this case, the use of RGB imagery gave better agreement with the data collected by conventional methods of sampling and characterization of

4. CONCLUSION

Sustainable development of agriculture, and production of agro-energy crops (and crop residues) as a renewable energy source in the form of biomass, requires the application of IT. Innovative methods, which include a number of techniques for collecting and processing a large amount of data on biomass development in the field, enable the approximation of sustainability through their application both in research and development programs and on the farm. As this is a relatively new approach, the methods are still being improved so that there is no universal model that would be applicable to a large number of crops and environmental conditions, which is to be expected given their biological diversity. The current level of development of these technologies enables monitoring of biomass development (primarily through the vegetation index and crop height) in real time and in the selected area. The data collected in this way are used to predict and take adequate agro-technical measures at the right time, which leads to high stable yields.

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ENVIRONMENTAL DATA SCIENCE SESSION

EVOLUTION OF INDUSTRY-RELATED VOLATILE ORGANIC COMPOUND LEVELS AFFECTED BY COVID-19 LOCKDOWN IN BELGRADE

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Abstract:

In this study, we have evaluated the impacts of emergency state and curfew period on the industry-related volatile organic compound concentrations in Belgrade, Serbia. Pollutant concentrations were registered during the three-month period by using Standard Proton Transfer Reaction Quadrupole Mass Spectrometer (PTR-MS) and data analyses included correlation analysis with hierarchical clustering, probability density functions, and bivariate polar plots. As shown, all compounds, except those registered at protonated mass m/z 121, exhibited a significant drop in concentrations only a week after curfew was introduced. The behavior of analyzed compounds suggests that the VOC concentrations are more affected by industrial than traffic emissions.

Keywords:

Air Quality, Volatile Organic Compounds, COVID-19, Lockdown, PTR-MS.

INTRODUCTION

The COVID-19 pandemic in Spring 2020 had a major impact on human behavior, which resulted in significant changes in air quality worldwide and reported benefits to the natural environment. In the period that followed, several studies have used this real-world experiment to enhance our understanding of air pollution and its sources.

The study of Berman and Ebisu has shown statistically significant NO_2 declines of 25.5%, as well as a somewhat smaller decrease of $PM_{2.5}$ levels in urban counties and counties where early non-essential business closures were introduced [1]. The study of Querol et al. investigated air quality changes across 11 metropolises in Spain [2]. Their results emphasized the importance of the massive use of public transport that was reduced because of the fear of infection. While NO_2 levels fell below 50% of the WHO annual air quality guidelines, $PM_{2.5}$ levels were reduced less than expected due to fact that traffic was not the major factor contributing to high PM levels, but also due to the increased contributions from biomass burning or meteorological conditions favoring secondary aerosol formation.

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In compliance with this, the study of Briz-Redón et al. has shown that the 4-week lockdown had a significant impact on reducing the atmospheric levels of NO_2, as well as CO, SO_2, and PM_{10} in some cities, but the levels of O_3 were increased [3]. The study of Chen et al. has concluded that the interventions adopted to limit the COVID-19 outbreak have resulted in improvements in air quality and associated health benefits in non-COVID-19 deaths, which could have outnumbered the confirmed deaths attributable to COVID-19 in China [4]. In this study, we have evaluated the impact of 3-month preventive measures and curfew on air quality in Belgrade (Serbia) based on industry-related volatile organic compounds (VOCs).

2. MATERIALS AND METHODS

The measurements of VOCs and meteorological parameters were conducted in Belgrade urban area (44.86° N, 20.39° E) in the period from 2nd March to 2nd June 2020. They covered two weeks before the implementation of the state of emergency introduced as a response to the COVID-19 pandemic and lasted almost one month after the measures were lifted. Standard Proton Transfer Reaction Quadrupole Mass Spectrometer (PTR-MS, Ionicon Analytik, GmbH, Austria) was used for online measurements of 21 to 270 amu mass range [5], [6], while Vaisala weather station was used for measuring meteorological parameters. Calibration of PTR-MS measurements was done according to Taipale and coauthors [7] by using referent gases and a liquid calibration unit (Ionicon Analytik). Data analyses included correlation analysis with hierarchical clustering, probability density functions, and bivariate polar plots [8]. Mobility data was obtained from Google and Apple.

Figure 1 shows industry-related VOC concentrations and human activity change which accompanies the start of emergency measures caused by the COVID-19 pandemic in Serbia. It can be seen that the evolution of concentrations did not indicate an immediate change in air quality with introducing a state of emergency.

Although the decrease in the intensity of human mobility and industrial activities started with the appearance of the first COVID-positive cases, this period was also accompanied by an increase in the concentrations of all measured compounds. For all compounds (except compounds with protonated mass m/z 121) a significant drop in concentrations was observed only a week later, when the curfew was enforced for quite some time, first for 9 hours, then for 12 hours, and finally throughout the weekends.

Starting from the second half of April, a gradual intensification of human activities and a decrease in the stay-at-home campaign could be observed (intensive adherence to extremely restrictive measures seemed to have lasted only 2, at most 3 weeks), but VOCs concentrations continued to fall. By the end of the measurement campaign, human activities had not returned to the level before the introduction of a state of emergency, especially mobility (walking and driving).
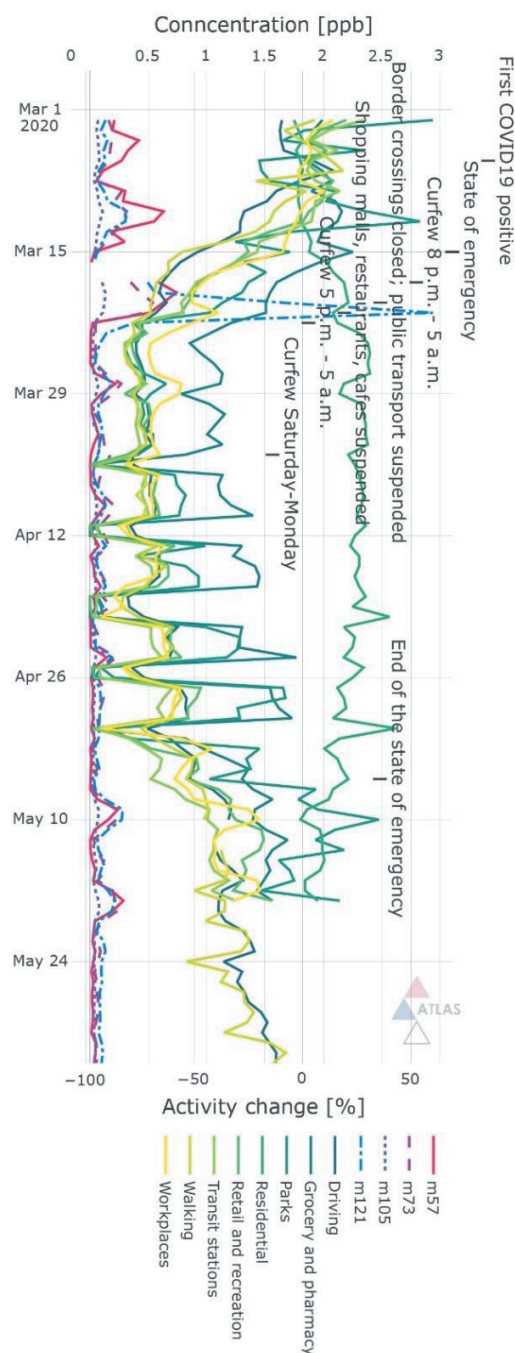
Figure 1 - Industry-related VOC concentration and human activity time series.

It should be noted that there were a few spikes of concentrations registered at all four masses in the period just before and during the lockdown. For compounds registered at m/z 57, the spike almost 4 times the mean concentration was observed a day before the start of the lockdown. For compounds registered at m/z 73, the spike almost 3 times the mean concentration occurred six days after the beginning of the lockdown. Compounds registered at m/z 105 had an intensity spike of 2 times the mean concentration in the event that has occurred 19 days after the start of the lockdown. The largest spike was observed for compounds registered at m/z 121, which raised almost 13 times more than the average readings, and it occurred at the same time as the spike of compounds measured at m/z 73 (six days after the start of the lockdown). General changes in compound concentrations during and after lockdown can be assigned to low industrial activity, while the origin of spikes demands further investigation.

In the period before the introduction of the emergency state, the correlations between all analyzed VOCs (r-values were in the range from

3. RESULTS AND DISCUSSION

0.81 to 0.95), as well as the interconnection of compounds detected at m/z 73 and human activities such as walking, spending time in retail, recreation and transit were observed (Figure 2). The correlation between compounds registered at m/z 105 and 121 was the strongest (r=0.95), while the weakest correlations were calculated between compounds registered at m/z 73 and other VOCs (lowest being between compounds registered at m/z 73 and 121 at r=0.81). During the state of emergency, the interconnection of all VOCs persisted, excluding compounds registered at m/z 121, as well as the correlations between the observed concentrations and human activities. No correlations between VOCs and human mobility were observed in the period following the lockdown, although the correlations between volatiles, including compounds registered at m/z 121, were re-established.

Figure 3 shows the relative changes in mean VOC concentrations during and after the lockdown compared to the pre-introduction period. During the state of emergency, the concentrations of all compounds (except compounds registered at m/z 121) dropped in the range from 30 to 73% compared to the period before its introduction. After the state of emergency was lifted, concentrations continued to fall (35-80%).

The concentrations of compounds registered at m/z 121 recorded an increase of over 36% during the state of emergency, while in the period after the lockdown the level was 20% lower compared to the period before the introduction of the emergency measures.
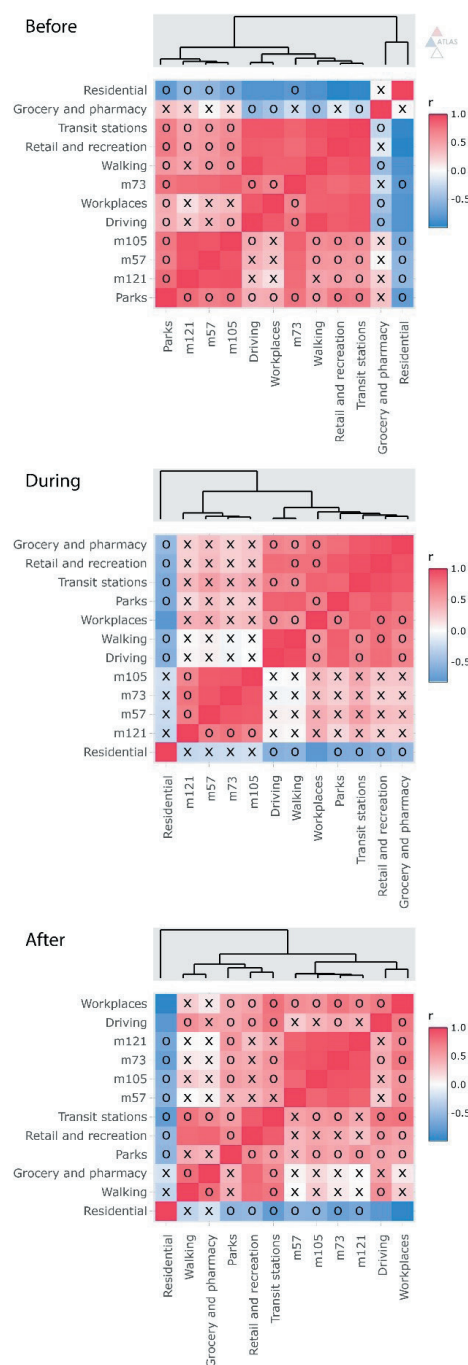
Figure 2 - Parameter value correlation matrix.
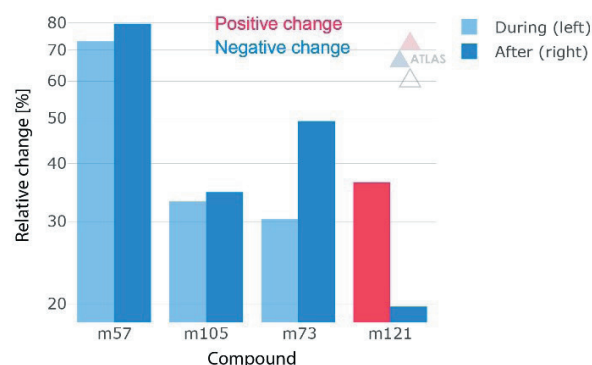
Figure 3 - Mean VOC concentration difference during and after relative to the period before the state of emergency.

The probability distribution functions (PDFs) showed unimodality with pronounced peaks during all three periods of the measurement campaign (Figure 4). The PDFs of m/z 57, 73, and 105 suggested lowering the intensity of emissions of dominant sources during the pre-lockdown period. The compounds that have been detected at m/z 121 had a similar unimodal shape of PDF during every period of the measurement campaign.
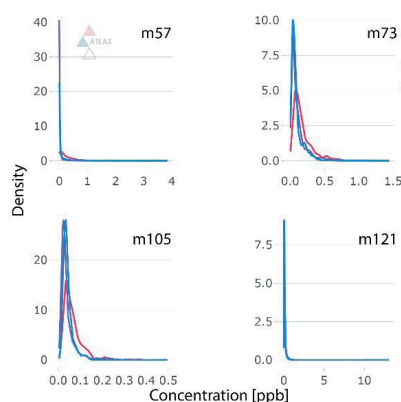
Figure 4 - VOCs density plots.

The dependence of concentrations on wind direction and speed before the restriction period indicated that the common sources for the analyzed compounds were located in the eastern, western, and southwestern directions from the monitoring site (Figure 5). Additionally, certain emission sources of the compounds registered at m/z 73, 105, and 121 were revealed northeast. The highest concentrations of m/z 57 were recorded for the wind speeds of 3 to 7 m s 1, coming from the western and eastern direction which suggests that the most intense

emission sources were distant ones. The compounds registered at m/z 73, 105, and 121 had similar behavior patterns. High concentrations for wind speeds ranging from 4 to 6 m s 1 also indicate the influence of remote sources.

With the introduction of emergency measures, a homogenization of pollution in the ground layers of the atmosphere took place, which was reflected in the relatively uniform distribution of concentrations of all analyzed volatiles regarding wind direction. The reduction of contribution of distant sources and the dominance of local ones was observed.

After the lockdown period, VOC concentrations remained low, with notable activation of the sources of compounds registered at m/z 73 and 105 in the western and southwestern areas.
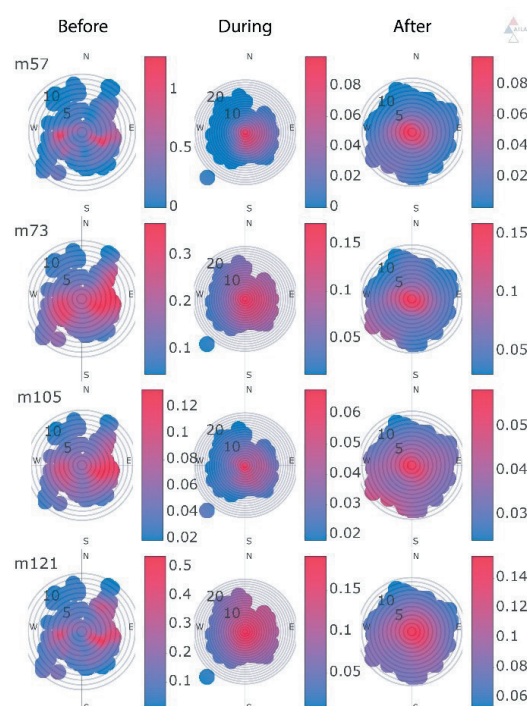
Figure 5 - Industry-related VOC dependency on wind parameters.

4. CONCLUSION

As can be concluded, an immediate change in air quality with introducing a state of emergency was not observed. A few spikes of concentrations of industry-related volatile organic compounds were registered in the period just before and during the lockdown, while the general decrease in pollutant concentrations during and after lockdown can be assigned to low industrial activity.

In the period before and during the lockdown, the correlations between all analyzed VOCs, with exception of compounds registered at m/z 121, and human activities were observed, while after the lockdown no correlations between VOCs and human mobility were detected. The probability distribution functions showed the unimodal distribution of the concentrations with pronounced peaks during all three periods of the measurement campaign. During and after the lockdown, the reduction of contribution of distant sources and the dominance of local ones was observed. As can be concluded, the industry appears to be the major source of analyzed volatiles.

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SYSTEMS-BASED APPROACH TO ENVIRONMENTAL INVESTMENT ANALYSIS BASED ON THE SERBIAN NATIONAL LIST OF ENVIRONMENTAL INDICATORS

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Abstract:

Environmental science generally fosters an interdisciplinary approach within the scope of its studies, but specific issues require additional attention. Environmental pollution is studied within natural, social, and technical sciences, but the existence of environmental issues suggests that a more intensive cooperation between scientists from different fields is necessary. The use of a systems-based approach to the analysis of studies within environmental science should emphasize the need for a detailed determination of the causes of environmental quality degradation and the methods for its mitigation.

Keywords:

environmental indicators, energy, subjects of the system.

INTRODUCTION

Environmental issues are studies within numerous sciences, such as ecology, biology, physics, chemistry, botany, zoology, mineralogy, geology, geography, statistics, sociology, medicine, law, economics, politics, and so forth. Analysis of the current state and the causes of environmental pollution as well as the consequences to wildlife is performed in an integrated manner and within an interdisciplinary approach. Environmental science is studied in the form of environmental engineering studies, supported by social sciences. The goal is to provide a detailed analysis of the influence of biological, chemical, physical, material, and energy processes on climate change and the quality of basic environmental elements. A systematic analysis of environmental issues began as early as the 1960s, with the enactment of international protocols and environmental legislation. Environmental conservation activities are carried out daily, in compliance with the prescribed and adopted measures for the preservation of biological balance.

Ecology and environmental science are fairly similar but can by no means be terminologically equated. Ecology studies the distribution and range of living organisms and the biological interactions between them,

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whereas environmental science mainly focuses on the interaction between living organisms and the environment. Ecology also takes an interdisciplinary approach, only as a branch of biology, following the principles of physics, chemistry, climatology, and geography. The environment is primarily studied in terms of pollution effects, using technical principles and knowledge related to environmental monitoring, spatial planning, statistics, information science, environmental quality indicators.

2. ENVIRONMENTAL QUALITY INDICATORS

The significance of environmental information and data was confirmed in 2003, at the Fifth Ministerial Conference "Environment for Europe" [1], held in Kiev, Ukraine. The conference emphasized the benefits of using indicators when defining policies and influencing public opinion to start resolving the environmental issues. It was concluded that mechanisms should be put in place to assess the environmental impact based on the relevant indicators. Global monitoring of the state of the environment is possible using indicators, which are adopted in accordance with national environmental policies, but also using general principles specific to global development.

Formation of internationally accepted environmental indicators and their use during the creation of national reports on the state of the environment represent significant progress for the monitoring of pollutant emission impact. Guidelines for indicator use are also very important because they have been developed by experts in environmental protection and statistics, hired by international organizations, academic institutions, and civil society associations.

Basic environmental indicators have been defined to allow easier monitoring of the basic elements [2], such as biochemical oxygen demand, biodiversity, climate change, ozone layer depletion, and cross-border emissions. Monitoring of specific pollutants is defined within indicator sets, which also prescribe the sampling methodology, the units used to present data, and the monitoring period. If the use of indicators is properly planned and based on a sufficient amount of time series data, it is possible to monitor changes and conduct a real assessment of the impact on the quality of basic environmental elements. The complexity of the set of national indicators can reveal a country's treatment of its healthcare and safe living conditions, as well as the financial possibilities to procure measuring equipment and to comply with international methodological recommendations.

Creation of the sets of indicators for sustainable development, environmental performance, or environmental quality is based on the indicators of environmental pressure, state, impact, and response. Identification and determination of indicator types is very important for the accomplishment of national and international environmental goals. A comparative analysis based on internationally recognized methods can contribute to data collection for the calculation of key indicators and the creation of an international database.

2.1. SERBIAN NATIONAL LIST OF ENVIRONMENTAL INDICATORS

In Serbia, monitoring of the state of the environment is performed using the National List of Environmental Indicators for the purpose of assessing the quality reduction of water, air, and soil, to inform the public, and to facilitate decision making pertaining to pollution mitigation.

The National List of Environmental Indicators [3] has been defined so as to allow an international comparative analysis of indicators. Yet, it should be noted that some countries in the region utilize more complex sets of indicators. EU members usually utilize more complex current state assessments, so it is impossible to compare all the parameters that are monitored in more developed countries.

Current state assessment and creation of the environmental assessment report are based on available data, so valid methodologies are implemented regardless of apparent deficiencies. Statistical data on environmental quality are publicly available and are publicized in a designated period, depending on the prescribed monitoring period. The report is created in accordance with international recommendations while adhering to the national legislation and the existing institutional mechanisms.

The Rulebook on the National List of Environmental Indicators ("Official Gazette of the Republic of Serbia", no. 37/2011) provides the general description of the indicators and classifies the indicators by subsections (pressures, state, impacts, influencing factors, and societal response) into topical sections. The General Description of Indicators elaborates on their [3]

1. national and international importance;
2. reporting relevance using a given indicator;
3. measurability and statistical adequacy;
4. simplicity and ease of understanding;
5. economic viability.

The data in the National List of Indicators are categorized into the following topical sections [3]:

1. Air and climate change;
2. Water;
3. Nature and biodiversity;
4. Land;
5. Waste;
6. Noise;
7. Nonionizing radiation;
8. Forestry, hunting, and fishing;
9. Sustainable use of natural resources;
10. Economic and social potentials and environmentally-relevant activities;
11. International and national legislation, as well as measures (strategies, plans, programs, agreements), reports, and other documents and activities pertaining to environmental protection;
12. Subjects of the environmental protection system.

The area of study is all-encompassing, but the issue is the lack of finances to implement the established solutions.

2.2. ECONOMIC POTENTIALS AND ENVIRONMENTALLY-RELEVANT ACTIVITIES

The National List of Environmental Indicators, specifically topical section 10, *Economic and social potentials and environmentally-relevant activities*, defines 17 indicators across seven fields: chemicals and health; industry; energy industry; agriculture; transport; tourism; and urbanization [3].

The above presented indicators from the tenth topical section suggest that special emphasis is given to the analysis of impacts from the energy industry and agriculture.

With regard to subsections, the impact indicators comprise only [3] *Total amount of particularly hazardous chemicals on the market* (10.59), while the indicators of state express the growth of urban settlements using the surface area of urban settlements and their populations (*Urban settlements* – 10.75).

The societal response indicators comprise [3] *Environmental management system* (10.60), *Share of recycling in the gross domestic product* (10.61), *Total energy intensity* (10.64), *Consumption of primary energy from renewable sources* (10.65), *Consumption of electrical energy from renewable sources* (10.66), and *Areas under organic agriculture* (10.67).

Topical section: Economic and social potentials and environmentally-relevant activities	
Chemicals and health	10.59. Total amount of particularly hazardous chemicals on the market
Industry	10.60. Environmental management system
	10.61. Share of recycling in the gross domestic product
Energy industry	10.62. Total consumption of primary energy by energy-generating product
	10.63. Final energy consumption by sector
	10.64. Total energy intensity
	10.65. Consumption of primary energy from renewable sources
	10.66. Consumption of electrical energy from renewable sources
Agriculture	10.67. Areas under organic agriculture
	10.68. Consumption of mineral fertilizers and plant protection products
	10.69. Irrigation of arable surfaces
	10.70. Agricultural areas of high natural value
Transport	10.71. Passenger and freight transport related to GDP
	10.72. Consumption of fuels and cleaner and alternative fuels in transport
	10.73. Motor vehicles
Tourism	10.74. Tourism intensity
Urbanization	10.75. Urban settlements

Table 1 – Economic and social potentials and environmentally-relevant activities [3]

The following indicators are considered as influencing factors [3]: *Total consumption of primary energy by energy-generating product* (10.62), *Final energy consumption by sector* (10.63), *Passenger and freight transport related to GDP* (10.71), *Consumption of fuels and cleaner and alternative fuels in transport* (10.72), *Motor vehicles* (10.73), *Tourism intensity* (10.74), and *Urban settlements* (10.75). *Consumption of mineral fertilizers and plant protection products* (10.68), *Irrigation of arable surfaces* (10.69), *Agricultural areas of high natural value* (10.70), *Tourism intensity* (10.74), and *Urban settlements* (10.75) are categorized as pressure indicators.

3. ENVIRONMENTAL QUALITY INDICATORS

The twelfth topical section, *Subjects of the environmental protection system*, contains the following five indicators, all under societal reactions subsection: *Budget expenditure* (12.77), *Investment and current expenditure* (12.78), *Income from fees and taxes* (12.79), *Resources for subsidies and other incentives* (12.80), *International financial aids* (12.81).

The Serbian Environmental Protection Agency, operating within the Ministry of Environmental Protection, is tasked with creating the annual Report on the State of the Environment in the Republic of Serbia [4], pursuant to articles 76 and 77 of the Law on Environmental Protection ("Official Gazette of the Republic of Serbia", no. 135/04, 36/09, 36/09 – another law, 72/09 – another law, 43/11 – decision by the Constitutional Court, 14/2016 – decision by the Constitutional Court). The most recent report was published for the year 2018 and was written based on the data collected via the information system of environmental protection and through direct cooperation with the relevant institutions that collect data on the state of the environment [4].

The report is intended both for decision makers in the field of environmental protection and for the professional and general public [4], and it is thus directly compliant with Article 74 of the Serbian Constitution, which establishes the right of citizens to a healthy environment as well as to timely and complete information about its state. It is also indirectly observable from the report to what extent the environmental policy aims have been achieved and measures implemented, as defined in several strategic and planning documents (National Environmental Protection Program ("Official Gazette of the Republic of Serbia", no. 12/10), National Sustainable Development Strategy ("Official Gazette of the Republic

of Serbia", no. 57/08), and National Strategy for Sustainable Use of Natural Resources and Assets ("Official Gazette of the Republic of Serbia", no. 33/12)) [4].

The report on the state of the environment is based on the indicators presented by topical section in the National List of Environmental Indicators.

The report data (Figure 1) show that budget expenditure for environmental protection amounts to only 0.3% of the GDP annually.
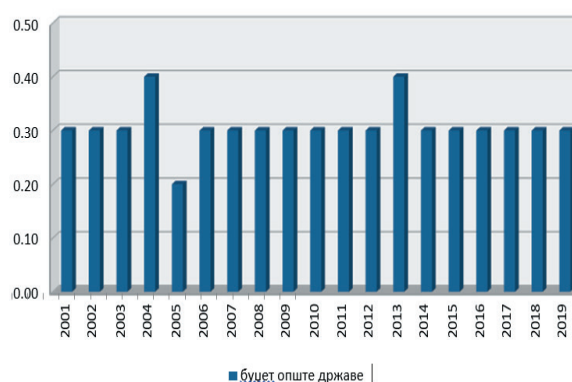
Figure 1 – Budget expenditure, % GDP [4]
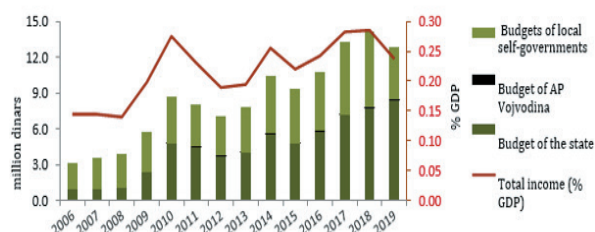
Figure 2 – Income from fees and taxes for environmental protection and improvement, % GDP [4]

The total income from environmental fees and taxes (Figure 2) has grown steadily from 2015 until 2019, when it dropped to 0.24% of the GDP.

The largest share of the income from fees comes from fees for emissions of sulphur dioxide, nitrogen dioxide, powder materials, and deposited waste (6.27 billion dinars), for products that become special waste streams after use (4.39 billion dinars), and for wildlife trade (1.78 billion dinars).

The analysis of income from environmental taxes shows that energy industry has the largest share of 85% (Figures 3 and 4).
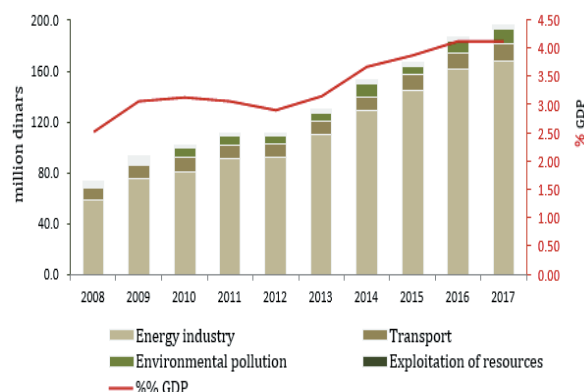
Figure 3 – Income from environmental taxes, % GDP [4]
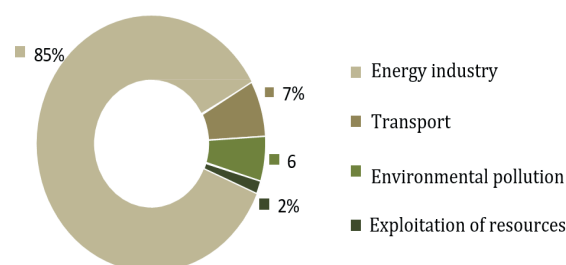
Figure 4 – Sources of environmental tax income [4]

Environmental investments from the economy sector are also very small (Figure 5) and amount to 0.05% of the GDP (2.96 billion dinars), with the largest share coming from energy industry and mining (85.9%), followed by industry in general (7.9%). The allocated resources for subsidies (Figure 6) have been estimated at 0.08% of the GDP (5.15 billion dinars), with the recycling industry being the largest recipient of these resources (79.9%).
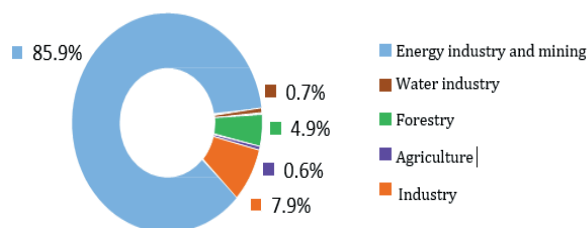
Figure 5 – Sources of investment from the economy sector [4]
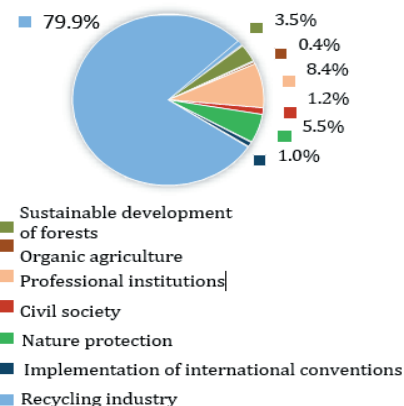
Figure 6 – Allocated resources and target areas [4]

Financial incentives from the state concerning the environment are shown in Figure 7.

1-Total (million dinars), 2-% GDP
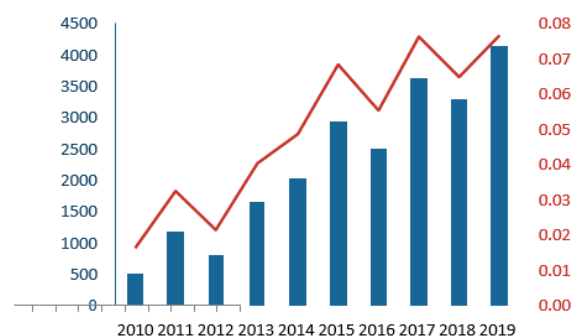
Figure 7 – Financial incentives from the state, million dinars and -% GDP [4]

It is also important to emphasize that international donations for the sectors Environmental Protection and Water Supply and Waste Management (Figure 8) amount to 0.08% of the GDP (4.6 billion dinars), with the biggest donations coming from Germany, Sweden, and the EU.
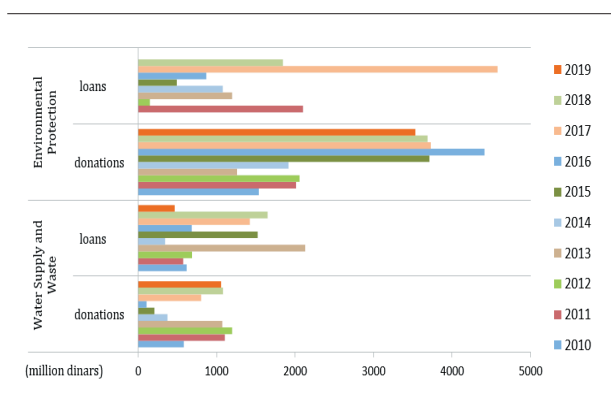
Figure 8 – International financial aids – donations and loans for the sectors *Environmental Protection and Water Supply and Waste Management* [4]

In 2019, the biggest donors for the Environmental Protection sector were the EU with 1.9 billion dinars, Germany with 1.1 billion dinars, and Sweden with 448 million dinars [4]. The total amount of financial resources for investments and current expenditure is 0.72% of the GDP.

4. CONCLUSION

The data presented in the paper indicate that environmental investments are rather small in relation to the GDP, which makes it impossible to maintain the quality of basic environmental elements at a satisfactory level, regardless of scientific development and achievements. It is essential to regularly conduct environmental monitoring and publish reports that depict the actual state.

The real picture of investment in a healthy environment at the national level can only be obtained based on the indicators such as *subjects of the environmental protection system* and based on the use of relevant data and information derived from the official data by state institutions, scientific and professional organizations, and other involved parties. A systems-based approach to the analysis of environmental issues provides a good foundation for grasping the situation and making comparisons against environmental investments in other countries.

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INFORMATION SECUITY AND ADVANCED ENGINEEING SYSTEMS SESSION

AN INSIGHT INTO FACIAL MASK AND SOCIAL DISTANCE MONITORING SYSTEM BASED ON DEEP LEARNING OBJECT DETECTOR TO PREVENT COVID-19 TRANSMISSION

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Abstract:

During the COVID-19 pandemic, facial mask detection and monitoring the social distance between persons is an essential and challenging task. Along with other several machine learning techniques, deep learning has been successfully applied for object detection. In this paper, we have thoroughly explored the deep learning object detection methods for facial masks and physical distance. We have discussed an overview of object detection methods in the form of taxonomy and analyse one-stage and two-stage object detectors. In the end, some open research challenges have been presented as well.

Keywords:

COVID-19, Deep Learning, Machine Learning, Social Distance, Object Detection.

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INTRODUCTION

COVID-19 is an infectious disease caused by the SARS-CoV-2 (2019-nCoV) virus, first identified in Wuhan city of China on 29 December 2019 [1]. Due to its worldwide infections in millions of people, the World Health Organization (WHO) declared it as a pandemic in March 2020. In this response, governments have imposed wearing masks, social distancing, and increasing awareness of hygiene. It is a respiratory disease and the reproductive ratio of corona virus is greater than other acute respiratory problems like SARS and MERS [2,3]. Therefore, for safety some precautions measures needed like washing hand regularly, wearing a face mask, and maintaining social distance between people [4].

The deep learning object detection model is divided into two types, the first type is one-stage detector including SSD [5] and YOLO [6] and the other is a two-stage detector including R-CNN model [7] and Faster R-CNN model [8]. These detectors have gained tremendous success in the field of machine learning to overcome corona virus. Therefore, it is necessary to take precautionary measurements like wearing a facial mask and keeping social distances. Therefore, facial mask detection and social distance systems have many applications in the domain of machine learning.

The facial mask detection system is closely related to object detection techniques that identify whether a mask is present on the face or not and recognize the location of the face. Face detection system achieved high accuracy and performance with deep learning SSD refinement face detector namely Refine Face [9]. Correct wearing face mask with classifier SRCNET applied deep learning detector and achieved accuracy 98.70% [10].

Artificial intelligence is a powerful way to predict and fight against COVID-19.AI and deep learning technique help to monitor social distance by using fixed monocular camera and thermal image with detector Faster R-CNN and YOLOv4 [11,12]. Another social distance maintenance problem scenario has been provided statistics during violation with Social Signal Processing methods based on deep learning. Estimation of Visual distance measurement is automatic and also maintains privacy policy but needs attention to work more on the effectiveness and ethical process of visual social distance system [13]. YOLO v3 has been applied for social distance monitoring with deep learning bounding boxes of object detection and frames in video display index violation [14]. In another research [15], object detectors handle facial mask detection, social distance monitoring, and measure body temperature based on the Internet of things (IoT)by using OpenCV Harcascade classifier. Faster R-CNN and SSD indicated that ensuring proper use of face masks and maintain social distance to restrict virus growth [16-18]. An automated monitoring system has been effectively worked against the fight of controlling respiratory disease COVID-19. There have been broad research aspects of the abovementioned era of corona virus. To limit the scope, we mainly study (2015-2021) facial masks and social distance measuring deep learning detectors representing the research contributions. To the best of our knowledge, no taxonomy has been presented related to deep learning detectors for facial masks and measure social distance in the existing literature. In literature, we propose taxonomy to give a summary of the evolution in the area of deep learning detectors in Section 2. Based on the in-depth exploration, research challenges have been upraised in Section 3. Lastly, the discussion is concluded in Section 4.

2. TAXONOMY

Corona virus has caused the deaths of millions of people all over the world. In this epidemic, the best precautionary measures are facial masks and maintaining social distance. In the literature, several object detection

models have been proposed to automate and improve the efficiency of facial masks and measure the social distance between persons. These models are categorized into (i) one-stage detector and (ii) two-stage detector, as shown in Figure 1.
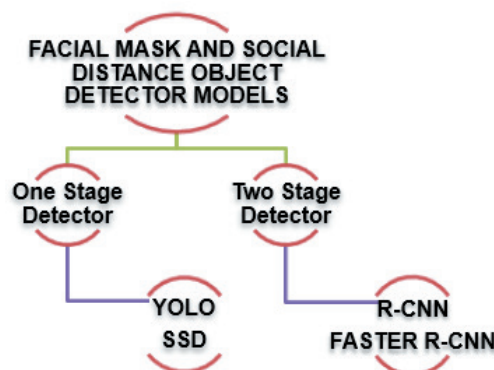
Figure 1- Taxonomy of Facial Mask and Social Distance Object Detector Model

2.1. ONE-STAGE DETECTOR

One-stage object detectors belong to supervised machine learning classification and regression methods helpful to detect facial masks and measure social distance. The algorithm runs clearly and concisely distributed into training and testing. Generally, testing directly alters the input data into output image data and makes a resultant detection frame over decoding. On the other hand, the labelled data encodes during training to create constant with the consistent output data of CNN and compute loss. One-stage detectors are YOLO [6], SSD [5].

2.2.1. YOLO

You Only Look Once (YOLO), a well-known deep learning detector, introduced by Redmon et al. [6] in 2016, uses a fully convolution network. The core concept is to treat the detector as a regression problem, using a feature extractor network that reduces false detection and reads 45 frames per second in real life. In the literature, various versions of the YOLO detector have been presented to automate the monitoring system of facial masks and measure social distance. Loey et al. [18] have proposed Yolo-v2 based on feature extractor network ResNet-50 to annotate and detect medical face masks. Besides, the author has applied mean IoU to the evaluation number of the anchor box and achieved 81%

average precision by using Adam optimizer. However, CUDA is used for GPU learning with MATLAB, Tensorflow, and Deep learning libraries. The author also observed a deep learning detector to solve classification problems in the technical field.

In this regard, Said et al. [19] proposed the Pynq-YOLO-Net light-weighted Convolutional Neural Network with YOLO framework to detect face masks. Moreover, the system has been executed on Pynq Z1 embedded quantized acquired 94.6% Precision and 95.8% Recall. Based on computation, the face mask detection system used feature extraction on hardware devices, and results were performed on software. To tackle the binary classification problem, the author eliminates the computation of class probability and YOLO calculates confidence scores of predicted bounding boxes and increases the speed of the detector. Similarly, NS Punn et al. [14] have presented a Deepsort technique YOLO v3 to check COVID-19 social distance between persons. The author also conducted a comparison with state-of-art detector Faster RCNN and SSD consider classification and localization with frames per second, mean average precision, and loss values.

2.1.2. SSD

Single shot detectors (SSD) based on COVID-19 monitoring system methods have been investigated for multiple categories. The detector contains a VGG16 network that directly predicts box offset and scores of bounding boxes for fix set in a feature map. Therefore, each feature map contains different scales of the default bounding box. Likewise, for different feature maps, a ratio of bounding boxes has been calculated with regular space among the lowest and highest layer. After that, matched bounding boxes compare with ground truth to enhance the accuracy and track the principle of the feed-forward convolutional neural network [14].

In another research work, Deng et al. [20] have projected an improved facial mask detection method based on SSD. To prove the value of the presented solution, feature fusion and attention learning are used to determine a person wearing a mask or not. That is why we have obtained 91.7% accuracy and built a channel domain of attention procedure with a feature map. However, there are still some problems needed to be set, among these, the author used a small dataset that provided low performance. Hence the largest COCO dataset used by S Neelavathy Pari et al. [21] to monitor social distance in smart phone applications and cameras. The SSD model

handles Conv5-3 beside the VGG-16 layer that extracts the feature map. Ahamad et al. [22] detect a person in a region of interest using image processing, computer vision, and Single Shot Multibox Detector MobileNet. The distance has been calculated between people to be detected in the image and then associated with static pixels. The distance was scaled between the central points and the overlying boundary among peoples in the segmented tracking part. The author also worked on a violation system to generate alerts by using python.

2.2. TWO-STAGE DETECTOR

The two-stage detector belongs to the family of R-CNN. It is divided into two stages. The first step filters out Region of Interests (ROI) from an image by extracted feature. ROIs contain possible boxes in an image. The second step, utilize ROIs and features to calculate class probabilities and final bounding boxes. Therefore, to attain an optimum trade-off among accuracy and speed these types of detector are useful like R-CNN detector [23] Faster R-CNN detector [24].

2.2.1. R-CNN

It is a deep learning object detector that proved effective and well-organized based on region. The author Girshick [25] presented a Region Convolutional Neural Network detector that works on CNN model on dataset PASCAL VOC having advanced detection performance [26] using HOG-like features. Region Convolutional Neural Network detectors have four parts. The initial part produces class-independent region proposals. Each region proposal extracts the feature vector in the second part. The third part has a set of class exact linear Support vector machines to classify objects. The last part has a regression bounding box for exactly bounding box prediction.

A larger amount of dataset used by fine-tuning during the pre-training phase on the definite dataset is a better training way for CNN to attain faster convergence. However, Girshick firstly pre-train the deep convolutional neural networks on a larger dataset. The latter fully connected layer has been changed by the CNN ImageNet. The next phase has utilized stochastic gradient descent (SGD) toward modification of CNN constraints taking the twisted windows proposal. Finally, the classification layer has a fully connected layer with the (N+1) method.

2.2.2. FASTER R-CNN

This type of detector contains two networks with the R-CNN family, first is the Region proposal network (RPN) that detects objects by creating region and network proposals. Region proposal network positions box of the region (named as anchors) and intends having objects. Secondly, it generated features to get object features by using CNN. The classification layer helpful to predict class and the regression layer provide bounding box coordinates more accurately. Region proposal used a selective search algorithm based on CPU, which precedes about 2 s per image. Faster R-CNN not only carries the region proposal period from 2s to 10s however also permits the proposal region step to divide layers [8]. In another research, Singh et al. [27] applied Faster R-CNN and YOLO v3 to detect face masks. The resNet-101-FPN architecture is used as a backbone during the training phase of the model. The author proposed a method around the person's face to draw bounding boxes, check that mask present on the person's face, and keep record data of face masks of the person every day. Singh has also associated the performance of Faster R-CNN and YOLO v3 models.

3. OPEN RESEARCH CHALLENGES

3.1. SYSTEM FOOLED BY PLACING A HAND ON MOUTH AND NOSE

In literature, facial mask detection techniques along with their limitations have been discussed comprehensively. The deep learning-based facial mask technique can detect a face covered with a mask or not but the system can be confusing when placing a hand on the nose and mouth [32]. In another research, only front images of faces have been shown accurate results. The system cannot detect face masks when the right and left sides are seen [28]. So, researchers need to fill this research gap.

3.2. LIMITED DATASET

With the evolution in the era of deep learning, detectors based on facial masks and social distance systems require a large amount of data to maintain performance and accuracy. Until recently, limited datasets available to train and test models [15,36]. In the existing literature, a new object detector model MASK-R-CNN is not used in the area of the COVID-19 prevention method.

Deep Learning CNN algorithms utilized to optimize the facial mask system model. However, scholars have not introduced agent-based modeling (ABM) for facial mask detection systems to confirm the effects of the applied optimization techniques. Moreover, the ABM-based methods can play a major role to detect human face masks and measure social distance.

3.3. LACK OF REAL-TIME IMPLEMENTATION

From the tables [11,16,22,34], it can be shown that 80% of the proposed deep learning facial mask and social distance control system are based on simulations that do not determine the same applicability in the real-time environment. One of the major problems in real-world implementation is that these methods depend upon complex mathematical models that do not achieve well in the real world [37].

4. CONCLUSIONS

In this paper, we have presented taxonomy for automated facial masks detection and social distance with a deep learning object detector system. These systems can handle two types of detector i.e. one-stage detector and two-stage detector. These detectors, based on SSD, YOLO, R-CNN and Faster R-CNN, are discussed along with objectives of each technique. After that performance of these systems are compared and the research gap in the existing literature has been highlighted.

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Author	Method	Objective	Performance	Limitation
[28]	Single shoot detector	Proposed largest dataset of masked faces for detection and recognition	Achieve 95% accuracy with multi granularity model	only front side face images collected for dataset from internet
[29]	Single shoot detector	Face mask detection in image/video	Accomplish accuracy by tuning hyper-parameters	Difficult to detect faces in crowd
[30]	R-CNN Faster R-CNN	Enhanced ability of face mask detection with single shot RetinaNet detector and feature pyramid network	Obtain accuracy 2.3%& 1.5% greater than base-line for precision, 11.0% and 5.9% greater than base-line for recall.	ResNet backbone not work with other component due to limited dataset performance
[31]	Single Shoot detector	Compare deep learning classifier with optimization algorithm to check performance of face mask detection	ADAM has high accuracy as compared to ADAGRAD and SGD MobileNetV2 classifier also high accuracy during testing	Absence of alert system And social distance measurement, security issues
[32]	Deep learning Convolutional Neural Network	Facial mask detection in smart city through CCTV camera, in violation case inform to smart city authority	98.7% Achieve accuracy	Confuse system with hand covered face, incorrectly identify person location on vehicle.
[15]	OpenCV library, ontology	IoT based system to detect face mask, check social distance and sense temperature without contact	Mask detection accuracy 84-91%, distancing check 65-73%, temp. Sensing 0.5-2.5 °C	Low frame rate in image/ video, Missing efficient security and mask allocation
[14]	YOLO v3	Monitoring real time social distance	YOLO v3 with deep-sort acquire better result as compared to mAP and FPS	Video frames violation occurrence are not recorded, Privacy issue
[11]	Faster R-CNN and YOLOv4	Artificial intelligence detect real time social distance and critical density	Accuracy and performance are good to monitor social distance	Do not record real time data, crowd analysis still a challenge
[33]	YOLO Single Shoot detector	Crowd counting and social distance measure	Robust performance	Incorrectly detected image of person on banner
[34]	YOLOv3	Social distance monitoring and track violation	Accuracy with transfer learning 98%, without 92% and tracking model 95% accuracy	Improve model for Indoor and outdoor environment in future.
[35]	YOLOv2	Indoor and outdoor environment AI system for social distance classification and measuring, also body tempt analysis with thermal camera	high accuracy and low computational power	Newly YOLOv4 use in future, 2D parameters used only to detect person, not 3D
[22]	Single shoot detector	Indoor and outdoor social distance with feature based segmented ROI alert system	Outdoor testing accuracy level 56.6%-60%, indoor 100%	Outdoor detection is difficult

[36]	Single shoot detector	Social distancing, face mask detection to maintain safe environment	MobileNetV2 model 94.1% face mask accuracy and social distance is more than 90% accuracy	Limited feature data, Partially hidden face by a person create model confusion, missing contactless attendance
[16]	Faster R-CNN	Face covered with mask and social distance for road construction worker	Accuracy Face mask detection 90%	Only reliable for the Four road construction worker.
[37]	Single shoot detector	Face mask and physical distance with alarm system	accuracy rate of 97%	Do not detect face mask and physical distance at the same time, require high performance in detecting and recognizing
[17]	Single shoot detector	Face mask and social distance detection and generate alert signal	Obtain accuracy 85% and 95%	Not analysis coughing and sneezing detection non-available

Table 1 - Literature Review

COMPARATIVE ANALYSIS OF CONSENSUS ALGORITHMS IN BLOCKCHAIN NETWORKS

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Abstract:

Since 2009, with the invention of Bitcoin, the usage of blockchain technology is constantly increasing. From its initial financial use case, blockchain as a decentralized data storage system has grown to an entirely new information ecosystem and has been successfully applied in a wide range of applications in other industrial sectors, outside of finance. Given that the data is decentralized, the computer nodes participating in the network are in charge of adding new data to the blockchain, the authenticity of which is determined by consensus algorithms as a mechanism for maintaining data integrity. Bearing that in mind, consensus algorithms and their application are crucial for the reliability and data security in a blockchain. The aim of this paper is to perform an analysis of currently most used consensus algorithms, as well as their impact on key blockchain attributes.

Keywords:

Blockchain, Consensus algorithm, Decentralization.

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INTRODUCTION

At its core, the blockchain represents a decentralized database, developed in the form of a ledger with its data being timestamped and immutable. Bitcoin was developed using such technology, as a form of digital money, serving as the first such implementation to successfully solve the double-spending problem, due to the nature of how blockchain works [1]. With the growing popularity of Bitcoin, other "currencies" based on the same technology have been developed, and due the fact that the technology significantly relies on cryptography, they are collectively called cryptocurrencies. Although it has been attracting public attention since 2009 with the advent of Bitcoin, the concepts presented in the Bitcoin whitepaper written in 2008. date significantly earlier. Back in 1982, David Chaum presented in his dissertation a protocol that significantly resembles a blockchain [2]. Its application would allow for the development of a computer system in which participants do not have to have mutual trust, but the system is designed as trustworthy allowing such parties to interact. Relying on his work, Harber and Stornetta developed a document time-stamping system as a mechanism to guarantee its integrity [3].

As a blockchain system is distributed and spreads through a computer network, it is necessary that all participants in the network agree on the correctness of the data it holds. For these purposes, the so-called "Proof of Work" (PoW) was first to be implemented and used as a consensus algorithm to guarantee the credibility of the data that the network participant was trying to write on the blockchain. PoW was first presented in 1992 as an attempt to combat spam emails.

Although it is considered a new revolutionary technology, it can be noticed that the foundations of blockchain were built years ago and have a sound scientific basis. From its inception until today, Bitcoin has had significant fluctuations in terms of market value. Starting at just $0.09 in 2010, the value of Bitcoin has had significant ups and downs over the years, but looking at the general trend, the price of Bitcoin seems to constantly rise. The popularity of Bitcoin has contributed to the further development of cryptocurrencies and blockchain as a technology. As a consequence of this development, other blockchain implementations were designed promoting Turing completeness and providing the possibility of writing programs that could be both stored and executed within the blockchain. Such programs are called smart contracts, with Ethereum being an example of a blockchain that provides such a possibility. It was developed in 2014 with an original cryptocurrency called Ether. Although the primary focus is on the financial sector, blockchain as a decentralized database has found application in other fields as well, such as healthcare, supply chain, voting systems, Internet of Things, insurance, digital rights management and real estate [4] [5] [6]. This expansion in blockchain's applicability has naturally led to the further development of the technology itself. Initially, the proposed consensus algorithm, PoW, although meeting the needs in terms of data security and integrity, turned out to be impractical from the scalability point of view. This scalability issue has served as a catalyst to the emerging interest for finding the alternative algorithms upon which the network participants would agree and thus keep the blockchain secured [7] [8] [9]. The aim of this paper is to analyse currently most used consensus algorithms, compare their advantages and disadvantages and suggest situations in which it is appropriate for them to be used.

This paper is organized through five chapters: After the Introduction, the second chapter presents blockchain core principles. The third chapter provides an overview and analysis of existing consensus algorithms, while the fourth chapter is devoted to comparative analysis. Finally, a conclusion was given with plans for further development of the proposed idea.

2. THE PRINCIPLE OF OPERATION OF THE BLOCKCHAIN

The first version of blockchain was developed on top of the model provided by Bitcoin's whitepaper and thus has laid the foundation in terms of the blockchain technological principles [1] [5]. The main idea behind the blockchain is the removal of the third party whom the business participants have to trust.

In the initial implementation, this has meant the removal of financial institutions, allowing the participants to transact directly, which Bitcoin blockchain successfully allowed for [10]. By doing so, Bitcoin has served as an example, spreading the idea of independence from centralized third parties to industries outside the financial sector [5] [6]. In order to achieve such independence, the blockchain is designed as a decentralized database, where each computer (node) in the network contains part of or the entire data set. It consists of interconnected blocks of data, each containing transactions portrayed in a form of Merkle's tree and being cryptographically linked to the block preceding it. As the blocks are arranged chronologically, the blockchain can be seen as a ledger containing the history of all transactions. In order to maintain data integrity, nodes in the network work together as transaction validators and only when most of the nodes agree on the correctness of transactions, and the block itself containing them, the block is added to the chain. This decision about data correctness is based on a consensus algorithm defined at the blockchain level. The Bitcoin blockchain uses the PoW consensus mechanism, and currently popular next to it are "Proof of Stake" (PoS) and "Delegated Proof of Stake" (DPoS) [8]. When it comes to cryptocurrencies, nodes participating in the network and thus making it possible are rewarded with appropriate amounts of cryptocurrency [8].

From the access point of view, blockchain networks can be divided into private and public ones. Regarding private blockchains, only computers that are granted access can interact with the blockchain, while with the public ones anyone can access and interact with the blockchain. Bitcoin and Ethereum are examples of a public blockchain, while the popular implementation of private blockchain Hyperledger Fabric [1] [11]. From the extensibility point of view, some blockchain implementations can be additionally programmable, i.e., provide the ability to implement and execute program code. This way, applications that could previously only be executed through a trusted intermediary, now

can work in a fully decentralized manner, without the need for a central authority, while providing the same set of functionalities. Bearing that in mind, blockchain is said to enable thrustless networks, because interested parties can participate in transactions even though they do not trust each other. This absence of intermediaries means faster and often more reliable transaction resolution [12]. Program code execution within the blockchain is achieved by deploying and triggering smart contracts, and the blockchain networks that support them are considered to be Turing complete. Depending on the platform, there is a wide range of programming languages for smart contract implementation, the most used among them being Solidity, initially designed for Ethereum blockchain.

Although the concept of smart contract directly corresponds to applications related to the financial sector, they can be used for various forms of blockchain programs and are considered a distributed form of business logic [5] [13]. An example of a smart contract that is used significantly is the Uniswap decentralized application. It represents a decentralized cryptocurrency exchange where anyone can, unlike centralized exchange where it is previously necessary to prove their identity, trade cryptocurrencies as long as there is enough liquidity for the cryptocurrency of concern. That being said, users are divided into two groups: traders who pay a certain amount of fee for participation in the trading transaction, and liquidity providers who expose their cryptocurrencies to exchange, to make the exchange possible, and in return are rewarded with part of the fee from participants [14]. An example of an application that is not intended for financial services is the application for the implementation of decentralized voting in elections [6]. With blockchain, the entire voting flow was performed in a decentralized manner, and the management was left to the software, thus removing the need for trust in any intermediary.

3. ANALYSIS OF BLOCKCHAIN CONSENSUS ALGORITHMS

Consensus algorithms are used to determine the credibility of a network node trying to write data to a blockchain [1] [7] [8] [9]. The first such algorithm, POW, although satisfying security needs, was criticized upon its development primarily for its poor scalability as well as intensive use of computing power resulting in significant power consumption [8] [9]. Blockchain implementations of the two most popular cryptocurren-

cies, Bitcoin and Ether, are currently facing this problem. As a solution, alternative consensus algorithms have been developed and proposed, however, each brings with itself certain advantages and disadvantages [8]. As mentioned in the previous section, currently most used consensus algorithms are PoW, PoS and DPoS, and in this chapter an analysis of each of them will be performed, followed by a comparative analysis. It is important to mention that the consensus mechanism of the Ethereum blockchain mechanism is in process of transition from PoW to PoS [15].

3.1. PROOF OF WORK

Proof of work is a consensus algorithm that relies on performing computer-intensive operations. This way, the participant in the network guarantees that he has done enough work to be worthy of capturing the transaction on the blockchain, while nodes in the network compete to perform such an operation faster.

The process is organized in such a way that the participant in the network who has successfully completed the work attaches evidence for other members of the network to confirm the authenticity of his contribution. The mentioned computer-intensive work is called mining, and after the network participants have confirmed the performed work, the node is being rewarded with cryptocurrency serving as the origin for the mining analogy [1] [16]. This approach to consensus relies on the assumption that more than half of the nodes in the network are honest. That way, if someone possessed more than half the computer power of the network, he would be able to compromise the data. Such a form of attack is by its nature called "51% attack". The additional limitation of this approach relates to costs in terms of power consumption and hardware requirements [8]. The pronounced hardware needs are the result of the complexity of operations performed by nodes, which negatively affects the time required to process the transaction. However, this form of complexity makes such an attack difficult and unprofitable in large blockchains, such as Bitcoin [1]. Consequentially, the main problem that arises when using such an algorithm relates to the scalability of the network [18].

3.2. PROOF OF STAKE

Unlike PoW, where network participants compete using their computing power to be selected to write data to the blockchain, and are rewarded for that, PoS is a consensus algorithm stating that the decision on which computer authors a new blockchain block directly depends on the stake that network participant has accumulated. This form of stake corresponds to a number of cryptocurrency coins that are locked, i.e., invested in the network. In that sense, participants who own large amounts of coins have an advantage over others. The first cryptocurrency to apply this approach was Peercoin in 2012 [8]. This process requires information about the coin possession of each of the participants, as well as the amount of time spent in their possession. Participants are required to stake more coins than they can be rewarded upon adding a transaction on the blockchain. In case of detecting a transaction that is considered to be fraudulent, the network confiscates all the coins that are being staked from the participant who tried to carry out such a form of attack. The advantage of this approach is that it is not as hardware-intensive as PoW, and therefore more environmentally friendly. It is important to note that this approach also relies on computing power when generating the block, but significantly less than is the case with PoW. Bearing in mind that participants who own more coins have a higher chance of adding transactions to the blockchain and thus be rewarded with cryptocurrencies, this process potentially makes them richer from the point of view of cryptocurrency as the time goes by. That way, a member who owns a significant number of coins could endanger the network [8]. Also, it should be taken into account that the possession of so many coins locked could represent an extremely large monetary representation of the cryptocurrency. If such a member would jeopardize the network, it would negatively affect the market value of the cryptocurrency, which would in turn jeopardize his own profit, thus making the "attack of 51%" less likely than in PoW blockchain implementations. Although unlikely, such attacks could be subtle and difficult to detect.

3.3. DELEGATED PROOF OF STAKE

The DPoS algorithm is the successor to the PoS algorithm, with significant improvements in terms of transaction execution speed and network scalability, first proposed in 2014 by Daniel Larimer [17]. This approach utilizes a significantly smaller number of nodes

to maintain network security and add new blocks, thus significantly increasing the speed of execution of new transactions, whose time is often fixed and much smaller than those using PoW or PoS [17]. A small number of participants who ensure the operation of the network is enabled by providing a voting system by the stakeholders. The stakeholder is a special member of the network who has staked coins, an approach that is inherited from PoS. As is the case with PoS, such a member proves its credibility to participate. However, this participation process does not imply directly submitting and validating transactions but participates in the voting process for the node that plays that role. Voters with the largest number of coins have the greatest voting power, and after voting a certain number of so-called witnesses are selected to validate the transactions and write them on the blockchain. After the successful transaction execution and validation, witnesses are rewarded with digital coins that are also distributed proportionally to their voters. The entire process is monitored by specialized nodes called delegates, who, among other things, can propose a change in block size, transaction costs, the amount of money that selected witnesses will be rewarded for participating in transactions, and more. Delegates are also elected by voters. The primary motive of this approach as an improvement of PoS is to reduce the influence of centralized entities that have a significant number of coins in their possession. Also, having in mind that the number of nodes that process and validate transactions is significantly lower, the transaction processing is faster up to several times [17]. However, although the influence of central entities is reduced, the blockchain network itself is more centralized in terms of the number of nodes that have the privilege of performing transactions than is the case with PoW and PoS.

4. COMPARATIVE ANALYSIS

The first analysed parameter is the amount of necessary computational resources, given that network nodes are using their computational power while adding pieces of data to a blockchain, being awarded for doing so with cryptocurrency. Figure 1 shows the analysis of the three used algorithms in terms of hardware load.
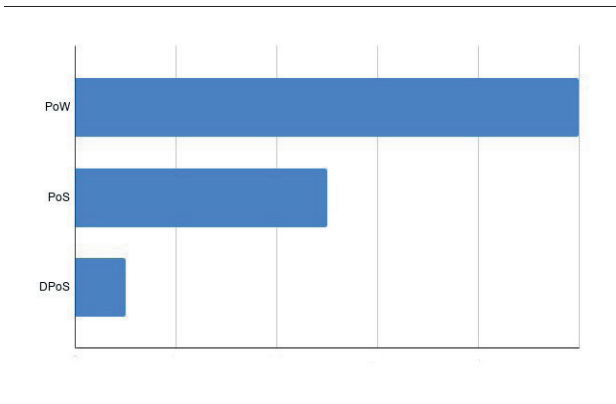
Figure 1 - Hardware load of network participants

PoW uses the most amount of computing power, while DPoS uses the least, which gives DPoS a significant advantage over other algorithms.

One of the key parameters of these algorithms, which directly affects the performance of the network, is the number of nodes participating in the validation process of the credibility of the proposed block. From the point of view of the observed algorithms, only DPoS works with predefined fixed (usually around 20) nodes, while PoS and PoW rely on the entire network [17]. The more nodes are involved in the transaction validation process, the more decentralized the network is considered, and consequently, the more secure it is. In this regard, it is concluded that PoW and PoS promote higher levels of decentralization compared to DPoS.

Number of participants	PoW	PoS	DPoS
Entire network	x	x	
Fixed (20)			x

Table 1 - Number of nodes in the network participating in block validation

In addition to the analysis based on one parameter, very useful indicators are comparative analysis based on multiple parameters.

Decentralization and scalability are often seen as key attributes of a blockchain network. Figure 2 shows the results of this comparison.
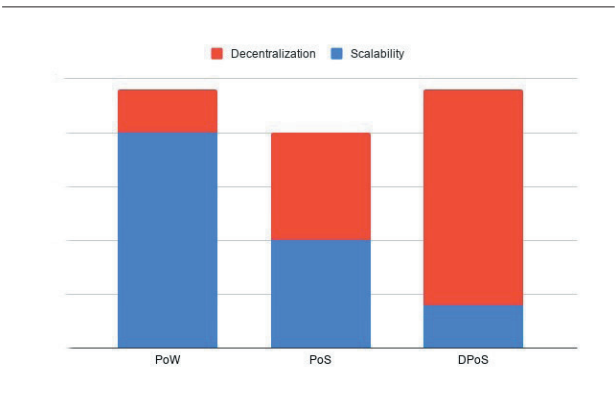
Figure 2 - Attributes of the blockchain network (scalability/decentralization)

The conclusion to be drawn is that networks that are highly scalable are very poorly decentralized except in the case of PoS where this ratio tends to be more neutral. Thus, deciding which algorithm is better directly depends on the need for a centralization / scalability ratio. It's worth noting that private blockchain networks might be a more suitable match for DPoS given that they by definition are less centralized.
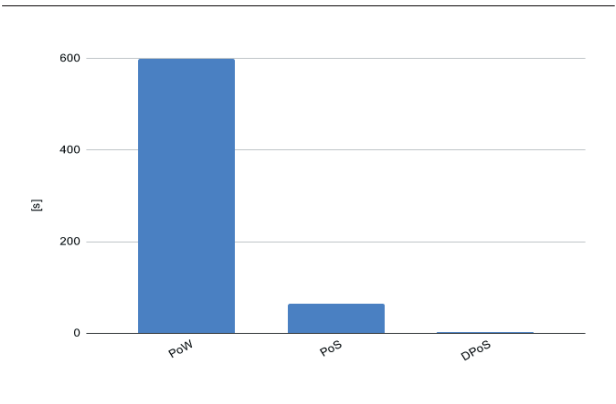
Figure 3 - Block addition time

The key parameter, if the network speed is observed, is the time required to add a block in the blockchain. Figure 3 portrays how this time is the highest for networks that use PoW, being ten times longer than what is necessary for PoS. On the other hand, in PoS this time is twenty times longer than in DPoS [17].

In that sense, from the point of view of the time required to write a block on a blockchain, DPoS gives the best results. Each of the mentioned algorithms comes with its advantages and disadvantages and therefore the selection process of these algorithms should be done carefully, in accordance with the case of use that a specific blockchain is trying to solve.

5. CONCLUSION

This paper presents a comparative analysis of the three most popular consensus algorithms used to prove the data integrity within a blockchain. Thus, for the purposes of this paper, Proof of Work, Proof of Stake and Delegated Proof of Stake were selected. These algorithms were observed and compared with each other from different aspects in order to show the comparative advantages and disadvantages of each other. A number of parameters were analysed and comparative results were presented graphically. The analysis shows that there is a great diversity in the optimization of several criteria by which algorithms can be described. It is concluded that certain algorithms in accordance with their properties are better or worse for specific practical applications. Further work will be focused on the analysis of additional algorithms and modification of existing ones in order to improve their characteristics.

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THE TOOLS AND RESOURCES FOR CLINICAL TEXT PROCESSING

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Abstract:

The expansion of electronic health has produced a large amount of information in medical information systems in a structured and unstructured format. The processing of unstructured data in the form of text is performed using natural language processing techniques. Natural language processing requires specific resources for processing text depending on the domain of the text as well as the language in which it is written. This paper aims to present the available tools, lexical resources, and corpora used in the analysis of clinical texts.

Keywords:

natural language processing, clinical texts, lexical resources.

INTRODUCTION

Most countries today use e-health and keep large amounts of data about patients and their illnesses that are usually used to manage individual cases as well as administration. Data stored in medical information systems can be structured and unstructured. Unstructured data contain free text such as anamnesis, radiological reports, patient care notes, and other similar clinical texts. This data carries information that is important not only for resolving an individual case of the disease but also for extracting general information. Health care is one of the top priorities of every state. We are witnessing that diseases have no borders and language barriers and that the fast and efficient availability of data can save people's lives. Most developed countries are seriously processing information from clinical texts to improve health, but most of the research is for the English-speaking world. Creating standards for storing medical data in a multilingual system could contribute to the faster development of medicine. If there was a single platform through which COVID-19 patients would be monitored, it would be possible to get information

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about places of potential hotspots of infection [1], clinical characteristics and prognostic factors using natural language processing methods [2]. The ability to process reports of patients treated in countries where English is not an official language allows for global aggregation of data, which is extremely important especially for rare diseases [3]. This paper provides an overview of available resources for processing clinical texts in different natural languages. The paper is organized into six sections. The second section presents a description of the basic concepts on which the work is based. The third section shows the processing of the clinical text. An overview of the corpora used for different languages is given in the fourth section. The fifth section contains tools for medical classification and annotation of clinical texts. The last section contains the conclusion and directions for further research.

2. THE BASIC CONCEPTS

Introduce the basic concepts of clinical text processing that are the main points of consideration in this paper: clinical text, electronic medical reports, natural text processing, clinical text processing, resources for clinical text processing, and medical classification.

Clinical texts are written by doctors, medical staff, and other health care providers. They are used to document the patient's condition and the health services provided. They describe patients, their pathologies, their personal, social, and medical history. Clinical texts differ from scientific texts and are not prepared for publication. They do not use complete sentences, they use medically accepted expressions and abbreviations that do not belong to the natural language in which they were written.

Electronic health records (EHR) carry a lot of important information such as the patient's condition on admission to the hospital, the course of his recovery, then the state of health at discharge. This information is still most easily expressed in natural language, which makes information extraction more difficult [4]. Specific medical terminology is defined by different standards and classification systems. Classification and descriptions of diseases, treatments, and drugs control the vocabulary used in medical reports and administration reduce ambiguity and increase the degree of clarity.

Natural language processing (NLP) is a field of linguistics, computing, and artificial intelligence that explores ways in which computers can understand and use text or speech in natural language and apply them to some useful activities [5].

Clinical text mining is the extraction of information from clinical texts [6].

Resources for processing clinical text are all data sets that help in research, and they can be: sets of diagnoses, symptoms, drugs as well as clinical corpora.

Medical classification and terminology are classification systems and terms used in reports, administration, classification and description of diseases, treatments, and medications such as ICD coding diagnosis, SNOMED CT, MeSH, UMLS, ATC, and others [6].

3. THE CLINICAL TEXT PROCESSING

Clinical texts represent the basic form of communication between healthcare professionals. Using natural language processing methods, it is possible to extract information from these texts that are hidden in free text and which are not easily usable for computer analyzes. Most of the authors are engaged in the analysis of data from clinical texts written in English due to their public availability as well as the public availability of clinical text processing tools for English. Two approaches are used to process natural language in clinical texts: a rule-based approach; and machine learning algorithms. The first approach requires the existence of specialized clinical dictionaries that support complex clinical logic such as the MTERMS tool [7].

The second approach based on machine learning requires a set of manually annotated clinical data. An overview of the use of machine learning over clinical texts until 2020 is given in [8], where the results of 110 research available on PubMed from the period from 2015 to 2018, which concern the machine processing of clinical texts in English, are presented. Examining the properties of the data used, it was concluded that most of the research used hundreds or thousands of documents.

There is a small number with a very small data set of less than 50 and a very large of 10,000 documents (ten papers). Many of the data, although available, remained unused. The main reason for unused data is that they are not marked. If the data annotation is done manually then it is a hard job and prone to errors. Active learning algorithms enable the processing of documents even with a smaller number of manually annotated data, whereby new annotations use more algorithms and compare their results. Existing structured data are often used for annotation, so the textual part of the medical report can be labeled using the diagnosis code [9].

Semi-automated annotation can also be used. Often the data being processed comes from one institution, so the relevance of that data is questionable. Very often the results published on one data set did not give the same results on another set [10]. The clinical application of such data processing is wide from diagnostics, prognosis, protection, risk prediction, improvement of service provision, management, etc.

4. AVAILABLE CLINICAL CORPUS

It is very difficult to reach the clinical corpus due to the sensitivity of the data it contains. Each clinical corpus must have ethical approval for use. The data must pass the deidentification process to preserve patient privacy by taking into account names and identification numbers, telephone numbers, and addresses. There are several corpora available for both English and other languages.

For English, more data sets are annotated and consist of discharge lists, medical histories, nursing reports, radiological reports, sentences from the medical domain, and other medical reports. Some of them are available:

- Informatics for Integrating Biology & the Bedside (i2b2) [11]
- Computational Medicine Center (CMC) corpus [12]
- ShARe/CLEF eHealth [13]
- Multiparameter Intelligent Monitoring in Intensive Care (MIMIC) [14]
- BioScope Corpus [15].

There are clinical corpora in non-English languages, but they are smaller and cover fewer different medical contents. The number of publications in the field of natural text processing in different languages in PubMed is shown in the graph (Figure 1).
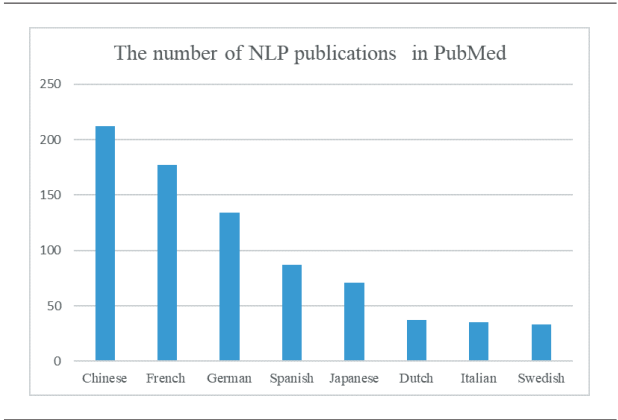
Figure 1 - PubMed's publication for query: "natural language processing and (French| German| Chinese| Spanish| Japanese| Dutch| Italian| Swedish) ".

Non-English corpora are commonly from the researcher's institutions and require special permits and contacts for their further use. These corpora contain labels for: diagnoses, symptoms, medications, and therapies. Some of the corpora of clinical texts in non-English languages used in the scientific papers are presented in Table 1.

Language	Description	No. of texts	Ref.
Spanish	discharge reports	142 154	[16]
Bulgarian	clinical texts	100 000 000	[17]
Bulgarian	outpatient records (diabetic)	500 000	[18]
Serbian	medical records (B05)	5000	[19]
Serbian	medical reports	4212	[20]
Serbian	medical documents	200	[21]
Swedish	Stockholm EPR Corpus	2 000 000	[22]
Danish	clinical narrative text	61000	[23]
Dutch	EMC Dutch clinical corpus	-	[24]
Finnish	intensive care nursing narratives	2800	[25]
French	clinical texts	170 000	[26]
Italian	clinical texts	23 695	[27]
Italian	clinical texts	100	[28]
German	clinical texts	18 000	[29]
German	leukemia laboratory results	12 743	[30]
German	nephrology records	6 817	[31]
German	discharge reports	118	[31]
Chinese	medical documents	1100	[32]

Table 1 - Non-English corpora

The lack of appropriate lexical resources can be solved by applying unsupervised methods [33].

5. TOOLS FOR MEDICAL CLASSIFICATION AND ANNOTATION OF CLINICAL TEXTS

Medical terminology and classification systems are used in healthcare to facilitate interoperability among institutions and to collaborate, medical professionals, scientists, and other stakeholders. There is a justified need to integrate the various medical terminology and classification.

International Statistical Classification of Diseases and Related Health Problems (ICD) has been used since the 18th century with constant revisions and additions. It is used in over 150 countries and is available in more than 40 languages and it is under the jurisdiction of World Health Organization [34]. Classification of diseases is a system of categories that are assigned to certain diseases according to defined criteria. The International Classification of Diseases is a standard tool used in epidemiology, health management, the analysis of population health, and monitoring health problems.

SNOMED CT [35] is a structured clinical vocabulary used in any electronic health record (EHR). It is the most comprehensive and accurate clinical health terminology product in the world.

It provides that data can be shared between health and social care institutions and service providers. SNOMED CT is available in American English, English, Argentine Spanish, Danish and Swedish. Translations into French, Dutch, Lithuanian, and several others. SNOMED CT is clinical hierarchical terminology that contains medical terms and their relationships as well as synonyms, including over 320,000 terms (Figure 2, Figure 3).
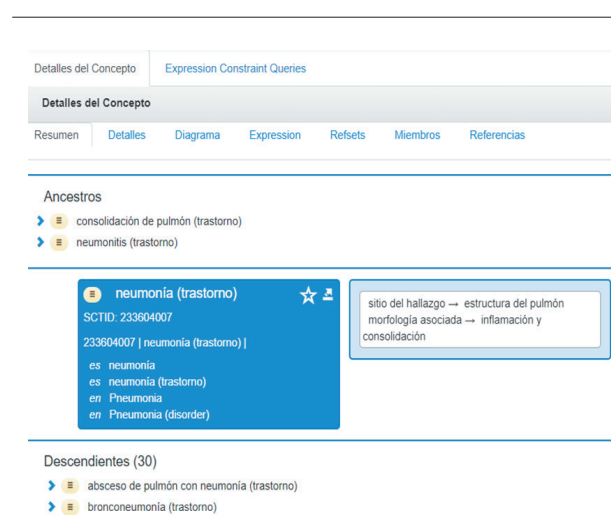
Figure 2 - SNOMED CT Spanish edition 2020
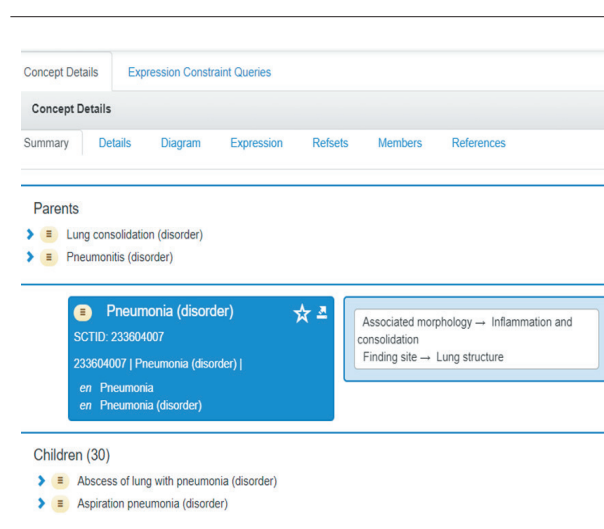
Figure 3 - SNOMED CT United States edition 2020

UMLS (Unified Medical Language Systems) [36] integrates and distributes key terminology, classification and coding standards, and associated resources to promote the creation of more effective and interoperable biomedical information systems and services, including electronic health records.. UMLS supports mapping between different terminologies. UMLS contains several million concepts derived from hundreds of bio (medical) dictionaries, such as ICD, SNOMED, OMIM, MeSH, GO, as well as medical abbreviations (Figure 4). It consists of three parts:

1. Metathesaurus - very large, multi-purpose, and multi-lingual vocabulary database that contains information about biomedical and health-related concepts
2. Semantic Networks - categorization and connections between all resources in metathesaurus
3. Specialized Lexicons - lexicons for biomedical and general English.
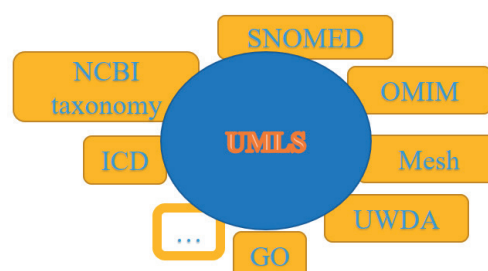
Figure 4 – UMLS concepts

Metathesaurus contains 215 different lexicons for 25 languages, of which the most are resources for English (144), followed by German, Spanish and French (Figure 5). There is interest in constantly updating these resources for different languages.
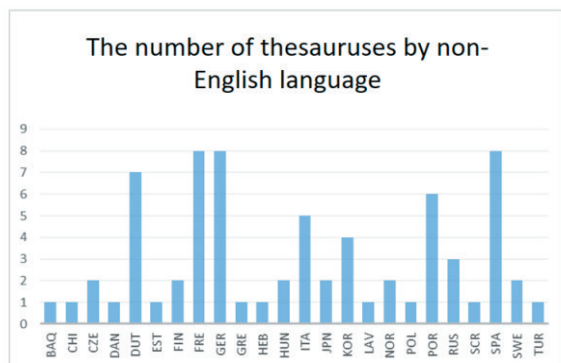
Figure 5 – The number of thesauruses by different languages

The most commonly used UMLS products are metathesauri, followed by MetaMap [37] which is used to map concepts from metathesaurus in the text. The creation of reference corpora is crucial in the process of developing appropriate methods for solving the problems of machine translation, deidentification, drug interaction, etc. [38] [39].

The three most popular information retrieval tools are MetaMap [40], cTAKES [41] and CLAMP [42]. The common feature of these tools is to perform mapping named entity based on UMLS. MetaMap is a tool for extracting biomedical information. cTAKES is a natural language processing system for extracting data from clinical free text from electronic medical records using machine-based rules. It contains all the basic functions of NLP processing for the English language, such as tokenizer, POS tagger, named entity recognizer, negation detection, machine learning functionality, etc. The latest NLP tool for clinical text CLAMP has greater flexibility in the development of custom schemes with the possibility of their application for information retrieval. CLAMP is a Java tool, it has built-in natural language processing modules for English text. By comparing these tools in [43], it was shown that CLAMP has the best performance in terms of F1 results, and higher accuracy, and slightly lower recall compared to cTAKES and MetaMap.

Figure 6 shows an example of the application of the CLAMP tool on the example of an EHR medical report in English:

"Blood tests revealed a raised BNP. An ECG showed evidence of left-ventricular hypertrophy and echocardiography revealed grossly impaired ventricular function (ejection fraction 35%). A chest X-ray demonstrated bilateral pleural effusions, with evidence of upper lobe diversion."
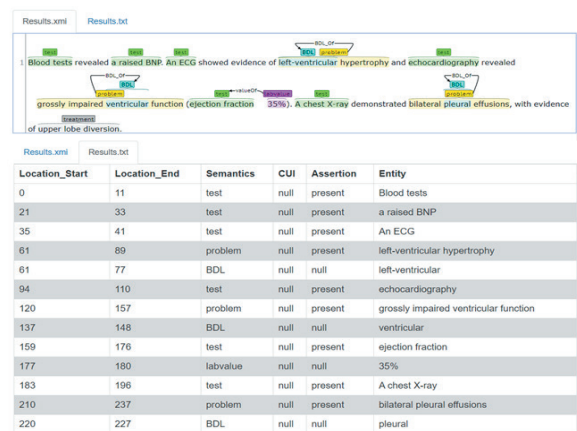
Figure 6 - CLAMP tool application example

Figure 6 shows the .xml and .txt result of mapping different medical entities in the text such as: tests, symptoms, different laboratory analyzes, and more.

6. CONCLUSION

By analyzing the existing resources for processing clinical texts in different natural languages, it can be concluded that most resources and tools are made for the English language. Great efforts are being made to create tools for other natural languages as well. The specific tools for processing the appropriate natural language are needed to be able to process clinical texts, as well as lexicons of medical terminology in the appropriate language. Some of our future goals are to create appropriate resources for the Serbian language.

7. ACKNOWLEDGEMENTS

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INFORMATION SECUITY AND ADVANCED ENGINEEING SYSTEMS SESSION

MICRORAPTOR GUI - A LIGHTWEIGHT REMOTE RENDERING PROCESS MONITORING SOFTWARE

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Abstract:

The rendering of a large number of images is a demanding task, usually delegated to remote rendering farms. This necessitates the creation of software for the management of these remote rendering tasks. Several commercial and non-commercial solutions can be used for this task. However, they are not specialized for rendering, and thus require either additional configuration and expansion, or familiarity with the remote rendering machines and the manual setup of rendering tasks. In this paper we present a solution to alleviate this issue. The solution consists of two components: Microraptor GUI and Microraptor client. Microraptor GUI is a lightweight web-based task monitoring and manipulation panel. Its backend is implemented in Python using the Flask framework and the frontend is implemented using the Angular framework. Microraptor client is a Blender plugin that allows for the direct access to rendering processes.

Keywords:

Remote rendering, Remote control software, Distributed rendering.

INTRODUCTION

Rendering a large number of images can be a computation-heavy task, especially in the case of photorealistic, high-resolution images. Thus, these tasks are usually performed on dedicated hardware or clusters of dedicated hardware, often called render farms. Such hardware is usually placed in rooms specially designed to house it, protected from moisture and with efficient cooling systems as it is often required to operate under high load for long periods of time. This makes the hardware inaccessible to its end users without specialized software tools for remote access. The most utilized solution for this is the use of a Secure Shell (SSH) client. As these clients often provide only a command line interface, they require the users to be sufficiently proficient and familiar with terminal syntax and commands available on the system they are accessing. The command line interface also limits the use cases for such applications, as they do not provide means to visually inspect rendered images or track the rendering progress and hardware load without the use of specially written scripts that output that information to the console.

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Another solution is the utilization of screen sharing and remote control software. This includes commercial solutions such as TeamViewer [1] or AnyDesk [2], as well as open-source software such as Apache Guacamole [3] and Remmina [4]. These tools function by streaming the screen of a host machine to a client, as well as sending commands from the client to the host.

This allows users to access the desktop of a remote machine and manipulate it through a GUI as they would a local machine. Although easier to an end user, this process is more resource demanding than plain SSH access. These tools are meant as a general-purpose remote access solution, mostly for technical support. As such, they are not specialized for the monitoring and control of rendering tasks. Web-based tools for remote system administration such as cPanel [5] and Webmin [6] provide a more specialized environment with tools for remote system configuration. These solutions provide tools to track system load, start, end and monitor processes, access and manipulate the host file system through a web client. As these tools are often operating system agnostic, the end user does not need to be familiar with the remote machine's system, only with the tool they are using. However, these solutions do not provide native tools specialized for the manipulation of rendering processes.

In this paper, we present Microraptor GUI, a distributed remote rendering process monitoring software with a web-based GUI. In the second chapter, we provide an overview of related work. In III, the software architecture is presented. The fourth chapter contains a discussion of implementation details. In V, we demonstrate our solution using a simple use case scenario. Finally, in VI, we conclude with an overview of the implemented solution, and a discussion of possible future improvements.

2. RELATED WORK

In [7], the authors present a solution for a grid-based rendering farm based on Condor, an open-source high throughput computing software framework. A configuration file, containing rendering parameters is passed to the Condor software via a command line interface. The authors note that a major drawback of this approach is the difficulty of manually writing the configuration files and deploying them to the grid. In a follow-up paper [8], the authors attempt to solve that issue by implementing a GUI for the generation of the aforementioned script files.

The created interface also allows for the tracking of currently running jobs. Checkpoints for individual jobs are not supported. Hence, if a job fails during rendering, the entire job must be restarted. Due to this deficiency, the authors suggest the creation of smaller individual jobs.

In [9], the authors present a collaborative animation rendering system in order to speed up the rendering of digital animated videos created by undergraduate art students. However, the system provided only a command line interface for the remote control and monitoring of tasks.

As such, it required its users to be familiar with cluster computing and Linux terminal commands, which presented a barrier for most students. In order to increase the usability of the rendering system, the authors expanded upon their work in [10] by creating a simpler GUI in the form of a web portal. The portal supports user registration and authentication. Users can upload Blender files which contain the 3D animations to be rendered and submit rendering jobs. An overview of previously submitted and currently running jobs, as well as a preview of rendered videos are also provided. The interface lacks advanced output settings, allowing only for the generation of a single video from a Blender file. This is due to the GUI being designed for a narrow use case.

3. SOFTWARE ARCHITECTURE

Our proposed solution is a distributed rendering system. A central node is utilized as an access point for end users, which can be used to assign new tasks and monitor running tasks. Tasks are distributed to Microraptor clients which are installed on individual rendering nodes. Each rendering node executes a single rendering task and returns metadata associated with the task, and the URLs of the render output files. The metadata contains the rendering node's hardware load, which includes CPU, GPU and RAM load, global rendering parameters, as well as the progress of the currently running rendering task. Figure 1 shows the data flow and main components of the Microraptor GUI rendering system.
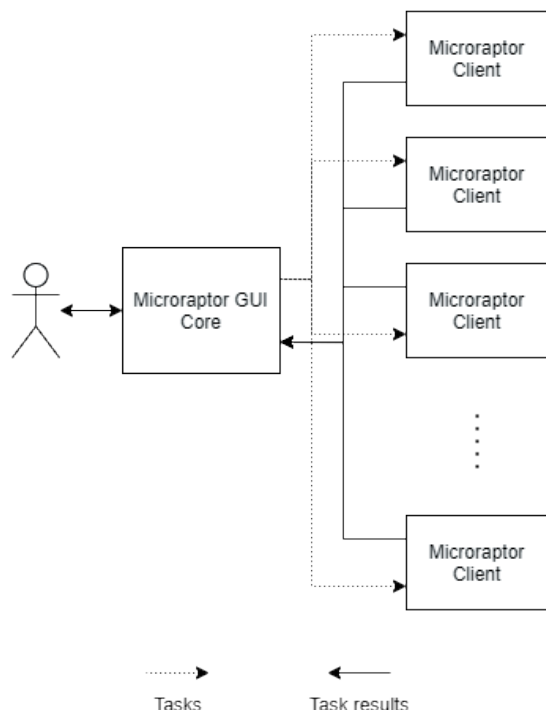
Figure 1 - Architecture overview

Figure 2 shows the class diagram of our proposed solution. Each user can create an arbitrary number of tasks, by assigning them a title, start and end frames if the rendering task in question is an animation, and a priority, the value of which will determine the task's position in an execution queue. For each rendering output of a task, a task result is generated that contains the URL of the output file, the date of task termination, as well as a status message. Additionally, each task result may contain an arbitrary number of TaskResultMetadata objects. These objects contain key-value pairs, allowing for a flexible definition of a task result's metadata.
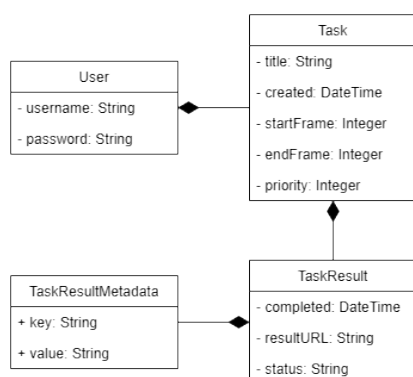
Figure 2 - Class diagram of the Microraptor GUI application

A sequence diagram illustrating a typical use case is shown in Fig 3. A logged in user creates a task by accessing Microraptor GUI. The user is then notified about the successful creation of the task. Once the user commences task execution, the task is deployed to a Microraptor client for rendering. Upon deployment of the task, the Microraptor client confirms the task deployment to the Microraptor GUI, which then informs the user that the task was successfully deployed. While the task is being executed, task results are sent from the Microraptor client to Microraptor GUI and accumulated there. The user can request a status update of the task being executed, upon which all the accumulated task results are returned to the user by the Microraptor GUI.
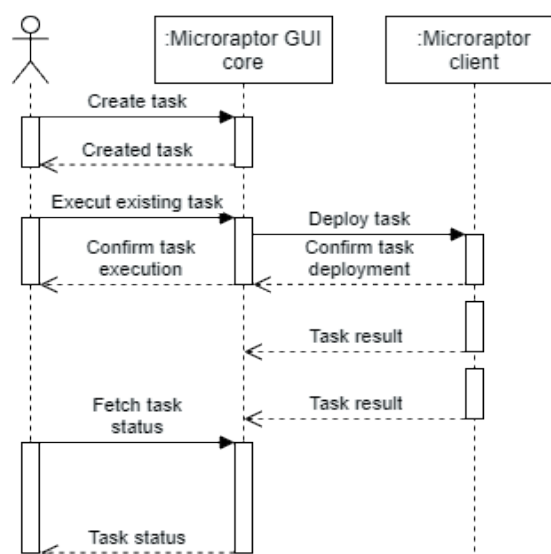
Figure 3 - Sequence diagram of a typical usecase

4. IMPLEMENTATION DETAILS

The backend of Microraptor GUI is implemented as a web application in the Python programming language, using Flask, a lightweight WSGI framework [11]. The frontend of the application is implemented using the Angular framework [12] and the Angular Material UI component library [13]. Apache CouchDB [14] is used to store the task results received from the clients.

The Microraptor client is implemented in Python as a Blender plugin. This approach allowed us to directly access the rendering process and extract data such as the current frame being rendered, estimated render time and render result. The Python os and psutil libraries were used to extract system information such as CPU, RAM and GPU load.

The communication between the Microraptor GUI and the Microraptor client is realized by using the ZeroMQ [15] library.

Figure 4 shows the task overview panel of the Microraptor GUI. It contains a form for adding a new task, and a table displaying previously added tasks. For each task, the user can view its current status, request additional details, deploy it, terminate current deployment or restart a completed task.

Figure 6 is the preview of an individual frame. It contains the start and end time, and duration of the rendering process, as well as metadata associated with the frame, and an image preview.

Figure 6 - Frame details panel
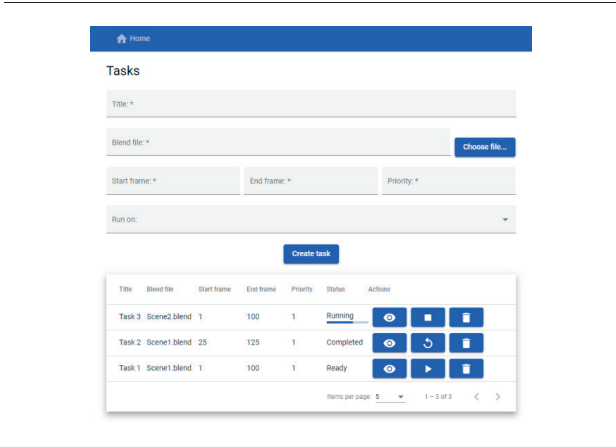
Figure 4 - Tasks overview panel

Figure 5 shows the task details overview for a single task. On this page, the user is presented with the name of the current scene being rendered, the name of the node it is rendered on, current rendering progress and average rendering time per frame. This page also contains information about the hardware load of the node. Each rendered frame is displayed in a table and can be viewed independently.

5. CONCLUSION

In this paper we showed a solution for monitoring and controlling a remote rendering process using a lightweight distributed web-based software. The software consists of two distinct components: Microraptor GUI, an end user access point for the software, and Microraptor client, a Blender plugin that enables direct access to the rendering process. The solution allows for the management of rendering tasks using a GUI, thus eliminating the need for familiarity with the rendering node's system and command line tools. The proposed solution can be expanded upon in order to facilitate the deployment of tasks other than the rendering of a scene. Another direction for improvement would be to update task results on the Microraptor GUI immediately upon a change on the client, without the end user needing to explicitly request updates.

Figure 5 - Task details panel

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INFORMATION SECUITY AND ADVANCED ENGINEEING SYSTEMS SESSION

AUDIO SIGNAL PREPARATION PROCESS FOR DEEP LEARNING APPLICATION USING PYTHON

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Abstract:

This paper was created as a part of the project "Development of software to improve communication, academic and social skills of children with disabilities [1]. "

Artificial Intelligence today represents a wide area of different computer algorithms and systems with one main goal – to mimic and eventually replace human thinking and logic.

One of the most important parts of the mentioned software in development is correct and meaningful collection and preparation of relevant data. Deep learning model structure, model training and results heavily depend on thoughtful identification and processing of relevant data.

As a part of a wider project, this paper is representing a short overview of sound record digitalization and recommended steps required in data preparation for use in artificial intelligence applications.

Keywords:

Audio Signals and Processing, Deep Learning, Python.

INTRODUCTION

Artificial intelligence (AI) is the future happening today. Already a part of our lives, in last several years, AI literally exploded worldwide. Significant increase of computer processing power and especially power of graphical processing units that were made available to AI algorithms, applications of these systems increased exponentially.

Artificial Intelligence is a broad definition of computer machines and algorithms trying to mimic and perform human thinking and behaviour. At first, it was applied to development of systems that would simulate intellectual processes as characteristics of humans, like reasoning. Today, we find countless of uses and applications in everyday life, like in web search, internet portal recommendations, chat bots, smart home appliances (vacuum robots, heating, cooling systems, air filters, …), shape recognition systems (cars without drivers, drones, airplanes, …), medical diagnostics, vaccine creation, agricultural applications, solving mathematical problems, autonomous playing of computer games, sound recognition, sound generation, …

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Machine Learning is a part of Artificial Intelligence that is based on statistical models and techniques that are helping machines in decision making. Most often, designer of machine learning systems is deciding which inputs and outputs are going to be used in the models created.

As a separate part of Machine Learning, Deep Learning is often using extremely large datasets and algorithms that can decide on inputs and outputs with no human help. Deep Learning systems are relying only on the model created and "experience" gained thru training large dataset models. One of main characteristics that is differing them from simpler Machine Learning systems is the use of multi-layered neuron networks.
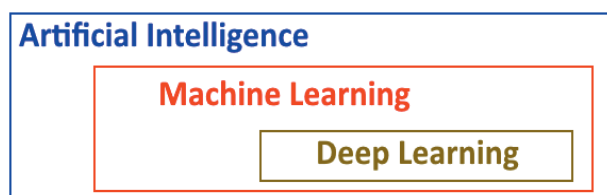
Figure 1 – Artificial Intelligence and fundamental concepts

Using traditional Machine Learning, we would select multiple sound characteristics we prepared in advance and use them as a base to manually create, use, and test the machine learning model algorithm. In this case, results are strongly depending on many human-related decisions. In case of using machine learning systems, developer is selecting sound features to be used by himself.
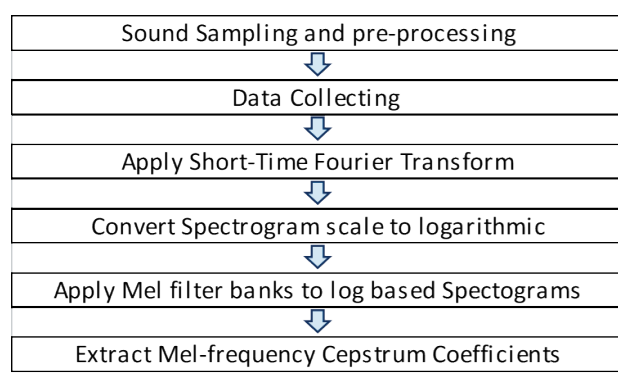
Figure 2 – Audio Signal Preparation Process

Deep Learning (DL) requires large datasets as a base to be able to produce good results. Having large database with data provided to the system, DL algorithms are providing the opportunity to developers not to extract certain coefficients from the sound themselves, but to use complex data as direct inputs. In case of working with sounds, this can be a raw unstructured audio signal, calculated spectrogram, or any other form of sound data record. Deep Learning algorithms can extract relevant audio features automatically, with no additional help or assistance from a human.

2. SOUND SAMPLING AND DATA COLLECTING

Sound is a mechanical signal, accumulation of waves, transmitted via air molecules that are oscillating. As a result of change in air pressure, sound is caused by a vibration of an object. By its nature and type, sound is analogue physical signal.

As computers are working with digital data exclusively - before any action is performed with a sound, we need to convert that analogue signal into a digital one. To use this type of data in any of artificial intelligence systems, we need to have it ready in digital form.

Audio signal waveform is a computerized visual graph, representing a sound. It contains all the details, characteristics, and specifics of a sound. With this type of record, we can reproduce and generate the original sound anytime (Figure 6).

To be able to work with any signal using a computer, we must digitize it and prepare it for computer processing. After digitalization is completed, with use of algorithms and mathematical methods we can extract all required characteristics and specifics for further signal processing.

2.1. SOUND SAMPLING

Digitalization process, depending on sampling quality and rate, can provide larger or smaller datasets.

Analogue sound signals are continuous in frequency and in time. Depending on digitalization (sampling) process, certain quantity of data describing the signal will be lost. Level of loosing signal data is directly proportional to digitalized quality of the signal.

Inside analogue signal, between two values, we have countless number of values describing it. After we convert it to digital form, we are creating a list of finite number of elements.
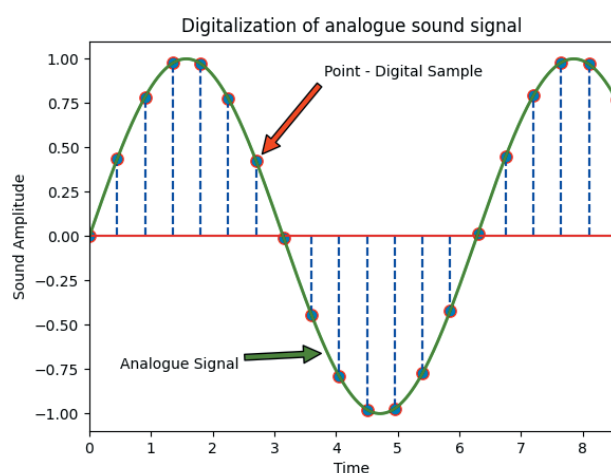
Figure 3 – Sampling: conversion from analogue to digital.

One of the most important tasks for a developer is to use a proper method of sampling generating quantity of information that would be sufficient for meaningful further mathematical processing.

Digitalization is based on defining fixed time periods for signal sampling, but also on defining fixed steps in frequency for quantization of signals. Number of computer bits used for defining quantization levels are called "resolution" or often "bit depth".

After we convert analogue signals to a digital form, we can save them permanently on a computer storage device. Keeping this data safe sometimes can become a problem in case we did not consider the size of it. This is one of especially important facts we need to consider when we decide to start sampling sound records. We can decide keeping the data without any loss or compressing it to save some space.

Based on the approximate dataset size, we should always take into consideration required storage space before we start creating a database. Calculations are based on several important factors:

```
S – Required digital space for preserving sound
data.
P – Sampling period (Standard CD quality
frequency rate is 44.100 Hz).
B – Number of quantization levels in bits
(for 16 levels, we are required to use 4
bits).
T – Time recording period in seconds.

Example:

S = P x B x T
S = 44.100 Hz x 4 bits x 60 s
S = 10.584.000 bit = 1.26 MB
```

Equation 1 – Required space based on sampling details.

Quantization of analogue signal is also resulting with a data loss, that needs to be considered during sampling process. Depending on future data use and its application, it needs to be decided on the number of sampling frequency levels, meaning, quality of the future digital signal.
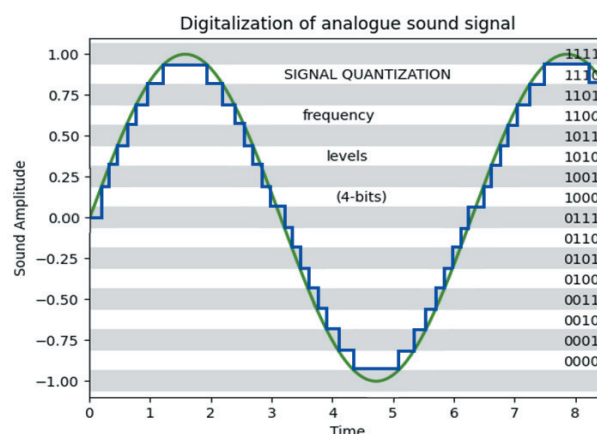
Figure 4 – Quantization resolution in this example is 4.

In the figure 4, we showed quantization with 16 different frequency levels, which means that future frequency values will be only one of pre-defined ones – defined by 4 digital bits. Like in figure 3, where the same rule applies for time segment of the sound sample.

2.2. DATA COLLECTING

Digitized sounds on computers can be presented visually as waveform graphs. Basically, sounds are made of multiple simple and complex sound characteristics, that are describing it. Some of the most common parameters, describing sounds, used in sound processing are frequency, period, amplitude, phase, pitch, cents, intensity, timbre, loudness, …

Some additional, most often used, relevant more complex sound features we can use for sound data processing are amplitude envelope, zero crossing rate, root-mean-square energy, …

One of the crucial decisions to be made by a machine learning model developer is related to data collection. Using Deep Learning algorithms, we need to provide largest database possible. The more data we have, we will be able to create a better and more suitable model for a future system. As Machine Learning depends heavily on data, without data, it is impossible for the "AI" system to "learn".

In most cases, we are not building separate databases, but rather finding sources and pointing our algorithms to them [2].
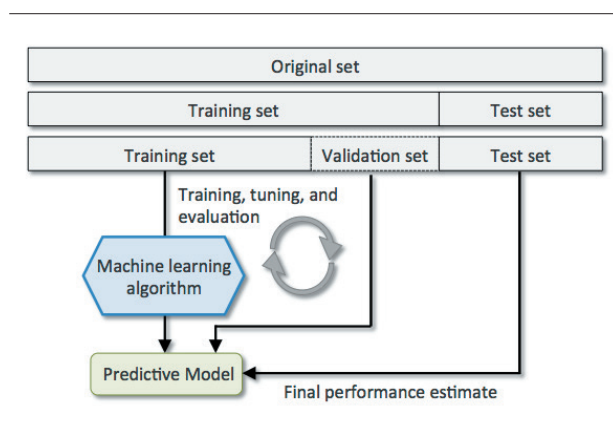
Figure 5 – Dataset use in Machine Learning.

Most crucial aspect of AI is dataset as it makes algorithm training possible. After creation of ML model, we train it, validate it and finally, test the set we created.

3. EXTRACTING AUDIO FEATURES FROM SOUND FOR MACHINE LEARNING

Following digitalization of analogue audio signal, best step to go forward with it is to extract most important characteristics from the sound and prepare them for further processing.

Basic characteristics defining audio signals - like tempo, frequency, noise, intensity etc. we extract using specific mathematical methods. Many characteristics of sound waves are defining them and making them unique. Today, there are many tools available to developers, starting from programming languages like C or Python, all the way to commercial packages for building Machine Learning based systems.

Tools used in developing software in the project "Development of software to improve communication, academic and social skills of children with disabilities. [1]" are based on programming language „Python" and available modules like „Librosa" [3].

In majority of cases, AI manipulation with sound data is happening using systems and algorithms for comparing photos. Sound data with its characteristics is being translated into coefficient-based diagrams, and after that, processed using ML models.

Like in other applications, using artificial intelligence systems (machine learning or deep learning) on sound signals can replace humans almost completely. In many applications, computers are working with this kind of data far more efficient than people.

Using AI systems with sound can enable automatic song classification, speech recognition, diagnostics and analysing words and sentences (in education, medical applications, or rehabilitation), song identification, instruments recognition, emotional analysis based on speech, …

3.1. DISCRETE FOURIER TRANSFORM

Before we apply any sound processing algorithm, it is required for the sound wave to be pre-processed. This means that the sound was trimmed, normalized and noise was filtered out as much as it was possible.
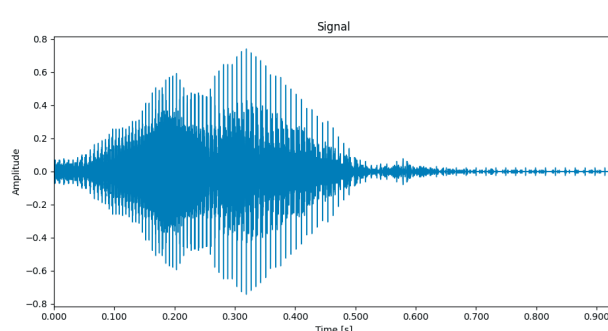
Figure 6 – Sound Waveform

By Fourier, every audio signal is made from several single frequency sound waves. On figure 5, we can see a characteristic sound waveform [4], where on x-axis we have time, and on y-axis is amplitude of the signal (Hz).

Discrete Fourier Transform (DFT) is a mathematical formula that, when applied, is moving a soundwave from the time domain into the frequency domain [4]. Fourier proved that every sound signal can be decomposed into simple sine and cosine waves that when added up and then again creating the original signal.
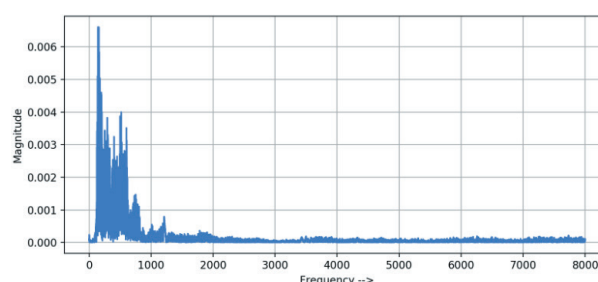
Figure 7 – Fourier Transformation applied to a waveform.

Fast Fourier transform (FFT) is an algorithm that is computing Fourier transform fast and efficiently. As many other features, for ease of use, it is incorporated into Librosa and many other Python modules.

After we apply this transformation to a sound wave, we call the result "spectrum" (as in figure 6). This spectrum is representing frequency representations in the signal, but it does not represent them in time.

3.2. SHORT-TIME FOURIER TRANSFORM

To add a time component to that diagram, we need to apply Short-Time Fourier Transform algorithm onto data. This algorithm is taking segments of the signal, computes FFT on overlapping windowed segments and creates a separate spectrogram for every processed segment. These segments are being joined into one large dataset. Result of this operation is a matrix of data that represents complex future spectrogram data with time component included.

Having Short-Time Fourier Transform (STFT) data in place, having both time and frequency data in it, we can visually present them in a human-acceptable manner in a form of a "Spectrogram".

Having Python as a programming language of choice, for our project, we were using one of the best existing libraries for sound management and manipulation - "Librosa" [3]. Using that library, we can easily create spectrograms, extract relevant audio data, and get other important sound characteristics.

3.3. SPECTROGRAM

Matrix of data created by applying Fast Fourier Transform formula on windowed parts of sound signal is a base for creating a visual representation named "spectrogram [5]".

Spectrograms are visually representing sound in linear frequency Hertz scale in time. This representation is mathematically correct, but it is not corresponding to human perception of sound. Humans can hear sounds between 20 Hz and 20.000 Hz, but if we compare human perception of difference between frequencies in lower and higher range – it is not the same.

Same difference in frequency (Hz) in lower range humans will not be able to compare to the same frequency difference in the higher range. We tend to be better at detecting sound differences in lower frequencies than higher.

As an example, we can easily detect a difference between 3.000 Hz and 4.000 Hz but will hardly tell the difference between 13.000 Hz and 14.000 Hz.
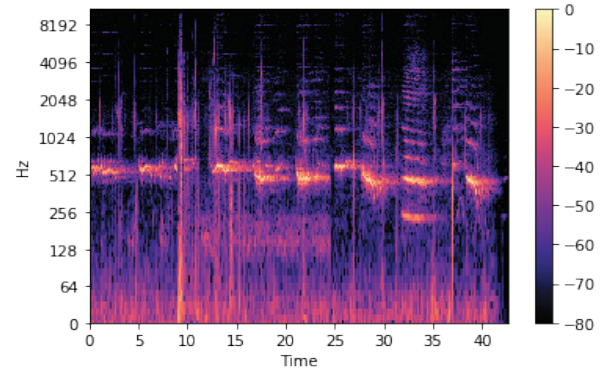
Figure 8 – Spectrogram

Spectrograms are graphically showing frequency representations of the sound taking in consideration time. They are significantly better than a simple Fourier transform algorithm applied to a data record. Anyhow, the downside of it is their frequency scale that is shown in Hertz.

Converting amplitudes from Hz values into dB values by applying logarithmic (log) function to data, we get a human perception like diagram.

3.4. MEL-SPECTROGRAMS

People perceive sound frequency logarithmically. Therefore, visual representation of spectrograms is more human readable if we apply logarithmic scale to it and present it in a different way.

Perceptual scale of pitches (judged by listeners) to have them equally distanced from one another is called Mel scale. Proposed by Stevens, Volkmann and Newmann in 1937, mathematical operation on frequencies is converting frequency in Hz to pitch in "Mels" and getting logarithmic scale as a result.

Optionally, applying Mel filter banks, we can additionally filter sound source and accommodate it for further mathematical use. Converting regular sound power spectrum into Mel Scale is fundamentally important in Machine Learning as it is mimicking human perception of sound.

A popular formula for converting f [Hertz] into m [Mels] is:

$$f_{Mel} = 2595 \log_{10} (1 + f / 700)$$

Spectrogram with amplitudes converted to dB (decibels) are a good base for creating mel-spectrograms. We do it by applying "mel" filter banks [6].
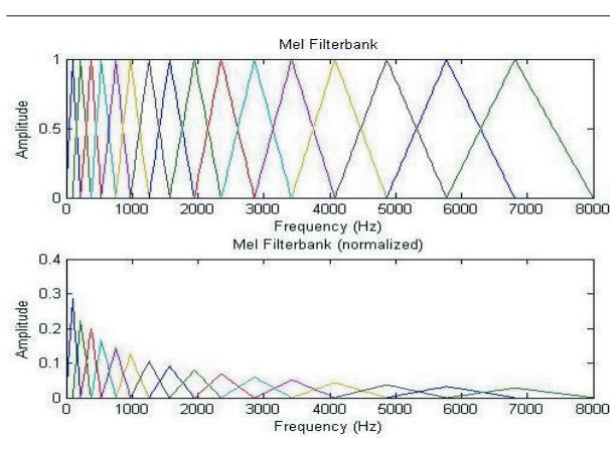
Figure 9 – Mel filter bank

Applying these filters, result is a sound representation that is mimicking human perception of sound. As the graph looks almost the same, frequencies on the y-axis are converted into mel-scale and on the x-axis, we keep the time.

3.5. MFCCS

Representation of the short-term power spectrum of sound, in linear cosine transform of a log power spectrum on a nonlinear mel-scale of frequency is called mel-frequency Cepstrum (MFC).

MFCC stands for Mel-frequency Cepstrum and Coefficients. Cepstrum is representing the information of rate of change in spectral bands.
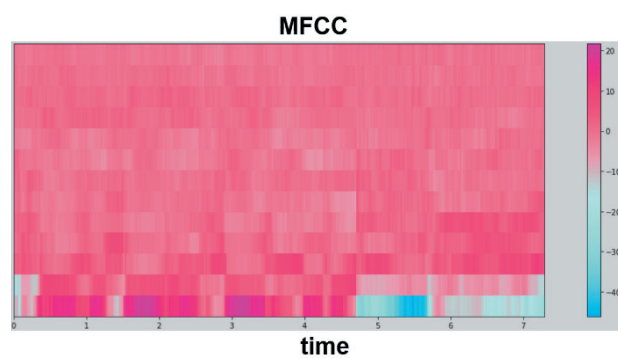
Figure 10 – MFC Coefficients

Discrete Cosine Transform (Fast Fourier Transform) is significantly simpler than Fourier Transform, providing non-complex (real value) numbers as coefficients. As for Deep Learning applications complex numbers are not acceptable, and Discrete Cosine Transform is providing acceptable results, we use it for further operations.

Mel-Frequency Cepstral Coefficients (MFCCs in short) are coefficients that collectively build up an "Mel-frequency Cepstrum" (MFC). They represent and contain sound characteristics that are very suitable for further machine or deep learning processing.

Out of total 39 MFC coefficients, mostly used are the first 12-13 coefficients as they contain and keep most information about the sound. After selecting MFCCs we are going to use in our application, we can also visualize them in coefficient/time graph.

3.6. ALTERNATIVES TO MFCCS

There are many MFCC advantages and some disadvantages. Using MFCCs we can describe large parts of spectrum, we can ignore fine spectral structures that could have negative influence on our data, and they are proved to be excellent working with music (genre classification, automatic tagging, recognition, …), and speech (speech recognition, person recognition, gender recognition, etc).

MFCCs are not good with synthesis of sound, they are overly sensitive to noise and overly complicated to use.

Apart from mostly used Mel-frequency cepstral coefficients, some of the most used algorithms for extraction of sound characteristics and analysis are:

- Linear Prediction Coefficients (LPC),
- Linear Prediction Cepstral Coefficients (LPCC),
- Line Spectral Frequencies (LSF),
- Discrete Wavelet Transform (DWT),
- Perceptual Linear Prediction (PLP), …

Depending on data source and application, artificial intelligence model designer should select most suitable algorithm model for extracting sound characteristics. Most often this is based only on experience and knowledge on the sound in AI.

4. CONCLUSION

Artificial intelligence as a scientific area is finding its way into all parts of our lives. Every day it is altering the world and we are finding new and better ways to use it in society, economy, governance, engineering, education, agriculture, etc.

As one of the most influential innovations in human history, we should all take the opportunity and find a way to apply it in our lives and generate benefits for all.

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INFORMATION SECUILY AND ADVANCED ENGINEEING SYSTEMS SESSION

COMPARISON OF THE EFFICIENCY OF AES IMPLEMENTATIONS ON MAJOR WEB PLATFORMS

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Abstract:

In this paper, the authors present an experimental study covering the evaluation of the average encryption and decryption times using different programming languages for the Web. This study covers the use of the most commonly used AES implementations for four major Web programming and scripting languages: Java, Node.js, PHP and Python. The aim of the study is to determine the cost of encrypting and decrypting data on these platforms, expressed as type per byte of data. The experiment covers data encryption and decryption with the AES algorithm in the CBC mode with 128-bit, 192-bit and 256-bit keys. In this paper, we present the results and pros and cons of use of the AES algorithm implementations on these major Web platforms.

Keywords:

AES, Web platforms, Experimental Study.

INTRODUCTION

Data encryption has become essential for companies to prevent classified information from leaking out. It means that all employee personal information, usernames, passwords, and contacts stored in databases should not be exposed. For example, the more prominent company is, the more critical data set has to be stored. That means that companies should not write plain text (open text form) in a database, especially passwords, because if the information system gets exposed, there is a possibility that the database is exposed as well. The third side can access classified information, and they can harm employees and the company. That is why encryption plays a big part in every information system. Some companies are hiring other companies from the field of Cyber-security to manage their classified data. Others are forming their teams. However, this will not be a topic in this paper.

Today we have many different techniques for data encryption. In this paper we will encrypt data that will simulate the most common file sizes (word and excel, for example). The algorithm that will be used is AES (Advanced Encryption Standard). Data will be encrypted and decrypted with mostly used programming languages like Java, PHP, Python, JavaScript, etc.

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Average encryption and decryption time will be calculated separately for every programming language in attention to compare performances.

Advanced Encryption Standard (AES) is a symmetric cryptographic algorithm using three different key sizes 128, 196, and 256 bits. When it was first introduced, the algorithm had more than three key sizes, but they were not accepted as standard. All data for encryption in the AES algorithm is processed in bytes, which means that all initial data, including the encryption key, is calculated in bytes.

The initial block size is 128 bits and all mathematical operations are performed with two-dimensional byte arrays. The number of rounds of execution of the AES algorithm depends on the length of the key.

The AES algorithm takes two inputs:

- The plain text, which needs to be encrypted;
- The key.

The key is usually accompanied by the initialisation vector, commonly abbreviated as IV in implementations of the AES algorithm in most programming languages.

The algorithm starts with the "Key Expansion," in which round keys are derived from the original key. After the expansion, an initial round occurs, in which the original key is applied to the plaintext. Depending on the key length, the algorithm will go through 9, 11, or 13 rounds. Each round performs four operations:

- Bytes substitution;
- Row shift;
- Mix columns; and
- Add Round Key.

Once these rounds are completed, one last round is performed, which has no "Mix columns" step.

After the encryption, AES outputs the cipher-text.

2. WEB PROGRAMMING LANGUAGES

Companies need to secure data now and then, and the best way is to use a secure algorithm with the most efficient programming language. Nowadays, people use encrypted data in everyday life. Social network sites, electronic newspapers, media web-sites, etc are using different algorithms, approaches, and methodologies to secure used data.

There are many programming languages that can be used on the Web. However, this research will focus on the ones most commonly used for Web application development [1, 2, 3, 4, 5].

2.1. JAVA

The Java programming language is a general-purpose, concurrent, class-based, object-oriented language. It is designed to be simple enough that many programmers can achieve fluency in the language. The Java programming language is related to C and C++ but is organized somewhat differently, with several aspects of C and C++ omitted, and a few ideas from other languages included. It is intended to be a production language, not a research language [2].

In our research, we use the Crypto Java library [7].

2.2. PHP

PHP *(recursive acronym for PHP: Hypertext Preprocessor)* is a widely-used open source general-purpose scripting language that is especially suited for web development and can be embedded into HTML. What distinguishes PHP from something like client-side JavaScript is that the code is executed on the server, generating HTML sent to the client. The client would receive the results of running that script, but would not know the underlying code. You can even configure your web server to process all your HTML files with PHP, and then there's no way that users can tell what you have up your sleeve [8]. We used the latest PHP version 8.

In our research, we use the OPENSSL Cipher PHP extension [9], which supports the AES algorithm in CBC mode with key sizes 128, 192 and 256 bits [10].

2.3. JAVASCRIPT (USING THE NODE.JS PLATFORM)

Node.js is a server-side platform useful for building highly scalable and fast applications. Node.js is a platform built on v8, the JavaScript runtime that powers the Chrome browser designed by Google. Node.js is designed to be great for intensive I/O applications utilizing the non-blocking event-driven architecture.

While Node.js can synchronously serve functions, it most commonly performs operations asynchronously. That means that when an application is developing, events with a call-back registered for handling the return of the function is called. While awaiting the return, our application's next event or function can be queued for execution. Once the first function completes, its call-back event is executed and handled by the function call that invoked the call-back. Node.js is a platform built on Chrome's JavaScript runtime for quickly building fast,

scalable network applications. Node.js uses an event-driven, non-blocking I/O model that makes it lightweight and efficient, perfect for data-intensive real-time applications that run across distributed devices [4].

In our research, we use the Crypto library [12].

2.4. PYTHON

Python is an interpreter, interactive, object-oriented language. It incorporates modules, exceptions, dynamic typing, very high-level dynamic data types, and classes. It supports multiple programming paradigms beyond object-oriented programming, such as procedural and functional programming. Python combines remarkable power with very clear syntax. It has interfaces to many system calls and libraries and various window systems and is extensible in C or C++. It is also usable as an extension language for applications that need a programmable interface [5].

In our research, we use PyCryptodome [14].

3. RESEARCH METHODS

For this research, we have used an experiment method to generate research data. A simple encryption and decryption program was written that automates the generation of the research data. The generated data was analyzed using quantitative analysis methods and the analysis outputs were presented in the results and discussion section of this paper.

The experiment covered in this paper aims to help identify the most efficient Web programming language and its most commonly used implementation of functions, methods of libraries for the use of the AES algorithm for encrypting data. The AES keys used in the experiment were 128-bit, 192-bit, and 256-bits in size. The AES was configured in the CRC mode.

To ensure equal conditions, the data for encryption was generated ahead of the experiment and stored in files and read before use for encryption. When measuring the time for encryption and decryption, only the time it takes to perform the encryption and decryption is measured in the highest precision possible in that platform.

Most platforms support microsecond precision, while Java supports nanosecond precision. To ensure that the results are of the same resolution, the microsecond precision was used for all platforms. There were a total of 30 randomly generated files, whose sizes ranged from 145 bytes to 8MB.

To ensure high precision, the process of encrypting and decrypting this data was repeated 100 times for each combination of data size and AES key size.

After the completion of this process, average times for both actions have been calculated.

The experiment does not cover the following topics:

- Generating cryptographic keys;
- Sharing cryptographic keys;
- Saving cryptographic keys.

The experiment was performed on the same hardware and software. The computer used to run this automated process used a 64bit Windows operating system, a total of 4GB of RAM and an Intel i5 3300 @ 3.0GHz 3.1GHz processor.

During the execution of the research data generation process, all non-essential processes were turned off and the system was disconnected from the Network. All high-load software was turned off for the duration of the experiment.

Table 1 shows the list of programming languages covered by this research, as well as theirs versions.

```
keys := Map(
  128 => read contents from 128.key,
  192 => read contents from 192.key,
  256 => read contents from 256.key
)
FOR len IN List(128, 192, 256) DO
  FOR file IN List( *.data files ) DO
    data := read contents from file
    key  := keys(len)
    encTime := 0
    decTime := 0
    FOR i := 1 TO 100 DO
      start := time_μs()
      encrypted = AES_enc(size, len, data)
      encTime := encTime + time_μs() - start
      start := time_μs()
      AES_dec(size, len, encrypted)
      decTime := decTime + time_μs() - start
    END
    store_results(file, len, encTime, decTime)
  END
END
```

Listing 1 - The data generation algorithm

4. RESULTS AND DISCUSSION

After running the previously mentioned programs that generate the research data containing the information about the size of the encrypted data, determined from the file, the key size, identified by the length of the key, in bytes as well as total encryption and decryption times, we can create a set of raw data records for further analysis.

Considering that the collected times of completion of data encryption and decryption are based on a total of 100 iterations, we have calculated the average encryption and decryption time per iteration. The increased number of iterations has helped minimize noise which may have occurred due to unexpected events on the operating system.

To further enable direct comparison of these results, these values were divided by the total size of the encrypted data to generate information about the total time per byte, for each combination of key size and programming language and its platform.

Information about the average amount of time in nanoseconds needed to complete encryption and decryption of a single byte of data, grouped by the platform, operation and key size, gained from the analysis of the acquired data is shown in Figure 1.
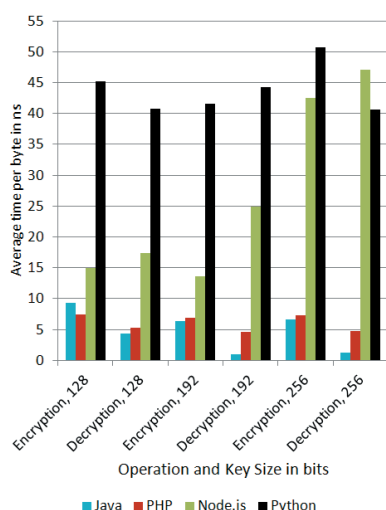
Figure 1 - Experimental results

This figure helps visually conclude that in terms of performance, in most cases Java has shown that it is the best choice for data encryption in terms of average time needed to complete decryption of data, while it was only

slower than PHP when performing encryption using a 128-bit key. PHP was second in terms of speed. PHP was configured in such a way as not to use pre-loading and PHP opcache for caching compiled code between iterations. The Node.js platform was third in the overall rating. However, it did end up slower than Python when performing decryption using a 256-bit key. Python, on the other hand, was by far the slowest of all four platforms. Python also did not utilize any code caching and was interpreted without using the pre-compilation option.

Considering these results of average time (in ns) to complete encryption and decryption, it is clear that at the moment, AES implementations in Java and PHP are, performance-wise, the most efficient and fastest.

Table 2 contains average times (in milliseconds) needed for the completion of encryption and decryption operations on each platform for contents ranging from 145 bytes to 8MB in size.

Data size	Java		PHP		Node.js		Python	
	Encryption	Decryption	Encryption	Decryption	Encryption	Decryption	Encryption	Decryption
145B	0,0013	0,0005	0,0018	0,0017	0,0070	0,0097	0,0400	0,0400
232B	0,0017	0,0005	0,0020	0,0018	0,0070	0,0144	0,0300	0,0600
333B	0,0022	0,0005	0,0426	0,0335	0,0073	0,0118	0,0400	0,0500
459B	0,0027	0,0005	0,0024	0,0026	0,0091	0,0320	0,0400	0,0600
579B	0,0035	0,0006	0,0026	0,0027	0,0091	0,0137	0,0500	0,0400
591B	0,0035	0,0006	0,0025	0,0018	0,0079	0,0116	0,0300	0,0600
659B	0,0041	0,0006	0,0027	0,0019	0,0102	0,0122	0,0300	0,0600
926B	0,0046	0,0007	0,0114	0,0082	0,0099	0,0163	0,0200	0,1000
1KB	0,0056	0,0009	0,0034	0,0022	0,0189	0,0267	0,0200	0,0800
2KB	0,0071	0,0010	0,0035	0,0021	0,0114	0,0177	0,0200	0,0800
28KB	0,1773	0,0198	0,0519	0,0154	0,0809	0,1683	0,3200	0,3299
56KB	0,3295	0,0369	0,1028	0,0300	0,1443	0,2662	0,6599	0,5999
84KB	0,4882	0,0550	0,1547	0,0453	0,2527	0,3828	0,9698	0,8999
112KB	0,6819	0,0742	0,2053	0,0573	0,2439	0,5109	1,2199	1,2098
143KB	0,8419	0,0945	0,2723	0,0748	0,3543	0,6393	1,5498	1,5098
223KB	1,3651	0,1516	0,4106	0,1149	0,6092	1,1449	2,3996	2,3397
285KB	1,7549	0,1898	0,5273	0,1460	0,7792	1,7376	3,2994	2,9898
334KB	2,1195	0,2474	0,6196	0,1695	1,0055	1,9356	3,8194	3,5796
445KB	2,8507	0,3381	0,8234	0,2226	1,2196	2,4182	5,4692	4,7795
557KB	3,6301	0,4341	1,0220	0,2803	1,4020	5,6863	6,9892	6,3091
570KB	3,9280	0,4403	1,0383	0,2833	1,4466	1,7638	6,6889	6,1593
668KB	4,4360	0,4758	1,2305	0,3390	1,7143	2,1266	8,1588	7,1591
779KB	5,6277	0,6444	1,4393	0,3943	2,2629	2,5276	9,8085	8,8790
891KB	5,7979	0,6153	1,6400	0,4470	2,0848	2,5663	11,1185	10,0487
1.1MB	8,4281	0,8539	2,6979	1,1123	2,5725	3,0785	14,2283	13,0181
1MB	6,5069	0,6842	1,9483	0,5476	2,5700	3,1188	12,2284	10,8585
2MB	16,8804	1,8979	5,7596	2,4347	6,3440	6,5832	30,5859	28,0962
1.5MB	9,7235	1,2348	3,7038	1,5790	3,2954	4,3860	19,0072	17,4979
4MB	28,4921	3,7201	9,9686	4,2270	10,5812	13,5297	52,2828	48,2036
8MB	56,8131	17,6285	19,7981	8,5810	20,2340	29,9842	98,9467	91,9176

Table 2 - Average times (in ms) by data size

Based on the experimental data, we can conclude that on almost all platforms, AES decryption in CBC mode, regardless of the key size is faster than encryption. Also, we can conclude that the compiled language Java outperforms other platforms. Of all interpreted languages, Python was least efficient in performing AES encryption and decryption, on average.

5. CONCLUSION

This study covered the most commonly used AES implementations for four major Web programming and scripting languages: Java, Node.js, PHP, and Python. The study aimed to determine the cost of encrypting and decrypting data on these platforms. The experiment has covered data encryption and decryption with the AES algorithm in the CBC mode with 128-bit, 192-bit, and 256-bit keys.

Results of the study show that decryption mode, almost all platforms, regardless of the key size is faster than encryption mode. Experiment shows as well that Java programming language has outperformed other used web-based platforms when it comes up to the speed of data encryption and decryption. We should consider that the version of Java which was used was at let least two years outdated compared to the release dates of other programming languages and platforms, this result. PHP programming language had similar results as Java while a 128-bit key was used, even better when it comes up to encryption. Both platforms performed those processes under 10 ns on the used hardware and software configuration. The performance of Node.js and Python AES implementations was not up to the authors expectations. While using a 128-bit key, Node.js was slower than Java and PHP when performing both the encryption and decryption operations. The Python implementation was the slowest.

We can conclude that Java is a platform which has the most efficient AES implementation. When choosing between interpreted languages, PHP is the second best option for this particular job. Security issues of the mentioned algorithms, as well as their implementation with other libraries were not addressed in this paper.

In our future research we will endeavor to reduce the impact of hardware and software configuration on the performance of these on the AES implementations on these and other platforms. We will aim to expand the list of tested programming languages and platforms and to test different implementations, using other, less-popular libraries and packages for each language. Additionally, we will endeavor to expand the list of tested languages to other platforms, and not only those used for Web application development.

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INFORMATION SECUITY AND ADVANCED ENGINEEING SYSTEMS SESSION

CYBER SECURITY AND PRIVACY PROTECTION DURING CORONAVIRUS PANDEMIC

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Abstract:

The coronavirus pandemic has brought a new reality to people around the world, who are facing uncertainty, fear of disease, sudden change of habits and lifestyles, while physical distance, social isolation, restriction of freedom of movement, mandatory self-isolation and other health measures during the epidemic instructed people to transfer their everyday habbits and professional obligations to cyberspace. The right to privacy is one of the fundamental human rights, which is recognized by the United Nations Declaration of Human Rights, the International Covenant on Civil and Political Rights, and other international and regional treaties. This right includes privacy of personal data or information, the protection of human body, protection of personal living space and the privacy of communications. Data security aims to ensure that any personal information that is collected, used, or stored is protected from unauthorized use. In order to fight Covid-19, the laws on the state of emergency are promulgated in the countries of Central and Southeast Europe, which has led to an increasing number of arbitrary arrests, surveillance, wiretapping and violations of privacy.

Keywords:

coronavirus, cyber security, right to privacy, personal information, privacy protection.

INTRODUCTION

As COVID-19 continued to spread, one of the necessary health measures for combat coronavirus pandemic was to reduce or even completely ban social contacts, in order to make people stay in their homes and to isolate them from other people. The coronavirus pandemic has brought a new reality to people around the world. People are suddenly facing uncertainty, fear of disease, sudden change of habits and lifestyles, which are stressful. [1] This led to the fact that the companies had to allow employees to work from their home, although this resulted in an inadequate level of cyber security, security loopholes, and a mass of deviant behaviours which made businesses vulnerable. Employees using home network and public internet services to access their official resources added a new set of security challenges, since privacy issue remain ignored in the wake of COVID-19.

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The right to privacy is one of the fundamental human rights, promulgated by the United Nations Declaration of Human Rights, the International Covenant on Civil and Political Rights and other international and regional treaties. This right includes privacy of personal data or information (such as people's medical records), the protection of human body (like for drug or other kind of testing), protection of personal home and the privacy of communications (via electronic mail or telephones).

Data security "aims to ensure that any personal information that is collected, used, or stored is protected from unauthorized use." [2] In this paper, we will present some of the most common problems that occurred worldwide as a result of cyber security breaches during the Covid-19 pandemic.

2. ABUSE OF MEDICAL DATA OF INFECTED PERSONS AND THEIR CONTACTS

Healthcare institutions around the world have introduced the practice of sharing medical information in order to coordinate the health strategic response to prevent the spreading and improve the control of coronavirus. These procedures must be in full compliance with national laws which are protecting the privacy of patients and infected persons, as well as protection of their right to the confidentiality of personal medical data and health status.

The World Health Organization declared COVID-19 a global pandemic on March 11, 2020. Governments have taken immediate measures to prevent the spreading of the virus and to protect the population. As countries around the world declared the state of emergency due to the pandemic, emergency rules of conduct transferred the responsibility on the citizens as individuals, since the government has imposed restrictions that often endanger some of their human rights.

The governments of Montenegro and Moldova exposed the medical data of people infected with the COVID-19 virus, while Croatia and Romania suffered from cyber-attack carried out on official websites and hospital computer systems. [3]

With a population of 640,000 inhabitants, the Government of Montenegro has taken drastic measures. Namely, the Government published a list of citizens who, according to the authorities, should have been isolated, since some did not respect the movement restriction order given to them. The government announced that they have received approval for this from the Agen-

cy for Personal Data Protection of Montenegro. After the Government of Montenegro published a list of all citizens in self-isolation, unknown authors created a web application that can locate all persons in self-isolation, as well as their possible movement. [4] From the human rights violations point of view, there are two reasons why this application is dangerous and humiliating: people who are in self-isolation are being practically hunted and stigmatized, but there is also a problem related to providing data and geo-location to unauthorized persons who want to see who is, in their close environment, in self-isolation. It remained unknown who is the owner of this application.

The right to data protection of the patient's health condition was also violated in Moldova, when the President himself on March 9, 2020 publicly named the first woman patient infected with Covid-19, who was in the hospital in Chişinău. This action clearly violated the Moldova law. [5]

Human Rights Watch (HRW) published on March 19, 2020 the document points out that "health data are particularly sensitive and that publishing data online can pose a significant risk, especially for people who are already in a specific situation or on the margins of society." [6] Moreover, "the scale and severity of the COVID-19 pandemic clearly rises to the level of a public health threat that could justify restrictions on certain rights, such as those that result from the imposition of quarantine or isolation limiting freedom of movement" [7] but "at the same time, careful attention to human rights such as non-discrimination and human rights principles such as transparency and respect for human dignity can foster an effective response amidst the turmoil and disruption that inevitably results in times of crisis and limit the harms that can come from the imposition of overly broad measures that do not meet the above criteria." HRW stated in this document that "even during previous health crises in the world, people with infection or disease and their families often faced discrimination and stigma, as was the case, for example, with HIV infection. Since the coronavirus outbreak, news reports from a number of countries have documented bias, racism, xenophobia, and discrimination against people of Asian descent." [8] This kind of data clearly incites discrimination and stigmatization and has been targeted by internet attackers.

Romanian antivirus company Bitdefender [9] has issued a statement that during March 2020, the number of web attacks associated with the Covid-19 increased by 475% compared to the February 2020, and that this

number is expected to continue to grow. It is worrying that almost one third of all attacks related to Covid-19 are targeted government authorities, retail, hospitals and health system institutions, transportation and field of education and research. [10]

3. ILEGALL CONTROL OF INDIVIDUALS' RIGHT TO FREEDOM OF MOVEMENT

State governments use a variety of technology to identify, monitor and to control the spread of the virus.

China and Iran were the first countries that started to use mass surveillance during the crisis, followed by Israel and other countries around the world.

China was the first country that introduced facial recognition and infrared temperature cameras in public transportation infrastructure, in order to immediately identify individuals who have a fever and who are, thus, potential carriers of the infection. [11] At the beginning of the pandemic, South Korea started using the "Corona 100m (Co100)" application, which would signal to mobile phone owners whether there are any people infected with coronavirus within 100 meters, giving everyone information not only about the location of an anonymous person, but also reveal the information about the date of infection of that person, their nationality, sex, age and locations that person visited. [12]

In Italy, immediately after the outbreak of the pandemic, the government began to develop an application that would identify people who were in contact with an infected person, and a similar program began to develop in both Australia and India. [13]

Israeli authorities have authorized domestic country's security agency to monitor mobile devices in order to track people infected with the coronavirus, but also to identify those they have encountered and seeing. [14] The Shin Bet's surveillance technology software has been tracking people and their contacts since March 2020 and through Jan. 20, 2021. This program was used to identify anyone with whom people infected with Covid-19 came into contact, in order to stop the spreading of the virus. At the beginning of March 2021, the Supreme Court of Israel banned this type of monitoring, stating that this is an example of a serious violation of people's civil rights and freedoms. [15]

The Constitution of the Republic of Serbia [16] guarantees the right to protection of personal data as a basic human right even during a state of emergency, while Article 128 of the Law on Electronic Communications [17] stipulates that access to mobile data (including geolocation) is allowed only by court decision.

4. PROTECTION OF EDUCATIONAL INSTITUTIONS AND STUDENTS FROM COVID-19 INTERNET FRAUD

As teaching in education institutions around the world has mostly been shifted to online classes, this pandemic crisis has provided hackers endless opportunities to see all the vulnerabilities of school's online systems, who are obligated helping their staff, students and their parents to avoid phishing attacks by providing them clear guidance how to communicate online: to clearly define all official and legal methods of communication and to be clear about other sources from which teaching materials are downloading and on which these materials are uploading; to explain to the users that IT staff will never ask for their login credentials via email; to provide and implement two-factor or multi-factor authentication whenever possible; to check out whether the email messages have been sent from authorized persons or institutions from secure servers, preventing spam and identifying false of phishing messages; to warn the students that they should not provide a credit card number for accessing the school resources; to avoid sending links via emails; to introduce to the staff and students an email address for forwarding suspected phishing attacks emails. [18]

5. PROTECTION OF EMPLOYERS AND EMPLOYEES WHO WORK FROM HOME

Covid-19 has disrupted working and professional lives in ways that seemed quite unimaginable a few years back. Mass working-from-home patterns have called into question the cybersecurity and technological solutions made in order to control the virus could seriously threaten our human right to privacy if the data involved is not handled responsibly.

Companies around the world have been forced to disrupt traditional workflows and to enable their employees to work from home. Many companies have taken data security risks they may never have agreed to in normal circumstances, which has largely jeopardized the already relative security of computer systems and the functioning mechanisms of large enterprises. Unlike employers, cybercriminals have adapted their own tactics to better exploit these new working patterns.

State authorities and health care institutions have a large amount of data at the moment while trying to develop technological solutions for bringing the virus

under control, such as different contact tracing applications. Every symptom update and restaurant check-in provides more and more information about the health and whereabouts of entire populations. [19]

6. FAKE NEWS WEBSITES AND SPREADING PANIC

Social networks and tabloid magazines have become flooded with fake news and propaganda spreading misinformation. Turkey, Serbia, Hungary and Montenegro imposed large fines, but also arrested citizens for posting on social networks because, according to the authorities, they caused panic and endangered security. [20]

The unit for cybercrime security of the Hungarian police has arrested several people for spreading false news since the beginning of February 2020, when the raid was at first been carried out. The sites that wrote about the coronavirus were closed by the police when they started writing about the presence of the coronavirus in Hungary before the official confirmation, [21] and after that, the police started to monitor the Hungarian online media due to false news related to the coronavirus. After these media reported about the state of the health system in Hungary, a package of pandemic-related laws passed by the Hungarian Parliament on March 30 gave the government power "to rule by decree indefinitely, bypassing normal parliamentary procedures: the act allows prison terms of one to five years for those who "spread falsehoods or distorted facts" that could alarm the public. These measures were temporary." [22]

On March 19, 2020, the Government of the Republika Srpska decided to ban panic and riots (including presenting and transmitting false news in the media and on social networks) during an emergency situation [23]. This decision was repealed on April 14, 2020. [24]

7. HOW HACKERS USE PANIC AND FEAR TO SPREAD COMPUTER VIRUSES

As the corona virus spreads around the world, hackers are using fear and confusion to spread computer viruses in increasingly calculated ways. As the phenomenon began to gain momentum during the pandemic, the BBC began to track some of the email scams reported by cybersecurity organizations.[25]

Hundreds of different criminal actions were noticed with millions of fake emails sent.

"Phishing" campaigns and online identity theft which rely on current news situations are not new, but information security experts say that increase in attacks related to Covid-19 are increased in the past year. Cyber attackers have mainly been active in hacking on individuals and their personal data, as well as to industry, healthcare, insurance companies, hospitals and factories.

It is impossible to determine the true scale of the e-mail epidemic, but some of the most commonly observed are these:

- „**Click here for a cure**"[26] – From February 2020, internet users began to receive various emails with the text that it is possible to receive coronavirus vaccines with one click. The message was sent by a mysterious medical expert, claiming to have exclusive news concerning the vaccine against corona virus, and that these news is provided by the Chinese and British governments. A user who clicks on the link provided in the message would be redirected to a website that looks convincing and credible, but it is actually designed to steal the user's personal information and to retrieve all users' login details, such as account names and passwords. This way, the user who is trying to get informed about the medicine against coronavirus becomes a victim of identity theft, giving hackers access to all documents and other sites to which the user previously logged in using the same email and password. The best way to see where the link will actually take you is to hold the mouse cursor over the given link and a real caption of its URL will appear. If it's suspicious, just don't click on it.

- „**WHO: Covid-19 tax refund**" - Many hacker campaigns falsely present themselves as the World Health Organization (WHO), allegedly offering users useful tips on coronavirus protection. Analysts say that the users who download content do not receive any useful advice, but instead their computer becomes infected with malicious software called Agent Tesla Keylogger.[27] Once installed, this malware records everything that is typed on a computer and sends it to attackers, which is a tactic that can provide access to online banking and financial accounts. In order for users to avoid this scam, it is necessary to avoid emails like this one from the WHO, because they are probably fake, but instead to visit the official website or WHO channels on social networks to get the latest advice.

- **„ We refunded your tax to help protect you from Kovid-19" / Little measure that saves**"[28] –This type of attack happened in the UK, as hackers devised an email sent on behalf of the UK tax authorities with a false promise that citizens who go to the site given in a sent message, entering personal data and their bank account details, will be able to recover taxes due to Kovid-19. This is one of the variations of the classic "phishing" campaign regarding tax refunds used by cybercriminals. The most effective fight against this type of fraud is not to respond to any request sent via e-mail concerning financial transactions, and especially not to enter data on users' bank accounts.

- **„CDC: Donate here to help the fight**"[29]– Represents another fake email allegedly collecting donations to work on the development of a coronavirus vaccine, exclusively in bitcoins. Like the WHO, the Centres for Disease Control and Prevention (CDC) has been used to misrepresent numerous different "phishing" campaigns. The e-mail address itself looks very convincing, just like the design of the e-mail. This example was reported to malware experts Kaspersky. Kaspersky says it has detected more 513 different files with coronavirus in their title, which contain malware.

- **Online Shopping Fraud** [30] – The media has reported that there are new specific scams related to online shopping, "selling" people protective face masks, hand sanitizers and other essential items from questionable and malicious sites, which have never been delivered to the buyers. The advice is to always check whether the online store you are making the purchase from is legitimate.

- **Malicious Newsletters** [31] – Cyber criminals are providing numerous articles about COVID-19 with a link to malitious and fraudolent company website, where victims are encouraged to click on a malicious link to subscribe to their daily newsletter for further updates on COVID-19.

8. CONCLUSION AND RECOMMENDATIONS FOR MAINTAINING CYBERSECURITY DURING THE PANDEMIC

As the whole world struggles globally both to stop the spreading of COVID-19 infection and raising panic for one's own health and the health of others, cyber attackers and hackers are profiting from people's fears and panic. However, it is obvious that we are witnessing major changes in the way that the world today operates –changes have been made "that will most likely have an impact long after this situation is over and we all return to our normal lives". [32]

In just over a year of the pandemic, only some of the problems threatening the cyber security and privacy of each individual in cyberspace have crystallized.

One of the problems was the spread of panic and misinformation at the very beginning of the pandemic. It is necessary to convince citizens that the best way to handle fake news is by warn the users to use only reliable sources of information, not just social media posts and suspicious emails.

Cyberspace has become flooded with fraudulent products. Internet users should purchase only from reliable sellers and companies, only when they are totally sure that the website is legitimate. [33]

At the time of the pandemic, hackers were frequent with phishing attacks, and the number has the tendency in rising even after the pandemic ends. In order to protect users from such attacks, it is necessary that Internet users pay attention when opening emails and to review emails carefully with grammar and spell checking or any other suspicious language signs, as well as to beware when opening links or attachments from unknown sender. Malware, often used in the process of cyber phishing attacks, can be handled with cyber defence tools, such as various antivirus programs.

Special anti-malware measures for preventing data theft must be applied when it comes to working from home, which has become a reality everywhere in the world due to the coronavirus pandemic. If employees use computers and digital technology while working from home, employers should inform workers of all possible hazards, as well as take data security measures into account. Employees need to be provided with data security protection when working from home involves sending confidential data outside the company's premises. The employer will have to make sure that the systems enables secure transmission of such data, by establishing a solid information system with the necessary security measures, but also to advise employees that it is essential to be equipped with appropriate skills which make the employee aware of all potential problems. Employees should be provided with training in order to refresh their knowledge.

In addition to data and internet security, it is necessary to take into account the physical health of workers who work from home during a pandemic. Employees needs to be offered a variety of tasks in order to change body

position frequently so as not to work in the same body position for a long time. The work equipment must be set up to minimize body twisting or excessive stretching, and workers must be encouraged to take regular breaks, and from time to time to have an opportunity to stand up.

Employers who have enabled employees to work from home must pay attention in securing the data, through encryption of channel connecting remote machines to, monitoring of internet traffic and connections as well as to secure protocols to accessing professional assets and data. This is especially important for organizations, which have higher risk profile and have appetite for investing more in security, to adopt the following practices of data classification, data leak prevention, monitoring the user behaviour and even email encryption. The professionals should only store necessary information, to share credentials only with relevant parties, and even implement two-factor authentication. [34]

In addition to all the dangers lurking on the Internet due to cybersecurity violations, it is very important to ensure the privacy of teachers and students in the process of online learning and during organizing online classes. There are several important recommendations that should be adopted when conducting online classes, especially during video-enabled teleconferencing, such as: recommending when and whether to turn on the webcam, to remind teachers not to share teaching materials over an insecure network, to avoid sending emails to parents because this spreads the circle of communication and thus creates possible dangers to cybersecurity, etc. [35]

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INFORMATION SECUITY AND ADVANCED ENGINEEING SYSTEMS SESSION

MODELLED NEURAL NETWORKS FOR MULTIPLE OBJECT TRACKING

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Abstract:

Recent development in artificial intelligence brought deep learning and neural networks that are applied in various areas, e.g. robotics, surveillance, autonomous driving, automation and medicine. Multiple Object Tracking very commonly utilises those architectures and there are many different approaches for this task. Those solutions are based on different kinds of neural network structures and this paper provides comparison of the corresponding algorithms that could improve further research. The paper investigates the performance of the Faster R-CNN, the VITAL and the RetinaNet methods with practical results and examines their different architectures used for object detection. The requirements for models are the detection of objects' position and their classification. For tracking the instances, we use algorithms that are based on object detection systems. For registering the location of items Neural Networks use the IOU (Intersection of Union) in order to determine which bounding boxes should be examined and according to the IOU we distinguish positive and negative proposed bounding boxes. The negative predictions impact the performance and negatively contribute to the wanted signal. The results of the Faster R-CNN method present those challenges. The object classification could become difficult in the event of occlusion. The RetinaNet method provides distinguished detection and classification results that could be applied for the Faster R-CNN and the VITAL computations. There are many evolving implementations for object tracking. The VITAL detector that uses the GAN for the motion prediction was evaluated on the custom set of image sequences, that are used for deep neural network adaptive parameter regulation..

Keywords:

Neural Networks, Object Detection, CNN.

INTRODUCTION

The aim of object tracking is to keep detection of items in video sequences, and to determine their number, location, activity and their characteristics. In the future those features are going to be implemented in desktop computers, smartphones, tablets and digital billboards in order to enable interaction with humans [1].

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Deep neural networks are applied for object detection challenges in object and background classification and various available datasets could be used for the neural network training. Object tracking tasks typically rely on object detection systems that could be divided into two categories: one-stage detectors and two-stage detectors.

Multi-target tracking algorithms that utilise the CNN features are two-stage detectors and are based on Region Proposal. In this approach the CNN (Convolutional Neural Network) calculates the dependences of positional features.

The idea is based on a pyramidal structure in order to first identify the concept of the lowest level before it is being transferred to the next layer for processing on higher levels. This model is inspired by the human vision that determines relevant elements of the whole scene.
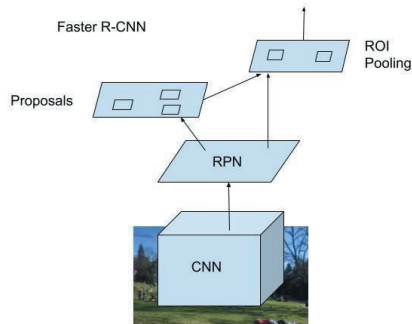
Figure 1 - Faster R-CNN [2]

The Faster R-CNN approach introduces the Region Proposal Network (RPN), that provides better performance than the Fast R-CNN and the R-CNN. Regions with Convolutional Neural Network (R-CNN) method is based on selective searching that proposes regions being classified one at a time with an output label and the bounding box. The Fast R-CNN provides better performance in generating Regions of Interest than the R-CNN.
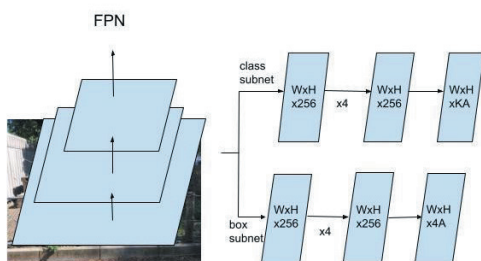
Figure 2 - RetinaNet [3]

Common one stage methods are YOLO and RetinaNet. You Only Look Once (YOLO) divides input images into cells and propagates them once through a neural network to calculate bounding boxes and class probabilities. The RetinaNet architecture is based on the Feature Pyramidal Network (FPN) that extracts features and takes original images on the input and calculates proportionally sized feature maps multiple times.

Generative Adversarial Networks (GANs) are a recent innovation in machine learning that use two different Neural Networks called Generator and Discriminator. The Generator provides data sets that are initially fake and are used for the Discriminator's training that can in this way learn the real data distribution.

The adaptive control is applied by collecting the input and output data in order to adapt the time wise dynamic implementation [4]. As the Discriminator might fail in classifying, the loss is computed based on the Discriminator's output in order to adapt the weights of the Generator's Neural Network. In this evaluation the given parameters of the RetinaNet algorithm were employed as the input values for tracking of motion using the VITAL method.

2. METHODOLOGY

For the purpose of this research frame sequencing of video captures was performed in python in order to provide a set of images for models' evaluation. The RetinaNet model was utilised for object detection that gave accurate results for the bounding box prediction and object classification. The set of sequential images was then used for training the GAN-based VITAL model. The RetinaNet could also provide exceptional results for video-based object tracking.

The VITAL involves Deep Learning used to simultaneously detect features in order to be aware of motion changes. It utilises the Sample Generator to collect data, extract regions and to provide proposed bounding boxes at the output. Reinforcement learning is approach that approximates values for input signals in unpredictable circumstances [5]

In the Faster R-CNN algorithm one image from the custom image set was transferred through the CNN. The object location is presented with a pair of values: (x, y) that correspond to coordinates of pixels in the image [ymin, xmin, ymax, xmax]. The image is then being resized in order to be adapted for features extraction. Feature detection is essential for object detection and it

is used to determine correspondences in order to generate models. The key point features that are examined are specific positions of objects in images. Those features could be matched based on their orientation and local appearance and could indicate object boundaries and occlusion events [6]. The VGG16 pretrained CNN Network processes the adapted image and extracts features with dimensions of 50 x 50 pixels. Around 2000 anchor points are generated on the image. Point features are used to detect the corresponding object locations in different images and that is applied for the category recognition. It is important to determine the key points in order to perform the successful matching in the event of occlusion and motion changes. For each anchor, several anchor boxes are generated. The anchor boxes represent predicted bounding boxes of a certain height and width. They are printed across the image and they are used for multiple object detection. The Intersection of Union (IOU) of bounding boxes is then calculated and if it is higher than 0.7, the object detection should be performed.

$$I_oU = \frac{|P \cap G|}{|P \cup G|} = \frac{|I|}{|U|}$$

Equation 1 – Intersection over Union [7]

In equation 1 P represents the predicted bounding box and G represents the ground truth box.

The Non Max Suppression (NMS) algorithm reduces the number of predicted bounding boxes for the particular object. It computes Regions of Interest (ROI) with positive labels, where the IOU is higher than 0.7. The region proposal algorithm processes input images and predicts where potential objects could be, without knowing if there are objects in that location. Regions of Interest (ROI) with IOU lower than 0.3 are classified as negative labels.

3. RESULTS

Figure 3 represents the accurate detection results using the RetinaNet. However, in object-groups' detections the overlapping of bounding boxes could be significant that makes overview of detected items unclear. The algorithm provides us with the bounding boxes coordinates, the classification and the class probability value.

Figure 3 - RetinaNet detection

The VITAL algorithm applies adversarial learning that tracks motion and generates the corresponding bounding boxes that are used for the adaptation of neural network input features. Figures 4, 5, 6 and 7 represent the results of the VITAL method evaluated on the custom set of images. It computes the bounding box corresponding to the positional changes over time (Figure 6). Figures 4 and 5 display the algorithm values of the applied cost sensitive loss. The locations of frames on image sequences are being calculated with the consideration of the distance from the ground truth locations [8]. As the input data for the VITAL algorithm the resulting bounding boxes of specific objects from the RetinaNet computation were used together with the custom set of sequence images.
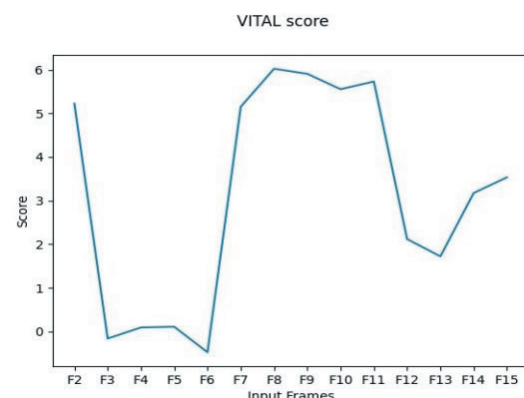
Figure 4 - VITAL score
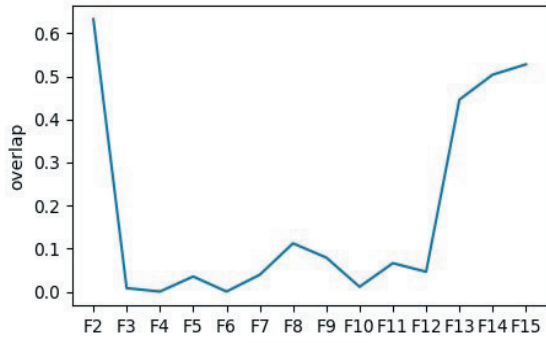
Figure 5 - VITAL overlap
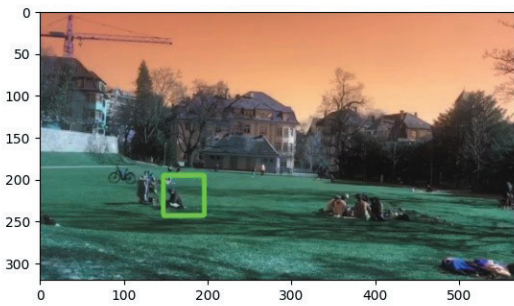
Figure 6 - VITAL estimated bounding box
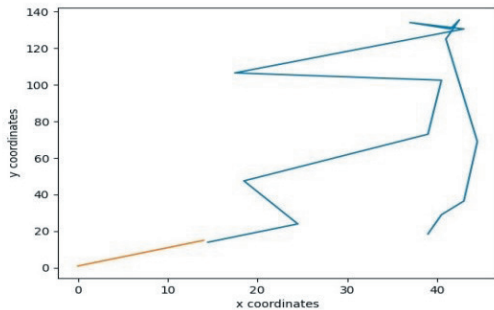
Figure 7 - VITAL tracking trajectory using middle values

In the Faster R-CNN algorithm localized items of interest are specified using bounding boxes. For the Faster R-CNN examination the coordinates extracted from the RetinaNet evaluation were used. One of the difficulties in the Faster R-CNN is that it generates many positive samples that overlap and affect slower performance during the process of recognition. The loss function [2] is calculated by the following equation, where j indicates the anchor, p_j represents the detected class probability, $p_j{}^*$ represents the actual label probability,

t_j represents the predicted object position and $t_j{}^*$ is the real position, N_{CLS}, N_{REG} and Λ are used for the normalization and balancing:

$$L\left(p_j,t_j\right)=\left(\frac{1}{N_{CLS}}\right)*\sum_j L_{CLS}\left(p_j,p_j^{\cdot}\right)+$$

$$\lambda*\left(\frac{1}{N_{REG}}\right)*\sum_j p_j^{\cdot}*L_{REG}\left(t_j,t_j^{\cdot}\right)$$

Equation 2 – Image Loss function [2]

The resulting loss function was L = 0.6940.

In vehicle tracking the data augmentation is necessary for the classifier and the detector training and the Faster R-CNN performs detailed scanning of images in order to predict the bounding boxes for object detection [9].
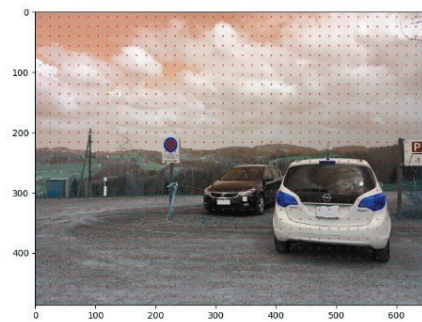
Figure 8 – About 2000 generated anchor points
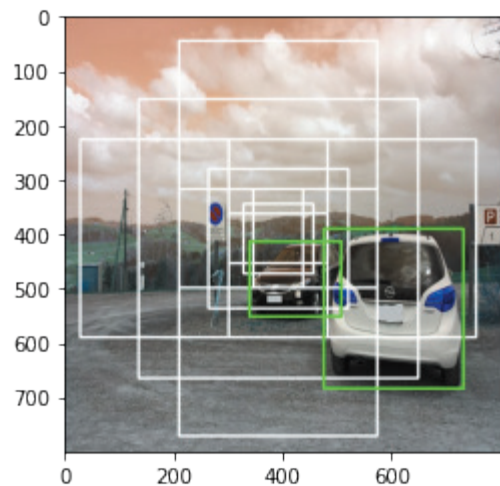
Figure 9 – Generated anchor boxes for one anchor point
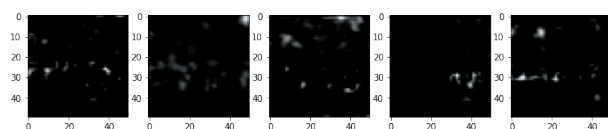
Figure 10 – Extracted features

4. CONCLUSION

Different approaches in object tracking and neural network-based architectures are examined in this paper and the various ideas behind object detection are associated. The reliable outcome of the RetinaNet could be applied for the Faster R-CNN and the VITAL approaches as they require the input data values for the items tracking. For multiple objects tracking the results of these algorithms could be applied for computing data correlation, data association, re-identification, and optimization parameters, that provides a wide field for following improvements.

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OPTIMAL PAYMENT INFRASTRUCTURE FOR THE INTERNET OF THINGS

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Abstract:

The term Internet of Things (IoT) implies the highest level of integration of people with devices and machines that are used in business processes and everyday life. This refers to a network of devices, machines, vehicles and objects, connected by communication networks such as the internet, NFC and RFID, equipped with microprocessors, sensors and appropriate software, which enables data collection, their processing and timely distribution. To utilize the full potential of this concept, a special payment infrastructure needs to be built, and its sole purpose would be to transfer funds in the context of the new information revolution. The subject of the research is the need for the creation of new payment infrastructure for the realization of all advantages of the concept of the IoT. By comparing key performances of the blockchain and tangle as technologies for distributed database management, the goal of the paper is to point to their potential for their application in payments in the ecosystem of the IoT. Based on the comparative analysis of bitcoin and IOTA, i.e. blockchain and tangle technology, that it is necessary to strive for a solution that will not burden the system and that will be a means for achieving security at a high level at the same time.

Keywords:

Internet of Things, cryptocurrencies, blockchain, tangle, bitcoin, IOTA.

INTRODUCTION

The development of information and communications technologies (ICT) in the second half of the 20th century has changed the way of doing business for most industry branches. In addition to the informatization of traditional manufacturing activities, conditions were created to develop new service activities. Computers and computer systems, seen as the highest form of ICT application in business and life, have enabled the collection, processing and distribution of a huge amount of data, which would practically be impossible with manual labor. Communications services and the financial sector have improved at great speed under the influence of technical progress, while the industry of consumer electronics would practically be unimaginable without these achievements. The end of the 20th and the beginning of the 21st century were characterized by

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a race of manufacturers to increase the clock rate of computer processors and graphic cards and bandwidth speed. In the last couple of years, however, the focus has shifted to connecting as many devices as possible and to their interaction when collecting, processing and distributing data. One of the key pillars of the new technological revolution is the Internet of Things (IoT), as the highest level of integration of people with devices and machines in their environment.

To utilize the full potential of this concept, integration of payment solutions is required. The inclusion of value transfer into the concept of the IoT leads to the Internet of Value (IoV), a global network which enables the flow of funds in addition to the flow of information. The problem with the realization of this idea is the fact that there is no adequate payment infrastructure.

The subject of the research is the need for the creation of new payment infrastructure for the realization of all advantages of the concept of the IoT. By comparing key performances of the blockchain and tangle as technologies for distributed database management, the goal of the paper is to point to their potential for application in payments in the IoT ecosystem.

The first part of the paper will explain the significance of the concept of the IoT for the revolution in business processes. The second part will focus on the characteristics of current and potential payment systems and their potential to contribute to the creation of the IoV. In the third part, the core functioning principles of blockchain and tangle technology will be compared, with the objective to identify the key advantages and disadvantages.

2. THE CONCEPT OF THE INTERNET OF THINGS

The creation and evolution of the internet have changed the outlines of the old society in many aspects. Namely, the application of new communications channels in all spheres of human life has considerably changed the character of how society functions and develops, whereas the development of the information-communications component was popularized during the last two decades. The implementation of new solutions has contributed to a noticeable change in conducting numerous activities to make them more efficient, i.e. easier and faster. That is why changes in the information-communications sphere can be seen as key drivers of development not only in the previous, but also in the upcoming period.

Among other things, the new information revolution is based on the concept of the IoT, whose founder is Kevin Ashton. The basic idea was to place an intelligent RFID bar code on a specific company product to know how many products have been sold at any time and when shelves should be restocked. In the early stage, it was noticed that this principle could be applied to numerous areas in everyday life.

The concept of the IoT comprises of all the devices which can be connected to the network and which can collect, send and function with the data they collect from the environment by using built-in sensors, processors and communications hardware [1]. That way, machines can communicate with other connected devices in a process called M2M communication (Machine-to-Machine). Users can adjust these devices, give them instructions or access data, which would represent a communication model called M2P (Machine-to-Person), although their operation is overall independent. This kind of technology enables access to everyday information in addition to other numerous activities, and it offers unprecedented possibilities thanks to the level of development and quality of equipment and components upon which it is based, but also thanks to the users' constant online presence in all spheres of business and life.

Today billions of devices form an integral part of this platform, where they use built-in hardware and software to send and receive messages through various communications protocol. Mobile phones could be used to access the internet, and they could also be connected to another part of hardware which would be located in the house or in the workplace. Based on that, it can be said that one of the end products of the concept of the IoT is the creation of a smart work environment and smart homes in which every device would function automatically to create a more quality and more innovative life for people [2]. In other words, the ultimate goal of the concept of the IoT can be interpreted as the creation of an automated life and work for people and the creation of a smart environment in which it would be easier for individuals to control all situations and in which conditions would be created that would make work and routine operations much faster.
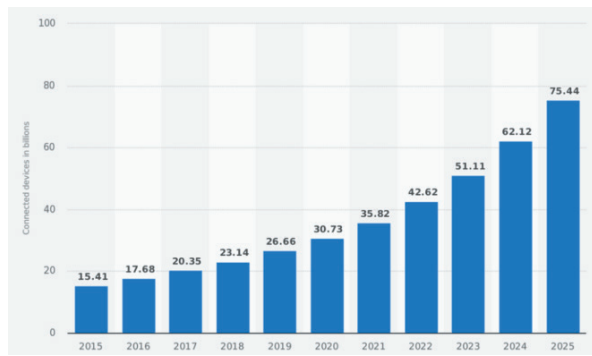
Figure 1: An estimate of how many devices would
be connected by 2025, shown in percentages

Figure 1 shows the concept of the IoT, where the increase in percentages from 2015 to 2021 was 20.41%, while it is estimated that the increase will even reach 75.44% by 2025.

By observing the evolution of the internet, it can be concluded that the concept of the IoT represents the third stage in communication via the internet [3]. In the first stage, the content was not interactive, so the users could clearly be divided into those who created the content and those who used the content. In this stage, the content on the web could be watched, listened to or read, but users could not participate in its creation. The next stage in the development of the internet offered considerably broader opportunities because the boundary between those who created the content and those who used it disappeared, because in this stage anyone could not only create, but also use specific content at the same time. All that is the result of the fact that most web locations also contain a social component which offers the possibility of participation by adding photos, videos, comments and similar content. Finally, it is precisely the concept of the IoT that is developed in the third stage of the development of communication via the internet. In this stage communication does not only exist between individuals, but also between specific devices, which means that things that are inherently passive now also have an active role, since communication can also be realized between them. This is a stage in which things will be transformed into "smart workers" that could exchange information about them and their environment.

3. APPLICATION OF THE EXISTING PAYMENT INFRASTRUCTURE IN THE INTERNET OF THINGS ECOSYSTEM

One might ask what kind of payment architecture would be suitable to the development of the concept of the IoT. In other words, the question is whether and to what extent the existing mechanisms of payment match the key characteristics of the new information revolution, and if not, which models of payment would be most suited to the given concept. Considering the given question, experts agree that the existing payment architecture would not be suitable to the new concept of the IoT for several reasons. First, they believe that payments in cash would not be by the desired level of automation on which the concept of the IoT is based, whereas traditional cashless forms of payment are unsuitable because they are slow and because their transaction costs are high [4]. Additionally, since it is believed that micropayments will play a key role in the new information revolution and smart environment, instruments of payment should accordingly be suitable to make payments of small amounts. Since debit cards are suitable for payments of large amounts due to processing costs, it is believed that these payment mediums would not be suitable to the planned environment.

From today's perspective, POS terminals represent a dominant channel, considering executing cashless transactions, but they would not represent a good solution as a payment channel in the concept of the IoT because they are stationary, i.e., they are tied to a physical location [5]. In that sense, the new information revolution will inevitably cause changes not only in the way the society functions, but also in the way payments are made in terms of channels and instruments. The creation of a special payment infrastructure, intended solely for the transfer of funds in the context of the new information revolution, would lead to the realization of the concept of the IoV. To achieve that, it is necessary to abandon the existing payment mechanisms and to base the future payment architecture on the organizational structure of the internet. In other words, to enable the transition to the concept of the IoV, it is necessary to unify the network of all payment systems, which would imply the integration of national and commercial banks, payment systems and electronic money systems.

According to the previously stated, when designing an optimal payment system for the concept of the IoT, two key prerequisites must be met: to create a digital identity of the device or to perform its integration

through the owner's identity and to make sure that transactions are economical, especially considering micropayments. Since it is to be expected that many devices will be used to make payments in the future, then these transactions should be institutionalized in some way. It is proposed that each device should get its own digital identity so that it would be recognized when executing future transactions. An alternative to this approach would be to create a centralized system with a digital identity, which is based on a unique device to which all other devices would be connected. From the current perspective, these devices are still in the development stage, although certain conceptual solutions already exist, which can be seen in the example of Amazon Echo.

To sum up everything that has been stated, the following question can be asked: could cryptocurrencies be an instrument of payment on which the functioning of a smart society would be based? It is overall undeniable that in the concept of the IoT, only electronic money could contribute to the development of its full potential. Among numerous variants of commercial electronic money, state forms of electronic money could emerge as one of the rational solutions soon. When it comes to cryptocurrencies, from the aspect of their basic characteristics, they would certainly be a suitable solution, having in mind that they are suitable for small payments and that they do not require large transaction costs. However, when it comes to using cryptocurrencies as one of the main payment methods in the smart society era, there is a considerable polarization of opinions. For one, it is pointed out how the chances of the current systems being in wider use are quite slim in future circumstances even though cryptocurrencies have their advantages, and that is mostly because of their high volatility, having in mind that their prices fluctuate considerably in short periods. In the case of bitcoin, a problem might also be seen in poor scalability because in the upcoming period, when everything will be automated to achieve greater speed and efficiency, it would be necessary to secure a satisfactory speed of carrying out transactions as well.

4. A COMPARATIVE ANALYSIS OF FUNCTIONAL CHARACTERISTICS OF BLOCKCHAIN AND TANGLE

The blockchain represents the first operational form of DLT. It is designed to function in an environment in which there is no central institution that can confirm the authenticity of data and in which the participants do not trust each other [6]. Blockchain consists of a series of blocks, in which the previously performed transactions are stored. The content of each subsequent block must be following the state to which the previously installed blocks have led. This means that entity X could not spend the funds in transaction q if it had already spent the funds in a previously accepted transaction p. If this entity X tries to do that, transaction q will be discarded and it can not become part of a new block. The mechanism by which the authenticity of new transactions is verified and by which new transactions are packed into blocks is called a consensus protocol [7].

The block has two parts: a header and a body. In the block header, the ordinal number is entered, then the timestamp, to determine the chronological order of the assembled blocks, then the previous block hash, afterward the Merkle tree root, which means that new transactions must be linked to all that was previously entered and with the hash record of the new block. The block body contains the transactions which the miner wants to confirm [8].

The blockchain is characterized by the division of roles among the participants. Nodes are the participants that have permission to perform transactions, i.e. to appear as payers and recipients of funds. Miners are the participants who pack transactions into blocks, confirm them and add new blocks to the chain. The validation process itself involves reaching consensus among miners and can be more or less compute-intensive [9]. The choice of the consensus-building protocol depends on the type of blockchain system which was used.

Overall, each cryptocurrency has its own blockchain and the largest number of cryptocurrencies (starting from bitcoin onwards) has a public blockchain, which can be accessed by anyone and all the transactions that have taken place in the chain of blocks can be seen.

Moreover, in this system, anyone can be a miner - anyone can perform transactions and participate in the creation of blocks. The mining process itself shall be further elaborated in the subsequent part of this paper. One of the key features of a public blockchain is the fact that the protocol that manages the system is in the form of

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an open-source code, and each of the participants can review it and suggest possible improvements in terms of code completion. On the other hand, numerous cryptocurrencies use private blockchain, which ensued as a result of the fact that some users of blockchain technology did not like the transparency in the public blockchain system along with the fact that this system is available to everyone. Following that, private blockchains have been designed in which the code is not visible to everyone, but only to those entities that have a license issued by the creator or owner of the blockchain. However, private blockchain systems are rarely used for cryptocurrencies and are mostly used for other business applications.

Based on the information mentioned above, key differences between these two forms of blockchain technology can be observed. On the one hand, public blockchains are open and they provide more freedom to participants both in conducting transactions and in the process of decision-making and improvement of protocols. It is precisely this transparency of public blockchains that represents their most significant advantages, primarily when it comes to stronger resistance of blockchains to potential attacks. Hence, it is very difficult to have such many nodes to jeopardize the normal flow of information through the network. Another advantage of public blockchains is reflected in the stability of the database due to the fact that the entire database is located on thousands of computers spread all over the world. Apart from that, a group of miners with a very large cumulative processing power maintain the blockchain network. Even if somebody wanted to perform a change of base, most participants would have to agree with that change, although it is very unlikely that most participants would agree to change something that could jeopardize the integrity and security of the network.

However, apart from all the advantages mentioned above, public blockchains also have certain disadvantages. Thus, the main disadvantage related to the concept of public blockchains is the slow system of managing and deciding, because it is necessary to establish consensus. Another disadvantage of public blockchain technology is reflected in a very limited capacity of blockchains, not only in the number of transactions which can be processed, but in the amount of data which can be stored in the chain of blocks as well. However, the stated facts depend on the protocol which was chosen for establishing consensus, but it is a general problem of all the key systems of crypto currencies.

The consequence of this is the lower efficiency of the network, which can be seen best in the example of the bitcoin network which can process only a few transactions per second.

Comparative analysis of blockchain and tangle raises the question of whether tangle is the technology of the future for storing and verifying the information. The first differences observed are the difference in the structure between blockchain and tangle, both of which continue to build an independent and self-governing network of transactions. Tangle is just one of the operational solutions of the DAG (Directed Acyclic Graph) system. It is based on a mathematical model and on the architecture used to organize, record, store and verify the information [10]. More precisely, tangle represents the system of records of individual transactions which were not collected into blocks and which were not linearly organized, as it is the case with blockchains.
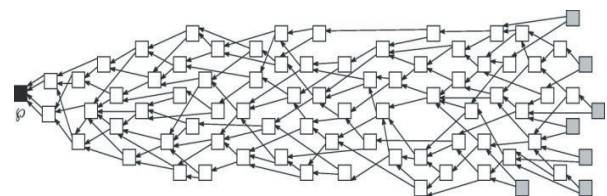
Figure 2: The structure of message validation in the network tangle [11]

Figure 2 shows the message validation structure in the network tangle. From this figure, one can see the validation of messages in the tangle network, which can be with a large and small load. Highlighted areas represent recent transactions. The direction of the arrows shows which other two transactions are confirmed when they occur. With more transactions, the process becomes more complex, which can lead to some transactions waiting longer until they are approved for the first time.

Prior to the execution of transactions via tangle, the previous two transactions have to be verified. At the same time, the word "acyclic" indicates that past transactions can neither verify future transactions nor present ones. The whole system comes down to the fact that the machines can communicate with each other M2M and they all together make one huge network.

On the other hand, one of the basic problems of blocking has been overcome by tangle. Hence, the devices can be connected to the network and perform their functions smoothly, even if M2M transactions are small. Another critical part of most blockchain systems is scalability, as the ledger becomes larger, a delay in functioning occurs - as a cause and effect relationship. Tangle technology is based on a different principle. The more devices are connected, the more the network develops, and thus creates a good basis for building an overall self-linking microeconomy, where machines can cooperate with each other and contribute to the acceleration of flow.

When it comes to cryptocurrencies, in addition to the investment aspect, one should also take into consideration their role in the future innovative and automated society, indicating that they could be an adequate payment instrument in the post-information revolution. A real example of this is the IOTA, for which many experts point out that it is designed for the concept of the IoT.

To be useful as a payment network, IOTA must provide a method by which the transaction will be considered securely validated, that is, when the transaction is accepted for public consensus. There are two approaches to creating consensus in the loop, and these are the currently implemented coordinator approach and the distributed approach. A coordinator is an entity that controls IOTA, where a zero-value transaction is entered every two minutes, by the values called a milestone. By using a coordinator, the definition of consensus is simple; consensus represents each transaction to which the confirmed milestone refers, while the others have not been confirmed. A consensus is defined by the coordinator and this consensus represents each transaction that already has a verified milestone. Also by using a milestone, this digital currency is safe against attacks, as it validates transactions that have been done in the last two minutes.

IOTA also has a transaction of origin, which is directly or indirectly confirmed by all other transactions [12]. If there is no direct confirmation path of the transaction between them, and if there are at least two paths in relation to the other transactions that connect them to the transactions, then those two transactions are indirectly confirmed. What is characteristic of IOTA cryptocurrency is that unlike Bitcoin and most other cryptocurrencies it is not based on blockchain technology but on tangle technology which means that transaction costs are insignificant [13]. Having in mind the information given above, as well as features which set IOTA apart from other digital currencies (no transaction costs,

no scalability problems), it can certainly be expected that this cryptocurrency will be far more significant in the future.

As it can be observed, tangle and blockchain have a lot in common. These are two technologies which are based on cryptography, with different systems of functioning. In the case of blockchains, each previous record with information on all executed transactions that are distributed among the special users who maintain the system (miners) in the chain of blocks must be verified for each subsequent record.

Each node in the blockchain must have a valid updated version of the public ledger. The updating of each public ledger leads to a burden, and thus causes a slowdown, as stated in the previous paragraph. So, it is concluded that the size of the block is limited, as well as the number of blocks that can be "built" during each hour. As the ledger becomes heavier, the task of mining becomes more and more complicated, the system becomes slower, and the mining process itself becomes more expensive. All of the above leads us to ask the question of whether new cryptocurrencies tend to overcome existing problems.

The approach used in tangle is based on the general ledger being distributed among all users, not just among miners, which actually means that each network participant must perform the function of a miner. With transactions performed via tangle, the system becomes more powerful, which means that each new record in the book contains the same amount of information as the previous one. The verification process itself is reduced to just two transactions, without the need to maintain the entire network.

Based on previously facts, it can be concluded that:

- Tangle has better power throughput and is more scalable, and over time it becomes faster and more powerful. However, the situation with bitcoin is different; the general ledger becomes more loaded with information, which leads to a slowdown and lower productivity.
- Tangle transactions do not produce high transaction costs as is the case with most blockchain-based cryptocurrencies.
- On the other hand, bitcoin, as a representative example of a cryptocurrency based on blockchain, shows that it is more secure and more resistant to hacking ventures than IOTA thanks to a complex verification algorithm.

5. CONCLUSION

The overall conclusion is that blockchain systems are expensive as the technical infrastructure for the payment system of the future. Such a conclusion may seem contradictory at first glance, since almost all cryptocurrencies are based on them. Tangle currently represents the technical basis of a smaller number of cryptocurrencies, of which IOTA and nano should be singled out. The advantage of tangle is the reduction of transaction costs by eliminating the division of participants into nodes and miners. The advantage that these cryptocurrencies have is that transactions are not packed in blocks, so the waiting time for confirmation of the transaction is shorter.

While most systems experience the problem of scalability with the growth of the number of participants and executed processes, the situation is different with tangle - the greater danger is posed by the absence of participants and by a small number of transactions because it increases the time required to execute an individual transaction.

The main problem is that neither IOTA nor nano are in the group of major cryptocurrencies. This does not mean that they have not yet been tested at the level of workload that they would suffer with the number of users who have ether or bitcoin. At the beginning of March 2021, bitcoin had a market capitalization of over 620 billion US dollars, IOTA around 3 billion, and nano only 0.93 billion of US dollars. Low capitalization was accompanied by lower trading volume. We can conclude two things: firstly, IOTA and nano did not have the opportunity to show real limitations in throughput and scalability, and secondly, since they are less attractive in trade, they were partially spared by the attacks suffered by systems of more popular cryptocurrencies.

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INFORMATION SYSTEMS, SOFTWARE DEVELOPMENT, INTERNET TECHNOLOGIES AND SOCIAL NETWORKING SESSION

COMPARATIVE ANALYSIS OF THE IMPACT OF SERVER OPERATING SYSTEMS ON WEB SITE PERFORMANCE

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Abstract:

This work analyses the impact of the server operating system on the overall performance of hosted web sites. In the paper, we are presenting the results of comparing the influence of the two most common server operating system families, Windows and the GNU/Linux distributions. Through experiments, we have collected data based on which we have concluded the impact of these operating systems on the performance of a web site developed using the most commonly used web platform - WordPress. The experiment was set up in such a way as to eliminate the impact of hardware on our measurements, which is done by using the same hardware, network and matching conditions. The experiment was conducted with a large number of repetitions to reduce relative errors in measurements. The performance analysis covers files of different sizes and types, including text and multimedia content typical for modern web sites.

Keywords:

GNU/Linux, Windows, web site, performance.

INTRODUCTION

Users tend to leave web sites that require extensive time to load their content [1]. In such situations, users search for alternative sources of information and services [2]. It is confirmed by research that at least one of the important reasons why users leave web sites is the time it takes to load them, compared to other web sites [3] [4]. This can lead to a reduction in sales, for commercially oriented web sites [5]. Whenever a web page loads only one second longer than other similar web sites, it reduces user satisfaction by as much as 16%, page browsing by 11% [6] and conversion rate by 7% [7] [8]. Therefore, the time to load the web site is one of the more important features that affect the satisfaction and success of the web site.

Improving the performance of the web site can lead to greater satisfaction of visitors of web site services, which can have a positive impact on business. Other than optimizing the web site's application code, the

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underplaying platform can also impact performance. Therefore, research is needed to determine what actions in preparing the web server platform can be performed which can affect the reduction in the load time of the hosted web site. Since several server features may affect performance, as well as other features of the web application itself [9], this research analyzes the impact of a single feature independently. The research aims to determine the influence of the server operating system on performance.

2. METHODOLOGY

To reduce the error of measuring the speed of loading the content of the web site on selected operating systems the experiment was designed to use the content of different types and sizes. Repeating the measurement many times reduces the relative measurement error. The content used in the experiment was formed to simulate different ranges of content sizes typical of modern web sites [10]. The file sizes used in the experiment were divided into ranges of typical textual content, smaller and larger images, as well as large video files. The research aims to show to what extent and in what way the choice of an operating system affects the performance of the site. Other characteristics of the architecture of the web server on which the web site is hosted and executed are unchanged so that they cannot affect the measurement results. To ensure virtually unchanged conditions regarding other features of this experimental platform, such as local network connection speed, the experiment was performed on a local network, thus excluding network capacity as a possible bottleneck of the model. This reduces the impact of changing the speed of the Internet connection due to changes in the connection load at different times of the day [11]. The web site was loaded from a local server exclusively purposed for the experiment. For both operating system families, the same computer was used as the server, each in term. The computer from which the content download request was made was disconnected from the Internet connection during the experiment. Also, all installed programs were turned off during the measurement. In this way, the influence of other software on the measurement results for the duration of the experiment was reduced. In the study, we tested the effects of systems from the two most commonly used families of server operating systems - Windows and GNU/Linux distributions [12] [13]. In the case of Windows, the latest version at the time of the research was 2019, build version 1903. In the case of the GNU/Linux

system distribution, the Ubuntu Server operating system distribution, version 19.04, was selected, which was up-to-date at the time [14]. The servers was set-up following the required server configuration, using an Apache2 web server [15] with a PHP interpreter [16] and a MySQL relational database management system [17] was used as a web server, and as a platform for web site hosting. The WordPress CMS [18] was installed with default settings, without additional configuration of layout, functionality and optimization. The operating systems have not been in any way modified and additionally configured from their default initial states, automatically configured during their respective setup processes.

The content used for the experiment for the download time measurement was divided into two categories: (a) files and (b) page content. Files are divided into four groups: (1) a small file of 12.9KB, (2) a medium file of 1.08MB, (3) a large file of 90.7MB, and (4) a very large file of 1GB, and pages into two groups: I) a small web page with textual content, with 3 paragraphs of text and (II) a large web page, with 50 paragraphs of text, 4 tables of average size, 30 embedded images, 5 sheets of 10 items and with a total of 100 links. The experiment is set up in such a way that a large number of consecutive requests are made to the server. The server is asked to deliver specified types of content from the web site hosted on the server with the tested operating system. For each request, we record the response time, as well as the response time for all request in the sequence. Requests were not sent competitively, but one at a time, each upon the completion of the previous one. The data collection process was performed for both operating systems.

We have used a Bash script to automatically query each category of content from the web site, which is delivered from pre-defined web site paths. For each content group, two content delivery times were recorded, the total time for the entire cycle of all iterations, and the average individual download time. The number of repetitions in a cycle is automatically increased from 1 to 100, and over 100, it is increased in steps of 10 repetitions, up to 500 repetitions of downloads for each content group. In this way, it is possible to determine whether a web site behaves differently when it needs to serve the same amount of content one or more times in a very short time. Averages and total times are recorded.

A listing of the part of the script that downloads content from the site, measures the total time and writes the results to a file for processing and averaging is shown in the following computer code listing:

```
#!/bin/bash
for repetitions in `cat sizes.txt`
do
    echo "(1) small file, x $repetitions..."
    start=`date +%s%N`
    for i in {1..$repetitions}
    do
        wget --cache=off \
            --no-check-certificate \
            --no-cache --no-cookies \
            -q $URL -O- > /dev/null
    done
    end=`date  +%s%N`
    time=$(( $end - $start ))
    echo "$SIZE $repetitions $time" >>
results.txt
done
```

Listing 1 - A segment of the data collection script

The script uses a supplementary file whose content supports the process of automated data collection for processing. This file is called sizes.txt and contains pre-defined repetition numbers from 1 to 100, with steps of 1 and over 100 to 500, with steps of 10.

Two essential variables used in the script are:

- $URL is the link from which the content from the web page will be downloaded in the given iteration. The value of the variable is set outside the script and changes before each script run for each subsequent content group by size.

- $SIZE is the symbolic name of the content group by size that is retrieved in that iteration.

The script ignores the content downloaded from the web site. It does not store it anywhere, but erases it immediately after the end of an iteration of the current cycle. After completing one download and after it records the measurement, it continues with the next planned iteration. This script is repeated for each group of content sizes and complements the results of the measurement with the results.txt file. Executing the script generates a total of 140 results for each content group, grouped by size. By repeating the process for all content groups, a total of 840 rows of results are created, which contain the symbolic name of the content group, the number of repetitions and the total duration, expressed in ms in the form of a real number value. Based on the duration and number of repetitions, the average content download time was subsequently calculated for each of the 840 result rows in the file and compared to the average calculated on the fly during the download process. This comparison is done for verification.

3. EXPERIMENTAL RESULTS

The completion of the experiment, which included data collection for the two tested operating systems and all content groups, grouped by size on the same hardware and using the same network infrastructure and configuration took 154 hours. Based on the collected measurement results, we were able to perform an analysis and create a report. This report explains the web site's performance in terms of response speed and delivery of requested content.

This section presents the measurement results. Speeds are calculated based on the total and average download times for all content groups. After the calculations were done, the maximum calculated speed for both operating systems was taken into account and the results were recalculated and set on a scale from 0 to 100 MB/s. The speed values are shown in the measurement results section graphically and in tabular form and explained in the following analyses.

3.1. ANALYSIS OF THE RESULTS FOR THE UBUNTU SERVER

Figure 1 shows a graph of average content download speeds for all six content categories, grouped by size, for each number of iterations, from 1 to 500, for the web site hosted on a server running Ubuntu Server. For clarity, the graph is drawn so that the numbers of consecutive repetitions of content retrieval ranges from 1 to 500 and are placed along the abscissa, and the values of average content retrieval speeds are shown in logarithmic scale, shown from 0 to 100, values from 0 to 100MB/s are along the ordinate.
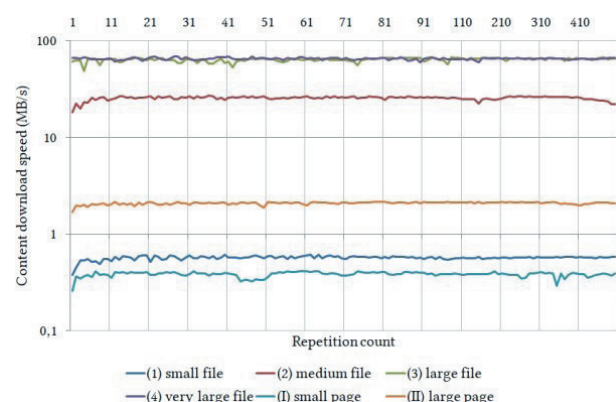
Figure 1: Results when hosting on the Ubuntu system

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From these measurement results we can notice that when downloading (I) a small page, the average download speed is lower when the page is downloaded consecutively a smaller number of times (up to 5), and increases for multiple consecutive downloads. The same is the case with (1) a small file. It is noticeable that the download speed is unstable when downloading

(1) small and (2) medium files, as well as (I) small pages, while in the case of downloading (3) large and (4) very large files and (II) large pages speed uniform.

We have measured oscillations in average download speeds during download (I) of a small page in cycles of up to 100 consecutive downloads. For some consecutive downloads, the average speed is the same for this content group.

The least number of oscillations was recorded when downloading the (II) large page. There are fewer oscillations observed when loading this page than when loading (2) medium, (3) large and (4) very large files.

This finding is contrary to our expectations, given that when downloading a file from a web site, the Apache web server accesses the served file directly from storage, without passing the request through the PHP interpreter, which would in term run the logic of the WordPress site. Direct access thus bypasses the connection to the MySQL database server data, and was expected to reduce the overall amount of processing time needed to deliver the file.

When measuring the average download speed (2) of the average file for the whole frame of the number of repetitions, it is noticeable that there is acceleration in situations when the same content is served consecutively up to 20 times. However, over 460 times, a lower average download speed is recorded, but the oscillations are smaller. When downloading (3) large and (4) very large files, the least number of oscillations were noticed, regardless of the number of consecutive downloads of the same file from the server.

Finally, it was observed that the average download speed of (2) medium, (3) large and (4) very large files is in the upper 50% of the speeds compared to other content groups.

3.2. ANALYSIS OF THE RESULTS FOR THE WINDOWS SERVER

Figure 2 shows a graph with the average relative download speeds for all six content categories, for each number of iterations from 1 to 500, from a web site hosted on a server running the Windows Server 2019 operating system.
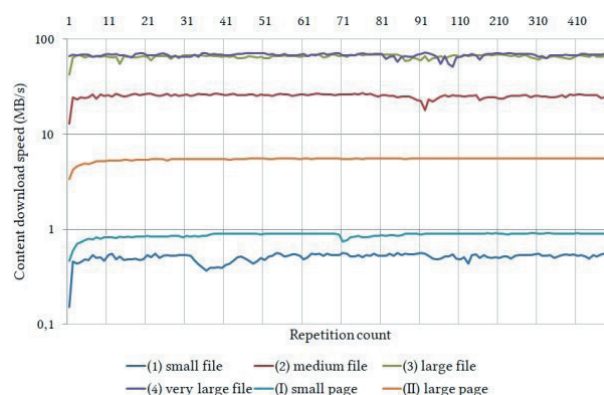
Figure 2: Results when hosting on the Windows Server

When hosting the web site on the Windows Server, we notice similar performance in the results, with some difference in performance evident with certain content groups. In terms of speeds expressed and calculated relative to the maximum speed in this configuration, the least number of oscillations in terms of average speeds were recorded in (2) medium and (4) very large files, while (3) large files recorded more oscillations for various ranges of consecutive download repetitions. When reviewing the results of downloading the contents (1) of a small file, we see that the average download speeds are unstable in the whole range from 1 to 500 repetitions, and it is particularly noticeable that up to 5 consecutive downloads, the speeds are significantly lower. In web page download scenarios, most oscillations were observed when downloading (I) a small file, while downloading (II) a large file was stable, except for the range of 90 to 95 iterations.

In the shown graph, we can see that the download speed for large and giant files is comparable, regardless of the large difference in file sizes.

Finally, we have observed that the average download speed of (3) large and (4) very large files is within the top 50% of speeds compared to other content groups.

3.3. COMPARISON OF THE RESULTS

In this section, we explain how we compared the obtained measurements. We express measurements as values from 0 to 100 MB/s, corresponding to absolute data transfer rates. We present them graphically.

To make it easier to compare the results of the average download speeds, the values were aggregated into four groups, based on the number of performed repetitions of content downloads, for each size group:

- A - The number of repetitions of content download is from 0 to 99;
- B - The number of repetitions of content download is from 100 to 190;
- C - The number of repetitions of content download is from 200 to 290;
- D - The number of repetitions of content download is from 300 to 500.

For each content group, we have made four subgroups, filtering the results by averaged speeds labelled as A, B, C, and D, as was explained above. These groups and their subgroups are hereinafter collectively referred to as Content analysis grouping labels. For further review of the performed analysis, we have labelled these aggregates as:

- A-1, A-2, A-3, A-4, A-I and A-II;
- B-1, B-2, B-3, B-4, B-I and B-II;
- C-1, C-2, C-3, C-4, C-I and C-II and
- D-1, D-2, D-3, D-4, D-I and D-II.

The results are shown in the graphs in Figures 3 and 4 with logarithmic scale in base 2.
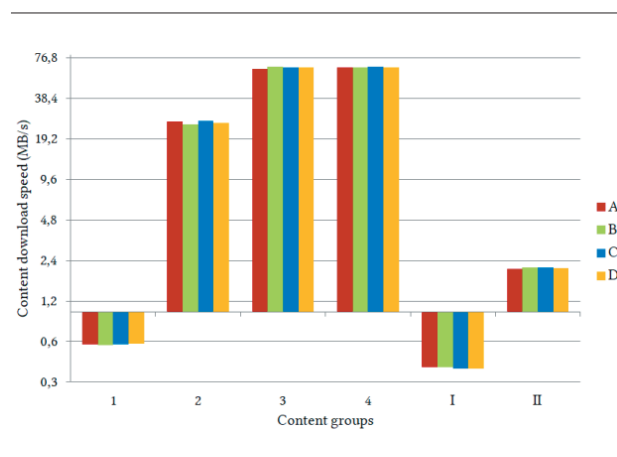
Figure 3: Measurement results on GNU/Linux
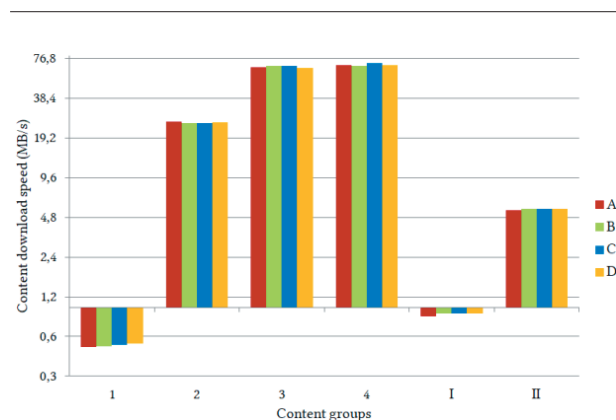
Figure 4: Measurement results on Windows Server

After reviewing the presented charts, we can conclude that the average download variance is low within the same repetition number group (A through D). Charts show that download speeds of content groups for files (1), (2), (3), and (4) are nearly the same. The variances are better presented in Table 1, shown below. Greater differences are observed in the area showing average download speeds of page contents (I) and (II) between the two experiments. Transfer rates of contents of (I) small and (II) large pages are lower, relative to their respective sizes when downloading from the web site hosted on the Ubuntu Server GNU/Linux distribution. When reading the chart, it is evident that the download speed of the (II) large page from the web site hosted on the Windows Server is double than the achieved download speed of the content of the same page from the web site hosted on the Ubuntu Server.

Table 1 shows the differences in average download speeds for contents of different sizes (1), (2), (3), (4), (I), and (II), grouped by repetition number ranges A, B, C, and D, from web sites hosted on Ubuntu Server and Windows Server operating systems. Table cells include additional indicators which show when the download speed difference is greater than 0 or less than 0, represented by collared arrow symbols, facing up or down, respectively. In our experimental results, we did not come across a situation when the difference was 0. Therefore, we did not include an indicator to show this scenario. From the given table, we can confirm that download speeds across different repetition number groups for (1) small files are nearly the same for both operating systems and that the Ubuntu Server has had better performance in this scenario. When it comes to the (2) medium file size, we can see increasing instability, while on average, the difference is still negligible in this scenario.

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Starting from the (3) large file size, it is evident that the download speed difference is steadily increasing and is growing in favour of Windows Server. Regarding web page contents, the download speed difference for (I) small pages is also negligible, while it does show that Window Server outperforms Ubuntu Server.

However, the difference for (II) large pages is comparably larger. On average, across all repetition number groups, it shows that the average download speed is 3,51MB/s greater when the pages are loaded from web sites hosted on the Windows Server, compared to that hosted on Ubuntu Server.

4. DISCUSSION

A comparative analysis of the results of the web site performance measurement performed on Ubuntu Server 19.04 and Windows Server 2019, build 1903 operating systems showed that the web site's performance on the Ubuntu Server system was slower for most content groups compared to the speed of content download from the same web site hosted on the Windows Server operating system. When it comes to content downloads which completely bypass the WordPress application code, by performing file downloads exclusively through the Apache2 web server file download handler, the performance of the web site hosted on the Ubuntu Server better only for the smallest file sizes. As file sizes grow, the download performance gradually shifts in favour of the Windows Server hosted web site. For content that does rely on the WordPress application code for generation and delivery, the download speed was always faster when downloaded from the web site hosted on the Windows Server, compared to the Ubuntu Server. In the case of downloading content (1) small files and (I) small pages, performance differences are negligible. When it comes to (II) large pages, it is noticeable that the average download speed was higher on the Windows Server system. Measurement results for (2) medium, (3) large, and (4) very large files clearly show that performance on the Windows Server system was better. There was a difference in average download speeds of (4) very large files for recurrence number groups A, B, C, and D, as well as for the download speed of (II) large pages, for all the same recurrence number groups. The most significant difference was observed during the transfer of (4) very large files. In this scenario, the performance was unequivocally better when the file was being downloaded from the Windows Server.

5. CONCLUSION

In this paper, we have described an experiment conducted to determine the impact of choosing an operating system on the performance of a web site hosted on the server. Both operating systems were installed with their default setup configurations without performing any post setup optimizations. Results of the experiment are measurements of average download speeds of the content of different types and sizes.

The types of content we used in the experiment were web pages and linked file resources. The four file size ranges are chosen to simulate typical text, multimedia, and audio-video content on modern web sites. The two pages are designed to represent pages of typical sizes, with common content, including text, referenced pictures, parsed links, rendered tables, lists, and so on. We have provided equal conditions for executing the web site on servers with two selected operating systems using the same hardware architecture, using the same local network, without actively connecting to the Internet for the duration of the experiment and deactivating all other software except those necessary for the web site. We used operating systems from the two largest families, GNU/Linux and Windows families. We used the server version of the popular distribution of GNU/Linux operating system - Ubuntu Server and the server version of Windows system - the Windows Server. For our experiment, we used the latest versions that were available at the time of conducting this research. Server software, database management system and web site development platform have been selected in the same way by analyzing market share data and overall representation of these technologies and we have not made any optimizations to these systems after their installation. The collection of measurements was automatic, performed using a script executed on a computer prepared exclusively for this experiment, and the data collected was subsequently imported, normalized, and processed. By analyzing the measurements, we have concluded that overall performance in terms of average content download speed from the web site is better when the web site is hosted on the Windows Server operating system compared to the one hosted on the Ubuntu Server distribution of the GNU/Linux operating system family.

6. FUTURE WORK

This experiment was intended to measure only the impact of a single factor of the platform configuration - the operating system. The research results have shown that choosing an operating system does have an impact on the web site's performance. For smaller contents, the performance is negligible. For larger contents it should not be ignored. Given that other features of the server platform configuration were not taken into account, and that their performance impacts were not considered in this research, it is conceded that additional research is needed to measure and show the impacts of other features of the server platform configuration, as well as to determine whether they influence each other in any way.

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INFORMATION SYSTEMS, SOFTWARE DEVELOPMENT, INTERNET TECHNOLOGIES AND SOCIAL NETWORKING SESSION

THE USE OF ICT DURING THE COVID-19 PANDEMIC IN THE CITY OF BELGRADE

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Abstract:

The current situation with the COVID-19 pandemic has indicated the need to use modern ICT to manage different systems. Local self-governments are forced to implement various measures to combat the pandemic and prevent the growth of the number of infected people. Moreover, the activities carried out by local self-governments often change and this is one of the reasons why efficient and effective information management has been imposed as one of the primary goals. The use of ICT has greatly facilitated the monitoring of the several parameters that affect efficiency in the combating current COVID-19 pandemic.

At the level of local self-governments, various entities are engaged during the COVID-19 pandemic. Therefore, coordination must be at a high level to implement various measures and achieve the desired results. Hospitals and other medical institutions, police, army forces, utility companies, Red Cross, volunteer organizations are some of the engaged institutions and organizations during pandemic.

This paper is the report one and direct contribution of this paper is to point out the way ICT is used by the city of Belgrade, as a local self-government, during COVID-19 pandemic. In addition to all the above listed institutions and organizations, local self-governments in the Republic of Serbia have the task of coordinating the entities at the local level through their headquarters for emergency management. The primary results of the paper are to focus on positive aspects of the use of ICT at the local level during COVID-19 pandemic, primarily in the area of easier and efficient coordination with citizens and institutions. In addition, the paper presents the weaknesses of the use of ICT some of which are the unavailability of such technologies in rural areas, different approaches to the use of ICT and the need to control access.

Keywords:

disaster management, headquarters for emergency management, information management, infodemic, coordination.

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INTRODUCTION

A new coronavirus infection named coronavirus disease (COVID-19) was discovered in Wuhan, China at the end of 2019, and has rapidly progressed. The World Health Organization (WHO) declared COVID-19 a pandemic in March 2020. COVID-19 pandemic was characterized by the rapidity of the outbreak that was accelerated by transportation networks worldwide. Researchers have attempted various approaches to manage COVID-19 pandemic, such as genome analyses, diagnostic methods,

treatments, and prevention. An 'infodemic' situation has developed, whereby misinformation has caused logistical disruptions and resulted in health hazards and shortages of supplies [1].

During this situation, it was necessary to apply adequate management tools. Namely, the decisions had to be made quickly, bearing in mind that the conditions in which the pandemic took place were constantly changing.

The primary goals related to the protection of human lives had to be met in the conditions of a global pandemic that threatened to provoke a new economic crisis. Situation control depended on the speed of processing available data and creating information that would serve everyone to better protect and preserve their own and others' lives.

A crisis is defined as the social changes which changes the characteristics of a society [2]. Crisis management involves the coordination of activities by different groups in an effort to avoid or minimize disaster impact. Nowadays, crisis management is not able to operate efficiently without the support of the state of the art ICT. In order to find an optimal operation model in crisis management it becomes more frequent to take the advantage of various technological innovations (e.g. trusted computing and agent-based infrastructure) or organisational solutions (e.g. cloud computing) [3]. In accordance with the previous definitions, COVID-19 pandemic can be viewed as a crisis during which it is necessary to apply the postulates of crisis management with the use of modern ICT.

The use of modern ICT has proven to be more than a useful tool during the COVID-19 pandemic. Processing data on the number of infected, monitoring the number of people in hospital and other types of treatment, the movement of the number of deceased, the need for medical and other protective equipment, indicated that only through ICT can monitor certain parameters and further assist state and local leadership to make timely and efficient decisions. The city of Belgrade as the capital of the Republic of Serbia faced big problems at the start of the pandemic. However, difficulties in functioning were visible and later in line with changes in the epidemiological situation. It happened that in a short period, the city authorities had to change the way they worked and to define the time and way of work of other companies and legal entities. However, the use of modern information and communication technologies has significantly facilitated the management of the city of Belgrade in the conditions of a COVID-19 pandemic.

2. USE OF ICT DURING A CRISIS

The COVID-19 pandemic is a global phenomenon. In this regard, local and national authorities have used various forms of ICT to facilitate the fight against the disease. Before giving some examples of use of ICT during COVID–19 pandemic as a crisis, the use of other forms of crisis situations caused by natural or manmade disasters will also be pointed out.

ICT can be used support the practice of disaster risk management (DRM) in times of crisis, as well as in times of planning and in times of reconstruction. The revolutionary potential of ICT lies in their ability to instantaneously connect vast networks of individuals and organizations across great geographic distances, and to facilitate fast flows of information, capital, ideas, people and products. ICT have become essential tools for cooperation and collaboration [4]. ICT should be used during earthquakes, floods, fires, forest fires, etc.

The tracking of patients and their contacts is imperative to public health in the fight against infectious diseases. Johns Hopkins University Department of Public Health, Baltimore, Maryland, USA, developed an interactive geographical information service (GIS) that was developed using ArcGIS (Esri, Redlands, California, USA) to display the number of confirmed cases of and deaths caused by COVID-19 pandemic on a map [5]. GIS is a very useful tool that is used in other areas as well, such as emergency management. Probably the most important and complex phase of emergency management in response. During this phase, responsible emergency institutions have a wide range of tasks to save and rescue people and protect environmental and heritage values. So, coordination is very important as it provides instructions on how to use resources most effectively [6]. As well as the response to the pandemic can be viewed as a response phase in emergency management with the basic goal of protecting and saving human lives, it is clear why GIS was used as a software and information tool.

It has also been reported that machine learning of medical images, such as chest radiographs and CT scans, can be used to accurately diagnose COVID-19-associated pneumonia [7]. Much of the available data related to COVID-19 pandemic are open access, and machine learning models to support clinical decision-making have made use of such data. The creation of electronic clinical guidelines has also been reported, whereby implemented data sets have aided the diagnosis and treatment of COVID-19 pandemic [8].

The use of tell meeting and teleworking systems using ICT became popular because of the many regional lockdowns that acted as a countermeasure to the pandemic. Various medical conferences have been held as teleconferences using video calling technologies, which has contributed to the spread of the latest medical information, including the latest developments in COVID-19 pandemic research [9]. Telemedicine is a very useful information tool in the current pandemic. The appearance of the COVID-19 pandemic was a total unknown to the medical staff. In that way, and in the conditions of limited movement, both at the national and international level, it was necessary to exchange opinions and results that were reached through telemedicine. The main goal was to raise the level of healing of people through telemedicine and save human lives. Telemedicine is not a new information communication tool. But during the pandemic, it showed several advantages and possibilities that should be used in other conditions as well.

Digital contact tracing was suggested as a means to help control COVID-19 transmission following both real-world experiences in Singapore and mathematical models [10]. To counter COVID-19-related misinformation, the WHO and other health organizations of many countries have ensured that accurate information is published. They have also blocked misinformation shared on social media and guided public information. Social media platforms also banned many accounts that propagated conspiracies related to COVID-19 pandemic. The role of social networks is significant during COVID-19 pandemic. Both the positive and negative sides of social networks have been shown. The positive side is, in essence, that information, instructions and epidemiological measures could spread quickly among citizens, especially bearing in mind that there were daily changes. On the other hand, the negative circumstances of the use of social networks during the pandemic show that rumors and inaccurate information were often spread, which led to the creation of panic among the population.

3. THE EXAMPLE OF THE CITY OF BELGRADE FOR USE OF ICT DURING THE COVID 19 PANDEMIC

The city of Belgrade has been improving electronic services for years. Since 2016, the Secretariat for defense, emergency management, communication, and coordination of relations with citizens has had the Beokom service for mobile phones. Through this application,

our citizens of Belgrade electronically report communal problems, receive important information for life in the city - service information about works in the city, changes in traffic, breakdowns. Also, the BG portal is operational, a site where citizens have the same opportunities provided by the Beokom service application, as well as some additional opportunities [11]. Further improvement of these services is planned.

The Belgrade Call Center also works at the Secretariat for defense, emergency management, communication, and coordination of relations with citizens, through which citizens can get all important information for life in the city, and since January this year, call centers have been operating in all 17 Belgrade municipalities, which are made available to the city headquarters for emergency management, and through which citizens of Belgrade are offered assistance in applying for vaccination and transportation to the place where it is performed, as well as assistance in applying for vaccination on the e-Government portal. In this way, the city of Belgrade helps the Ministry of Health so that all citizens of Belgrade who want to be vaccinated do so.

In the period that has followed us, the city of Belgrade has taken several steps to implement and improve electronic services, which have made life easier for citizens and functioning in times of an emergency, caused by the epidemic of the COVID-19 pandemic. During 2020, as in 2021, the city headquarters for emergency management made decisions (orders, conclusions, recommendations) at sessions held electronically. Last year, 102 sessions of the city headquarters were held, of which 101 sessions were electronic, and one was regular. This year, the city headquarters had 34 sessions and all were held electronically. The commander of the city headquarters for emergency management is the mayor. The deputy commander of the city headquarters for emergency management is the deputy mayor or a member of the city council. The city headquarters for emergency management performs the following tasks: puts on standby and engages entities of special importance for protection and rescue in local self-governments; orders the emergency headquarters of city municipalities to take measures and activities for protection and rescue if the headquarters of the city municipality does not make timely and appropriate decisions; order the use of the forces of the system of disaster risk reduction and emergency management, means of assistance and other means used in emergencies; engages entities of special importance [12]. It is obvious that even though the legal determination of the competencies of the work of the

Belgrade city headquarters for emergency management, it was necessary to hold regular sessions of the headquarters and make timely and efficient decisions under the conditions of the COVID-19 pandemic. The use of ICT made it possible to hold regular electronic sessions to prevent the spread of infection among management and staff members of the Belgrade city headquarters for emergency management.

The digital green certificate is a consolidated certificate proving whether you have received the COVID-19 vaccine and whether you have SARS-CoV-2 infectious disease test results. Also, this certificate contains the results of the following tests:

- PCR test (SARS-CoV-2 RT real-time PCR)
- Antigen Test (SARS-CoV-2 Ag-RTD Antigen Rapid Detection Test)
- Serological test (SARS-CoV-2 RBD S-Protein Immunoglobulin G (IgG) Test)

The digital green certificate is a certificate that is electronically stamped and as such cannot be falsified or misused. On 17 March 2021, the European Commission presented a proposal to create a digital green certificate to facilitate the safe free movement of citizens within the EU during the COVID-19 pandemic. Digital green certificates will be valid in all EU Member States. Key features of the certificate: digital and/or paper format; with QR code; free of charge; in national language and English; safe and secure; valid in all EU countries. National authorities are in charge of issuing the certificate. It could, for example, be issued by hospitals, test centers, health authorities. The digital version can be stored on a mobile device. Citizens can also request a paper version. Both will have a QR code that contains essential information, as well as a digital seal to make sure the certificate is authentic. The Digital Green Certificate contains necessary key information such as name, date of birth, date of issuance, relevant information about vaccine/test/recovery and, a unique identifier. The certificates will only include a limited set of information that is necessary. This cannot be retained by visited countries. For verification purposes, only the validity and authenticity of the certificate are checked by verifying who issued and signed it [13]. Starting from 12 May 2021, green certificates are issued at the level of the city of Belgrade. In this way, the city administration with the use of information and communication technologies helps citizens who need this type of electronic certificate.

When we talk about the e-Government portal euprava.gov.rs, which operates at the Office for information technology and electronic administration of the Government of the Republic of Serbia, as well as electronic services offered by the city of Belgrade, especially during the epidemic caused by the COVID-19 pandemic, it is necessary to improve electronic services and form a place where citizens will be able to provide as many services as possible, for which they previously had to physically go to various institutions. The e-Government portal of the Republic of Serbia is a central place for electronic services for all citizens, businesses and employees in the state administration. The use of the portal has made it easier for citizens to communicate with state bodies and the entire public administration in terms of an easier finding of information and appropriate forms, as well as easier submission of requests, receipt of decisions and other documents. The portal enables certain procedures before the public administration, which have been performed at the counter so far, to be performed from home without physically coming to the counter [14]. The portal has greatly contributed to bringing certain services together in one place and facilitating access to end users. The situation caused by the COVID-19 pandemic indicated that as many services as possible must be available on the portal. However, some of the services require a physical visit to the institution, regardless of the electronic registration on the portal. This should be one of the goals of improvement in the coming period, more precisely to reduce the number of visits to institutions for certain services for which it is not necessary.

When it comes to the city of Belgrade during the pandemic, the service available through the BG portal and the Beokom service was largely used. Citizens were able to see all the most important information and restrictions during the COVID-19 pandemic in one place through these portals. However, in this part, there are opportunities for further improvements in the use of IT technologies in order to communicate with citizens both during emergencies and during peacetime conditions.

Moreover, there are the weaknesses of the use of ICT at the level of the city of Belgrade like are unavailability of such technologies in rural areas, different approaches to the use of ICT and the need to control access. The city of Belgrade, in addition to the urban part, also has parts of a rural character. In these parts, it is difficult to expect citizens to be able to use ICT during the COVID-19 pandemic. Different institutions have different approaches to use of ICT. This made coordination even more difficult with the use of ICT during the COVID-19 pandemic. Taking into account the large number of people who worked during the pandemic in the management and use, special attention should be paid to the access control to prevent misuse of access.

4. RECCOMENDATIONS FOR IMPROVEMENT OF USE OF ICT AT LEVEL OF THE CITY OF BELGRADE

COVID-19 pandemic showed that the city of Belgrade has a well-developed mechanism for the use of ICT to inform citizens, facilitating access to services as well as management and leadership during the state of emergency. In addition, there are opportunities to improve and enhance the use of ICT at the level of the city of Belgrade.

As already emphasized in the previous chapter, it is necessary to work on uniting as many electronic services as possible in one place, which would be directly available to citizens. For example, solving communal problems that require the engagement of several communal companies can be united in one place where citizens would point out a problem that refers to several subjects through one request. A similar service already exists on the BG portal. However, when there is an individual solution at the level of one utility company, there are bureaucratic difficulties, slow administration and delays in implementation. The pandemic has shown that in these situations the use of ICT can be very useful to speed up the procedure and to avoid physical contact. Given the predictions that similar situations such as the COVID-19 pandemic can be expected in the future, there is an obvious need for increased use of IT technologies at the level of the city of Belgrade in order to facilitate communication with citizens and solve their problems.

The COVID-19 pandemic has shown that the city headquarters for emergency management must use IT technologies. Within the limits of physical contact city headquarters for emergency management could have maintained only electronic sessions. On the other hand, the representatives of the city government and the city Secretariat for defense, emergency management, communications and coordination of public relations led to the headquarters functioning smoothly during the entire pandemic. Thus, in the future, there is a need for the city headquarters for emergency management to have its own independent room for work with enough space and with all the necessary IT equipment that meets the standards for work in electronic mode. Also, such a space, based on the examples of the world metropolises, should be located near Beokom, which provides information and administrative support to the work of the headquarters.

Decisions during COVID-19 pandemic had to be made with constant time constraints. In such conditions, rapid data processing for efficient and effective decisions is crucial. In order to get usable information as soon as possible, it is recommended to use different software that processes data and creates different reports, comparative analyses, modeling, and more. There are many examples of such software, but for the needs of the city headquarters for emergency management, the government of the city of Belgrade should choose one that can be used in various forms of natural and technical disasters, such as epidemics and pandemics. Persons who would use this would go through previous training and persons with experience in working with the city headquarters for emergency management would be selected for that.

5. CONCLUSION

The global pandemic caused by COVID – 19 pandemic has indicated that many areas must rely on the use of ICT. Changes in business and operations were rapid and had to be applied in an unstable environment. In these circumstances, local authorities were also forced to rely on modern technologies to enable the functioning and provision of services to the population.

Use of ICT has proven to be very useful during various forms of emergencies. Regardless of whether it is an earthquake, flood, fire, the use of ICT raises the level of efficiency during the response phase as well as during prevention phase. The crisis caused by the COVID – 19 pandemic showed significant use of ICT.

The city of Belgrade is a good example of the use of ICT during the COVID – 19 pandemic. The work of the emergency management headquarters of the city of Belgrade was based on electronic sessions from the very beginning of COVID – 19 pandemic. This is especially important bearing in mind that it was up to this body to make key decisions regarding the restriction of population movements. Issuing certificates and providing various services to citizens were also realized during the pandemic with the help of electronic services and information and communication technologies. In addition to the above, the city authorities have identified a detailed analysis of opportunities to improve the use of information and communication technologies in cooperation and relations with citizens, such as combining as many services in electronic terms and without the obligation of physical visits to city institutions.

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INFORMATION SYSTEMS, SOFTWARE DEVELOPMENT, INTERNET TECHNOLOGIES AND SOCIAL NETWORKING SESSION

META-DATA SPECIFICATION FOR THE DESCRIPTION OF SOCIAL SCIENCE DATA RESOURCES – CESSDA METADATA MODEL

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Abstract:

Finding the necessary digital objects on the internet poses increasing challenges, and one way to overcome this problem is to use metadata that describes digital objects in a specific way. This paper aims to explain the importance and role of metadata and metadata standards/schemes, with particular reference to metadata used to describe data sets that researchers collect, archive, and disseminate in the Social Sciences. The paper describes the metadata model developed by the Consortium of European Social Science Data Archives (CESSDA ERIC) for the digital archiving of data sets in the European Research Area (ERA).

Keywords:

Metadata, Metadata Scheme, Social Sciences, CESSDA Metadata Model, Data.

INTRODUCTION

We are witnessing a digital revolution that has caused a flood of information. In the last 20 years, a considerable amount of data has been generated. The Covid-19 pandemic has caused an even more significant increase in the volume. The internet has become an almost infinite source of documents, images, e-books, music files, web pages and other data formats. Consequentially, searches are becoming increasingly challenging, especially since sources are numerous and diverse - governments, businesses, science, education, IoT, AI and similar. For that reason, most digital objects are described by metadata. Numerous software uses metadata as the basis of their functionality. The best examples are social media (Facebook, Twitter), video and music content providers (YouTube, Spotify) and many others. Metadata allows users to find the content they need.

In the field of scientific research, data plays a crucial role in analysing and testing scientific hypotheses. Researchers use different data types depending on scientific discipline, while the data collected and shared in social sciences and humanities could be particularly sensitive. The first reason is the inability for replication – the intersection of social phenomena is unique at a specific time, and the second is the possibility

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of compromising the privacy of respondents, which is regulated by law in most countries. For these reasons, data in social sciences and humanities have great value, so it emphasises the importance of their availability.

The paper is dividing into several sections. After the introduction, we covered the basics definitions and division of metadata and metadata standards/schemes. The third section contains a more profoundly explanation of metadata schemes in Social Sciences, while the fourth part introduces the CESSDA metadata model, which aims to describe digital objects containing primary data collected in scientific research.

2. METADATA AND METADATA STANDARDS/ SCHEMES

2.1. METADATA

The term "metadata" was first introduced by Jack E. Myers back in 1969 and became popular through the name of his company – "The Metadata Company".

The most straightforward definitions of metadata are "Metadata is data about data" or "The digital catalogue card" or "Information about the object [1], but they are too general to explain the essence of this concept. The National Information Standards Organization (NISO) provides a complete explanation through a more technically accurate definition – "metadata are structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage information".

The concept of metadata has proven to be very useful in various fields, especially in computer and communication sciences, libraries, statistics and numerous databases [1]. Technically, metadata contains basic information about data or digital content (or a digital object). The metadata structure is not universal but adapts to the specific content or object they describe. Metadata that describes photos, music or videos, e-books, files that contain information about a person will be different in scope and structure, but the most important thing is to describe the object as accurately as possible - to contain essential information. Typically, the metadata contains answers to the following questions: What?, When?, Where? Who? How? Which? and Why? [2]

Depending on the type of content or object that describes, the metadata is divided into several categories – Descriptive metadata, Structural metadata, Preservation metadata, Provenance metadata and Administrative metadata.

Descriptive data, as the name suggests, this type of metadata has the purpose of describing the content or a digital object, even though all metadata are descriptive. They are the most commonly used metadata. A simple example is an electronic description of a book, and the metadata contains the name of the book, the Name of the writer, the Year of publication, the Name of the publishing house and similar. There are certain situations when descriptive data become complex structures, and these are websites and code-driven projects.

- Example Properties: Title, Author, Subject, Genre, Publication date
- Primary Uses: Discovery, Display, Interoperability

Interoperability definition:

"*Enabling information that originates in one context to be used in another in ways that are as highly automated as possible*" [3]

Technical metadata is a subgroup of descriptive metadata. These metadata contain information about the technical characteristics of digital objects, such as ownership, object type (database, text file, music or video, and similar).

- Example Properties: File type, File size, Creation date/time, Compression scheme
- Primary Uses: Interoperability, Digital object management, Preservation

Structural metadata is more complex than descriptive ones and is most commonly used when it is required to describe how a digital object or resource is sorted. An example is a video material with specific duration sections, which fit in precisely the specified order. Structural metadata carries information that is important to users to place sections on the memory space properly.

- Example Properties: Sequence, Place in a hierarchy
- Primary Uses: Navigation
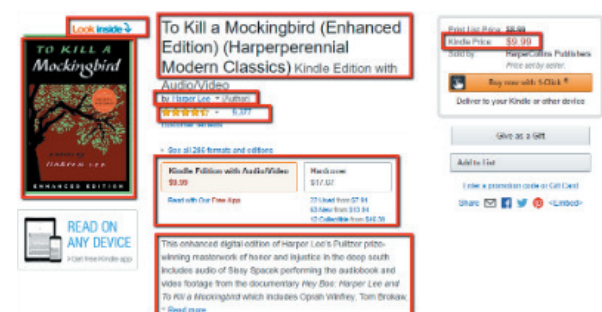
Figure 1 - An example of an Amazon book metadata [4]

Preservation metadata provide the information necessary in the process of maintaining digital objects. Preservation metadata has the function to record and store all changes that occur with a digital object during use to preserve its integrity. To track changes, the most commonly used form is Preservation Metadata Implementation Strategies, which tackles all activities conducted on a digital object and access rights.

- Example Properties: Checksum, Preservation event
- Primary Uses: Interoperability, Digital object management, Preservation

Provenance metadata are used in cases where digital objects duplicate, i.e. when copies are made. This phenomenon is very prevalent in the digital world and provenance metadata stores data on the object's earliest history. History information is vital in tracking the digital object's lifecycle. Provenance metadata may also contain information about users who made changes to the files.

Administrative metadata provide instructions to users about rules and restrictions regarding the use of a particular digital object. They are primarily intended for administrators, who use them to restrict access to files relative to the defined level of access - qualifications (guest, internal user, external user, administrator, and similar). This metadata is comprehensive and provides the ability to manage objects. They can also be seen as a basic version of a piece of data. Their role is also to make complex objects easier to understand by users.

- Example Properties: Copyright status, Licence terms, Right holder
- Primary Uses: Interoperability, Digital object management

Metadata are typically stored as a HTML, XML or MARC 21 document linked to the resource it describes.

```
<mets:amdSee ID="AMD_OTHER">
<mets:techMD ID="D09002ee180affcca-TEC">
<mets:mdRef ID="D09002ee180affcca-tdiv"
MDTYPE="PREMIS" MIMETYPE="text/xml"
LOCTYPE="URL"
xmlns:xlink=http://www.w3.org/1999/
xlink
xling:href="file/premis.xml" />
</mets:techMD>
</mets:amdSec>
```

Listing 1 - An example of administrative metadata from the XML file.

2.2. METADATA STANDARDS/SCHEMES

Bearing in mind that the types and purposes of digital objects are very diverse, appropriate standards need to be established to provide a unique set of rules. The primary purpose of these standards is to ensure the consistency of metadata and to enable interoperability.

In a specific sense, metadata standards, or schemas, define the necessary fields to describe a particular digital object. Therefore, the target fields are the essential elements of each schema metadata, and each of these fields contains the necessary information about the object. Depending on the type of object, the metadata scheme varies. In practical terms, any community that describes digital objects with metadata can have its metadata scheme [5].

Metadata standards are commonly associated with specific areas. Some examples are [6]:

- General metadata standards - Dublin Core (DC), Metadata Object Description Schema (MODS), Metadata Encoding and Transmission Standard (METS);
- Arts - Categories for the Description of Works of Art (CDWA), Visual Resources Association (VRA Core);
- Astronomy - Astronomy Visualization Metadata (AVM);
- Biology - Darwin Core;
- Ecology - Ecological Metadata Language (EML);
- Geographic - Content Standard for Digital Geospatial Metadata (CSDGM);
- Social Sciences - Data Documentation Initiative (DDI).

In the next part of the paper, Social Science metadata standards will be explained more broadly.

3. METADATA STANDARDS/SCHEMES FOR SOCIAL SCIENCES DATA SETS

Data Documentation Initiative (DDI) is an international standard for describing data sets obtained through different social and behavioural sciences observation methods. Standard is based on an XML format for content, presentation, transfer and preservation of documentation and data caps [7]. Initially, the standard was conceived as support in describing metadata in social sciences, but in later versions, it included data and other scientific fields.

DDI's goal is to anticipate key descriptive elements for data sets, which can be understandable to all parties, data creators, developers, librarians, and researchers. DDI encourages a comprehensive description for finding and analysing data. It is structured to enable machine find, functioning and interoperability of data (FAIR data) [8]. DDI provides a standard structure for all metadata that follows a data set, thus helping users interpret what is in the set. It is of great importance to everyone who uses a data set(s). Since metadata is expensive to produce, standardising metadata through DDI enables less time and money consumption and promotes interoperability. Also, DDI supports creating and using coders that are interactive, structured, and enable users to navigate more easily through metadata collections. DDI standard is continuously evolving and is actively working on customising its use in more complex data sets. In social sciences, it is very applicable because the creation of quality metadata is enabled to the maximum.

Encoded Archival Description (EAD) is the standard for coding information that comes from archive records. Archival timber is a specific form of timber. The main difference with the library structure is that the vast majority of the material is unpublished and unavailable online or elsewhere. With the development of the internet and the enabling of machine-readable records, it has become possible to consider developing digital aids that would help search archive timber. Work on the EAD standard began in 1992 at Berkeley, and the first version was released in 1998. After that, the second version came in 2002 and the last one in 2015 [9]. Today, this standard has wide use in archives, libraries, museums, and historical organisations worldwide. EAD enables users to find the primary sources they need through a standardised system for coding archive timber descriptions. The EAD uses a standard XML schema that determines the elements for describing the handwriting collection and the layout of those elements.

MIDAS Heritage. As the historic environment is an essential source of knowledge, it is clear that historical records are even more critical today because digitisation has enabled the transfer of most of the material to a digital format. MIDAS Heritage is the standard for historical data, i.e., data from the historic environment. It outlines what information should be recorded and which should not to enable effective exchange and long-term preservation of knowledge about the historical environment [10].

The MIDAS Heritage standard was created in 2007 in order to substantiate these needs. The standard creates records of buildings, monuments, archaeological sites, landscapes, parks, etc.. The standard is based on minimality - a minimum amount of information is required to describe cultural goods and includes all procedures involved in understanding, protecting, and managing goods. According to the formal text of the standards, its primary mission is to "share the knowledge of the past" [11] Government organisations use it, as well as local authorities, research communities and everyone else who deals with cultural goods in some capacity. Today, this standard facilitates modern life and enables the sustainability of records, ensuring that the same knowledge can be used and reused by future generations.

Statistical Data and Metadata Exchange (SDMX) is an international initiative aimed at modernising and standardising all mechanisms and processes to exchange statistical data and metadata between international organisations. Several organisations have teamed up to facilitate more efficient exchange of data and metadata in the field of statistical organisations, which are the Bank for International Settlements (BIS), the European Central Bank, Eurostat, the International Monetary Fund, the Organisation for Economic Co-operation and Development, the United Nations Statistics Division, and the World Bank [12]. SDMX has focused on facilitating the exchange and processing of data and metadata among organisations, which means that no typical data structure is exchanged among users. There are several different data formats and metadata: for time series, for cross-sectional data, for describing the structures of independent metadata sets, for structural metadata [13]. The standard focuses on statistical macroaggregates and is developed to support both microdata and unstructured data formats. Unlike other standards, SDMX focuses on increasing efficiency and ability to use and exchange data and metadata, not on metadata during the life cycle.

It is also valuable to mention **Open Archives Initiative Object Reuse and Exchange (OAI ORE) and Qualitative Data Exchange Format (QuDEx)**. OAI ORE defines standards for the description and exchange of web resource aggregations, sometimes called complex digital objects, to combine resources with multiple media types, including text, pictures, data, and videos [14]. QuDEx is an XML schema for documenting metadata for qualitative data sets. The QuDEx has been developed by the UKDA in 2006 [15], and it is intended for standard coding of metadata of qualitative collections. The scheme is entirely complementary to the DDI scheme.

4. CESSDA METADATA MODEL (CMM)

CESSDA ERIC is a vital element of the European Research Area in data management in social sciences. Bearing in mind that the Republic of Serbia is a Consortium member since 2019, the CESSDA recommendations are also an obligation for the Data Center Serbia for Social Sciences (DCS), the national research infrastructure and CESSDA's Service Provider for our country.

CESSDA aims to enable all national digital repository that collects, store and share primary data sets, a simple method for increasing visibility through its data catalogue (CESSDA Data Catalogue - CDC). In this way, data collected as part of national surveys can gain international visibility.

As part of the CESSDA Metadata Office project, which covers related topics, the CESSDA Metadata Model (CMM) has been created to introduce European digital archives into best practice in this subject. The broader concept, CESSDA Metadata Portfolio, consists of the "CESSDA Metadata Model, User Guide, CESSDA Vocabulary Service, European Language Social Science Thesaurus (ELSST), CESSDA Data Catalogue Profiles, CESSDA Metadata Validator, UML model, Supplementary Materials and Management and Maintenance Plan" [16].

The purpose of CMM is to describe every data set that researchers deposit into a repository and has a formal structure in this sense. It consists of primary and auxiliary elements. The main elements are Information on Study; Information on Persons; Information on Organisations; Information on Dataset; Information on Instrument; Information on Questions and Responses; Information on Concepts; Information on further Documents; Information on Publications (publications where data have been used); Information on Group of Studies and Information on Document Description ('metadata about metadata'). It is relying on DDI Lifecycle 3.2. The simplest way to understand CMM is through example. In this case, we will describe the first element – Information on Study, i.e. metadata about the study in which the data was collected.

Number and element	1 Study
Child element	1.1 Bibliographic Information 1.2 Content Information 1.3 Methodical Information 1.4 Access Information
Description	Information on the study/studies. No metadata element.
Mandatory/ Recommended/ Optional	Mandatory
Occurrence	1
Controlled vocabulary	-
Usage notes	.

Table 1 – Information on Study – The first level

Number and element	1.1 Bibliographic Information
Child element	1.1.1 Study DDI Identifier 1.1.2 Study Number 1.1.3 Study Title 1.1.4 Subtitle 1.1.5 Alternative Title 1.1.6 Funding Information 1.1.7 Principal Investigator Reference 1.1.8 Publisher 1.1.9 Publication Date (controlled) 1.1.10 Study Version 1.1.11 Contributor Reference 1.1.12 Reference Study to Document
Description	Bibliographic information. No metadata element.
Mandatory/ Recommended/ Optional	Mandatory
Occurrence	1
Controlled vocabulary	-
Usage notes	.

Table 2 – Bibliographic information – The second level

Number and element	1.1.1 Study DDI identifier
Child element	None
Description	Identifier of the study according to the DDI 3.2 structure.
Mandatory/ Recommended/ Optional	Mandatory for DDI 3.2, not for 2.5
Occurrence	1-2 for DDI 3.2, 0 for DDI 2.5
Controlled vocabulary	-
Usage notes	It is recommended to have both the URN and the combination of subclasses Agency, ID and Version as an identifier in DDI-L 3.2. However, it is possible to use only the URN or only the combination of Agency, ID and Version as an identifier.

Table 3 – Bibliographic information – The third level

All of the above primary elements are expanded by levels (in some cases up to five levels) to describe the data set properties in more detail. By applying CMM, all digital archives included in CESSDA ERIC become interoperable, and the data they store becomes internationally available and easily searched.

5. CONCLUSION

Metadata, structured according to the needs of specific scientific fields, helps researchers to locate digital objects, such as e-books, scientific publications, video materials, and similar. In addition to general metadata standards, many scientific and professional organisations have created their own standards and schemes to enable interoperability within the scientific field. Knowledge of standards and schemes is beneficial from two points of view. The first is the possibility for researchers to find the necessary digital material for their research, and the second is to make their scientific publications or data sets available and easily accessible to other researchers. For the needs of researchers in the social sciences, CESSDA ERIC has created the CESSDA Metadata Model intending to harmonise the meta-fields describing the data sets collected in the primary surveys, which are available in the public repositories of the national providers of the countries participating in this European infrastructure.

6. ACKNOWLEDGEMENTS

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THE INFLUENCE OF COVID-19 CRISIS ON SOCIAL MEDIA COMPANIES STOCK PRICES

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Abstract:

Technology and the internet development has led to changes in communication, therefore companies are increasingly recognize the importance of social media as a communication strategy. The aim of this paper is to determine whether social media have achieved expansion and recorded an increase in stock prices during the COVID-19 crisis. The research covered five social media companies (Facebook, Twitter, Snapchat, Pinterest and Weibo), which have listed shares on the stock markets. The results of the research showed that in the situation of a global pandemic considering digitalization, there is an increase in the number of users of social media, and that importance of investing in online advertising and e-commerce through social media has been recognized. Despite this, there is not the same positive impact of the COVID-19 crisis on all five observed social media companies and their stocks, and it is possible that increases and decreases in stock prices will not continue in the following periods in the same trend.

Keywords:

Stocks, Social media companies, Financial market, COVID-19 crisis.

INTRODUCTION

Social media on the internet enable activities such as publishing, sharing, creating and actively participating in various content, through which is possible to monitor virtual communities at the global population level and find out interests, thoughts and intentions in terms of various economic, political and cultural events [1]. The term „social media" was first used in 1997 when the first social platform, Six Degrees appeared [2]. Until today, this industry continues to expand and prosper, and it has become and exceptional tool through which it is easier to reach target groups, whether they are customers or investors. As internet habits and new trends in social communication develop extremely fast, investments in social media companies are constantly increasing, which is reflected in the prices of their stocks.

The focus of research in this paper is on the factors that caused the changes in the stock prices of social media companies. Research about the impact of the COVID-19 crisis on the expansion of social media

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companies is of great importance in order to explain the changes in the price of their shares on the stock exchange. Research that has dealt with the phenomenon of social media and pandemic indicating the impact of the crisis on this sector, can be found in the literature. Therefore in paper Susanto (2021) emphasizes the importance of using social media companies during a pandemic in order to reduce costs and increase business efficiency [3], while Cuello-Garcia (2020) shows the role that social media has on information and disinformation during the pandemic [4].

In times of economic crisis, investors need technology to get high-quality data in a timely manner and understand the impact of COVID-19 on stock market index. Hence, the combination of available information on stock exchanges and Big data in real time placed through social media, influenced the decision-making process of investors. In time of crisis greater interaction with target groups was achieved through social media. In order to achieve communicate fater and better with customers, partners and investors, companies have given more importance than ever to online campaigns, promotions and advertisments crarting attractive and relevant content that would evoke desires and interests, which were placed through social media. Today, the shares of many social media companies are on the stock market, many of them are just on their way to achieve that, slowed down by regulations and ordinance that have led them to remain private. But there are a number of social media companies that attact attention by seling their stocks to the public for the first time. Therefore, there are frequent advices which note that when it comes to the upcoming boom of high IPOs, should still be careful, and an additional reason is the COVID-19 crisis. The COVID-19 pandemic as a global health problem not only affects the routine and habits of people, but also affects the state of the economy. Certain sectors of the economy, such as tourism, catering industry and transport, have been most affected, which has led to major changes and has effects on financial stability and the situation on the stock markets.

2. LITERATURE REVIEW

Observed throughout history, it is evident that pandemics as an external shock, have a negative effect on the economy, macroeconomic and investment environment, which ultimately effects the situation in financial markets. The COVID-19 crisis has created an unstable environment that has changed the sate of stock market

aroung the world. Some authors compare the situation on the stock market with the effects of the H1N1 [5] from 11 years ago. The devastation in the global economy caused by the pandemic is shown on a scale not seen since the Great Depression [6], and thateven the Spanish flu did not have as much of an impact on the US stock market as COVID-19 [7]. Obseved by the change in the value of stock market indices, a regional character can be noticed because a larger decline in the value of stock market indices was recorded on the US stock market than on the stock markets in Asia and Australia [8].

Whereby stock prices represent potential future profit, concerned statements by investors on social media about future investments may affect the stock market during COVID-19. Using methodological approaches that can identify and analyze a large amount of market-driven information found in real-time online stock market forums, Ranco (2015) [9] and Sprenger (2014) [10] did research on how news posted on Twitter affected stock price movements.

For forecasting movements on the stock market, analysis of factors that affect the change in the stock prices of social companies, sentiment analysis was applied and data form social media were used, such as attitudes, feelings, emotions and opinions that play a role in assessing investors' opinions. There is empirical evidence that activities on certan social media, such as Facebook, have different effects on trading by different investors. Considering that Facebook is not official information channel, company will presumably strategically chose which information to distribute through this social media, which suggests that less sophisticated investors (who do not have access to professional data sources) will rely on this source [11]. In a growing market, such as the IT sevices market, investors rely more on optimistic reports and neglect those with a negative and warning signals. In a declining market, there a high probability, for investors to be more sceptical and analyse more pessimistic reports [12]. At the beginning of the COVID-19 pandemic in just 4 days in February 2020, the S&P 500 lost over USD 500 trilion [13]. Fear of uncertainty and the assessment that the company's profit will be reduced, had an impact on the lowest and highest prices of stock indexes in the United States. Therefore, it can be expected that the crisis will also affect on the stock prices of social media companies companies.

3. METHODOLOGY

In this research, the trend of stock prices of social media companies was analysed in order to determine the effect of the COVID-19 crisis on the change in stock prices of social media companies. This study include only those social media companies that have listed stocks, starting from the moment thery are listed on the stock market. Table 1 shows five social media comapnies whose stocks are listed on the stock exchange market, as well as basic data on the year of establishment, the date of the initial public offering, the number of employees and market capitalization.

The analysis will follow the change in stock prices from the first initial sale to April 2021. The analysis will observe: i) The trend of the average stock price on an annual basis; ii) Price change after the COVID-19 pandemic crisis; iii)

The relative ratio of stock prices between the observed social media comapnies; and iv) Defining the key factors that have influenced the changes in the share price of the observed companies.

Name	Year of establishment	Date of initial public offering	Number of employees	Market capitalization (in billions)
Facebook	2004	18.05.2012.	58604	857.52
Twitter	2007	07.11.2013	5500	53.53
Sina Weibo	2010	17.04.2014.	5073	11.69
Snapchat	2012	02.03.2017.	3863	92.46
Pinterest	2008	18.04.2019.	2545	47.13

Table 1 – Information about social media companies

The companies in the selected group do not have significant differences in the type of selected business activity, each of them refers to the social media. Differences appear only in the presentation and use of the displayed content on each network individually.

4. RESULTS AND DISCUSSION

The first company in the field of social media companies was registered in 1997. Since then, until today, their number has been constantly increasing. There are over 100 social media on the market today, with 3.6 billion users [14], and the value of this market is estimated at around USD 94.83 bilion in 2020.

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Pinterest								26.206	33.0549
Snapchat						17.0045	11.7801	12.9199	24.5822
Weibo			18.9236	15.149	32.5042	76.6495	94.1371	51.6879	38.5389
Twitter		49.6576	45.4515	35.3443	17.5711	17.8236	32.8285	35.5754	37.2158
Facebook	24.6729	35.4808	68.7622	88.7719	117.035	156.576	171.511	181.638	234.551

Figure 1: Relative ratio of the average annual stock price

Facebook is the fifth largest company in the world with a market capitalization of USD 756.74 billion. Although it has still lagging behind Alphabet (Google), the market capitalization value of Facebook is significantly higher than the nearest competitors such as Twitter or Snapchat. Primarily Facebook generates revenue by selling advertising space on its platforms, which include a social media website, mobile messaging apps Messenger and WhatsApp, 3D virtual reality Oculus, as well as an Instagram app for sharing photos and videos. Comparing 2020 wit the previous year, advertising revenue increased by 22%. In 2020, Facebook generated advertising revenue of USD 84.17 billion which makes 98% of the company's total revenue.

Facebook made its initial offer on May 18, 2012 (Figure 1) and raised more than USD 16 billion, making the largest IPO of USD 38 per share. Facebook had a large number of strategic acquisitions that fuel its gowth, and for the purposes of this paper, we will focus on the acquisition with the social media company Instagram in 2012 which in 2019 generated 31.8% of revenue, from the total revenue generated by advertising.

On the other hand, Twitter, after an initial public offering of USD 26 in November 2013, recorded a decline in the value of the stock, which can be seen in Figure 1.

During the period 2016-17, stock price dropped below the initial public offering to just USD 13.73 per share. Twitter divides its revenue into two categories, sales of advertising sevices, which make up the vast majority of the company's revenue; then data licensing and other services. During 2020, Twitter, in the name of advertising services generated USD 3.2 billion, or 86% of revenue, which is 7% more than in the previous year [15].

Snapchat ended 2020 with a net loss of USD 944.8 million, which is 9% less than in 2019, when it amounted to USD 1 billion. This data was not suprising because the company recorded a net loss in the previous 5 years. The largest net loss was recorded in the first quarter of 2017, when the company was listed on the stock market. Rewards to employees, primarily the company's CEO in the form of shares in the amount of USD 2.6 billion, are significant reason for the net loss. The price per share during the initial public offering of USD 17 reached USD 24.48 at the close, followed by a drop to the lowest price per share of USD 4.99 in December 2018. Snapchet then faced direct competition and slowed user growth, after Instagram, which is owned by Facebook, launched the Instagram Stories feature, essentially similar to the function that Snapchat own.

Snapchat generates its revenue mainly from the sale of advertising space, and 99% of the total revenue in 2020 is generated on this method [16]. Reveue during 2020, in the conditions of a pandemic, increased by 46.1% compared to 2019.
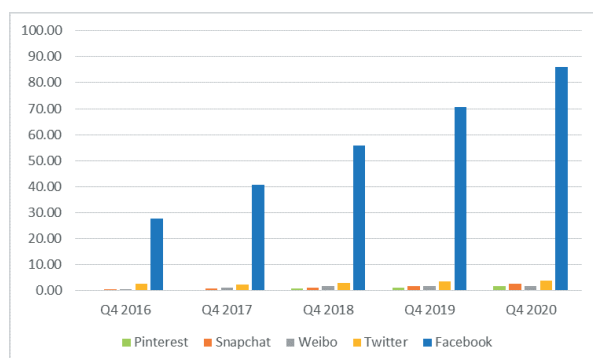
Figure 2: Facebook, Twitter, Pinterest, Weibo and Snapchat total revenue

Pinterest generates revenue by displaying ads on its web and mobile application, and approximately two-thirds of its revenue of USD 1.692,7 million in 2020 was generated through advertisments, which is 48% more than in the previous 2019.

The amount of market capitalization in April 2021 exceeds USD 37 billion. During the COVID-19 crisis, the lowest price per share was USD 11.64 in March 2020, and it ended the same year with a price of USD 65.90 per share, on December 31st at the close. It reached its highest price of USD 89.15 per share in February 2021.

As well as the previously mentioned companies, Sina Weibo (abbreviated to Weibo only) generates a significant majority of its revenue from advertising and marketing sevices – USD 1.486 out of a total of USD 1.689 million of revenues. During 2020, Alibaba alone generated revenue of USD 188.6 million. Weibo is often described as the Chinese equivalent of Twitter and Facebook, considering these two companies are blocked in China because of political incidents. Nevertheless, Facebook generates significant revenue from this country, presenting it in its annual financial report for 2020, which is linked to a limited number of resellers representing advertisers based in China [17].
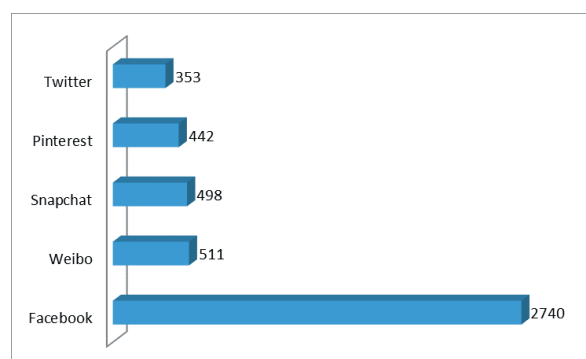
Figure 3: Active monthly users, in millions, January 2021

Figure 3 showes that the beginning of 2021 Facebook started as the most frequently used social media platform with 2.74 billion monthly active users, which is significantly more than the remaining four companies.

In the entire family of applications, Facebook includes Instagram, WhatsApp and Messenger with a monthly number of active users reaching 3.3 billion users. Considering Figure 1 and the collected data on the trend of the average annual stock price of five companies, it can be pointed out that only Facebook has a continuous growth trend of stock prices from 2012 until today. As it has only been listed on the stock market for one year, Pinterest does not provide enough information by year for comparison.

After the outbreak of the COVID-19 crisis, the largest increase in stock price in 2020 compared to 2019 was achieved by Snapchat with an annual average growth of 90.27%. The last closing price in 2019 was USD 16.33, while at the end 2020 it was USD 50.07 with an average change of 206.61%. Right behind Snapchat is Facebook with a 29.13% increase in the average stock price in 2020 compared to 2019; then Pinterest with 26.14% and Twitter with 4.6%. Weibo is the only one of the five observed social media company with a decrease of 25.44%.

According to the latest available data, at the close on April 30th 2021, the highest value of shares had Facebook – USD 325.08. The value of Facebook share is about 5 times higher than the value of shares of other social media companies. The value of Snapchat share was USD 61.82; Twitter USD 55.22; Pinterest USD 66.37 and Weibo USD 50.40. Facebook company has a large amount of user data at its disposal to help targeted marketing; the company has also recognized the future importance of networks and conducted acquisitins of Instagram and WhatsApp networks. This enabled it to cover a larger target market through photos, text, publications and communication, as well as a higher engagement rate. The engagement rate provides data on the percentage of people who viewed, responded to, commented on, or shared a post that can measure customer potential. This is an important difference in relation to other social media companies that are the subject of this paper, and which do not have such diversity in activities.

Harmonization with regulations also contributed to a sharp increase in Facebook's revenue from advertising. Legislation issues have been discussed in 2018 when it was found out that Cabridge Analytica had collected the personal data of millions of people without their consent and used if for political advertising purposes. After synchronization with the law in 2019 and the increased number of users, the shares of the Facebook achieved significant growth. Last year Facebook pointed out that privacy regulations and changes to the updated Apple ios 14 software could interfere with ad targeting and affect the price of ads.

This regulation would require from users to consent to the collection of data and their monitoring by social media. Otherwise, both the social media companies and advertisers would be denied feedback on ad performance. In March 2021, the price of the Facebook stock achieved an increase of 4.1% after the announcement of the company on the prediction of positive outcomes related to this regulation. This company has introduced protocol that consolidate and delay reporting, but at the same time allow the measurement of campaign results. Advertisers expect changes in Facebook's advertising and business tools, delivery, measurement, audience selection and reporting. Such changes are still accompanied by rising stock prices.

The COVID-19 crisis in the previous year was crucial for the introduction of e-commerce in the application of Facebook, Instagram, WhatsUp and Messenger, especially after the reduced financial potential of advertisers, but this regulation certainly accelerated the whole process. The effect of the COVID-19 crisis on Facebook was manifested through price growth, so that the highest price per share of USD 303.91 was reached on August 26th, 2020 (macrotrends 2021). This growth in shares was probably preceded by the strengthening of the Feed news function and the association with Shopify, Tienda Nube, BigCommerce, Cafe24, ChannelAdvisor, Woo Comemerce to support small businesses and launched Facebook shops, a new online shopping platform. During the COVID-19 crisis, Facebook achieved a growth of the daily active users by 11% compared to 2019 and the level of engagement observed through the number of likes, comments and followers, precisely due to the fact that there was lockdowns and digitalization of business. In the first quarter of 2021, the company continues the trend of revenue growth, active users, which leads to the highest share price in April of USD 329.51 per share.

It can be noticed that during 2020, Twitter recorded an increase in the average value of shares of 4.9%. In such a way, 2021 for this company started with a price of USD 54.49 per share, but already in January it decline about 17% and a price of USD 45.18 which is associated with account suspension of former US President Donald Trump. Following the published results for the fourth quarter and fiscal year, stocks increase about 41%, after that on March 1st, 2021, was reached the highest share price of Twitter at USD 77.63 at closing (macrotrends 2021). April brought another drop for Twitter's shares and a price of USD 55.22 at the closing on April 30th. This was preceded by the first quarterly report for 2021, which, despite the increase in revenue and number of active users, shows an estimate that the next quarter could be weaker because costs are expected to increase due to rise in the number of employees and a decline in advertising revenues as a result of the crisis.

COVID-19 brought for Weibo a 2% reduction in sales and marketing costs from USD 465.3 million in 2019 to USD 455.6 million in 2020. The change was due to diminished promotional activities. However, there was also a slower collection of receivables and a 3% de-

crease in advertising and marketing revenue as the number of advertisers decreased from 2.4 million in 2019 to 1.6 million in 2020. Weibo also encountered a drop in active users from 241 million in the first quarter of 2020 to 225 million in the last quarter of the same year. Shares of Weibo began to fall even after the government announced the investigation of Alibaba market abuse which has a 30% stake in Weibo.

Pinterest also reached its highest price per share of USD 89.15 in 2021. This was preceded by the published report for the fourth quarter of 2020, which showed an increase in revenue of 76% to USD 706 million, which contributed to the growth of the number of monthly active users of 37%. The advantage of this company is in the content that is focused on products, projects, hobbies and ideas, while platforms like Facebook are more focused on the exchange of personal data.

The COVID- 19 crisis brought the highest stock price increase for Snapchat so far. The reason for this is the highest rate of daily active users – 265 million; which is 22% higher compared to the same period a year earlier; generated revenue of a record USD 911 million, which is 62% more than in 2019: as well as reduced net loss.

Apple's changes to data privacy pose another risk to reduced targeted advertising, but Snapchat sees the solution to this problem in informing advertisers about the use of independent data as well as direct sales opportunities through their platform in which Facebook is currently their biggest competitor.

5. CONCLUSION

The aim of this research was to determine the effects of the COVID-19 crisis on expansion and change in stock prices of the five social media companies (Facebook, Twitter, Snapchat, Pinterest and Weibo).

Based on the research results, it can be concluded that the impact of the COVID-19 crisis was not the same on the growth of the stock price of all five observed social media companies. In the year of the crisis, Snapchat achieved the largest price increase per share, while Facebook had almost 5 times a higher value of shares compared to other five companies. Pinterest and Twitter achieved an increase in the share price, despite occasional declines due to the negative impact of political developments. The negative effects of the crisis are most visible in the Weibo social media, which is only social media company that recorded a drop in price per share.

These data suggest that changes in stock prices in the coming periods will not continue the same trend, as the effects of the crisis subside and life returns to normal. It is certain that social media will contrinue to be used more actively and frequently to perform everyday life activities, which will continue to have an impact on the actions of these companies.

Some of very popular social media are not yet listed on the stock exchange (eg Reddit and TikTok), which is the biggest limitation of this research. In addition, the social media Instagram is an integral part of Facebook, so it is possible to follow it only through the stock prices of Facebook.

In the following research, the authors will deal with a more detailed analysis of investments, strategic decisions of companies, as well as the impact of antitrust policy on the business of social media companies individually.

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INFORMATION SYSTEMS, SOFTWARE DEVELOPMENT, INTERNET TECHNOLOGIES AND SOCIAL NETWORKING SESSION

BLOCKCHAIN SERVICE NETWORK - A DIGITAL EXTENSION OF THE BELT AND ROAD INITIATIVE

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Abstract:

During 2020, the Chinese government launched an initiative to create a global blockchain-based network, which would serve as a framework for the development of business applications. The project was named the blockchain service network (BSN). It is complementary to the Belt and Road initiative, as both projects aim to build global infrastructure, which would enable acceleration and increase in trade volumes, creating above all an opportunity for international partnerships for Chinese companies. The subject of the paper is the position that BSN will occupy in the international business environment. Paper has objectives to determine what advantages BSN could enable as a global network of blockchain applications and to predict the reaction of key international actors to its emergence. It is concluded that the key advantages of the initiative are cost savings, accessibility and use flexibility. On the other hand, the project will inevitably face serious issues when it comes to the acceptance at the international level. Distrust in data security and the fact that the whole project is initiated by the Chinese government can discourage potential clients.

Keywords:

blockchain, cryptocurrencies, blockchain service network, belt and road initiative, state monitoring and control.

INTRODUCTION

The Belt and Road Initiative (BRI) has been a central pillar of Chinese foreign policy since 2013. It refers to the global infrastructure development policy implemented by Chinese government, which should include investments in over 70 countries around the world [1]. Typical examples of infrastructural investments covered by this project are roads, railways, ports, bridges and tunnels, which are in the direction of belt and road development. The belt is a brief name for the "Silk Road economic belt", which represents several directions for the development of land transport connections across countries of Central Asia and the Middle East. The goal is to establish firm connections by road and rail transport between the People's Republic of China (PRC) and Europe, across Russia and Turkey. The road is a brief name for the "21st century maritime silk road", which represents several directions development maritime

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connections between PRC and South and Southeast Asia, and also the Middle East and Africa [2]. The goal is to establish permanent connections with key international ports through ports in China, Pakistan and the Malay Peninsula. Not taking into consideration political connotations of this project, the key goal of the BRI is to create a global trade network with PRC as an initiator.

During 2020, the Chinese government launched an initiative for creation of a global blockchain network, which would serve as a framework for business applications development. The project was named the blockchain service network (BSN). The Cryptography law, which established national standards for cryptographic protocols, began to apply at the beginning of 2020 as a support to the project [3]. The Chinese government, along with banks and largest information and telecommunications companies, has invested significant resources in the creation and maintenance of this network. Therefore, it can be concluded that the goal of the Chinese government is not only to take a leading role in the distribution of physical products, but also to create an infrastructure for e-business.

The construction of a global blockchain network gives the PRC an advantage over key competitors in the field of digital business transformation. The question is what will be the reaction of the competitors, but also of those countries that represent key foreign policy partners in the BRI. In terms of functioning, BSN could lead to standardization and reduce costs of key services, but it can also increase other countries' IT dependence on the infrastructure of the PRC. The subject of the paper is the position that BSN will occupy in the international business environment. The analysis of the paper subject itself is inevitably connected with the analysis of its political and economic context. Therefore, equally important objectives of the paper are to determine the advantages that BSN could enable as a global network of blockchain applications and to predict the reaction of key international actors to its emergence.

The paper is divided into four key parts. The first part will analyze the key settings of the blockchain technology. In the second part, the attitude of the Chinese government towards blockchain as well as towards cryptocurrencies will be analyzed. In the third part of the paper, the key characteristics of the BSN project will be analyzed. Finally, the fourth part will discuss its advantages and limitations.

2. FUNDAMENTALS OF BLOCKCHAIN TECHNOLOGY

Blockchain is a new technology, whose practical foundations consist of previously known achievements in the field of cryptography and mathematics, such as asymmetric cryptography, timestamping, Merkel tree, hash function and smart contracts. It is used for distributed management of large databases.

Although it is not directly mentioned in the Bitcoin white paper [4], blockchain technology has become known as technical basis of cryptocurrencies, decentralized forms of electronic money. However, today, blockchain technology is used for various forms of business applications, which could be very heterogeneous by their nature and purpose.

Blockchain is a permanent ledger of previously executed transactions. It consists of blocks in which transactions are packed. In this case, transactions do not imply just the transfer of financial resources, but also any form of business activity that changes the state of the system. The content of each block depends on the transactions that were entered in the previous blocks, so the new state of the system depends on the previous state and changes brought by new transactions. Change of the contents of a previously installed block would lead to changes in the state of the entire system in the present. Therefore, a hash record of the previous block is entered in each new block, which prevents the change of transactions history [5].

Due to the way of organizing members, blockchain systems are divided into permissionless blockchains and permissioned blockchains. They differ in the possibility of system access and the roles that a user can perform. Permissionless blockchains have open access. This means that interested users can execute transactions or participate in their validation and block installation [6]. Because of the availability of all roles, these blockchain systems are often referred to public. Permissioned blockchains are characterized by a clear division of roles among the participants. In this case, users who validate transactions and install blocks are known and predetermined [7]. The systems may differ from each other in terms of the capabilities of other users. In some systems, membership is open, so all previously registered users can send and receive transactions. In other systems, all users must receive a special invitation to participate. Depending on whether the invitation system is managed by a single entity or an organized group, terms like private or consortium blockchains appear in the literature.

According to the basic idea, blockchain should have enabled the formation of ledger in a situation without trusted authority. Then a large number of participants, who do not know each other and do not trust to each other, decide which transactions are true by reaching a consensus. While this corresponds to the principles on which cryptocurrencies are functioning, the great transparency of the system could bring anarchy to business applications from other fields. Therefore, the development of private blockchain systems has been more important for the advancement of this technology in the last few years than the creation of new cryptocurrencies.

The functioning of private blockchain systems is in contrast to the original principles of decentralization and equality of participants. Moreover, under certain circumstances, they open the possibility for political control (regardless of who is the executor of that control) over the entire business application, which was desirable to be avoided.

3. THE ADOPTION OF BLOCKCHAIN IN PRC

The attitude of the PRC towards blockchain technology is complex and multidimensional. Complexity is reflected in contradictory data regarding the use of cryptocurrencies, which can be found in the professional and academic literature. On the one hand, there are claims that Chinese miners make up about 65% of the total computer resources invested in Bitcoin mining, while Russian and American miners have only a 7% share [8]. Such large mining capacities required not only high financial investments, but also coordinated action. Numerous authors emphasize that such a high concentration of miners in one country could be a threat to the stability of Bitcoin as the largest cryptocurrency, which would affect the entire market [9]. The concern proved to be partially justified, when in mid-May 2021, a large number of Chinese investors sold their cryptocurrencies to bring down the entire market by about 50% [10]. On the other hand, there is a sharp critical attitude of the Chinese authorities towards cryptocurrencies. During 2017, the initial coin offerings (ICO), i.e. the auction sales of new cryptocurrencies, were banned. Two years later, the existing crypto exchanges were closed and the establishment of new ones was prohibited on the territory of the PRC. Finally, in May 2021, financial institutions were prohibited from offering users any service denominated in cryptocurrencies, such as savings programs, clearing and settlement of transactions in cryptocurrencies and others [11].

The last ban also led to the mentioned disturbance on the market. Despite institutional bans, individual users are not prevented from mining or owning cryptocurrencies. These activities are not supported and users are advised not to engage in them, but they are not legally prohibited.

Multidimensionality is reflected in the different attitude towards to the technology itself and to cryptocurrencies, as the most well-known form of its use. While the possibilities of using cryptocurrencies are institutionally limited, the development of business applications based on blockchain is stimulated. At the end of 2019, the government publicly invited companies to start investing in the development of their own applications, emphasizing that the PRC must seize the opportunity to become a world leader in the development of blockchain technology. At the end of the same year, the Shenzhen Stock Exchange developed the Blockchain 50 Index, which includes the 50 most important companies that do business with some form of blockchain technology [12]. In April 2020, an initiative was launched to create a BSN, which will serve as a framework for the development of business applications.

The Chinese government's determination to take a leading position in the development of blockchain technology has not received nearly as much attention as those actions taken in the field of 5G network expansions and development of artificial intelligence. The fact that the PRC has far greater coverage of 5G base stations than the United States of America (USA), not only in absolute terms but also per capita, and that mobile phones capable of using 5G technology are immeasurably more affordable in the PRC, are often highlighted as a key point of technological inferiority of the USA [13]. The consequence of the pronounced rivalry between the two powers in the domain of 5G technology is the ban on the sale of Huawei equipment in the USA from May 2019. As it has been identified as a key partner of the Chinese authorities in this process, the governments of the USA and some Western European countries have proclaimed Huawei to be a threat to data security [14].

Regarding the artificial intelligence development, the authors generally agree that, unlike other segments of ICT, the volume of investments does not necessarily mean a certain advantage. However, the volume of investments is at the same time the only measurable indicator of researches. The PRC shows dominance in this category as well, albeit with a slightly smaller difference compared to the rest of the competitors [15].

While the Chinese government states that artificial intelligence will help shape the national economy by balancing supply and demand, Western authors do not fail to express the view that its primary purpose will be to monitor and control population [16]. These reactions represent radical attitudes, which were not typical for situations in which technological progress came from a single country of origin. At the same time, the motives for the development of the 5G network and artificial intelligence are not questioned in any other country, even in those countries that have a history of monitoring own citizens. Given the harsh rhetoric related to 5G technology and artificial intelligence, it is surprising the lack of reaction to the plans that the PRC has with blockchain technology.

4. BSN FRAMEWORK

Blockchain-as-a-service (BaaS) is an approach to improving efficiency in the development and management of blockchain applications. Service providers facilitate the implementation of blockchain applications by renting cloud computing services or customizing their own platform to client's needs. However, the solutions that emerge are usually vendor locked. Depending on the service provider, clients are either tied to its cloud or its blockchain platform. In addition, the client must have their own programming team with specific knowledge in the field of blockchain [17].

BSN is a Chinese government initiative to create a global core network for the development of heterogeneous business applications. Chinese State Information Center, China mobile, China Union Pay and Red Date Tech, which is responsible for the technical development, are the initiators. The technical basis is the FISCO BCOS open source protocol. The project was supported by well-known companies in the field of software development, hardware suppliers, finance and telecommunications, such as Huawei, Baidu, Tencent, Ant Group, Beyondsoft, Digital China, WeBank, Shenzhen Securities Communications and others. So far, a number of public blockchain systems have been integrated, the most famous of which are Ethereum, NEO, EOS, Tezos, IRISnet and Nervos. In addition, key private blockchain systems have been integrated: Hyperledger Fabric, ConsesSys' Quorum and Corda R3 [18].

The goal of BSN is to facilitate the development of blockchain applications for medium, small and micro enterprises, through the public provision of required services.

Businesses that access BSN do not need to lease server space or cloud computing services, which further lowers operational costs. Although the initiative is primarily intended for private and consortium blockchain applications, it will be possible to connect public blockchain with it, as has already been done on the example of several cryptocurrencies. In this sense, BSN represents a more comprehensive concept than standard BaaS solutions.

The project is based on a network of public nodes located in cities. This means that network nodes will not be owned by individual entities, but will be tied to a data center located in different cities. The plan is that at the full capacity the network has about 200 nodes located in the largest Chinese cities, but also in other world metropolis. At the time of writing, over 120 public city nodes are already connected in PRC, as well as 8 located abroad, including Tokyo, Sydney and Paris [19]. Public city nodes will be portals through which interested companies will enter the network.

They will make available services that are stored in a massive computer cloud, will control access, process transactions and store data [20]. The network is designed so that interested clients contact those nodes that are closest to them and buy services directly from them.

The key benefits of the initiative are cost savings, accessibility and flexibility. BSN enables medium, small and micro enterprises, and even individuals, to develop their own business applications with significant resource savings. Common tools and pre-built application patterns and templates shorten the development time, reduce the total amount of work required to run applications, and simplify maintenance. Thanks to them, the process of launching simple applications and their maintenance can be performed by developers without specific knowledge in the field of blockchain. It is estimated that the enterprises' costs related to specific blockchain activities will be reduced by as much as 80%. On the other hand, the existence of common online services and the recognizability of templates and patterns will make switching between applications easier. If cryptocurrencies are taken as an example of a business application, then BSN would enable faster transfer of values between different systems, with minimal transaction costs. A pictorial explanation was given by the CEO of CyberVein, who says that if cryptocurrencies can be viewed as individual wells, BSN then represents a network of pipes that makes a water supply system complete [21]. However, this is a simplified explanation, because a similar project already exists.

It is the Cosmos project, which is a blockchain system for exchanging digital assets between cryptocurrencies. BSN is a more complex system, because in addition to enabling the interoperability of existing platforms, it creates conditions for the quick and easy development of new ones.

5. POTENTIALS AND LIMITATIONS OF BSN

The comprehensiveness of the services that BSN will offer goes beyond the BaaS concept in terms of what commercial platforms have offered so far. The question that arises is why there was no reaction of key competitors in the technology race. The European Union (EU) is preparing to establish its own blockchain infrastructure called the European blockchain services infrastructure (EBSI). However, there is a fundamental difference in the purposes of these two networks. While BSN is conceived as a global network for the development of various business applications, EBSI has a primary purpose in the EU internal market [22]. The EBSI should be used to verify diplomas, provide notary services and verify the "European identity" of persons without the intervention of central authorities.

In other words, EBSI should take over part of the services provided by public institutions, unlike BSN, which is intended for commercial projects. There is no similar initiative in the USA.

A possible explanation for the lack of reaction is the uncertainty in the final form and scope of application of blockchain technology. For 10 years, cryptocurrencies have remained the only recognizable form of application of blockchain technology. In contrast, it was emphasized that the primary use of BSN should be for closed business systems and not for cryptocurrencies. Furthermore, as a significant number of cryptocurrencies have emerged on a wave of anarchism and resistance to the traditional financial system, BSN is probably not an attractive partner for most of them. Although there are indisputable potentials for the application of blockchain in other areas, ranging from public services, through supply chains and automated production, all the way to transport, it cannot be said that there has been a significant shift in any activity. The situation in which blockchain would become the industry standard in any field is years away. Gartner's vice president for market research, Avivah Litan, believes that this will not happen before 2028 [23]. In such circumstances, it is possible that key rivals of the PRC do not want to waste resources on technologies whose future they are not sure about.

The fact that the PRC is far ahead of the competition in other areas of the technological researches gives the opportunity to run the initiative of the global blockchain network independently.

BSN comes at the right moment for national interests of the PRC. The network is complementary to the BRI, as both projects aim to build a global infrastructure that will accelerate and increase trade, creating opportunities for international partnerships for Chinese companies. Both projects should enable the shaping of the specific position of the PRC in the international framework and can serve as a foreign policy tool. Many analysts agree that the realization of the BRI has been misunderstood from the very beginning as it will not be based on purely material investments. They believe that technological advances such as blockchain will actually be a basic building block of future trade infrastructure and in that context will replace concrete [24]. BSN could have a greater reach than the BRI in terms of creating business infrastructure, because the business processes it will host will be intended for (probably for the most part) local and national relations, as opposed to physical investments that primarily target international trade relations.

It has already been emphasized that cost saving is considered a key advantage. A survey conducted for the BSN white paper shows that the average annual price of leasing and maintaining infrastructure for a consortium blockchain is over $ 15,000 (100,000 Yuans). The same set of services supported by BSN would cost less than $ 500 annually (up to 3,000 Yuans) [20]. However, the essential advantage lies not only in lower costs for those clients who use the blockchain application, but also in increasing the availability and bringing the blockchain closer to a wider circle of potential clients. Lowering the technical requirements and the needed level of developers' skills creates conditions for blockchain business solutions to be widely used in companies that previously could not afford it. This can facilitate dispersion of blockchain platforms and accelerate the emergence of new ones, and ultimately act as a catalyst for a complete technological transformation. In this sense, BSN has the potential to make blockchain the industry standard.

However, a large number of analysts are skeptical about the future of BSN. They cite the fact that the project was initiated by the Chinese government as a key problem. One problem is that over-reliance on Chinese information infrastructure can lead other countries to a state of economic and technological dependence. The other is that Chinese state-owned companies provide

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the infrastructure base, rent server space and provide all software tools, including the cryptographic solutions. A large number of the professionals does not have full confidence in Chinese cryptographic standards and believes that the SM2 and SM3 protocols, that would be used, could provide the system owner with an option for access to confident files. Therefore, it is not unrealistic to expect that they can also have access to monitor all business applications. The PRC was previously accused of industrial espionage, while in this case it could have a complete insight, without hacker attacks. Although there is a possibility that these allegations are true, exactly the same arguments could be applied against the use of the Internet as a business infrastructure.

6. CONCLUSION

In the best case scenario, BSN will accelerate the expansion of blockchain-based business applications. Using of familiar tools, patterns, and templates will not only enable interoperability between applications, but will also lead to a process of standardization. With a reduction in average costs, the accessibility and understanding of blockchain applications will increase, which will ultimately create the conditions for mass application in various public and business functions. In not so-good scenario, BSN will lead to polarization when it comes to the development of blockchain applications. Political factors and distrust in security of information could deter most business clients from using offered services. Companies from countries that are considered to be partners in the BRI are likely to focus on using the infrastructure offered by BSN, while companies from Western Europe and the USA would use one or more separate platforms.

A key limitation of the paper is the uncertainty of the entire project at the time of writing. Although BSN is already operational, it is not even close to its full commercial capacity, because the network of public city nodes has not been established yet. The number of business applications is at a negligible level, so it is not possible to determine the ability of the network to cope with the information load, nor the positive effects of interoperability. In addition, there is a lack of reliable literature that would allow complete understanding of the concept. The white paper was published only in Chinese, while the English version is a translation of the original text, which is considered not to have been done most accurately. The technical characteristics of the project are not fully clarified either, and important details regarding cryptographic solutions are still unknown.

Undoubtedly, clarifying of perplexities will contribute to a better understanding of the project and an increase in the feeling of security.

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INFORMATION AND COMMUNICATION TECHNOLOGIES: USE BY COMPANIES IN THE REPUBLIC OF SERBIA

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Abstract:

In modern business conditions, development of information and communication technologies leads to everyday changes in a way of doing business in different industry sectors. Information and communication technologies include elements and skills which are oriented toward information and its creation, transmission and data storage. Relevance of previously mentioned technology can be noticed in reduce of money, time and etc. The importance of the development of the domestic digital society was also recognized by the state through the definition of the Strategy for the development of the information society in the Republic of Serbia until 2020. The strategy deals with issues related to the development of the digital society in the country. Report contains results regarding the use of information and communication technologies in operations of corporations during 2019 and 2020, which is published in Republic Bureau of Statistics. Based on those results, it has been concluded that there is tendency of growth when it comes to the use of information and communication technologies in the business operations of companies in Republic of Serbia. According to mentioned, there are data that indicate that hundred percent of companies use internet connection, there is increase in use of web sites and active use of portable devices with noticeable growth over the years.

Keywords:

ICTs, Digitalization, Cloud, COVID-19, Enterprises.

INTRODUCTION

Fast development of information and communication technologies (hereinafter ICT) lead companies to more efficient everyday operations, in a way of reducing money, time, energy and etc. In the global development agenda named Serbia and Agenda2030 [1] it is being highlighted that Serbia is in the process of developing ICT, which worsened the position of international competitiveness. The initial assumption is that ICT has become a key factor for successful adaptation of companies to new business conditions, especially in times of pandemic caused by the COVID-19 virus. According to [2] information technologies, information systems and business applications became key factors for successful adaptation of organizations to new business conditions.

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Use of ICT in everyday business operations brings major reduce of different resources by reducing time that is necessary to conduct business operations, as well as reducing complex bureaucracies. Furthermore, it increases quality of products and services and improves relations between companies and external business entities. Also, it is pointed out that today the application of ICT is inevitable for companies because the use of these technologies is so widespread that if the company does not use them, it negatively affects its competitiveness in the market, which can jeopardize its survival.

The fourth industrial revolution, ICT had enormous impact on development of digitalization [3]. Therefore, digitalization is becoming the main initiator of innovation, modernization, economic growth, competitiveness and comprehensive socio-economic progress and development. Nevertheless, global pandemic created environment where companies are orienting their business practices in a completely digital manner, due to completely changed way of life and business practices [4]. When it comes to new market conditions caused by the emergence of a global pandemic caused by COVID-19, great success has been achieved by companies that have managed to adapt their business procedures and practices. Effective reaction to new circumstances is another important element. Companies that have managed to successfully implement their business processes and convert them to online mode in short period of time have achieved good results. When it comes to the economy of the Republic of Serbia, many positive changes took place during the time of global pandemic. There is increasing number of eGovernment users and the importance of the existence of platform have been particularly evident in the previous period. The eGovernment portal was created by the Government of the Republic of Serbia with the idea of providing the citizens of the Republic of Serbia with faster and easier access to a large number of administrative tasks without physically going to various state institutions [5]. This was significant during the initial enforcement of measures that were need to comply with and referred to the measures of social distancing, reducing the number of people who are able to be present in certain area, etc. The analysis of the "Digital Serbia" initiative, shows that every third company in the Republic of Serbia accelerated the work on digitalization during the COVID-19 pandemic, even though less business activities in many areas has been performed [6].

2. TYPES OF CONTENT

Digitalization represents the use of existing technologies and information to improve or replace business processes, creation of profit and creation of environment for digital business in which information plays crucial role. On the other hand, digital transformation was defined as the integration of digital technologies in all areas of business that are the cause of fundamental changes in the way of doing business and the process of delivering value to customers [7]. The comprehensive use of digital technologies that fundamentally transform business models, completely change business processes. Beside the radical transformation in organization, digital transformation has a huge impact on the economy, government and society.

Therefore, the digital transformation represents unique evolution that will bring changes and growth in all business areas if it is used correctly and all opportunities that are being provided over time, while reducing the negative effects of all the challenges it can bring [8]. Also, it is important to mention that the digitalization of business processes has contributed to higher productivity, automatization processes, business control, data analysis, security of data storage as well as lowering operating costs and less possibility of errors in business processes. Aim of digitalization is being noticed in the use of advanced technology in business processes in corporations, in order to achieve capital market competitiveness [9].

The key elements of business digitalization are reflected in the following [10]:

- Cloud technology, which is one of the key elements in the process of improving the level of competitiveness in the market, optimizing costs and improving overall business efficiency. It enables central data storage, control of data access, easier retrieval of required documents and information, easier report writing and data security. It is crucial to indicate that main use of cloud technology is data centralization. According to Flexera report, research indicate that there is an increase of use of cloud technology, more than expected and reason behind it is restrictions made by COVID-19 during 2020. Furthermore, results indicate that up to 92% of surveyed companies use some form of cloud technology. Thereby, large companies are in the lead in terms of strategic planning and the amount of budget they allocate for the implementation of cloud

solutions in the future [11]. Research has shown that cloud alternatives can contribute to increasing productivity levels in the range between 35% and 40%, and that collaboration and cooperation via cloud technologies can increase the efficiency of internal business operations by as much as 90%. Cloud technology is available today in the following three different forms: public cloud, private cloud and hybrid cloud [12].

- Digital documents, in comparison with traditional paper documents, provide all data in digital format, which significantly reduces the cost of creating, sending and archiving documents. One of the key features of digital documents, in comparison with traditional documents, is their potential for automatic processing, because they can be generated and transferred automatically and directly from the sender to receiver.

- Data security – comparing with local servers, cloud technology offers more advanced level of security, because data has been stored off-site, in another word, the data is never in one place, which eliminates possibility of losing data. From the aspect of data security, certain individuals and some company departments can be banned from accessing the servers. Any changes in document, including opening and editing is usually registered in the activity log so all changes and who made them can be tracked all times [10].

3. USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN COMPANIES

Statistical Office of the Republic of Serbia monitors the development and use of ICT in companies and households. In the continuation of this paper, an overview of ICT trends from the aspect of companies operating in the Republic of Serbia will be presented. Statistical Office of the Republic of Serbia has issued a publication entitled as Use of Information and Communication Technologies in the Republic of Serbia, 2020, on the basis of which information regarding the work of enterprises during the reporting period will be presented. Previously mentioned research was conducted in march 2020 based on telephone interview. The sample included 1,571 companies operating in the territory of the Republic of Serbia and the response rate was 80.60% (1,270 enterprises) [13]. In order to compile the sample, classification of legal entities was conducted on the following basis:

- Small sized entities (10-49 employees): 583;
- Middle sized entities (50-249 employees): 424;
- Large sized entities (250+ employees): 263.

Due to unusual circumstance during 2020 as a result of COVID-19 where companies had to modify their business practices, the results show that in the Republic of Serbia, 100% of companies have an Internet connection. However, due to the introduction of a state of emergency during 2020, the Government brought a Decree on organizing the work of employers during a state of emergency, which organized work from home. In this regard, the results of the analysis showed that 81% of households in the Republic of Serbia have an Internet connection, which is an increase of almost 1% compared to 2019. Furthermore, it is important to indicate that 97,8% of households with income over 600 euros owns internet connection. From the aspect of computer usage, the number of users increased by almost 2% compared to 2019.

From the aspect of mobile internet usage for business practices, analysis shows that during 2020, 77% of companies use a mobile internet connection through portable devices, such as: smartphones, laptops, tables and etc. According to the size of legal entities, use of portable devices for mobile internet connection is mainly used by large entities with a share of 91.1%.

During 2020, 84.4% of companies own website, which is an increase of almost 1%, compared to 2019. When it comes to the structure of companies by size, analysis shows the following results:

- Small size entities: 82,8%;
- Medium size entities: 89,1%;
- Large size entities: 95%.

In regard to e-commerce, during 2019, 27.9% of companies in the Republic of Serbia, places their products and services via the Internet. When it comes to the structure of companies by size, analysis shows the following results:

- Small size entities: 28,1%;
- Medium size entities: 30,2%;
- Large size entities: 14,7%.

During 2019, there was an increase of electronic invoices that were being automatically processed, and in regard to this, the analysis shows the following results when it comes to the structure of companies by size small: 18.8%, medium: 18.1% and large: 30.7%. On the other hand, the share of electronic invoices sent electronically, which are not suitable for automatic processing, was much higher, small: 68.9%, medium: 69.8% and large: 89.1%.

However, it must be noted that the largest number of invoices are still issued in paper form, where small legal entities have participation of 98.8%, medium entities have participation of 97.4% and large entities have participation of 100%.

4. USAGE OF CLOUD SERVICES

As previously mentioned, cloud is synonym for availability, speed and efficient data management. They also include ICT services that are accessed via the Internet for the purpose of using software, storage space and etc.

Main features of cloud services:

- They are located on the servers of service providers;
- Can be used at the request of users;
- They are paid based usage space capacity.

From the aspect of cloud usage service, Statistical Office of the Republic of Serbia displays following data.

Exactly 18.6% of companies in the territory of Republic of Serbia pay for cloud services via the Internet. From the aspect of company structure by size, the analysis displays following results:

- Small size entities: 15.4%;
- Medium size entities: 29.1%;
- Large size entities: 33.6%.

Cloud services that are being used over the Internet are as follows:

1) Email:
   a) Small size entities: 78.1%;
   b) Medium size entities: 80.00%;
   c) Large size entities: 78,1%.
2) Office software
   a) Small size entities: 65,6%;
   b) Medium size entities: 81,50%;
   c) Large size entities: 73,1%
3) Hosting database of legal entities:
   a) Small size entities: 58,9%;
   b) Medium size entities: 65,70%;
   c) Large size entities: 50,3%.
4) File storage:
   a) Small size entities: 50,30%;
   b) Medium size entities: 58,70%;
   c) Large size entities: 48,90%.

5) Software applications:
   a) Small size entities: 53,70%;
   b) Medium size entities: 45,10%;
   c) Large size entities: 37,30%.
6) Customer relationship management (CRM) software applications for customer information management:
   a) Small size entities: 23,10%;
   b) Medium size entities: 21,80%;
   c) Large size entities: 24,60%.
7) Computer power to operate and manage software used by a legal entity:
   a) Small size entities: 21,30%;
   b) Medium size entities: 26,80%;
   c) Large size entities: 24,90%.

Medium and large entities are at the forefront in terms of strategic planning and the amount of budget they allocate for the implementation of cloud solutions in future business practices. Also, when it comes to cloud services, it is important to note that there are numerous benefits, such as efficiency and flexibility of business practices, increased availability and security of data (better security of IT systems), availability of various options (public, private and hybrid cloud), cost optimization, increased productivity and time management.

5. ICT EXPERTS AND TRAINING

The term information and communication technology imply various elements and features for creating, storing and transmitting information. However, crucial element in the field of information and communication technology is the staff, which are call ICT experts, such as developers, system analysts and designers [2]. According to [4] there is increase in number of experts in the field of ICT, as well as their demand in the domestic and international labour market.

Based on the previously conducted analysis of the ICT usage in companies in Serbia, it can be concluded that there is an upward tendency of usage of ICT in company operations. Companies employed 19.3% of ICT professionals during 2020. In terms of size, large entities employ 69.2% of ICT professionals, while small entities employ 12.1% of ICT professionals. Furthermore, it is worth mentioning that large entities provided various training to employees for the purpose of developing ICT skills during 2019. In large entities, 76.7% of employees perform ICT functions, while in small entities 57.9% of external suppliers are in charge of ICT functions.

6. CONCLUSION

The technological revolution of ICT and digital technologies have created environment where companies and the economy as a whole had to adopt a completely new business concept. Nevertheless, it is important to note that main goal of the company's business remained unchanged, which is to maximize profits. Adequate implementation of ICT and digital transformation that is done in a timely manner, can drastically affect productivity, time savings, efficiency of management of available resources, reduction and optimization of costs. From the aspect of the usage of ICT by companies, operating in the territory of the Republic of Serbia in the period from 2019 to 2020, there is an upward trend in growth according to all analysis. According to the data presented in the paper, when it comes to the existence of the Internet connection, all companies (100%) included in the analysis have it. In addition, it is important to note that 77% of companies use a mobile internet connection through the portable devices, such as tablets, laptops and smartphones. A large number of observed companies (84.4%) have a website, which indicates the existence of awareness and willingness of companies to create their own image and present themselves online.

Taking into consideration the changes that have happened during the period of global pandemic, which are referred to the period after displayed results, it is necessary to look at this aspect in the future. It is important to note that when it comes to changes in business processes due to pandemic, companies probably did not change fundamental business philosophy, which is profit maximization, but only changed the forms of business activities that embrace bigger (or complete) transition to digital business.

Given that the emergence and spread of the pandemic in the previous period has posed a great challenge to companies in terms of the ability to adapt to new circumstances, the question remains whether this situation in the long run will affect the ways in which companies conduct their business operations. Question remained to be answered whether companies in Republic of Serbia, when pandemic is over, will continue with the positive trend regarding digitalization or it will decide to return to the traditional ways of doing business which were standard before the pandemic.

7. ACKNOWLEDGEMENTS

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APPARENT PERSONALITY ANALYSIS BASED ON AGGREGATION MODEL

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Abstract:

Apparent traits personality analysis based on multimodal traits from text, handwriting, images, and audio is a challenging problem in computer vision, signal processing, and deep learning. To improve models based just on one of the input parameters we will combine all four of them with the aggregation layer. Models based on handwriting and images are the best predictors of the Neo-PI-R results/profile derived from the results of the NEO-PI-R. In addition, to get the best results we showed different aggregation layers (Max, Min, Median, Mean). We obtain the highest prediction certainty for Consciousness, Extraversion, Agreeableness, and Neuroticism. While Openness to experience was very hard to predict with the use of the aggregation model. As the five traits are not homogenous, but consist of facets that do not necessarily converge, and deeper analysis of the facets shows that the score on the main trait is nothing more than the mean of the facets scores, and that limitation could be overcome by analyzing the facets' behavior and predictability. This limitation can be overcome with further research done in the domain of apparent personality analysis with traits and their facets.

Keywords:

Apparent personality analysis, personality classification, feature classification, aggregation functions.

INTRODUCTION

The first impression based on Big Five Personality Traits, or so-called OCEAN (Openness to Experience, Consciousness, Extraversion, Agreeableness, and Neuroticism) is one of the most frequently and explored models in human trait analysis. Vinciarelli & Mohammadi [1] showed in their paper that the automatic recognition, perception, and synthases of personality are some of the hardest domains of Computer Science. The personality traits approach is one of the most promising ones to assess personality characteristics/features, and the BIG-5 model is one of the most explored and possibly promising ones. The best model in the field of trait prediction is the model based on multiple input parameters, called multimodal trait prediction.

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This model is trying to have many important aspects of a person as an input, such as a person's handwriting, a person's digital text, a still image of a person or image sequence, and an audio signal of the person's voice. Gavrilescu & Vizireanu [2] showed that state-of-the-art models based on handwriting have an accuracy of more than 80% for all traits. Ponce-López & Chen [3] showed that some traits are easier to predict than others, such as "Agreeableness" which is very hard to predict out of the video material. State-of-the-art models have more than 90% accuracies as shown in the paper written by Zhang C. L. and Zhang H. [4].

They propose Deep Bimodal Regression (DBR) framework. Their model is based on the video which is broken down to images and audio features, where they combine the scores of the visual modality and scores of the audio modality. Studies in psychology are dealing with behavior (B), which is represented as a function of the person (P) at the given situation (S) [5], and apparent personality (A) is conditioned by the observer (O) and that is described by the function A = f(P, S, O). Our approach is trying to minimize the subjectiveness of the observer [6], and also the results shown by Vinciarelli [7] are allowing us to create statistical models of automatic personality computing. The main assumption is that traits are not rigid and if we want to have a better and more realistic model we need to combine more than two models. The main limitation of the previous research is that they are based on a small amount of the input parameters. In this paper, we are trying to combine more than two inputs and create the multimodal model with the combination of text, handwriting, image sequence, and audio-visual traits and a suitable aggregation function, aggregation layer which goal are to predict OCEAN profile better than a single input model or models based on the single neural network. The purpose of the aggregation layer is to convert an array with spatial dimensions to a vector that has a fixed size.

Aggregation functions that are represented in this paper are Mean, Median, Max, and Min. We have shown that the aggregation function can give us a better approximation of traits and give us more accurate results when we compare it to NEO Personality Inventory (NEO PI-R) test.
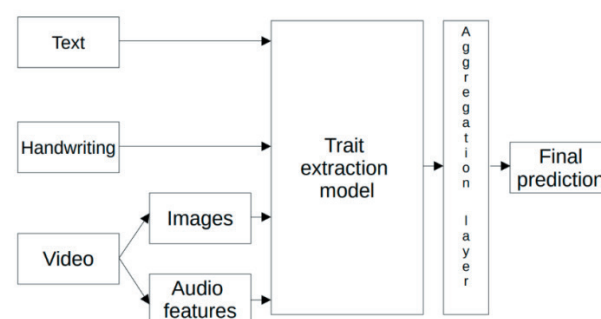
Figure 1. Framework of the proposed model with Aggregation layer, video is treated as having two natural modalities, and text and handwriting one natural modality, the final predicted personality traits are created from the aggregation layer by the fusion of all outputs of text, handwriting, images and audio features.

The challenging part of the personality analysis is connected to many factors that can affect results such as individual and cultural differences, observation conditions, random noise that can be found in camera and microphone, different styles of articulation, etc.

The proposed solution of combining four modalities with an aggregation layer strives to give a better result and to minimize factors that can affect the result. The aggregation layer will be created out of the aggregation function that we can find in the work of Grabisch & Marichal [8].

2. RELATED WORK

In this section, we will review the work that is related to apparent personality analysis from text, handwriting, images, and audio feature using deep learning.

2.1. PERSONALITY DETECTION FROM TEXT WITH MACHINE LEARNING

Deep learning methods that are used in previous papers are based on seven layers: input layer used for word vectorization and convolution used for sentence vectorization combined with max-pooling layer. After that, we have 1-max pooling for document vectorization and concatenation layer and linear with Sigmoid activation for classification and two-neuron softmax output layers [9,10]. The best approach as an input parameter to textual modality will be to uses vectorized words from wod2vec models [11,12,13].

Models proposed only from the text for extracting traits have lower results than other models. Best results are shown in previous works when CNN is used with document features. The same work is showing us that we cannot get better results if we use n-grams.

The best results are showed with the combination of Mairesse[14] and CNN[9] with accuracy O = 62.68, C = 57.30, E = 58.09, A = 56.71 and N = 59.38.

The advantage of this solution is that we need little data about the subject to predict their traits, which is why this model is very popular among the papers that are based on predicting traits on social network platforms. The drawback of a solution based on text is very close to 50% or very close to random prediction. To be useful this model needs to be combined with other models which are more precise in their prediction. The output of the majority of models proposed in several papers is binarised [0,1] which leads to a low prediction score and with a combination of accuracy of prediction it can lead to false predictions.

2.2. PERSONALITY DETECTION FROM HANDWRITING WITH MACHINE LEARNING

Handwriting analysis is a scientific method of understanding personality traits from patterns present in handwriting also from strokes. Paper proposed by Champa & AnandaKumar based on a set of rule-based classifiers has an accuracy of prediction rate of 68% [15].

Non-intensive three-layer architecture [2] based on offline handwriting offers prediction accuracies of 84.40% for Openness to Experience, Extraversion, and Neuroticism to 70% for Conscientiousness and Agreeableness. Very close to this model are Support Vector-Machines, k-nearest neighbors, and AdaBoost classifiers with 72% accuracy proposed from Chen & Lin [16] and Hidden Markov Models and neural networks Fallah and Khotanlou [17] with 78% accuracy.

Predicting personality, OCEAN traits from handwriting is the oldest scientific method. A drawback of this method is that we need to have a written message from the subject.

2.3. VISUAL-BASED PERSONALITY EXTRACTION WITH MACHINE LEARNING

Visual-based personality extraction is mainly done with the part of machine learning called deep learning and reinforcement learning. Deep learning is mainly related to the work in the domain of Convolutional Neural Networks [18,19] wherefrom each image or image sequence we can extract different traits. A different approach than this is mainly done in the domain of reinforcement learning and the long-short term memory approach [20]. Deep Bimodal Regression is represented in a method based on deep regression for the visual modality [4].

	Accuracy of prediction
NJU-LAMNBDA[4]	91.1
LSTM[18]	69.4
GME-LSTM[18]	76.5

Table 1. Comparison of visual-based personality extraction with convolutional neural networks, reinforcement learning, and long-short term memory and Deep Bimodal Regression.

The advantage of this solution is that prediction is very accurate, and most of the time with state-of-the-art approaches. A drawback is that we need many images for training, and the classification of the images can be very hard. Therefore, this is why databases for this specific problem are hard to find. Some of the predictions within the traits like Openness to experience and Neuroticism are hard to detect accurately.

2.4. AUDIO-BASED PERSONALITY EXTRACTION WITH MACHINE LEARNING

The main methods of predicting audio-based features are time domain and frequency domain features. Linear Prediction Cepstral Coefficient (LPCC) [21] and Mel Frequency Cepstral Coefficients (MFCC) [20] are based on short-term spectral-based sound features which are obtained from spectrum-of-a-spectrum of audio files [4].

Deep Bimodal Regression uses a log filter bank called log bank features based on Mel Frequency Cepstral Coefficients (MFCC) and results represented with the DBR are outperforming MFCC results by 0.75% with an accuracy of prediction of 89%. In the majority of papers, this method is used if we want to find binarised output [0,1], and this will lead to unrealistic predictions.

3. THE PROPOSED AGGREGATION METHOD

Aggregation method that we want to explore in this paper is based on several Aggregation functions. Aggregation function is the function that is the process of merging multiple values into a single value which in this case will represent our trait. The main problem with previous methods is that all of the methods are good at predicting some of the traits while some traits are not represented in the way that we want. For example, it is very easy to predict Neuroticism from handwriting and very hard to predict this trait from images [2,4]. Openness as a trait is very hard to predict from handwriting and images and videos are giving us better results [2,4,15,16,17,19,20]. The output value of the aggregation function needs to compute a value that will represent all possible inputs and give us a very close, sometimes near-perfect approximation of the real input. The input of the aggregation layer can be represented as a matrix of size 5x4, and this will be the same for all aggregation layers, and with the output represented as a vector of size 5. The matrix that we have on input will be represented with values $0 \leq input \leq 1$ (1) and the vector that we have as output will be represented with values $0 \leq output \leq 1$ (2).

$$M_{input} = \begin{bmatrix} T_o & H_o & I_o & A_o \\ T_c & H_c & I_c & A_c \\ T_a & H_a & I_a & A_a \\ T_n & H_n & I_n & A_n \end{bmatrix} \tag{1}$$

$$V_{output} = \begin{bmatrix} O & C & E & A & N \end{bmatrix} \tag{2}$$

Matrix will be represented o through the values extracted from the Trait extraction model shows in Figure1. Variables $\{T_o, T_c, T_e, T_a, T_n\}$ will represent personal traits detected from text, $\{H_o, H_c, H_e, H_a, H_n\}$ are OCEAN traits detected from handwriting. Traits from images will be represented as $\{I_o, I_c, I_e, I_a, I_n\}$ and $\{A_o, A_c, A_e, A_a, A_n\}$ are the set of audio-based traits.

Vector *Voutput* will represent the final prediction of all traits O - Openness to experience, C - Consciousness, E - Extraversion, A - Agreeableness, and N – Neuroticism, and output values will be represented in the range of $0 \leq output \leq 1$.

Min and Max aggregation functions are represented with the formula (3) (4). The output of the min function should yield the numerically smallest of the numbers between $\{x_1, ..., x_n\}$. The output of the max function should yield the numerically largest of the numbers between

$\{x_1, ..., x_n\}$. In literature, we can find that minimum and maximum functions can be represented using the lattice operations ∧,∨ shown in formula (3) (4)

$$Min(x) = \wedge_{j=1}^{n} x_i \tag{3}$$

$$Max(x) = \vee_{j=1}^{n} x_i \tag{4}$$

The next function that is represented will be the arithmetic mean function AM: $I^n \to I$ (5). The mean function is also known as the expectation function or average function.

$$AM(x) := \frac{1}{n} \sum_{i=1}^{n} x_i \tag{5}$$

The median aggregation layer should return the median of the elements in a list. To get the median of the list we need first to have a sorted list, or the average of the two center elements if the list is of even length. We need to make a difference if the input to our median function is an odd number of elements (6) or is an even number of elements (7).

$$OddMed(x_1, ..., x_{2k1}) := x_{(k)} = \\ \wedge_{\substack{K \subseteq [2k-1] \\ |K| = k}} \vee_{i \in K} x_i = \vee_{\substack{K \subseteq [2k-1] \\ |K| = k}} \wedge_{i \in K} x_i \tag{6}$$

$$EvenMed(x_1, ..., x_{2k1}) := AM(x_{(k)}, x_{(k+1)}) = \\ \frac{x_{(k)} + x_{(k+1)}}{2} \tag{7}$$

4. EXPERIMENTS

The only problem is the lack of a database that contains text, handwritings, and video and extracted traits for the model proposed in Figure 1. To support the study, we build our database. The database contains a collection of text, handwriting, and video, including images and audio features from 64 subjects (31 females and 33 males), where the subject age is between 18 and 70 years old, as well as their result of the NEO PI-R test from which personality traits are evaluated correctly. All subjects took the NEO-PI-R test and the main evaluation of our model of prediction will be when we compare results of the NEO-PI-R test with the results of the model proposed in Figure1. Also, we collect a short video sequence with audio from all subjects and an example of their handwriting as well as a short essay.

For the text, we used a model based on CNN + Mairesse [9] and for handwriting, we used non-intensive three-layer architecture [2]. The text is based on vectorized words from wod2vec models [10,11,12,13], and audio–based features are based on Mel Frequency Cepstral Coefficients (MFCC) [20], with values represented with 1 or 0. We need to be very careful how we are going to use text and audio-based traits in the final prediction because of the polarity between 0 and 1.

Traits based on	Absolute error[Δx]				
	O	C	E	A	N
Image	0.03	**0.01**	0.03	0.03	**0.01**
Audio	0.14	0.11	0.10	0.03	0.06
Handwriting	**0.02**	**0.01**	0.02	0.02	0.03
Text	0.24	0.17	0.03	0.07	0.10
Max aggregation	0.27	0.29	0.35	0.32	0.34
Min aggregation	0.55	0.46	0.46	0.45	0.48
Mean aggregation	0.11	0.07	**0.01**	0.03	0.04
Median aggregation	0.07	0.05	0.04	**0.01**	0.02

Table 2. Results of proposed aggregation model compared with NEO-PI-R results and different trait prediction models, absolute error.

Traits based on	Relative error[δx]				
	O	C	E	A	N
Image	2%	9%	14%	3%	5%
Audio	9%	13%	10%	4%	2%
Handwriting	**1%**	4%	8%	3%	5%
Text	31%	25%	15%	10%	8%
Max aggregation	52%	60%	72%	63%	68%
Min aggregation	81%	79%	75%	71%	77%
Mean aggregation	10%	6%	**7%**	**1%**	**1%**
Median aggregation	5%	**3%**	15%	5%	5%

Table 3. Results of proposed aggregation model compared with NEO-PI-R results and different trait prediction models, relative error.

Results showed in Table 2 and Table 3 are the representation of absolute and relative error based on the result from the NEO-PI-R test and different models. Models based on handwriting and models based on images are models which are closest to the result of NEO-PI-R tests. Proposed models based on Max and Min aggregation are models that have the highest error of prediction when we compare them to the NEO-PI-R model. Models based on Mean and Median have an improvement over models based on handwriting and images. Openness to Experience is best predicted from models based on handwriting [Δx]=0.01,[δx]=1"\%" , while the models proposed in this paper have a large deviation of NEO-PI-R results.

Model-based on Mean aggregation gives the best prediction when it comes to Consciousness[Δx]=0.08,[δx]=6"\%". Extraversion [Δx]=0.03,[δx]=7"\%", Agreeableness[Δx]=0.03,[δx]=1"\%", and Neuroticism[Δx]=0.04,[δx]=1"\%" are best predicted from the model based on Median aggregation.

5. CONCLUSION

Apparent personality analysis based on multimodal traits is an extensive problem in computer vision and machine learning research. To improve results based on a different state-of-the-art model for apparent personality prediction, this paper has proposed different aggregation functions or layers built in the multimodal trait prediction. The revised NEO-PI-R [22] is one of the best instruments used for the prediction of Openness to Experience, Consciousness, Extraversion, Agreeableness, and Neuroticism. The solution showed in this paper showed that we can get very close predictions from multimodal models based on Mean and Median aggregation functions, for every trait apart from Openness to experience.

Feature work in the domain of apparent personality analysis can be improved in the domain of prediction not only BIG-5 traits but also their facets [23]. This can lead to a more accurate model and a better representation of the subject's traits.

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INTERNET TECHNOLOGIES AND APPLICATIONS IN EDUCATION AND LANGUAGE LEARNING SESSION

EDUCATION IN THE CONTEXT OF IT REALITY

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Abstract:

The technological reality of the global village has expanded man's senses and led him to a new translation and revaluation of patterns of behavior, mutual communication, culture, lifestyle at the speed with which new technology improves and marks reality. In the new context of shaping knowledge, attitudes and values, education appears as a mediator of the individual and the community, desires and possibilities, freedoms and norms. Education has a role to enable those who learning to understand contemporary culture and society, to shape their own identity and resistance to media manipulation, to respond alternatively, creatively to the challenges of modern mediated and alienated society. The process of education becomes more complex because in addition to technological configurations, numerous social and institutional factors participate as bearers of power, influence and manipulation in the system of mediation. In the context of the above mentioned, media didactics and media education are constituted as synchronous sciences that interact mutually and develop concepts of critical analysis of one's own environment as well as the content of contemporary media and consumer culture, its meanings and effects. The critical perspective opens with the constitution of critical media pedagogy based on solid communication, sociological and philosophical foundations and knowledge of the ontological, epistemological and value dimensions of each media mediation and education.

Keywords:

education, media, pedagogy, technology, internet.

INTRODUCTION

By the nature of its social mission, education is always a kind of mediation between the man and the world, between truth and reality, between being and thinking. That is why the whole school and educational system necessarily has its intermediary or media dimension. In an effort to reach a set ideal or pattern of knowledge, attitudes and values, the school has always emerged as a mediator between the individual and the community, desires and opportunities, freedoms and norms. Not only education, but all other spheres of human life, depend on intermediaries and the rules they establish.

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Human knowledge and the overall results of cognitive processes are largely determined by intermediaries or media that are placed between the subject and the object of cognition. McLuhan's maxim "The medium is the message" is valid not only for the world of journalism, but also for the world of science and scientists [1] and the educational process becomes complicated when we know that, in addition to technological configurations numerous social and institutional factors participate in the mediation system as holders of influence and manipulation. In the Media Manifestos, the French mediologist Debray points out: "The mediator creates the law".

Mediation determines the nature of the message; the relationship takes precedence over the being. In other words, it is bodies that think, not mind. The compulsion of incorporation produces corporations - those intermediary bodies and institutions of knowledge, standardized and normative, which we call schools, churches, parties, associations, thinkers' societies, etc. [2]. Critical *media pedagogy* must therefore be based on solid communication, sociological and philosophical foundations and knowledge of the ontological, epistemological and value dimensions of any media mediation.

The main purpose and mission of critical media pedagogy would be to enable students and all citizens to understand contemporary culture and society, to create their own identity and resistance to media manipulation, as well as to encourage media to create alternative and creative forms of culture in order to transform contemporary media and alienated society: "Critical media pedagogy develops concepts and analyzes that enable readers to analyze the contents of contemporary media and consumer culture critically, discover the meanings and effects of their own culture and thus help them gain control over their own cultural environment. I think that the criticism of culture and media pedagogy requires the application of social theory and that this critical theory of society should also be based on the media and the study of culture as critical methods, in order to provide an essential insight into the structure of modern social life. Thus, this project combines methodological strategies, theories and concepts of both modernist and postmodernist theories, trying to create a critical perspective suitable for analyzing the most important cultural and social phenomena of the modern age." [3].

Pedagogy encounters the phenomenon of the media not only at the aforementioned critical and communicative-philosophical level, but also at the daily, methodological-technical level. We will show that on the example given by the famous German media teacher Tulodziecki. Imagine that a teacher plans to convey and explain the content of the term "park" to his students. He can do this by going with them to some real park near the school; may also process the content of the term park using a park model with trees in a sandbox; furthermore, the teacher can show the students a film or a series of slides about the park; and finally, he has the opportunity to explain verbally the concept of a park to students. Based on this example, it is possible to distinguish at least four forms of presentation of teaching content:

- a real form, which exists in active action in reality, personal encounter with people or in practical relationship with things,
- a form of model, which is represented in the use of reality models or in simulation in role-playing,
- a form of mapping, when information and knowledge are obtained by means of a representation that is true to reality or is given as a schematic representation,
- a symbolic form, consisted in obtaining information through written or oral verbal presentation [4].

In the broadest sense, any form that represents content can be labeled as a *medium*, and based on such a definition, it can be concluded that all teaching and educational procedures and processes contain one media component. This component plays a very important role in the performance that learners will develop about reality. It is obvious that most of the forms of presentation of some teaching content represent a reduction or interpretation in relation to the real world. Cognition through models, schematics, or verbal symbols can lead students to inadequate or misconceptions about life and the world. Hence, the theory of learning emphasizes that teaching processes and models should be based as much as possible on real situations and solving real life problems. Of course, that is not always possible and it is not always necessary. On the one hand, there are scientific disciplines that by their nature are more oriented towards the world of symbols and abstract concepts. On the other hand, there are numerous situations in which students already have direct experiences about some parts of reality and therefore can learn well and acquire knowledge based on models, schematic representations or symbolic forms of presentation of teaching content. Such considerations lead us to two important epistemological and pedagogical questions:

- Which media and what forms of content presentation are the most suitable for students to create appropriate representations and knowledge about the section of reality that is being processed?

- How to counteract the danger of creating inappropriate or misconceptions about reality through the media?

The answer to the first question constitutes a discipline called *media didactics*. The goal of media didactics is to establish the best ways to use the media in order to encourage and support the learning process. Media-didactic research was first conducted in the form of comparative research on the effects of different media on the success of learning success. The question of where in a teaching process a particular medium is most appropriate has led to the development of media taxonomy. Taxonomy refers to classification systems in which media are classified according to some of their features or characteristics. Such features can be a way of perceiving the media (visual, audio, audio-visual); form of encoding media messages (pictorial, schematic, symbolic); suitability for certain functions in teaching (attention, thinking, etc.) [5].

The answer to the second question explores the field of *media education*. In this discipline, the media themselves, together with their educational potentials and dangers, become the subject of teaching or educational reflection and re-examination. Media education gained special importance in the time of rapid development and influence, first of television, and later of the Internet, as media that shape not only the world of education, but also the way of living and thinking as a whole. As within media education, the media themselves become the subject of pedagogical research, all theories and results of general media theory are interesting for this area. These theories are often classified according to the elementary model of communication (transmitter, message, and receiver). Thus, we can distinguish between research of broadcasters (e.g. studies on the institutional conditions of media production), research of messages (e.g. analysis of media content) and research of receivers or recipients (e.g. studies on the impact of the media on the audience, everyday life, values and behavior of children and youth).

Media didactics and media education are not separate sciences, but areas that overlap. Taken together, these two disciplines make up *media pedagogy*. In the literature, both the term media and the term media pedagogy are used in several different meanings, but the mentioned definitions can be a simple and clear guide for further research [6].

2. TECHNOLOGICAL AND SOCIAL CONTEXT OF NEW MEDIA AND THE INTERNET

The problem of content acquisition, learning and education is becoming greater with the strong penetration of new media and the Internet, which should be respected, and which are first manifested through two approaches: the first approach refers to *the issue of media form* and it asks how new forms of media communication can be adequately described. The other approach does not emphasize new technical developments and new technical forms so much as *subjective perceptions* of new media and *ways of handling* new media. Thus, the long-established opposition of medio-centric perspectives and perspectives turned to reception, i.e. users, continues in the scientific study of the media.

From the long history of this opposition in the study of mass communication, we know that we must connect both problems with each other, the media issue of form with the problem of subjective handling of the media, which especially refers to the field of new media. New forms of media show what is technically possible, and subjective ways of using it show what can be realized [7].

New forms of internet communication open up, firstly, individual approaches to media offers, and secondly, increased individual possibilities of intervention and organization. From the recipients who observe, people become users who actively create text. There are new ways of information, communication and entertainment. In the *field of information*, particularly striking spaces for communication are those of the "wiki" type, primarily the online encyclopedia Wikipedia. In general, everyone can write and correct texts. This space provides the ability to cooperatively create, correct and actively update texts. Unlike the generalized offer of the media in the field of mass media, it is noticeable here that the texts are constantly spreading, but they are also always changeable. Unlike books, which all offer one identical text, Wikipedia offers - always only potentially - changeable texts. It is surprising that Wikipedia, despite these possibilities of organization, and thus interference and abuse, also provides very high quality information. It can be reasonably assumed that the possibilities of participating in the creation of determinants are much less used than the possibilities of reception, i.e. the use of Wikipedia [7].

Various forms of chats, forums, blogs, etc. have emerged in *the field of communication*. On this platform, students leave information about themselves and this information is used to organize many things in everyday life,

such as looking for a roommate. In general, the boundary between private and public has become blurred, when choosing between restrained, business or personal access to the Internet.

In *the field of entertainment*, there are game worlds or virtual spaces like "Second Life", in which people meet to play and create artificial worlds together. Of course, the mentioned areas of information, communicative exchanges and entertainment cannot be clearly separated, moreover, there is a lot of overlap here [7].

It is certainly logical to describe these developments as shifting boundaries, especially the boundaries between producers (authors) and recipients (users) and the boundaries between private and public. Media sociology tries to shed light on such aspects of new forms of media communication. Here, in addition to the well-known possibilities of feedback, intervention and organization, other specific features should be mentioned, such as the anonymity of the participants and the related depersonalization of communication. Internet communication is often not about connections between specific persons who are perceived, identified as persons, but about intertextuality, connections between texts. The written form of the text in communication creates an insurmountable difference towards oral conversation insofar as users do not interact with people, but with texts, ie. symbolic representations. Personalities thus become symbolic representations [8].

In this context, even chat, which is rated as very interactive, loses its innocence. Written conversations can be closer to social interactions in terms of share synchronization, but the technological environment and communication transfer can always be observed. Communication procedure and reception processes, i.e. understanding as well as additional communication are separated, and communicative technology convincingly comes to the fore here. When the contingency and non-transparency of communication increase in this way, different streams of meaning can arise for more people participating in the chat. This is just a matter of explaining on an example which observations and analyzes the debate on media competencies in the context of Web 2.0 would be based on from the media-sociological point of view.

In addition to the issue of media form, as mentioned, when studying new media, *subjective observations and ways of acting of users* as a starting point can be analyzed. The interactivity of new media and their importance stem initially from the user's active and practical handling. But what does the practical handling of new media, ie. the Internet mean? This is indicated by some results of an online study entitled: "Onliner 2007: Network of participation in the age of the Internet" [9]. As the title shows, there is interest in active participation in the network, which grew from 2006 to 2007 from one quarter to one third of Internet users. The great interest of half of the users between 14 and 19 years of age is a less surprising fact. Yet the share of active creators is relatively small: three-quarters of weblog users are just looking for information. In the case of Wikipedia, this relationship is even more pronounced, which is certainly surprising for many: only 6% of users have written an article or added information at least once, and it is similar with video portals. The number of active users who create content is disproportionately smaller. The basic motivation and value for many users is obviously not the ability to participate actively in the network, but to be able to consume attractive content [9]. It seems familiar, if we compare this with the primary success of the leading traditional media, television. From a media point of view, there is undoubtedly a profound shift in media from one-sided mass media to networked "interactive" media, from a user point of view it seems that new possibilities are still little used: Wikipedia or YouTube for example, look more like mass media, only content is created and designed by individual users. What is the cause of the great reluctance to participate actively, ie the difference between the media available potentials of active participation and the insufficient realization of these potentials, is of great importance for the scientific study of the media. The issue of media competence in the context of new media is not less important.

As in the field of traditional media research, we need a research strategy that avoids one-sidedness. It threatens when we focus only on the problem of media form or only on the contexts and processes of the subjective way of handling. The requirement to observe not only the problem of the form of new media but also the contexts and ways of handling new media is placed to the same extent in the field of interactivity. The possibilities of new communication through computers should not be viewed only at the level of media form and subjective perception and use, but also in *given social contexts*. New possibilities of online communication and online groups are "twisted" into social contexts and in terms of their advantages and disadvantages, they depend on these contexts "If the interaction within an online group is connected to a social network, which also exists in the offline world, then it is called *the social embedding of online interaction* in the networks of the offline world"[10].

This embedding plays a central role in organizing and improving online interactions. Typical problems here are the ability to control or also the ability to build trust. It is often helpful to use the possibility of direct interactions outside the Internet so as to solve such problems. Internet-based competence learning and acquisition processes depend on social conditions, which can be organized and shaped.

3. MEDIA IN THE TIME OF THE INTERNET

The rapid growth of Internet use among young people has been accompanied by controversial views on the importance of experience in cyberspace and their impact on adolescents. The Internet has long been an integral part of adolescents' media everyday life. According to research data in Germany, 95% of households with young people aged 12 to 19 are connected to the Internet. The number of Internet users is increasing proportionally. The use of the Internet by young people has reached a certain level in the last ten years, after which no increase is expected. From the perspective of the generation of parents, it seems that the higher intensity of Internet use that is present among young people is a problem [11].

The virtual worlds that young people roam around while sitting in front of their computers are completely foreign to most adults. However, observing the great dynamics with which the media everyday life has changed during the last decade, it becomes clear that the habits of the Internet use by young people and the experience with the media of their parents have nothing in common. Parents and teachers seem to think that using the Internet carries various risks. So it seems that there is a great danger of getting lost online due to the time it takes to use the internet.

Content that endangers youth (violence and pornography) as well as contact with anonymous Internet users who present themselves as their peers seem problematic. Already in the 90s, when the use of the Internet was much less widespread among young people, we have scientific papers that emphasize the risks and chances of using the Internet in the context of media socialization and identity development: Critics of Internet communication point out that the everyday concept of identity is suspended. Who wanders in the virtual, does not want authentic. Personal identity is an illusion in a world ruled by techno-social cyborg mechanisms [12].

On the other hand, proponents of new media believe that the Internet offers a bunch of personal experiences and an important understanding: I am the crowd. The

pages on the Internet a new conception of a multiple but coherent identity illustrate in a particularly plastic way [12]. The Internet has become a metaphorical abode of the Self, and the user's identity is the result of the connections and relationships they establish. The Internet is a medium for expanding our intellectual and emotional identity in the age of globalization. According to some authors, Internet users who surf are at home, everywhere and nowhere. Children and young people become nomads on their own again. They can move from one point on Earth to another - and at the same time sit and live at home. Through this "new nomadism" humanity is being re-created and re-creating its world. As a technique used by today's youth on a daily basis, the Internet has proven to be a condition that determines the environment that determines the everyday life of a generation and its behavior. [12].

Bearing in mind the developmental tasks of young people, it can be expected that information and communication technologies for building new relationships could be functional, especially in relation to increased mobility options.

If we look at the historical development of the media, we can notice the flow of completely *autonomous media*, such as books or newspapers, through *diffuse media* that operate with the help of wave frequencies and cable connections (eg radio or television), through *communication media* such as the telephone, to *interactive media* as they emerge in the age of the Internet. Media communication on the global network has the following characteristics:

- multimedia
- hypertextuality
- non-existence of "gatekeeper"
- elasticity interactivity [13].

While traditional mass media use one or two dominant ways of conveying messages, multimedia involves combining text, images, graphics, animation, audio and video. Hypertextuality allows media content to be accessed in any way, without a firmly defined hierarchical structure. The Internet is an open network, in which no one but the computer determines the way in which the information will be transmitted. By elasticity we mean the fact that the Internet allows both instant communication (live) and multiple variations of delayed broadcasting of media content. Finally, interactivity implies a model of interconnected and mutually induced communication, which fundamentally changes the relationship between the media and the audience [13].

The first electronic online edition of the daily newspaper appeared in the spring of the 1990s, when the *Chicago Tribune* became available online. While the first electronic newspapers were content to be a digital copy of a paper edition, much more independent and creative sites soon emerged with the advantages offered by the network: interactivity, hypertextuality, openness to other digital sources of information [13].

Continuous updating of newspaper sites and interactions with readers in real time enables the personalization of media to the extent that they become the collaboration between producers and audience. Personalized and interactive multimedia communication changes the very essence of mass media: Compared to traditional, cyber journalism - as science fiction fans like to call it - takes the role of *gatekeeper* to extremes: The network is a huge information supermarket, where news gathering often resembles collage and hypertext connecting various sites of news agencies, television, business companies, public administration, with the scarce space left for writing and for individual creativity. There is a risk that the Internet will become a place of post-journalism, trapped in itself, where the encounter with reality remains in the background and always takes place through someone's mediation.

Another great novelty of monitoring information and learning on the Web is *interactivity*: the process of content personalization develops two-way information channels between those who post content and recipients, readers. This creates a possible remedy for the social opacity created by the abundance of supply, leaving wider freedom of choice to users, but also by renouncing the one who offers content from his own historical role of guide and orientation. Newspapers risk adapting to the supermarket formula, arranging ever richer shop windows, but avoiding the possibility of choice.

4. CONCLUSION

Digitization of media messages and integration of modern forms of communication, through the synergy of mobile phones, digital cameras, television, computers and the Internet, destroy the traditional media order and enable the emergence of the so-called civic access to content. It is a trend that, instead of professionals, media content is generated by technologically equipped amateurs who who happened to be on the site of an important event. Even traditional, institutional media, such as the BBC, realized the potential of a new kind of journalism, encouraging users on their site to send their photos and videos to the newsroom, with the message: *Important things may happen anywhere and anytime - we we want you to be our eyes.* Once something appears on the Internet, it can multiply endlessly, it allows people to see what they want to see. 'Broadcasting', the traditional model of 'old' media, is slowly but surely replacing 'clicking': instead of 'receiving' (the official film of execution), content is now 'taken' (a recording of the hanging taken by a mobile phone). The unexpected effect of technology, which increased state surveillance capabilities to Orwellian borders and exacerbated *Big Brother* syndrome, is the fact that we no longer have to be just objects of control: armed with digital cameras, mobile phones and the Internet - we are also watching them.

Marshall McLuhan predicted that the development of electronic media would unite the world into one big *global village*. As soon as technology expands our senses, there is a new translation and revaluation of culture, at the speed with which new technology is perfected and marks the world of reality. McLuhan's prediction has been fully realized. Something that happened in any part of the world almost simultaneously becomes news that can affect all people on the planet.

However, even the ingenious McLuhan could not have foreseen all the speed and depth of the changes brought about by the Internet and new communication and media technologies. These are new phenomena such as digitalization, media integration and interactivity, which call into question the very concept of mass media. The Internet opened up new perceptual and cognitive possibilities, set different standards in the preparation, transmission and reception of media messages, and opened up unimagined perspectives on communication. Of course, the Internet brought new controversies, starting from the question of whether it is a medium in the full sense of the word, or the Internet is just a virtual space in which all media are united, to the question of responsibility for the quality and reliability of online information.

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INTERNET TECHNOLOGIES AND APPLICATIONS IN EDUCATION AND LANGUAGE LEARNING SESSION

VISUALIZATION OF FORMAL SEMANTICS - POSSIBILITIES OF ATTRACTING FORMAL METHODS IN TEACHING

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Abstract:

The goal of formal semantics of languages is to reveal the nature of a language beneath its syntactic surface. One of the popular and frequently used methods is operational semantics. Its categorical representation using coalgebras is a new approach to semantics. Current trends show that software visualization of various calculations contributes to clarity and easier understanding. To support students' interest in semantic methods, we designed and prepared a software tool whose task is to visualize computations in coalgebraic operational semantics.

Keywords:

Coalgebraic Operational Semantics, Formal Semantics, Software Visualization, University Didactics, Education.

INTRODUCTION

The global COVID-19 pandemic has directly influenced the change of the basic worldwide concept of head-to-head teaching in schools and universities [1,2,3,4]. It was necessary to react quickly and reorganize teaching to be all online, using online platforms as virtual classrooms. Initially, all forms of online communication were used, from Skype, Viber, through Zoom, Discord, Webex platforms to Google classrooms, only to establish communication with students. Now, after more than a year of constant online teaching, the choice of platforms has stabilized and schools have mostly decided to use one platform in their teaching. In this way, the education was implemented in the home environment.

Besides that, the COVID-19 pandemic has provided an opportunity to strengthen and to spread digital learning, in last decades with a development of ICT, contemporary education has already started with use of visual applications which facilitate comprehension of the teaching subjects [5,6,7]. Dynamic Geometry Software (DGS) is widely used for visualisation in teaching and learning mathematical topics [8, 9, 10, 11, 12].

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The KEGA project (cited in Acknowledgment) is focused on improving and making teaching methods more attractive applied in the lecture and laboratory part of the subject. Its topicality is growing especially in the present, when the current full-time teaching replaced by a combined and distance form. Our goal is to apply modern software solutions in this course as a significant help in lecture and laboratory activities during the teaching of the subject, in all forms teaching (full-time, part-time, distance) and to a large extent also support independent preparation of students.

In the future, we want to apply the proposed software solution for the evaluation part of the course (tests, exams). During the work on the project, we focus on the preparation and implementation of an integrated package of programs that will allow illustrative and understandable use of semantic methods. In this way we will achieve a greater clarity of the applied procedures and principles in the teaching of the subject.

The paper is organized as follows: The second section provides an overview of related work. Section 3 introduces our coalgebraic operational semantics translator which translates Jane language into coalgebraic operational semantics. In the Section 4 we give the architecture of most important parts of application. Last section concludes the paper.

2. RELATED WORK

The practical usage of the coalgebras in computer science used for teaching of formal methods for young software engineers is given in [13]. Operational semantics was introduced by Plotkin in [14]. Structural operational semantics of imperative language Jane is presented in [15].

Due the pandemic, e-learning become the main form of educational activity at all levels of education [1,2,3,4]. On the other side, when e-learning was not mandatory, as it was in during last year, it was often associated with problems resulting from the lack of interactivity and the simple transmission of knowledge from the computer screen. To overcome this shortage, we have developed web application where students can see how semantics works: in coalgebraic (operational) semantics, the Q endofunctor performs one calculation step for each application [16].

3. COALGEBRAIC OPERATIONAL SEMANTICS TRANSLATOR

Coalgebraic operational semantics translator is a web application, which translates extended version of Jane language into text and diagram representation of coalgebraic operational semantics. The translation is done in the following steps:

1. Code input
2. Lexical and syntax analysis
3. Code structure
4. Showing result

First, we have to write text input (see Listing 1), that should be a code in Jane language.

```
var x;

input x;
x:=x+1;
print x
```

Listing 1 - An example of a code written in Jane.

The input goes through lexical and then syntax analysis. Basically, if input is not written in Jane language or has some lexical or syntax errors, we cannot translate the code into coalgebraic operational semantics. If there are no errors in user typed code input, then we can do semantics analysis and go further with translation.

With syntactically correct code we create a code structure, which is our representation of code output. We analyse each line of code and create their instances. Each line of code instance has all information about that line of code. For example, from assignment statement we keep information of variable, in which we assigned an arithmetic expression and we also keep information about the arithmetic expression as well, so in next step we have all needed information for translation. We create code structure even if code had grammar errors, but of course we won't have information about execution of lines of code, we will instead have information about those grammar errors, what caused them and on which line and column of code the given error occurred.

In the case of getting grammar errors, we show them to user, so the user can fix his code and do the process all over again. Otherwise, we translate code structure into coalgebraic operational semantics and show its text, as shown in Figure 1, and diagram representation as shown in Figure 2.
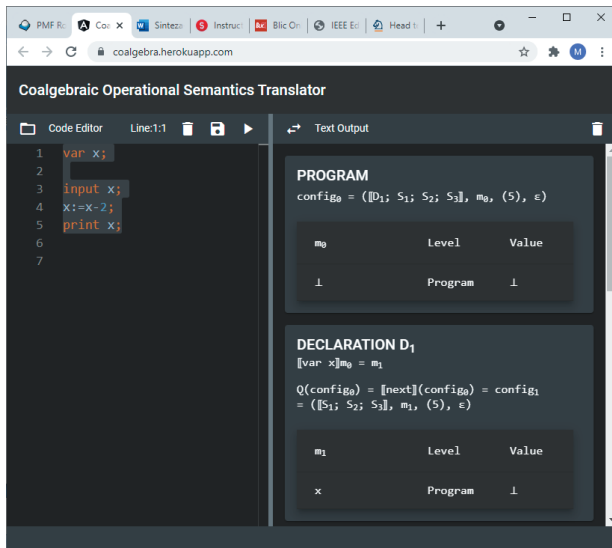
a) Program and Declaration
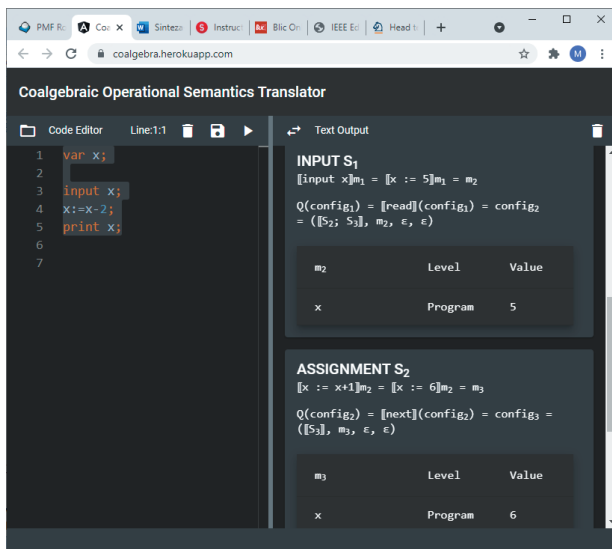
b) Input and Assignment
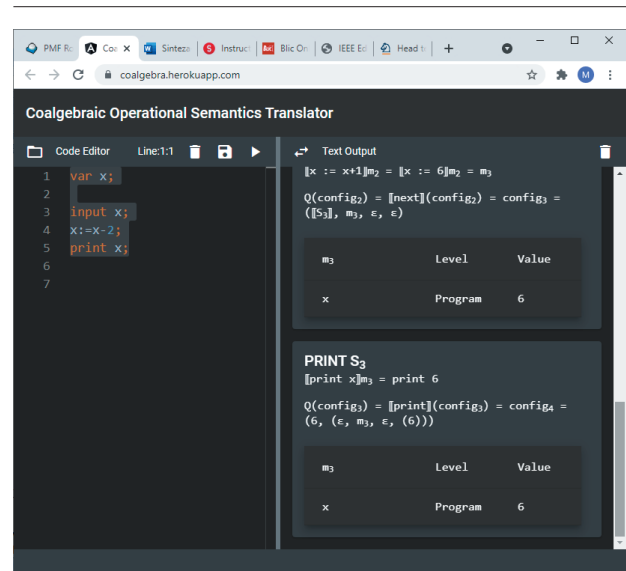
c) Print

Figure 1 – Text output for x=5.
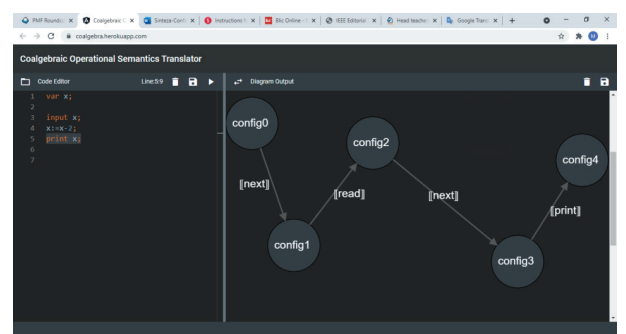
Figure 2 – Diagram output for x=5.

4. ARCHITECTURE

Behind steps explained in previous section is the architecture separated in two logics: front-end and back-end (Figure 3). On front-end we have implemented code editor powered by Monaco editor [17] created by Microsoft and derived from their Visual Studio Code editor. As the code is inserted, it is sent to back-end, and the code structure is obtained. When the result gets back, it is shown to user. If there are errors, the interactive error message containing information of issue that caused the error is shown together with a line and a column, where the error occurred. When there is no error, it is shown the translation into coalgebraic operational semantics.

The text representation is also interactive; all executed lines of code are clickable, highlighting the lines of code, which were translated. In diagram representation of coalgebraic operational semantics all the configurations and steps between them are shown, with clickable nodes, also highlighting the lines of code, which were translated.

Back-end part consists of analysing the code input with lexical and syntax analysis done by ANTLR created by Terrence Parr [18]. ANTLR also gives us the opportunity to easily attach semantics analysis to the process. We have created grammar for ANTLR given in [19].
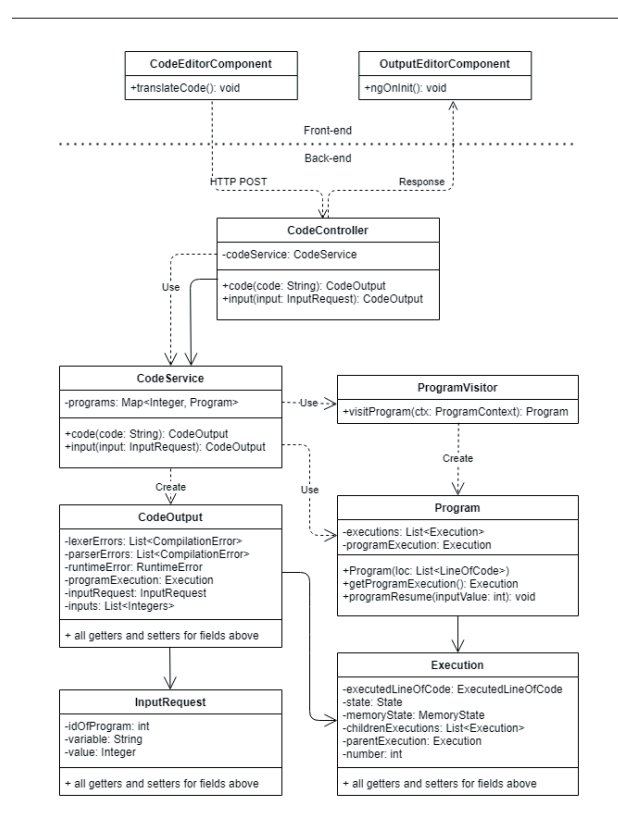
Figure 3 – Architecture.

5. CONCLUSION

In this article, we presented the results achieved in the field of research and development of software tools, which contribute to the attractiveness of teaching semantic methods and which contribute to the clarity of the semantics and its deeper understanding. Educating young IT experts is always a challenge: how to keep up with trends in information technology and how to pass on information to students. Formal methods have their irreplaceable place in software engineering. Almost all formal methods have their basis in the formal semantics of languages.

Thanks to this, the education of future software experts is always supported by a course on formal semantics. In the field of formal semantics, there are several directions, some of which require deeper mathematical knowledge, other methods are also suitable for developers who work with a mathematical basis only minimally.

The use of category theory highly contributes to a solid mathematical basis for formal methods. Categories have a strong expressive ability and allow to model relationships between mathematical structures in a very elegant way. The software tool we presented in this work allows us to visualize and model the coalgebraic operational semantics defined in [20].

We want to further apply the results from the modeling of categorical semantics in teaching. Experience shows that the software has a very good response from students. Students understand the principles of methods very well, if they do not work exclusively with mathematical relations, but can visualize calculations in semantics on an interactive basis.

We are of the opinion that the development of (own) visualization software tools will contribute to the attractiveness of teaching formal methods for students and engineers in practice, especially during distance learning, but also during full-time teaching, as interactive visualization brings some dynamism to the teaching process.

6. ACKNOWLEDGEMENTS

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INVESTIGATING MECHANISMS TO INCREASE STUDENT ENGAGEMENT IN HIGHER EDUCATION LEARNING ENVIRONMENTS: TESTING EMERGING AND IMMERSIVE TECHNOLOGIES TO MEET TEACHING NEEDS

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Abstract:

Based on the current research evidence on the effectiveness of lectures, it is possible to conclude that lectures can be of value, provided they are structured as interactive events and not periods consisting solely of presentations by the lecturer. With such a range of educational technologies available (including augmented and virtual reality), it is important to ensure that the appropriate digital tools are adopted. One of the key factors in this decision must be the views of staff and students. In this paper, a part of workshop-based research (involving teaching demonstration, direct interaction and feedback) about immersive technologies with staff and students (N = 33) from King's College London was presented. The findings have shown that participants had a wide variety of views about the use of augmented and virtual reality, as well as different needs regarding technological solutions in learning environments. Novelty of this research is demonstrated providing an overview of the landscape of pedagogical possibilities of immersive technologies using simplified didactic process maps.

Keywords:

higher education learning environments, students' engagement, technology-enhanced learning, augmented reality, virtual reality.

INTRODUCTION

Conventional lectures are the dominant form of instruction in most universities. Yet there are several issues with them as a mechanism for educational delivery. Kelly et al. [1] observed student engagement across three instructional methods (lecture, problem-based and team learning) and found engagement to be the lowest in the lecture. The common one-to-many transmissive nature of lectures can create a passive learning experience and does not always foster sufficient engagement. Further, large attendance lectures are not always successful at providing interaction opportunities. Also, as Schmidt et al. [2] argued, lectures often "do not promote critical thinking; student attendance tends to be low and so is cognitive engagement" (p. 12), and many students find lectures to be both lacking in interest and only partially effective at aiding learning.

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Additionally, Mann and Robinson [3] pointed out that boredom in lectures is a significant factor in diminished academic achievement. Indeed, this has led some such as DiPiro [4] to question why we have lectures at all. However, while there are issues with conventional in-person lectures, their use is widespread, and they can be a positive learning experience for many students [5].

Saito and Smith [6] identified some factors relating to engagement, which emphasised the environment and psychology of the learner. Lectures incorporating active learning methods have a strong empirical basis for increasing student engagement and examination grades as compared to traditional lectures. For example, the research conducted by Freeman et al. [7] found that undergraduate science, technology, engineering and mathematics (STEM) students' performance on examinations and concept inventories increased by 0.47 standard deviations under active learning, and that students in traditional classes were 1.5 times more likely to fail compare to students in classes with active learning sections.

Given the importance of engagement this has been the focus of several reviews. These reviews suggest a need to explore what engagement is from the students' perspective i.e., get their views. They also suggest that it is the responsibility of universities to engage students by fostering a suitable environment and one way to do this is by using innovative digital technologies. A comprehensive literature review [8] covered directions for future research, and two key points it raises are: "exploration of the concept of 'student engagement' from the student perspective" and "a locally grounded but internationally validated conceptualisation of student engagement" (p. 50). Those looking at a prospective policy framework for supporting universities, should see student engagement as a metric to raise attainment. Therefore, finding appropriate digital tools and solutions to support teaching and learning should be on the priority list.

1.1. DIGITAL TOOLS AND IMMERSIVE TECHNOLOGIES

A range of digital tools and technologies exist to increase learner engagement in HE, such as: audience response systems, backchannel communication, screen mirroring, virtual reality (VR) and augmented reality (AR) [9]–[13]. Alongside these tools, there are also different pedagogical approaches that can be used.

Immersive technologies (such as AR and VR) are emerging as tools that both HE staff and students express a great deal of interest in, and show promising

results regarding engagement in different academic disciplines [9], [13]–[17]. Scavarelli et al. [18] have conducted a literature review regarding the educational use of VR and AR within social learning spaces (e.g., classrooms and museums) and provided an overview of pedagogical foundations that support VR/AR learning, as well as explored several examples. Akçayır and Akçayır [14], in their systematic review, emphasized advantages and challenges associated with the educational use of AR, and Garzón and Acevedo [15] identified that AR has a medium size effect on the learning gains (d = .68) based on a meta-analysis of 64 quantitative research papers. Radianti et al. [17] conducted a systematic review of immersive VR for HE purposes and identified three key points (the domain structure regarding the learning contents, the VR design elements, and the foundational learning theories), as well as 18 application domains.

2. PURPOSE AND RESEARCH QUESTIONS

Even before the COVID-19 pandemic, the majority of universities worldwide were in some phase of digital transformation [19], and the King's Strategic Vision 2029 sets out a number of important points including to utilize modern technology to enhance teaching and research excellence.

This project was initiated to examine various emerging technologies and consider which ones could be useful in learning environments, as we need student perspectives on what is engaging but also recognise that staff must work with technology and views are often different [5]. Therefore, the key factor of this workshop-based research was that both staff and students had a physical (hands-on) experience and could give honest feedback about each technology and the practicalities of its use. In this research we aimed to address the following research questions (RQ) about immersive technologies:

- RQ1 What technological solutions do participants think they need in the learning environments to improve teaching and increase students' engagement, and what requests can be met with tested digital tools and immersive technologies?

- RQ2 How do academics and students evaluate potential benefits and challenges of the educational use of immersive technologies?

- RQ3 What would simplified didactic process maps of possible pedagogical aims look like?

3. MATERIALS AND METHOD

Ethical approval was obtained from the relevant Institutional Ethics Committee (Ref MR/16/17-744) in advance. The methods used in this research are described in detail in Detyna and Dommett [20] but briefly, teachers and students were recruited through advertising (posters, emails and via institutional VLE) at the King's College London and were not compensated for their time participating in demonstration sessions, hands-on activities and focus group discussion. All participants (N = 33) were provided with study information and written consent. In total 23 staff members and 10 students took part in this research.

Participants attended sessions which were divided into three parts. The first part of the session was a teaching demonstration using the topic of how elements are formed in the stars. The example was chosen because it can be delivered with a clear narrative arc and engage learners with the use of different technologies within the discrete period available. Immediately following the demonstration, participants were given around 60 minutes to interact with the different technologies demonstrated.

Presented technologies and tools were grouped, and the results regarding other tested digital tools (besides VR and AR) were covered in a publication by Detyna and Dommett [20]. The final part of the session aimed to gain feedback from participants about the individual tools and technologies. The research was continued with an in-depth focus group discussion, following Kahn's [21] conceptualisation of engagement which emphasized social interaction and group dynamics about the potential value of the technologies. Discussion centred on the following questions: (a) "What learning goals could this tool help you achieve?", (b) "How could you use this in a teaching environment?" and (c) "What are the pros and cons of this technology?". Responses were audio recorded.

3.1. DATA ANALYSIS

The audio recordings of focus groups were transcribed generating in total circa 15,000 words of response and then thematically analysed using the process outlined by Braun and Clarke [22]. Additionally, simplified didactic process maps were created using a visual approach which builds on the work of Döbeli Honegger and Notari [23].

4. RESULTS

4.1. RQ1 IMPROVING TEACHING AND ENGAGEMENT

A number of staff requests came up in response to prompts about technologies to best support their students. These have been codified by discourse.

Table 1 shows the major "blue skies thinking" themes discussed by academics and students based on their prior experience. The results indicated that the staff and students highly prioritized the need for improving students' engagement during the lectures with technological solutions. AR/VR technology can be potentially useful for improving the visual presentation of teaching content and providing interactive solutions for improving student engagement.

Themes	Example quote	n
Student communication	"For teachers and students to have a way of communicating that is anonymised, and that is easy to do." "Mobile phone exchange between staff and students like text messaging."	6
Better visual technology	"Visualisers in every room."	6
Improved lecture capture	"Lecture capture more easily editable." "Adding text captions to lecture capture."	5
Student collaboration	"Anything that allows students to collaborate and share thoughts about content in real time."	4
Physical infrastructure (tech)	"Better WiFi" "Space to have plug sockets in lecture theatres to do work on laptops."	4
General (not specified)	"Something seamless to make students engaged, and that is integrated into the classroom."	2
Bringing the outside world	"Bringing experts or other locations to the classroom."	1
Futuristic mobile devices	"Just my mobile device with seamless ways of captures my thoughts, content and arranging them in a neat pattern based on AI."	1

Table 1 - Thematic analysis of "blue skies thinking".

4.2. RQ 2 POTENTIAL BENEFITS AND CHALLENGES OF AR AND VR TECHNOLOGIES

Participants' comments (in the discussion) regarding AR and VR technologies were mixed. On the one hand, participants saw potential advantages of "high-end" VR headsets (e.g., a powerful effect in experiencing different environments and high interactivity), "low-end" (*Google Cardboard*) VR apps (e.g., the cost is relatively low, avail-ability of content, relatively simple content creation), as well as of *Microsoft HoloLens* (e.g., can create environ-ments for safe practice - "a good way of letting future doctors fail in a more low-stress environment" and high interactivity) and mobile AR (e.g., it is relatively easy to use, affordable and can be useful in specific cases such as language learning). However, on the other hand, par-ticipants pointed out potential limitations such as: VR/AR headsets (*Oculus Rift* and *Microsoft HoloLens*) can be used only with small groups of students due to still high cost per unit; dizziness and motion sickness issues (especially with the Oculus Rift and Google Cardboard headsets); complicated user interface, heavy to wear and hard to control virtual 3D objects (comments regarding *Microsoft HoloLens*); can be hard to manipulate the paper and phone at the same time (comments regarding mobile AR); low quality of some AR/VR apps and expe-riences; challenges with "bring your own device" (BYOD) model of integration (e.g., a requirement for students to have a suitable phone); hygiene issues (cleaning materi-als are necessary and keeping shared equipment clean can be challenging); lectures/students readiness to create AR/VR content; could be gimmicky and may not work for certain fields ("dependent very much on discipline").

4.3. RQ 3 SIMPLIFIED DIDACTIC PROCESS MAPS

Discussion with staff and students led to simplified didactic process maps creation on how specific aims could be achieved with given technologies and tools. We should stress that there was a large number of such maps created, but in this paper, we presented only simplified didactic process maps to reflect VR possibilities (Figure 1). For each there was a specific pedagogical goal and a se-ries of steps to achieve that goal outlined.

4.3.1. FIGURE 1 - SIMPLIFIED DIDACTIC PROCESS MAP FOR VR

Take a VR field trip:
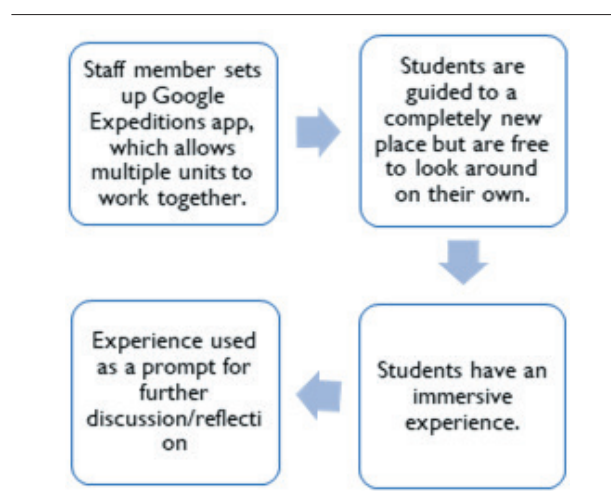
Very simple VR content creation via smartphone camera:
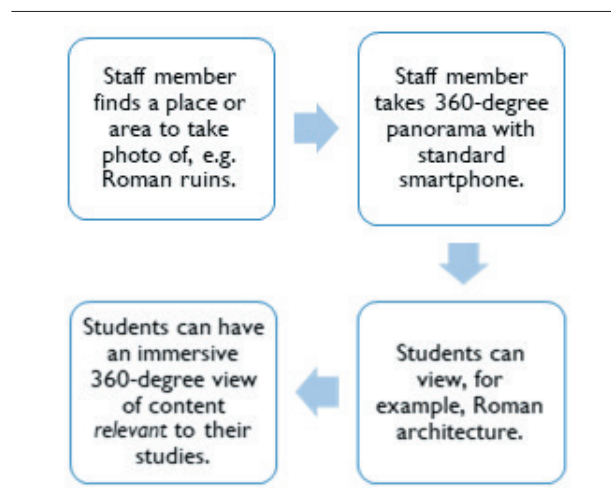
Creating a VR app:
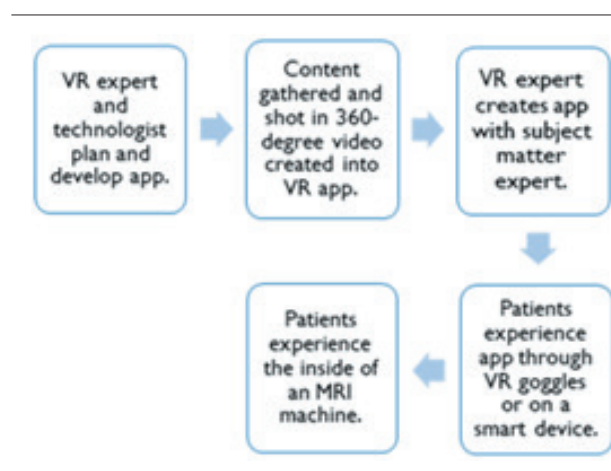
5. DISCUSSION AND CONCLUSION

There are several points to bear in mind in reviewing the data since students and staff members had a wide variety of views and needs; and there is no one perfect digital "solution" for improving students' engagement. The results of the other research questions (from this research) are presented in Detyna and Dommett [20].

The research question related to staff members and students' 'blue skies thinking' showed needed technological solutions in learning environments. The most prominent themes were regarding improving communication and collaboration in the lectures as well as improving visual presentation technology, lecture capture and physical infrastructure of the classrooms. Some of the indicated needs can be met with digital tools and technologies investigated in this research [20], but for some demands, technologies are not there yet.

In terms of the research question about benefits/ challenges of immersive technologies, VR can be used to create "high end" immersive experiences, but also aspects of "lower end" VR (e.g., 360° environments) can be used to add a degree of interactivity and engagement to student communities both online and on campus [24].

Interactivity was mentioned by a number of participants as being of benefit, which chimes with the literature on the subject [25]. However, participants expressed skepticism that premade (off the shelf) AR/VR apps would work well in all disciplines. Also, one of the biggest problems with the use of immersive technologies in learning environments is that it is sometimes hard to transfer the interest of new technologies to the interest of the materials being studied [26].

The last research question was related to the simplified didactic process map creation. The simplified maps shown in this paper (regarding the use of VR) are a small subset of those created, and wider use was made in the institution. Additionally, as Zhou et al. [27] states, VR and AR use in education should be used to build on and help construct knowledge, based on existing understanding. We have built on the work of Radianti et al. [17] to give examples of implementation in practice. We should also be mindful of the resource implications, e.g., the last use case is dependent on significant time, resources and content creation outside of a lecture with a VR specialist. Reflecting back, having a diagrammatic representation was found to be of use by the academics involved in the study, and could potentially be of broader use.

5.1. LIMITATIONS

Limitations of the present study should be acknowledged. Firstly, the sample size (N = 33) is reasonable but could have been increased to get greater depth of results. Secondly, we should be mindful that the landscape of digital AR/VR tools changes over time. For example, Google has announced that it is cancelling its *Tour Creator* authoring tool and the *Expeditions app* in 2021. Another (third) limitation to consider is the fact that the research did not study the long-term use of the tools.

5.2. FINAL POINTS

This research has shown that there are a number of promising avenues to help engage students in a learning environment, partially with digital tools. Still, the AR/VR technology should be an enabler rather than a means to an end, and sound pedagogy is the foundation of every good teaching approach (whether using digital technology or not).

We should also note that the current situation with the COVID-19 pandemic is likely to introduce significant changes in education and the wider world. The AR/VR technology will likely gain in importance as a mechanism for students to experience field trips and fieldwork activities "virtually" if they are unable to visit in person [28]. Opportunities to combine face to face and online environments will also influence HE teaching.

5.3. DECLARATION OF INTEREST STATEMENT

The authors confirm there is no conflict of interest in relation to financial or non-financial interest in the area studied.

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INTERNET TECHNOLOGIES AND APPLICATIONS IN EDUCATION AND LANGUAGE LEARNING SESSION

PODCAST – AN INSIGHT INTO ITS BENEFICENCE IN LANGUAGE LEARNING AND STUDENTS' EXPERIENCE

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Abstract:

Podcasts and videocasts, well-known Web 2.0 tools have been in use in foreign language teaching for more than a decade now. Extensive research, on a global level, on the potential and proven benefits of using podcasts for developing all language skills (in particular listening), can create a belief that podcasts are now widely used on all levels of foreign language study in Serbia. This type of belief, combined with an ever increasing number of available language learning tools, may lead us to think that in 2021, podcasts are outdated and should be substituted with Web 3.0 or even Web 4.0 tools. However, this paper aims to show that students entering their Ist year of study on a tertiary level are not that familiar with the above mentioned technology and are not informed of their value in both in-class and out-of-class language learning. Bearing in mind the soaring popularity of short digital recordings available online, it is our opinion that the "podcasting culture" is yet to thrive in our country. This will, in turn, lead to an increase in its usage for educational purposes particularly in the field of foreign language teaching and learning.

Keywords:

podcasts, language learning, digital technologies, student attitude, educational value.

INTRODUCTION

Digital technology, particularly Internet based technology has permeated every aspect of our lives and COVID-19 pandemic has greatly contributed to the diffusion of this technology even among those who resist technological change. Amidst the numerous lockdown and quarantine measures imposed on both national and international levels, various types of human activities had to undergo a drastic change, shifting to an online realm. This is certainly true for the educational sector where the World Economic Forum reports an astounding number of 1.2 billion children referred to online learning platforms and tools [1]. In this particular scenario, teachers needed to be as inventive as possible and rely on available, mostly free, resources which could easily and quickly be adapted and efficiently implemented in the teaching process.

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In a Serbian research conducted in 2017, which investigated the methodological application of different digital media in interactive music and language learning, teachers of both English language and music-related subjects stated using podcasts as one of the numerous digital media in their teaching [2]. However, the research did not show how many teachers used podcasts and how frequently.

The availability of such data for the past two (pandemic) years is scarce as well. Furthermore, the applicability of podcasting for teaching and learning English and integration of this technology in the Serbian context should be further researched as there is a lack of available literature in this particular area.

2. THE EVOLUTION OF EDUCATIONAL TECHNOLOGY

It has now been more than 15 years since O'Reilly first talked about Web 2.0 (preceded by Arpanet and World Wide Web) and even more since the early days of using technology in classrooms (radio technology in the 1920s, television in the 1950s, programmed learning in the 1960s). Today, in the 21st century we are discussing the use of sensory emotive Web (Web 5.0) where web technology and human interaction become intrinsically intertwined. Authors of [3] as pioneers in the establishment of the theoretical framework for the implementation of podcasting in a university setting particularly stress flexibility, knowledge continuity and learner control as key considerations in deciding on a particular technology in language learning. Podcasting is proven to fill out these criteria besides increasing student contribution in the language learning process and enabling a higher level of cognition (better understanding of the learning materials). While today's podcasts can't be called novel language learning tools, the rise in their popularity over the past few years is shining a new light on them. They are now more than a mode of distributing audio and video content on the Internet.

3. PODCASTING

Podcasting technology has first appeared in 2004. and since then has gone through an evolution of its own. Wide adoption of smartphones with internet access led to a prompt rise in the popularity of podcasts. Namely, in 2014, Apple counted 7 billion podcast downloads and in 2018 that number increased to 50 billion podcast

downloads and streams [4]. There are currently over 2 million podcast shows and over 48 million episodes on a global level [5]. Podcast.rs (established in 2019 as part of the USAID Strengthening Media System Project) is the most famous Serbian podcasting platform with over 200 available podcasts (both in Serbian and other languages). Currently, there is no available research on the total number of podcasts in Serbia, particularly language learning podcasts prepared and presented by Serbian authors. Still, Spotify, a new music streaming service available in Serbia from 2020 (besides Apple Music and Deezer) and the number of podcasts on Podcast.rs that has doubled in just one year, show a growing interest in this form of technology.

Podcast popularity is said to be related to its numerous advantages such as low production costs, low to medium level of digital literacy needed for their production, affordable price (or no price at all), a wide range of topics to be covered, its transience (so it does not become tiresome and can be "consumed" on the go) and its accessibility to people with visual impairment.

3.1. DEFINING PODCASTING

The term podcasting (portable on demand broadcasting) is said to be coined from the terms iPod and broadcasting and it represents a collection of technologies for automatic distribution of audio (and video) content over the Internet through publishing and subscription models [6]. Podcasting is different from the traditional broadcasting as it entails the use of RSS (Really Simple Syndication) technology for the subscription so that the podcast content can be automatically "pushed" to subscribers for download. Users can store their favorite podcasts into online repositories (provided by a particular company offering the very podcasts such as Google, Apple, Podbeam, etc.) or they can download them to their own devices such as laptops, desktop computers, mobile phones, etc.). [7] similarly defines podcasting as the process of capturing an audio event, song, speech, or mix of sounds and then posting that digital sound object to a web site or blog in a data structure called an RSS 2.0 envelope or feed. Podcasts can be categorized based on different criteria but one of the basic ones is made on the form in which they appear:

1. audio podcast (the simplest in form as it contains only audio content);
2. enhanced podcast (with both audio and visual elements – pictures, photos, slides, short videos which all serve to provide additional information on a particular topic);

3. VODcast (video podcast also known as vlog – contains both video and audio files).

Podcasts come in a variety of length (which also serves to show their flexibility) but they mostly last from 20 to 60 minutes with an average length of 41 minutes and 31 seconds in 2019 [8]. In 2019, podcasts in the education category lasted an average of 20.40 minutes while the language learning podcasts seemed to be the shortest, lasting around 7.98 minutes [8].

3.2. PODCASTING PHASES

The process of setting up a podcast is rather simple as it can be divided into the following steps – production, publication and generating a RSS feed. Once this is done, the user can subscribe to a podcast (through a podcast aggregator) which enables automatic download of the podcasts.

Lastly, the user can reproduce the contents of a podcast as many times as he/she likes. [9] Discusses 11 steps in creating your own podcast:

1. Creating and editing an audio recording;
2. Recording and interview by phone;
3. Setting up listener feedback;
4. Levelating the podcast;
5. Encoding to MP3 format;
6. Adding ID3 tags;
7. Setting up the hosting service;
8. Creating a Feedburner RSS feed;
9. Validating the feed;
10. Submitting the feed to iTunes, Zune & Blackberry
11. Submitting your feed to all the other podcast directories.

4. PODCASTING IN EDUCATION

From the moment they appeared, podcasts immediately found their use in different educational institutions. Today, podcasts are much more than innovative teaching resources and tools for delivering teaching materials. Research has shown that podcasts have positive effects on students' long-term memory, autonomous learning in students, consistency of student experience, student motivation and engagement, learner discussion, use of different instructional approaches, etc. As technology becomes more advanced and both students

and teachers acquire new technology-related skills, it becomes easier and pedagogically justifiable to implement them in all forms of formal learning. The author of [10] discusses unconstitutional use (substitute to traditional lectures), supplementary use (provision of summary and additional materials) and creative educational use of podcasts (constructing knowledge). According to authors of [11], educational podcasts can be divided into: teacher-driven, service-driven, marketing-driven and technology-driven.

4.1. PODCASTS IN LANGUAGE LEARNING

Modern languages were one of the first areas identified as being "eligible" to benefits of using audio and video resources. One of the first studies (performed in 2006.) to investigate students' perception and use of podcasts for language learning purposes showed a lack of student knowledge on podcasting technology and 64.9% of interviewed students stated that they have never or rarely downloaded a podcast [12]. Since then, numerous research pointed out the positive effects of podcasts on students' listening and speaking performance [13], [14], vocabulary acquisition [15], [16] and even perception of self-efficiency in learning English as a foreign language [17]. Previous research on students' perception and attitude towards podcasts in language learning is rather positive as students enjoyed the experience and found it beneficial for their language skills [18], [19], etc.

5. RESEARCH METHODOLOGY AND RESULTS

Literature related to the use of podcasting technology in Serbian context is rather scarce and does not offer sufficient information on students' experience in relation to language learning with the aid of this technology. This study was conducted to develop a better understanding of students' familiarity with podcasts (general use and language learning use – whether they have experienced supplemental podcasting and creative podcasting) as well as to understand their attitude toward the use of audio materials in language learning activities (in and out of classroom). We were additionally interested in understanding to what extent are students prepared to implement this technology in their everyday practice of language learning.

The study was conducted with first year students of Academy of Professional Studies South Serbia – Department for Business Studies Leskovac, at the very beginning of the first semester of their study. 37 students agreed to fill out an online questionnaire comprised of 14 questions (close-ended items). The questionnaire was prepared on the basis of a questionnaire used in a research presented in [20], which explored students' readiness and attitudes towards repetitive and supplemental podcasting.

The first three questions obtained information on the accessibility i.e. audio capabilities; the results show that 83,8% of students currently own a device which can be used to play audio (mp3 files). In terms of listening to audio files, 70,3% of students said that they mostly use their mobile phones to listen to audio files as opposed to 16,2% who use their desktop computer and 10,8% who use their laptop computer to listen to audio files. These results are not surprising since the respondents are digital natives who feel confident in using modern (particularly mobile) technology; question aimed at understanding students' use of mobile technology showed the following:

	Listen to music	Listen to audio books	Listen to class lectures, interviews (other audio)
Never	2	25	11
Once a month	3	8	9
Once a week	6	1	8
Once or twice daily	15	2	6
Several times daily	11	1	3

Table 1 - How frequently do you use a mobile phone for the following activities?

The distribution of answers is quite different in the "listen to music" category as compared to "listen to audio books" and "listen to class lectures, interviews and other audio files". Namely, students (86,4%) listen to music on their mobile devices rather often (once a week or more often) while only 10,8% said to be listening to audio books in the same frequency (once a week or more often). The results are somewhat better for other audio materials as 45,9% of respondents claim to listen to interviews or any other type of audio materials on a weekly/daily basis.

As for the I year students' familiarity and experience in using podcasting technology, the results indicate a low level of familiarity and experience with podcasts. 51,4% of students is familiar with the term podcast (as opposed to 48,6% who are not) and 32,4% of the respondents said that they have very little knowledge on podcasting technology (a total of 64,8% without any podcasting knowledge). In view of these findings, the results to the question "How often do you currently download podcasts" came as no surprise – 70,3% of the students said that they never download podcasts and only 4 students (10,8%) claimed to be downloading podcasts fairly often. Podcast subscription seems to be even a greater issue with I year students as 91,9% of the research participants said that they have never been subscribed to any podcast. In a different question, students were provided with a short definition of a podcast and asked to answer (in view of what a podcast is) if they have ever listened to any type of podcast: 56,8% of the students answered that they have never listened to a podcast in their life. Furthermore, 81,1% of the respondents said that they never heard of Podcast.rs – the most famous podcasting platform in Serbia.

Language learning podcasts are not very popular with the research participants. To be specific, we asked the participants to share their experience in using some of the most popular English language learning podcasts (free time activity):

	Yes	No	First time hearing about it
BBC podcasts	1	19	17
5-minute English	2	20	15
English To Go	2	18	17
ESL Lab	0	17	20
Business English Pod	3	17	17
English Lane Podcast *(Serbian author)	1	16	20

Table 2 – Have you ever used any of the following language learning podcasts?

The results show that very few students have actually used any of the above stated language learning podcasts as the majority hasn't even heard of them. We asked the students to remember if their high school

or primary school teacher of English language has ever used any podcast in their language class and 56,8% of the respondents answered No and 37,8% answered that they might have been exposed to a podcast in their previous language learning experience but that the teacher never stressed that they were listening to a podcast. We were further interested in learning about the overall student experience with audio materials in the language classroom and asked the students how often their high school language teacher used audio materials in his/her teaching.
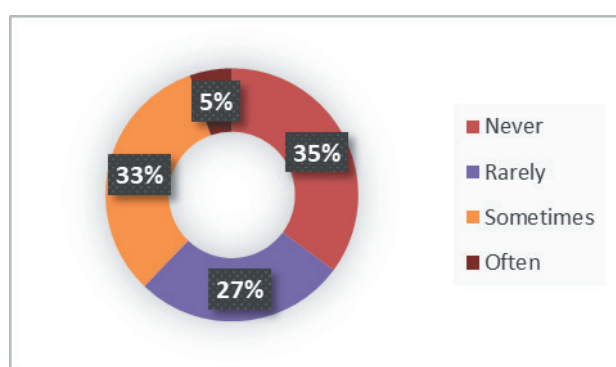

Figure 1 – How often did your high school language teacher use audio materials in the classroom?

None of the students opted for the remaining option named "every class" which stands to show that teachers didn't expose their students to a great deal of listening materials. On the other hand, students who were exposed to audio materials said that they found them beneficial i.e. they believe that audio resources contributed to their learning in that particular class in which they were used (54,1% gave a positive answer). Finally, we wanted to investigate students' preferences in terms of types of language learning materials and a great majority of students expressed an interest in using both printed and audio materials – 51,4% (as opposed to using only one of these two types of materials).

While the study was conducted on a small sample, it shows that the first year students aren't familiar with the podcasting technology particularly in terms of its use for foreign language learning. Lack of sufficient exposure to authentic audio materials in their previous foreign language study (formal and informal) hasn't been detrimental to their motivation for using audio tools and language materials which leads us to believe that, with adequate mentoring and progressive integration of podcasting technology, students will be able to comprehend and experience their beneficence in language learning.

6. IMPLEMENTATION IDEAS AND ACTIVITIES

Implementation of podcasting technology in a language learning environment depends on numerous factors. The teacher first has to consider the overall course aims and course contents in order to establish a number of learning goals. In line with [21] findings that there are 3 modes of implementing podcasting technology in the language classroom – students as consumers, students as producers and student practice through various exercises, we propose the following ways of implementing podcasts in language learning classrooms:

1. Classroom listening activities (consumers) – listening comprehension quiz, listening comprehension discussion, listen for grammar activities, listen for pronunciation activities, listen for vocabulary activities (jigsaw listening, spot the error, etc.), teacher feedback activities;

2. Classroom speaking and writing activities (producers) – audio and written reviews, audio commentary on social network contents, student interviews (teacher-student interviews, student-guest speaker interviews), audio tours, teleprompter writing/reading/speaking activities, debates, dramatic read-alouds, quick question-and-answer sessions, writing a letter to a podcaster;

3. Practice activities – shadowing activities, practising the pronunciation of a target sound, sentence intonation or rhythm, musical interpretations of provided texts, pair taping free-flow activities.

Teachers should try using both pre-made podcasts (which can be edited to suit particular learning aims) and their own (original) podcasts that can best fit each individual lesson aim and objective.

7. CONCLUSION

As technology improves, the importance of having advanced digital skills increases. English language teachers, as many others, are no longer able to rely only on traditional models of teaching and have to look for ways to make language learning more efficient. Audio implementation is a unique way to engage students relatively easy and provide new learning opportunities the students will enjoy and benefit from. Podcasting technology is can be rather easily tied to the already existing teaching methods that some teachers feel more

comfortable working with. The results of the conducted research show that podcasts are a novelty to students entering tertiary education in the south of Serbia as only a small percentage of students have ever listened to or downloaded a podcast. Research additionally shows a low level of audio exposure in previous language learning together with a positive attitude towards the use of a combination of printed and audio materials in a language classroom.

In view of the proven positive effects of podcasting on student language learning (vocabulary acquisition, development of all four language skills), self-efficiency in language learning, motivation for language learning and other, teachers should first dedicate sufficient time educating themselves on advantages and possibilities of using podcasts as teaching tools. The experience of students involved in the research shows that teachers shy away from using podcasts in their teaching and lack of research in this field in our country adds to the belief that language teachers should pay additional attention to this particular language learning tool. While we may easily assume that all our students are digital natives, teachers should pay special attention to determining the level of technological abilities of their students. Research shows that, when given proper support, students can relatively easily and with little stress involved, overcome the technological hurdle when dealing with the new technology [22]. Teachers should spend an appropriate amount of class time to introduce and explain the medium. Once braving with the new learning tool, teachers need to remain focused on the actual learning outcomes and goals for a particular course and each unit so that the tool fully contributes to their achievement. As podcasting is gaining momentum both in Serbia and globally (particularly in higher education on a global level), further research is needed to understand the full degree of possible hindrances in the implementation of this technology in a local setting. Podcasts, as many other technological advancements, as language learning tools are here to stay - in the words of the author of the famous podcast The House of #EdTech - the best time to start a podcast was 2004; the next best time is right now [23].

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TECHNOLOGICAL AIDS, IT-APPLICATIONS AND ONLINE EDUCATION IN ENGLISH LANGUAGE TEACHING AND LEARNING

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Abstract:

This article deals with online education in learning English. The article presents the effective ways of employing online education in teaching and learning English. Examples are given of good teaching practice. Furthermore, the article deals with the efficient use of some of the technological aids and IT applications in learning English.

Keywords:

online education, IT applications, English.

INTRODUCTION

There are two reasons for writing this article, first, to describe the practice in the author's teaching supported by the use of modern technology and contemporary applications to support online education. Second, the article deals with using technological aids.

The goal of this article is to describe and present the ways of language teaching by using modern technology and different technological aids frequently found in many modern classrooms. My teaching experience lasts for ten years and within it I used many ways to employ modern technology in teaching.

Many modern classrooms have computers that can be used in many ways. For example, the Microsoft office package can be used for using PowerPoint presentations to support course books. PowerPoint presentations are an ideal way to highlight the most important aspects of class, present lessons, insert text, point out the important questions, and insert interesting and relevant pictures and illustrations to follow the lesson as well as graphs and tables. PowerPoint presentations are presented to students on the whiteboard by using overhead projectors and, of course, by using computers.

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Interactive presentation software is Genial.ly for making online presentations and creating engagement in class. A teacher can add slide(s) situated on the left side on Figure 1, texts and images, quizzes, etc. to a presentation to create an entertaining presentation. The examples of its usage are illustrated in Figure 1 (see Figure 1).
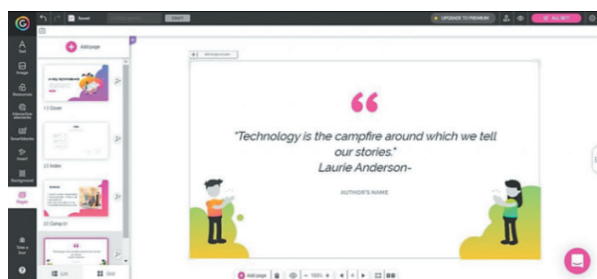

Figure 1 Genial.ly app for making presentations

2. COMPUTERS AND IT APPLICATIONS IN LEARNING ENGLISH

Learners of English are especially interested in the use of modern technology in learning. To support their writing and finding the unknown words, students use computers to find electronic dictionaries to help them in learning [1], [2], and [3].

2.1. IT APPLICATIONS

The Internet is used in (online) class to find out relevant information on different topics or simply to do the research necessary for writing case studies found in many books with computer-based research using the Internet. Also, digital presentation or story writing is current and applicable in teaching. Learners of English are especially interested in the use of modern technology in learning. To this end, various computer applications (for example, British Council) that can be mobile phone applications as well are used to learn English independently. One of the useful smartphone quiz apps in English and tool for teaching is Quizlet. The cognitive modality stands out when solving tasks on these applications.

2.2. VIDEO/DVD PROJECTIONS

Important parts of the lesson are video and DVD projections on different topics (everyday life, jobs/careers, solving problems, moving house, friendship, film and music, entertainment etc.). Depending on the way we learn, different modalities stand out. For example, through video watching, a visual-sensory modality develops because students concentrate both on watching the projection and hearing the content.

2.3. ONLINE EDUCATION

Online education is used in the Moodle application. Moodle (Modular Object-Oriented Dynamic Learning Environment) is used in schools and at colleges in Serbia. This application was invented by Martin Dougiamas [4]. The research helped him in inventing Moodle. Martin Dougiamas did his Ph.D. on "The use of Open Source software to support a social constructionist epistemology of teaching and learning within Internet-based communities of reflective inquiry" [5]. The application is used to publish presentations, lectures and tests, audio and video content and different audio recordings.

Collaborative online spaces are Skype, Zoom, Google collaboration tools, forums etc. Video communication is supported by Google Meet developed by Google. People who have Google account may create an online meeting. The number of participants is 100 and each meeting may last an hour and longer per meeting.

In order for you to participate in a meeting using your mobile phone you must have a Gmail account created. The approach to the Internet is necessary as well as built-in camera and a supported operating system.

A sense of having company in online education is supported by the Zoom application. Zoom is a way to communicate online with many students, hold classes, chat, make use of speaking activities and it enables us audio-visual experience and the presence in an online environment and texting in comments. To bridge the gap between the classroom and the workplace a teacher can organize job interviews simulation via Zoom. Always make sure that the sound/ camera is turned on while using Zoom. In what follows are some tips and tricks for teachers educating on Zoom [6].

- Starting a class:
  - If it's your first time using Zoom, visit the Educating Guide: Getting Started on Zoom and complete the steps in advance of your class to get you set up.

- Schedule your class in the Zoom application for your desired date/time and copy the invitation details to send to your students. Please note that students will not need to register for an account to join.

It is also important to join your class a couple minutes early to ensure a proper connection then follow the below tips for a quality online learning experience.

- Tips and Tricks for Virtual Lessons:
    - For your first class, set aside some time to introduce your students to Zoom and ensure that they're able to connect their audio and video.
    - Take time to promote questions, comments, and reactions from your class. Give a minute to allow your students to utilize reactions, write their questions in chat, or be unmuted to ask their questions live.

Students can be divided into smaller groups for a discussion on a certain topic. You can use Zoom's Breakout Room feature to either pre-assign or auto-assign students into groups for a short period of time so they may discuss things together.

- Teaching Over Video - Delivery Tips and Tricks:
    - Look at the camera to create eye contact with your students. This helps to create a more personal connection while teaching over video. And the last one in this level.
    - Speak as if you're face-to-face with the class while ensuring you're at the appropriate distance from the microphone for the best audio experience.

Give your students a moment to open or take in what you've shared (presentation, shared images, files or video).

- Great Tools Built into Zoom for Engagement:
    - Breakout Rooms: https://support.zoom.us/hc/en-us/articles/206476093-Getting-Started-with-Breakout-Rooms
    - Chat: https://support.zoom.us/hc/en-us/articles/203650445-In-Meeting-Chat

There are two types of meetings online: synchronous meeting and asynchronous meeting.

2.4. SYNCHRONOUS AND ASYNCHRONOUS E-LEARNING

E-learning has two types: synchronous and asynchronous. Synchronous e-learning is Zoom meeting, video conferencing, instant messaging and chat. An asynchronous meeting is discussion forum, e-mail and blog. The synchronous discussion makes it easier for learners to find more facts, to have a look in a book and do detailed postings [7]. Synchronous e-learning makes it easier for learners to respond quickly, because they do not want to disrupt the conversation [7]. The work of Hrastinski was to determine when, why and how a teacher should incorporate asynchronous or synchronous e-learning tools and what are the advantages and disadvantages of asynchronous and synchronous e-learning [7]. Table 1 illustrates when, why and how to use asynchronous and synchronous e-learning [7].

Synchronous communication, as e-learners reveal in the interviews, is "more like talking" in comparison to asynchronous communication. It serves to discuss less "complex" problems. The synchronous meeting provides students with the psychological action and motivation because a quick response is expected. It is similar to face-to-face communication. Students become psychologically active in synchronous meeting because of the ability to convey and observe facial expressions and body language.

Questions	Asynchronous	Synchronous
When?	Reflecting oncomplex issues When synchronous meetings cannot be scheduled because of work, family, and other commitments.	Discussing less complex issues Getting acquainted Planning tasks.
Why?	Students have more time to reflect because the sender does not expect an immediate answer.	Students become more committed and motivated because a quick response is expected.
How?	Use asynchronous means such as e-mail, discussion boards, and blogs.	Use synchronous means such as videoconferencing, instant messaging and chat, and complement with face-to-face meetings.

Table 1 Asynchronous vs. Synchronous Learning

These are especially evident in smaller classes. Learners are also more motivated in synchronous e-learning because synchronous communication enables monitoring the receiver's reaction to the message and receiver is immediately more motivated to read and answer the message. Of course, the response is also immediate. A drawback of synchronous e-learning is that the emphasis is often on quantity (trying to write quickly as in chat) rather than the quality of words, because "someone else will say what I meant to say". In asynchronous communication the receiver has more time to understand the message, since the sender does not expect immediate answer (as in e-mail, e.g.).

The example of using asynchronous way of communication is for example a teacher leads and writes a blog about the course or a student may have his/ her blog. Synchronous way of communication is a teacher giving an online lecture via Zoom for many students at the same time. Another example is a chat on any topic.

The combination of synchronous and asynchronous e-learning is the best to exchange information between teachers and learners, collaborate and get acquainted with each other. The author of this paper uses the combination of these two ways of online learning, Zoom is synchronous and writing a blog is asynchronous way of online learning to support e-learning.

2.5. TECHNOLOGICAL AIDS

The most used technological aids in classroom are CDs and audio tapes supported by the course book package. CDs and audio tapes are useful in listening practice for learners. Teachers must check if the tapes are in the correct place before the lesson, and use the counter on tape recorder so that the tape can be rewound to the original correct position. Students usually need to listen to the recording more than once. Students can also be recorded when speaking and in this case their motivation is high. Learners can speak freely and listen to the tape and correct mistakes that they hear or that the teacher highlights [8].

Second, video or DVD provides a variety of input through the combination of listening and visual information while we listen, such as the body language. Some videos and DVDs are especially for English Language Teaching and that have the advantage of grading language and tasks that are appropriate for lower level classes and worksheets that follow by. Learners can also be recorded while they perform a role-play and it is similar to a DVD recording in their production [8].

Overhead projectors serve to prepare before the lesson and teachers in this way can control what they want to show students. The transparencies can be prepared using coloured pens or can be photocopied on to. The biggest advantages of this are that teachers can take time to prepare diagrams, examples sentences, grammar exercises, without having to write them on the board under pressure during the lesson. By covering the parts of transparency with paper, teachers can control when things are revealed. Useful activity is to use the overhead projector in students' writing activities, to do them in small groups or in pairs, and they can be written on a transparency and displayed immediately for the rest of the class to read [8].

Computers can be used in variety of purposes in English Language Teaching. The Internet is the biggest source of teaching material and learning material. There are also software packages that can be downloaded and used in teaching and for learning. When used in classroom, computers enable learners to do group work and share ideas in English and different experience to that possible when studying alone [8]. The best is a mix of traditional teaching supported by using technological aids and digital tools in online education.

3. CONCLUSION

To conclude, using technology in class is an essential tool for English language teaching and learning. The author of this paper wanted to present IT applications used in teaching and in learning English. The paper offered modern applications and platforms for learning English with examples of good practice. The ways of learning online and online education are presented in this paper. Furthermore, different and modern technological aids are described in detail as well as their usage in class.

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SPRINGEXTRACTOR APPLICATION FOR WORK REVIEW AUTOMATION

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Abstract:

Modern times go hand in hand with the technology – every day we meet a lot of new modern smart gadgets. Consequentially, the need for IT experts is enormous. To meet the needs of the market, it is necessary to educate competent professionals. Increase in number of students majoring in electrical and computing sciences, as well as software and IT engineering confirm that the interest for making it in the IT sector is extremely big.

Rise in number of students created a problem related to the evaluation of knowledge. Tests, written and oral exams, homework assignments and projects are organized in order to check student's knowledge. Every one of these needs to be revised – teaching staff are met with an exponentially growing amount of work and time spent to finish the job of evaluating students correctly and objectively in the given timeframe. Teachers are under more stress, so the risk of an error is bigger as well. To solve this problem, minimize it and overcome it better, it's been worked on a proof of concept (semi) automated software that would be used for revising student work. The goal is to create a tool that would be fairly easy to use and efficient enough in solving given problem. At this point in time, we are implementing the concept of a web application (*SpringExtractor*) which will automate (partially in the beginning, and in later versions fully) the process of revising and evaluating student work. In this research, following concepts will be explained: motives and essential concepts of technologies planned for the realization, architectural organization, as well as potential points of expansion and improvement for the initially planned functionalities of the software.

Keywords:

work revising process, *SpringExtractor*, automatization, *Java*, databases.

INTRODUCTION

Software products used for solving different problems of high abstraction and complexity gradually take precedence – there is a growing need for platforms that would enable process automatization and optimization. Taking into consideration problems of the modern society, it is necessary to create a safe software which would satisfy given criteria.

As computers reached the peak of performance and process power, with the evolutive progress that can be seen in their programmability and the possibility of processing enormous amount of data, it is now possible to integrate them into almost every sphere of modern day.

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Development of sophisticated platforms is getting more and more dominant thanks to the trend.

In order to implement an automatization application which would eliminate the human factor in the repetitive parts of work that would furthermore drastically reduce human error caused by manual execution, some thought should be given to the way of possible realization of the software. About that, it would be also be good to consider web-oriented applications. Comparing web applications to the console ones, there is a certain advantage in the fact that the user interface is more intuitive, there is no need for the extensive training which needs to antedate using the application. Web based software put more attention to security (security in the electronic and other ways of business plays a big part in today's time), which presents a additional advantage.

There is a number of challenges that the teaching staff is facing. First and foremost, there is a central problem of this research which consists of revising student work process that needs to be attended to in the beginning. The gap between time allocated for the evaluation and the number of students that need to be graded is getting bigger and bigger. This is directly consequential to the rising number of students enrolling into IT colleges. In order to unburden the teachers to a certain degree, an idea was born of developing a software which would be able to download all student exams, create a table with grades and enter personal information about each student that attended said exam. Doing this would partially automate the process of grading student work, and reduce the number of errors caused by humans.

Pandemic of COVID-19 affected almost every aspect of life, among which is the area of education. This new situation influenced the introduction of a new type of schooling which was, until that moment, not usual in the Republic of Serbia – online schooling. Schooling which was performed on numerous online teaching platforms also implied provided teaching units, but in a somewhat different way. With the regards of changing the teaching regime, verification of students and evaluation of their work had to also be realized in a proper manner. Therefore, no matter if we are talking about the classic education model, online model or some combination these to in order to implement the teaching process, there is still a problem of validation and grading of student work. That is why the idea of development of a software tool for automatization part of the grading student work process is getting more and more thought about and is gradually getting to the implementation consideration, details of which will be further explained in this paper.

2. MAIN CAUSE FOR THE APPLICATION DEVELOPMENT

Previously explained problem in the teaching process has been around in quite some time. Consideration of the way in which it could be solved lead to the conclusion that the need of hiring teaching staff becomes less important, that it requires less effort and time, while also making the whole process of evaluation simpler and more resistant to unintentional error.

There was a lot of work considering solving the problems of student grading in the past period. This brought initial conceptual solutions to light. Shortcomings to these solutions are contained the complexity of usage the tool, as well as the fact that manipulating the software meant that the user went through advanced IT training (it is expected that they will be able to singlehandedly configure, and later correctly use the framework that the platform provides). Based on that, we come to the conclusion that automatization, beside paying attention to solving the problem by sacrificing effort and time, need to take into consideration ease of use.

Only a few competent professionals engaged in the topics of introducing automatization in the education sector. There were even some ideas in some scientific papers that artificial intelligence could be incorporated in the solution. Also, this potential solution could be based on the software predictions about which future occupation (based on propensity tests) the student might choose.

„*Artificial intelligence, automation and work*" [1] is an example of the paper which discusses usage of artificial intelligence and machine learning to automate repetitive parts of the work. In this case, elimination of human error would mean training the neural network. The network would afterwards be able to, using adequate training set, come to the conclusion on how it should process given set of data (student exams that need to be graded). In this case the advantage of introducing the concept of automatization could be seen in increasement of productivity, as well as reducing the number of errors. Core shortcoming of this approach would manifest in overly automating stuff – some parts of the work should still be trusted to be done by humans.

A representative example of the second scientific paper that dealt with the problem of introducing automatization in educational system is the paper named „T*he Benefits and Generic Procedure of Automating and Academic Student System in Primary and Secondary Schools as an Impetus for Educational Technology*" [2].

The paper is based on analysis of an idea of a software tool whose purpose would be to download student exams and prepare them for grading. The platform would later would require a teacher to log in, after which the data would be available for evaluating. The process of evaluating and grading exams would still have to be done manually, which furthermore means that the serious problem of the gap between the number of exams that need grading and the number of available teachers. This approach would mean automatization to a certain degree – once the grading is complete, results should be fed back to the software which would do automatic analysis and comparison of student grades. This means that the described process is not fully automated – precoditions for only automating crutial part of the systems have been created, while avoiding the potential overly used automatization.

While doing a detailed analysis of previous scientific papers, in combination with objective problem all of us at the faculty are facing, automatization has been stated to be a must-have functional requirement. Special attention must be payed in order for it not to become a cause of aditional problems which would be of direct consequence of its overuse. *SpringExtractor* is a web application which represents a compromise of all previously stated – details of which functionalities shall be available and which users will be described in following chapter.

3. SOLUTION ARCHITECTURE

To work on development of software solutions which would integrate automatization concepts and teaching process needs setting up a quality starting point for future implementation of a software product which satisfies defined normative. As to make this application usable on a wider spectrum, we need to create a solid base which would later be a reference point from which future development could start, and later on also improved.

The platform used for automatization of student work evaluation process is still in development phase – architectural starting point that would allow all of the above is still being brainstormed. Concept mentioned in the following chapters represent crucial guidelines of the future implementations.

3.1. SYSTEM PARTICIPANTS

User (participant) of the system is defined as a subject whose need are being met by the implementing the software solution. In the case of the application which would support the teaching process from the student grading aspects, we will consider that the administrator, teaching staff and other unregistered users all have the role of a User.

User defined as a teacher has to be registered first, which is not the case with other Users. Teaching staff, before the administrator gives them the role of a teacher, has to perform the process of registration on the system and while doing so send a request for promotion to a higher rank. System administrator is a predefined User with special privileges – they have access to all parts of the application. Besides that, they can also accept or decline the request for promoting to the teacher role. This mean that the administrator is being in full control of the hierarchical control functions. All other types of Users are considered as unregistered users – students and other visitors (f/e faculty board members, potential freshmen etc). Use case diagram of system participants are represented on Figure 1, where the previously explained roles can be seen.
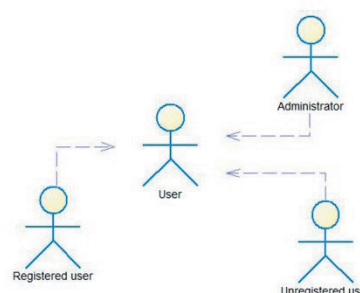

Figure 1 – Participants in the system

3.2. FUNCTIONAL SYSTEM REQUIREMENTS

It is an imperative to segregate participants and give specific access to all of the defined classification clusters in order to allow the system to support correct functionality division. For that reason, the idea is to make the software solution divided in three modules with available actions.
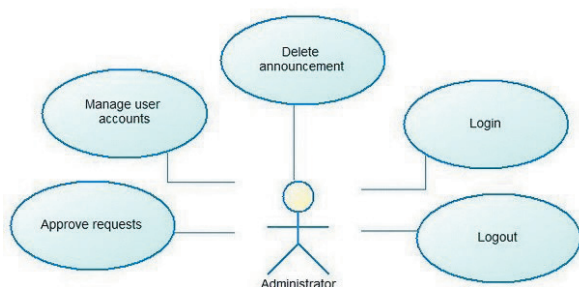
Figure 2 – Administrator module

Use case diagram for the administrator role is shown on Figure 2. First module is available exclusively to the administrator. Supported actions for the administrator are user registration on the system, manipulating of the user profiles (change of the registered users' information, activating/deactivating profiles and deletion of registered users), accepting/declining promotion requests for the roles of a teacher, removing news updates about a subject and logging off from the system.

Registered users that are teachers can, beside registration, log on and off the system, also do actions of personal information change, uploading collections of archived student work, uploading the grading scale, downloading machine-prepared archived and ready for the process of manual evaluation (in which is also the table for grade input), as well as creating news announcements for a subject (uploading grades in *.pdf* format). Registered user module, including its functionalities is shown on Figure 3.
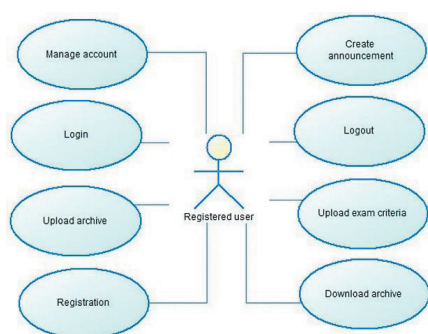
Figure 3 – Registered user

Unregistered users cannot log on the system, so advance options are unavailable - they are limited only to viewing uploaded news about a subject and downloading a PDF document that has student success on the previously performed knowledge evaluations. Allowed options are shown on Figure 4.
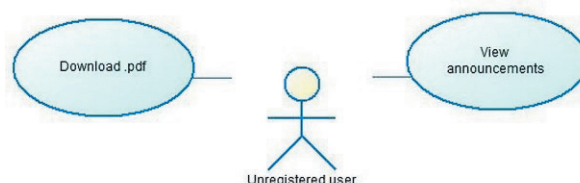
Figure 4 – Unregistered user

4. PLANNED TECHNOLOGIES FOR THE SOFTWARE SOLUTION DEVELOPMENT

The platform whose usage would be seen in automation of the repetitive parts of the verification and evaluation process of the submitted student work's implementation will be based on modern technologies from the web-oriented spectrum. Reason for this lies in advantage that is brought by web implemented solutions: ease of use of the concept that will be the base of solution implementation, access to adequate documentation which will help in removal of potential problematic places in the source code, easily understandable of the source code, adaptability to the future application updates, portability and creating client-server communication protocol.

Currently planned programming language is Java, with the assistance of Spring framework. Other technical requirements for this solution will mainly depend on Maven, application build tool. Java, Spring and Maven will be used for their numerous combined benefits. One of key guidelines for implementing the software product will be security as well, so the academic integrity will not be endangered (this might happen in cases where the application makes unauthorized access available).

Angular framework will handle the presentational layer viewed by system users. To make the visuals more intuitive and more understandable, we will use Bootstrap and SweetAlert libraries.

If the need for the additional frameworks, libraries dependencies and programming languages arise in any of the future iterations, we will be able to alter the application with minimal effort and modification, thanks to the fact that the platform will be created with pluggable modules.

5. CONCLUSION

With the educational system being a complex domain that requires software solutions to the repetitive parts of the work (with attention to the minimal error possibility), automatization can be used in this area. Usage area for the application for automatization of student work evaluation process will for now be limited to the cluster of programming courses in higher education facilities. The platform whose implementation is yet to come will secure less work for the teaching staff (tiring operations will be done by the applicative software), as well as reducing error occurrence.

On the basis of everything shown so far, it is evident that the need for this kind of automatization software is reaching its peak. There are numerous domain problems that the modern world is facing and that need maximal focus to solve. Some parts of the work can be performed without human assistance – they should be separated into a different domain area on which the software solution would work. Given this context, automatization would make sense and would be a tool that could help increase the working speed for the repetitive tasks, as well as increase productivity and accuracy. The process of solving the problems of modern society undeniably needs assistance of a human. To make sure that the work is done according to given criteria and principles, it is necessary to take care that the automatization is only implemented to a certain degree.

Therefore, the idea of introducing automation tools is justified, with the proviso that there must be a previously defined line of automation that must not be crossed.

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DICTATION SOFTWARE DEVELOPMENT AND ITS APPLICATION

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Abstract:

The aim of this paper is to present a new digital tool for writing dictation which can be used as an effective teaching technique in English language classes because it creates an optimal learning environment in the digital age. The first part of the paper provides an overview of theoretical interpretations on the importance of using the dictation as a writing technique in foreign language classes, after which a new digital solution is presented. The presented digital platform for dictation writing allows users, both students and teachers, to install and use this feature without additional complications. The new platform is implemented in Python using the Flask web application framework, and it provides a single interface through which users can access and manipulate dictation related entities. Teachers can perform CRUD operations for entities such as students, groups, dictations, submissions. The automatic grading is implemented in this platform by utilizing the longest common sequence algorithm to compare the original dictation transcript with the student submitted text. In that way grading is done automatically, providing complete objectivity without the need to manually search for errors within each submission. The advantage of this platform is seen in the fact that traditional language learning techniques are being modernised and thus completely integrated in the new digital teaching era.

Keywords:

Dictation, language learning, software development.

INTRODUCTION

As a result of school closures due to the global Covid 19 pandemic, digital distance learning, where technologically possible, has been taking a major role. Therefore, teachers and students are using digital platforms, applications and contents, all with the aim of adapting teaching and learning strategies to this, relatively new learning environment [1]. Since teaching English as a foreign language is based on teaching the language through four language skill – listening, speaking, reading and writing, many teachers experienced a problem with the implementation of the writing technique – dictation in an online environment. Dictation as a writing technique is of extreme importance for foreign language learners of all level, since it affects the development of other language

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skills such as listening, speaking and of course writing [2, 3, 4]. Thus, the need to create a way to implement this writing technique in online teaching led to the creation of the new dictation software whose development and application in teaching will be explained in detail.

2. RELATED WORK

There are numerous platforms that can be used to conduct the dictation in an online environment, but detailed analyses of the same reveal a number of shortcomings that make them impractical for further use in a classroom situation. Most of these platforms are based on the idea of converting text to speech, which is a technologically advanced alternative for reading text out loud in situations when the teacher is absent [5, 6, 7]; however, it is rather inconvenient to be used as a platform for conducting a writing activity such as dictation since the reading is continuous and has no characteristics of the traditional dictation reading (the example of such platforms are: Natural readers[1] and From text to speech[2]). On the other hand, there are platforms such as Speechling[3], DailyDictation[4], and Listen and Write[5] that allow users to control the speed of dictation, insert the text for dictation and see corrections immediately after the dictation is completed; however, the limitations of these platforms are reflected in the inability of the teacher to see students' results – since these platforms' primary function is to support independent language learning outside of the classroom situation.

Another thing regarding existent online platforms for dictation writing is the lack of the possibility of repeating individual phrases or semantic units, which is an important characteristic of traditional dictation writing [8]. Reading and repeating individual phrases and/or sematic units is extremely valuable in language learning because of idioms and similes that should be herd and learned as a whole [9], thus, repeating them enhances students' ability to remember them in such a way. Due to all of that, the need for development of new dictation platform was needed in order to continue using dictation as a language learning tool in online teaching environment.

3. IMPLEMENTATION DETAILS

Since the dictation platform is intended to be used by users of various skill levels the solution had to be available on most devices without the need to perform any special configuration or installation procedures. Thus, the solution presented in this paper is implemented as a web application. The backend of the web application is implemented in Python [10] using the Flask web application framework [11], whilst the frontend is implemented using the Angular framework [12] and Angular Material UI components library [13]. The solution provides a single interface through which the users, teachers and students, can access and manipulate dictation related entities. The entities that can be manipulated through the web application are students, dictations and submissions. Teachers can add, edit and remove all of the aforementioned entities. Figure 1 shows a class diagram of the entities available in the web application. As can be seen on the diagram, each student can be assigned to one or more groups. These groups can represent skill levels, study groups or any other criteria by which students should be segregated. Dictations also have an assigned group. This allows for dictations to be delivered to the students of the corresponding group only. Additionally, dictations contain the original transcript which can be used to automatically grade student submissions. Each student submission is described by the Submission class. Instances of this class are created automatically when a student access the dictations for the first time. Once the student submits his dictation the existing instance of the submission is updated to contain their answer. Submission instances are also used to track the time at which the students have started the dictations, as well as due time and time at which the students have submitted their answers. Furthermore, the Submission stores the score, which can be assigned automatically upon dictation submission or afterwards manually by the teacher. The creation and submission IP addresses are also stored in the Submission instances. These can be used to verify that the same student commenced and submitted the dictation.

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1   naturalreaders.com/online
2   fromtexttospeech.com
3   speechling.com
4   dailydictation.com
5   listen-and-write.com
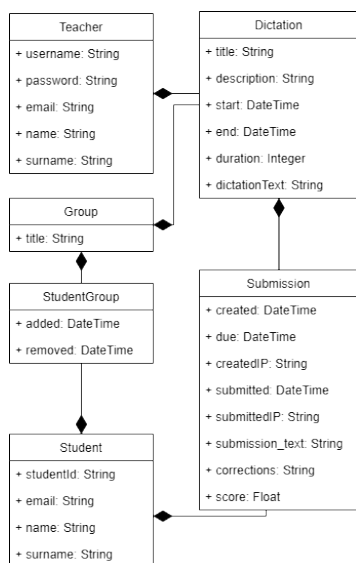
Figure 1 - Dictation software class diagram

The automatic grading is implemented by utilizing the longest common sequence algorithm to compare the original dictation transcript with the student submitted text. If the algorithm returns a result indicating that less than 10% of the student submitted text must be changed in order to equal the original transcript the submission score is set to "passed" i.e., to a numeric value of 1, otherwise the score is set to 0. Additionally, upon automatic grading, all of the necessary corrections are stored in the submission instance. Although this grading scheme is very rudimentary it effectively reduces the time that teachers have to spend grading the students manually. Furthermore, storage of the corrections allow teachers to easily review any student submission and to grade them in any desired way without the need to manually search for errors within each submission.

The user interface of the application can be divided into two major components the teacher panel and the student panel. The teacher panel is accessed by logging in through the teacher panel login page show in Fig 2. The home page of the teacher panel, shown in Fig 3, presents the teacher with a form for creating new dictations and a table of all of the currently available dictations. Each dictation shown in the table can be deleted or their details can be requested.

Figure 2 - Teacher login screen

Figure 3 - Teacher panel home screen

Figure 4 shows a page displaying details of a single dictation. At the top of the page is a form that contains all of the dictation data. This form can be used to edit any of the dictation data displayed within it. Below the form is a table displaying all of the submissions made for the viewed dictation. Each submission can be deleted or its details accessed by clicking a corresponding action button.

Figure 4 - Dictation details page

A submission details page, shown in Fig 5, contains data about the original dictation, the student who created the submission and the submission itself. On this page the teacher can edit the submission's due time, if the submission is not already expired and set the score for the submission.

Figure 5 - Submission details page

A page to register and view all of the registered students is shown in Fig 6. The form at the top of the page is used to register new students while the table below shows all of the already registered students. Each registered student can be deleted, and their details can be access through the actions available in the table. The page displaying student details, Fig 7, contains a form used to display and edit student details and a table showing all of the submissions made by the student whose details are viewed.

Figure 6 - Teacher panel students page

Figure 7 - Student details page

Similarly to the teacher panel, the student panel is accessed by first logging in through the student panel login page shown in Fig 8. The home page of the student panel shows a table of all the dictations available to the logged in student at the time of accessing the student panel. This page is shown in Fig 9.

Figure 8 - Student login page

Figure 9 - Student panel home page

By clicking the details button next to each dictation, the student is shown a page containing the information about the start, end, duration, and dictations instructions. In case that the student has not already commenced the dictation, a button to create new submission is shown at the bottom of the page, Fig 10. Upon clicking this button a new submission is created, the dictation recording is automatically played, and the page is updated to show the time at which the submission was created, due time, and remaining time. Also, a button to pause and play the dictation, a progress bar showing the remaining dictation time, an input field to enter the dictation transcript, and a submission button are added to the page. An example of this page is shown in Fig 11.

Figure 10 - Dictation before being activated by the student
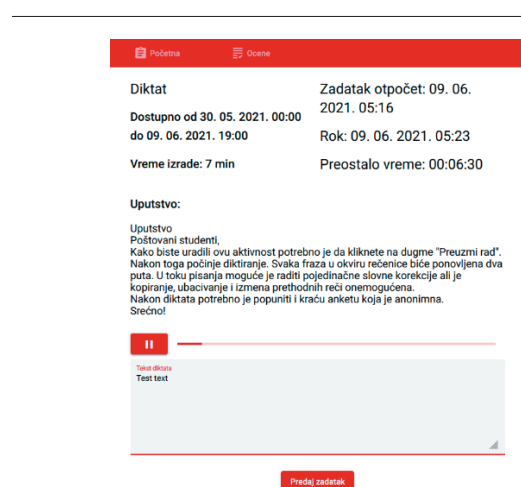
Figure 11 - Dictation after being activated by the student

Besides pages showing the available dictations and dictation details, the logged in student can access a page showing a table of their previous submission, Fig 12. This page allows students to view their grades once they submit their dictations.
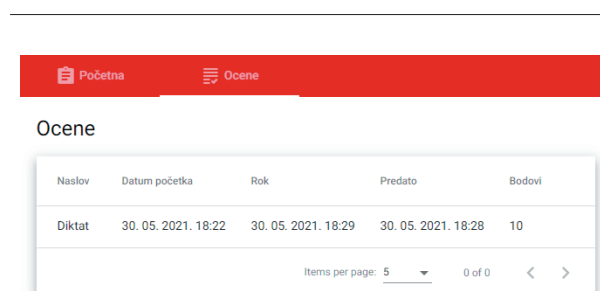
Figure 12 - Student's grades page

4. CONCLUSION

The relevance of this paper lies in the fact that the traditional language teaching techniques that have been used for years in foreign language classes can be used in the new digital environment in an almost unchanged form. The fact is that we are entering an era of new, digital humanities that, given the changes in society and the education system, require results that are precise, accurate, fast and digital [14]. Therefore, the previously presented platform for writing dictation is a new intelligent learning system whose importance is reflected in the simple implementation in the process of traditional teaching.

The most important advantage of using this digital tool in traditional language teaching is reflected in the fact that it improves the quality of work of both teachers and students.

Students are given the opportunity to do dictation assignments not only in class, but also as a form of additional practice at home; the presented platform allows them to repeat, revise and write down the newly learned words and phrases, completely independently. This type of dictation practice has so far been possible only with the help of teachers, friends or parents who would dictate texts to students, but correcting them would take time, so this activity was often neglected in independent work at home. The implementation of the technique of writing dictation in digital form enables students not only to independently practice texts processed in class in a new, modern environment, but they simultaneously practice typing skill – a skill which is the necessity of the

digital era. The feedback is received momentarily after they submit their task, which is another of the characteristics of the digital age, which at same time enables them to register their own progress in the form of self-evaluation [15].

As for the benefits for teachers, they are also numerous. Tasks once entered on this platform are always easily accessible, reducing the time spent on their creation, editing, recording. The assessment is objective, accurate and precise with the possibility of a detailed analysis of each error in the work. The use of digital tools of this type in teaching allows the teacher to take into account the individual needs of students, because at the same time the teacher can play several different versions of dictation, where the volume of text, complexity of written words, reading speed and number of repetitions can be completely adjusted to individual needs of students.

This platform can also be used as an assessment tool, with immediate feedback.

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IT APPLICATIONS IN SPORT SESSION

THE USE OF "SYNERGY SPORTS TECHNOLOGY" FOR THE COLLECTION OF BASKETBALL GAME STATISTICS

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Abstract:

Basketball games have been analyzed in great detail, providing valuable information for coaches and team scouts to tactically prepare the team for the upcoming games. "Synergy Sports Technology" company provides one of the greatest databases for basketball coaches. Regarding the basketball game, there are 10 standardized play-types in offense and 2 standardized play-types in defense. Using Synergy, every basketball game is logged separately, storing data in a general database from which scouts and coaches or researchers select specific information or video for further data analysis. In basketball, there is a large number of data collected and processed all the time, regarding the great number of games played. Applicability of these data presents a great tool for detailed analysis and creating scout reports. Using this program for further research could be very helpful and can contribute to a better, more accurate, and detailed analysis.

Keywords:

Sports technology, Scouting, Research in sport, Data application.

INTRODUCTION

Analytics in basketball has recently experienced rapid development. Recently, basketball games have been analyzed in great detail, providing valuable information for coaches and team scouts to tactically prepare the team for the upcoming games [1]. To be successful, it is important to acquire precise information about the opponent, therefore a way of collecting data is a very important factor [1].

Notational analysis has been one of the most commonly used methods for data collection, which is described as a process of collecting data and diagnostics of events during the game [2]. Filling out observation sheets can be a very difficult job for one person, regarding the great number of games that need to be analyzed during the season. That is why most coaches use video technology for data collection.

"Synergy Sports Technology" company provides one of the greatest databases for basketball coaches. Experienced video loggers analyze and log data regarding basketball games, which is further used by coaches and team scouts for creating scouting reports.

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What is even more important, collected data is often used for scientific papers related to basketball box-score or game statistical analysis [3]–[6]. Considering that there are several standard play-types in basketball, analysis and systematic organization contribute to easier data processing and, therefore better and quicker preparation for basketball games.

As technology takes up an increasing part, both in basketball as in everyday life, it would be significant to present the Synergy logging program as a tool for more efficient data collection, regarding basketball games.

The aim of this paper is to present the Synergy Sports Technology logging program and database in detail and describe its use in basketball scouting and basketball research.

2. DATA COLLECTION

Regarding the basketball game, there are 10 standardized play-types in offense and 2 standardized play-types in defense.

2. 1. OFFENSE PLAY-TYPES

As mentioned, 10 offense play-types are:

1. Cut – Player movement inside the three-point line, mostly going to the basket, before receiving the ball for immediate scoring;

2. off-screen – Setting the screen for the player without the ball;

3. Isolation – Playing 1 on 1 against the opponent in an isolated situation;

4. "Pick and Roll" and "Pick and Pop" – Setting the screen for the player with the ball, after which the screener opens up going to the basket or wide from the ball;

5. Spot-up – Mostly used play type, it presents every situation in which player receives the ball and takes the shot or penetrates to the basket;

6. Post-up – Playing 1 on 1 near to the basket with back turned to the basket (in most cases this is played by Centers);

7. Transition – Quick offense, resulting in scoring or taking the shot before the defense is set;

8. Hand-off – Ball is given to a teammate in close distance (literally handing over the ball) after which he penetrates or takes the shot from distance;

9. "No play type" – This is marked in a situation where none of the above can't describe the play type (i.e. Last-second shots from the other half of the court); and

10. Offensive rebounding – player in offense takes the ball after his team took the shot and missed.

Each offensive play-type is created as a string of certain actions which can be ended with different types, such as shot made, shot missed, turnover, or no violation (a situation where the ball remains in the same possession – i.e. defense picks the ball out of bounds). In each offense, only the last action is being logged as a string, i.e. if there are multiple hand-off situations or "Pick and Roll" actions, only the last one in the current offense will be logged as previously mentioned. Of course, strings are constructed in much more detail, but a detailed explanation is beyond this paper.

2. 2. DEFENSE PLAY-TYPES

There are two standardized defense systems – "Man to man defense" where every defender has a specific player which he guards. The other system is "Zone defense" where every player is responsible for defending a specific area of the court. There are other defense play-types, but most of them are combinations of these two defensive systems.

Every basketball game is logged separately, storing data in a general database from which scouts and coaches select specific information or video for further data analysis. Besides team game analysis, data is also used for player analysis, which is a very important part of the scouting report. There are different types of scouting reports, depending on the competition. A basic scouting report should consist of offensive structure, defensive structure, individual analysis about the opponent's strengths and weaknesses. When the scouting report is written independently, it is important to recognize every play-type on both offense and defense. Sometimes a bad camera angle makes it impossible to evaluate certain plays. This is one of the advantages of using the Synergy Sports Technology database. All plays are already arranged and ready for use.

Further, using box-score for analyzing data has become very popular recently. There is numerous research that has addressed this problem [4], [6]–[9]. Reaching for several box-score tables and data separately can be very exhausting when analyzing multiple games from different competitions. Synergy database allows access to multiple box-score information using the same program.

In Figure 1 is shown a logging program for collecting data. Data are collected by a great number of professional loggers, trained to recognize specific situations.

Every play that occurred during the game is first logged as single play-by-play, which is part of Synergy string during logging.
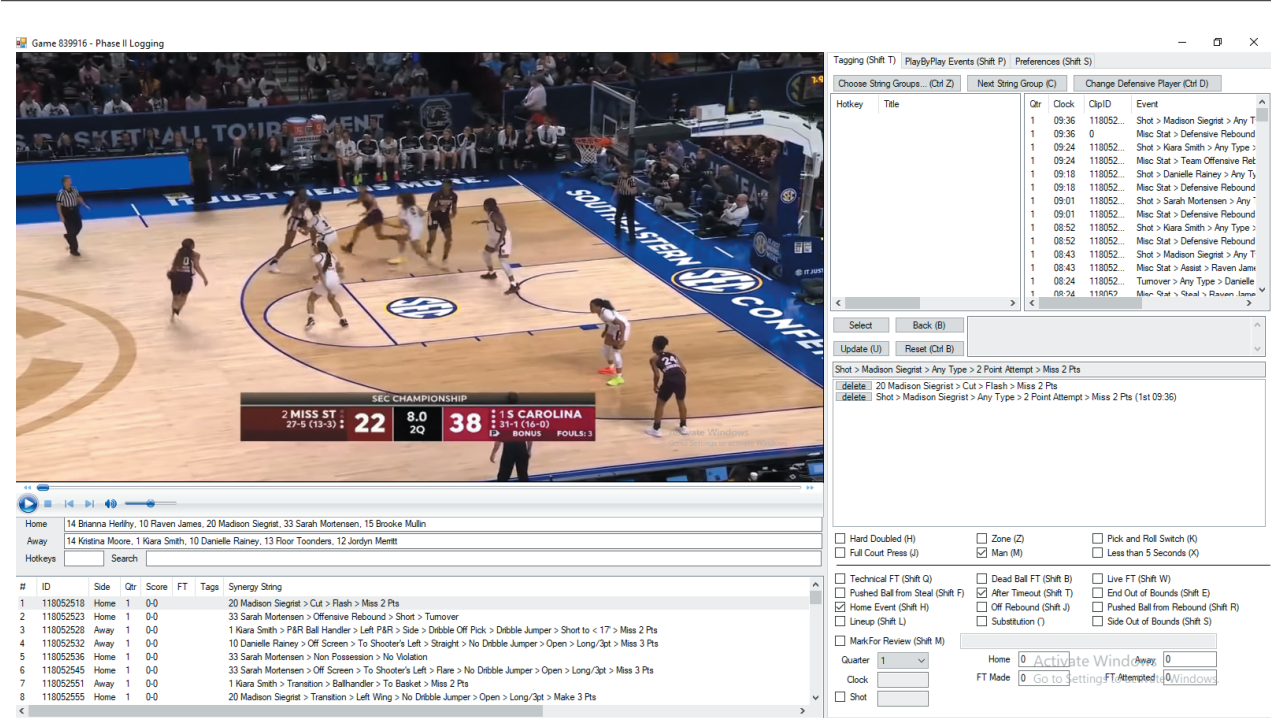
Figure 1 - Synergy logging program, used for data collection

3. DATA APPLICATION

Scouting presents one of the crucial parts of team strategy. According to scouting reports, specific team tactic is organized, regarding the opponent. In Table 1 an example of defensive play-types which are applied by the opponent is presented. Each play type presents one part of the overall team strategy. Based on this information, it is decided which offensive strategy the team will apply.

For a long time, the collection of video data and assessment was a very hard job for coaches [10]. Using the Synergy database, game data processing is greatly facilitated. Good data organization is very important in a tight match schedule, such as in the NBA league, where teams sometimes play 3 or 4 games per week. It is necessary to obtain these data quickly and prepare scouting reports to prepare team strategy in time.

3. 1. USING DATA FOR SCOUTING

After data is retrieved from Synergy's main database, the final task is to organize selected data and write a scouting report. When writing scouting reports, it is

important to be as concise as possible so that players are not burdened with too much unnecessary information. Sometimes this is the key to writing a good scouting report. A part of the scouting report related to the opponent's defensive structure according to the offense is shown in Table 1.

Defensive Structure	Play Types	Comment
P&R Top	Shadow + show & back	Main shadow + show & back-soft
P&R Side - 45	Shadow + Force on baseline + show.	Main Shadow + Force baseline + show #4.
P&R double elbow	Shadow + show & back	Main shadow #5 + show and back-soft #4.
Double Team	NO	
Screen Play	Follow + Over	Guard most of time follow + Over
Low Post	BACK	Back, strong body. Personal coverage, help from baseline.

High Post	Normal	
Pressure defense	YES	They like to play full-court press a few times per game.
Deny (face to face)	NO	
Zone defense	YES	Zone 2-3 on out of bounds.
Match up	NO	
Def. vs. shooter	Normal	.

Table 1 – Defensive Structure – part of scouting report showing defensive play-types according to the offense strategy.

3. 2. USING DATA FOR RESEARCH

Besides the practical application, obtained data is often used for research, mostly for analyzing shooting structure [5], [11] or specific game factors that affect success in basketball [2], [3], [6]. When writing a scientific paper, it is necessary to collect a large number of data to perform a detailed analysis. That is why using the Synergy database can be very helpful, because analyzing a great number of games from two, or more seasons can be done easily.

Marmarinos [3], analyzed the "Pick and Roll" (PnR) offense in top-level European basketball teams using the Synergy Sports Technology database. Analyzing a total of 12,376 PnR, significant findings have been made. It is shown which player takes the shot most often and which players are the most efficient after playing this play-type. It should be noted that PnR is just one segment of an offensive structure since it is difficult and impractical to analyze the whole playing structure in detail. In this research, an example is given of how using a huge database can affect on the simpler application of data in the preparation of scientific papers, saving more time.

4. CONCLUSION

In basketball, there is a large number of data collected and processed all the time, regarding the great number of games played. A thorough analysis could be very long and exhausting. That is why using specific sports technologies can be of great help for basketball coaches and team scouts, as it would for researchers.

Synergy Sports Technology presents a program for direct data collection regarding basketball games, which is systematized in detail. All collected data is stored in a general database, available for use. Applicability of these data presents a great tool for detailed analysis and creating scout reports. There is a lot of research done on basketball box-score analysis lately [7], [9], [12], [13]. Using this program for further research could be very helpful and can contribute to a better, more accurate, and detailed analysis.

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IT APPLICATIONS IN SPORT SESSION

MODERN TECHNOLOGIES IN SPORT, WITH REFERENCE TO VIDEO TECHNOLOGIES

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Abstract:

Modern society is characterized by the global use of advanced technology. One of the spheres of life where technology has great use value is sport. In this paper, we deal with modern technologies that improve sports and results in it. We especially deal with the possibilities of video technology on the sports result itself, the safety of athletes, but also on fairness in decision-making, on economic aspects through the media and the like. The challenges lie in the poor training of users, the lack of creativity to use this technology in a proper way that can achieve better results. Some of the technologies mentioned are video systems in football, water polo and tennis. These are technologies that are now visible and well known to everyone, regardless of whether they believe that this technology has a negative or positive effect on sports. In modern sports, various technologies are implemented that affect the result, whether they are in the form of clothing or protective equipment. These technologies as well as video technology can greatly contribute to improved sports performance in a variety of ways.

Keywords:

Video technology, modern sports, modern technologies, influence on sports, digitalization.

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INTRODUCTION

In recent years, there has been a lot of talk about the application of modern technologies in sports as well as in all other activities. In order for the changes in the field of sports to be successful, we must work on the modernization of knowledge and even equipment in sports organizations. Almost all of us know that technology plays a big role in sports, but very few sports workers decide to use that technology in their work. The reason for this phenomenon is usually a lack of knowledge to handle the technique or simply a lack of creativity to improve their work process with technology. The world of sports is constantly changing, and the use of advanced technologies is just one of those areas that have made an impact in many sports activities. [1] As technology enters sports, so do critics, who state that the use of modern technologies will lose the charm of sports competition.

On the other hand, for many, it makes watching sports more comfortable and fairer in terms of great help to referees in making difficult decisions. For a longer period of time, trainers are able to use video technologies in the training process. [2] With the advent of digital cameras, mobile phones as well as computers, coaches can analyze footage of their athletes and competitors. [3]

Accelerated development and high demand have brought digital video equipment closer to users at lower prices, which was previously a major obstacle in the procurement of such equipment. Until the expansion of the use of video technology in sports, it was not possible without the parallel development and availability of personal computers (PCs) and mobile phones, which are now at a very high level. Sport has increasingly become an interesting economic branch [2] for earnings, and therefore requires a lot of knowledge and resources invested in the development of new content. Videos and TV broadcasts [4] of sporting events are a significant research topic with potentially great commercial value. [5] Demands for efficient acquisition, archiving and post-processing of competitive sports video sequences are growing. [6] Television production requires new possibilities of monitoring and presentation, adapted to the profile of different viewers. Sports videos are structured as a result of competition rules and regulations. The research goals of computer analysis of sports recordings are efficient indexing and search of video sequences based on queries at a higher semantic level, as well as post-production and 3D graphic reconstruction of a sports event. The aim of this paper is to provide a better insight into what the new technology brings, especially video technology and the way in which it can be used effectively in sports.

2. LITERATURE REVIEW

By reviewing the available professional and scientific literature, it is possible to notice a large number of papers that in various ways look at the effects that can be achieved by applying various technologies in sports and thus the specific use of video systems. The works also deal with specific sports through which they analyze the application of video technology. Some of the sports studied are tennis, cricket and bambinton [7], which were among the first to develop a system for monitoring and assisting referees. It is interesting that almost all research is older than ten years, and that the weak representation of this technology in sports is still noticeable. The task of this research is to re-encourage researchers to deal more with this topic and to encourage direct participants to make greater use of available technologies.

3. MODERN TECHNOLOGY AND ITS IMPACT ON SPORTS

Modern technology consists of the use of computers and computer networks and modern information methods and techniques. Computer science (computer science and informatics) deals with the study of display and structuring of information, algorithmic processing processes, computer hardware and software. [8] It is experiencing rapid development and has a major impact on all areas of life and work. The media are based on the idea of accepting the means of transmitting information using computers, their digitization, processing and unification. They have become the most successful method of exchanging information among people.

The basic characteristics of information media documents are:

1. digitization of content,
2. computer content processing,
3. archiving in computer memories,
4. transmitting content over a network and
5. displaying content on the screen.

The field of sports is experiencing a very dynamic and intensive development, so the application of information technology is an important factor in its successful functioning. The main factor in the popularization of sports are modern technologies and the opportunities they provide to users. The development of modern technology has resulted in better conditions for both spectators and competitors. Through the development of new technologies, much has been done to improve the results, such as those visible in tennis, athletics and the like. Modern materials are used in the production of synthetic sports surfaces in athletics, so there is a great progress in the 100-meter race compared to the time when these races took place on clay, as well as sports equipment in the form of jerseys and shoes. Sports technologies have evolved for human needs and goals. Technology in sports are also technical means by which athletes try to improve their sports result.

Examples of sports technologies that have improved the sport itself are:

- golf clubs,
- tennis rackets,
- tartan track,
- balls,
- athletic spear,
- mats,
- sports equipment (clothing and footwear) etc..

The advantages of advanced technologies in sports are the preservation of health in athletes through heart rate monitoring and similar monitoring of the athlete's health. Through this type of monitoring, medicine itself is advancing, learning about important factors that occur in the human body during extreme loads that the athlete experiences.

Safety at all times is also possible through the development of certain sports equipment, such as helmets used in boxing and ice hockey. Sports equipment, such as a composite tennis racket that provides better control of hitting the ball and achieving greater speed and precision. Prosthetic devices are also designed to help athletes with certain disabilities. Other technologies such as "smart" equipment can be used to evaluate the results achieved, which includes sensors, computers and devices used for exercise, testing human reactions and frequency of movement. More modern technologies such as motion sensors are used to analyze sports results and achievements. This includes digital recording of the athlete's movements during sports activities that can be used to analyze and improve sports results or to educate sports coaches in training techniques and similar requirements.

4. METHODS AND TECHNIQUES OF APPLICATION OF VIDEO TECHNIQUE IN SPORTS

One of the basic applications of video analysis is the development of sports team tactics in the process of training or preparation for a match. [2] Methods for classifying video sequences into tactical templates are being investigated. The analysis of tennis game tactics is based on the classification of sequences based on the identification of the player's movements and the trajectory of the tennis ball. Performance analysis of a team or player is based on analysis of movement and activity in the game. Coaches and players are interested in the results of the analysis, with the aim of improving the team's performance in future competitions. The basic techniques of analysis are detection and tracking of players and balls, behavioral analysis and active play. Methods of tracking players, balls and referees are the basis for further analysis. The basic technique is to evaluate the images of networked cameras that cover the sports field. Synchronized cameras follow the complete trajectory of the ball. These images are processed in a computer 3D system (HawkEye) [9] and the position of contact of the ball with the substrate and the bounce are generated.

Also known is the VAR (Video Assistant Referee) system used in football where it monitors aspects of the game that are in line with the propositions of the football game. A similar system is used in water polo called VMS (Video Monitoring System). As in swimming, where, as in athletics, he looks at the photo finish in sprint disciplines.

First, we need to describe the video technology commonly used in coaching. A simple mobile phone with a camera, which has become the standard for most people over the years. The phone can be combined with a laptop for feedback and qualitative analysis. [3] The goal and purpose of using video technology is to improve the field process and increase the performance of the athlete. [10] This technology also facilitates learning in the training process where it contributes to a better understanding of all aspects of the training process. [11] In addition to the training process, this equipment can be used in training in educational institutions, in preparing tactics by analyzing videos of opponents or by analyzing your videos in order to eliminate mistakes.

Video training technology, several video cameras and taking shots from all sides, a coach can have several different views on sports performance. By slowing down the recording, the coach can see the performance of his athlete and the mistakes he may make. [12] Sometimes, athletes who make small changes in technique feel that they have made a big change, but the coach sees well those changes that he can analyze with his athlete in order to achieve even better results. Another advantage is the placement of the camera in areas where the coach cannot go, and in this way monitor the work of both his athletes and competitors. In field sports a camera set high in the stands provides a field of view for the coach that is limited from the bench to the field, this is especially evident in football. [13]

5. THE FUTURE

The development of ultra-fast digital camera techniques and video processing methods has initiated research in all sports: recording and playback of networked cameras, player and ball tracking, video analysis and production of key event reviews. [3] Methods of tracking players, balls and referees form the basis for further analysis. In tennis [14], images are processed in a computer 3D system (*HawkEye*) and the position of contact of the ball with the surface and the bounce are generated.

This automated computer system called HawkEye for displaying the position of field boundary lines and automatically checking the correctness (IN / OUT) of the referee's decision. [9]

Using the Python programming language, it is possible to create a small program that can identify objects in the field and, based on the given parameters, signal some of the errors, such as offside or out. Such programs are taught to be made by undergraduate students and are therefore not very complicated, and can be adapted to various purposes that allow the video technique to be used in the best possible way.

This type of application of technology requires the involvement of several experts. In addition to the trainer, scientists who deal with analysis and a programmer who can enable the effective use of the technique should be involved. As in all other segments of life, the challenge is to synchronize these three seemingly difficult-to-connect professionals. Access to the maximum use of technology is possible only if the problem is viewed multidisciplinary, this is visible today in other segments such as medicine and similar sciences. One of the visible challenges is the poor training of trainers, who in a large number of cases are not trained at their faculties to use modern technology, and therefore use it in small numbers. [3] This is a very important segment of progress and application of modern means and should be given special attention, and faculties should pay more attention to these technologies so that students come out with rich knowledge of the use and application of modern technology.

6. CONCLUSION

The successful functioning of sports organizations and its employees depends on many factors, and one of them is the application of modern technologies that facilitate and improve sports results. In many organizations, the application of modern technologies in the form of information technologies is very poorly represented. A partial reason for that is poor training, but also a low threshold of creativity that would help in that intention. One of the technologies that stands out, and is accessible to everyone in some way, is video technology. This technology, among all others, has a very big impact on sports, but it is poorly used or misused by our experts, scientists and athletes themselves. This problem should be viewed multidisciplinary through, sports, technology, psychology, creativity, etc. The only way to progress in sports as well as in other activities is to join teams of professional and creative people with the goal of progress. Faculties that educate sports experts to apply technologies are in charge of creating the knowledge that is needed. But also the obligation of all other faculties to educate people to connect and to develop their reactivity that can enable them unprecedented progress.

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MODIFICATION OF STANDARDIZED AGILITY 505 TEST BY USING MODERN TECHNOLOGY

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Abstract:

The upright body position, the movements of the body segments, and any human activity require a certain level of motor skills. The quality of motor skills and the pace of their development (under the influence of training) directly affect human daily activities, as well as human health status. In sports, they are directly related to the result, whereas, in team sports, speed and agility are perhaps the most important ones. However, finding an acceptable definition of agility is most likely the result of the influence of various factors from different disciplines of sports science, which affect the manifestation of agility. The most accepted definition of agility is the rapid movement of the whole body with a change in speed or direction of movement in response to a certain stimulus, whereas examples of agility assessment protocols are 505, T-test, Step aside, Zigzag test. Of all the agility tests mentioned, the 505 test is the most commonly used for testing both junior and elite athletes. The test itself has the most possibilities for modification since only small corrections can take into account the specifics of the sports. In sports, there is an increasing tendency to save athletes from long testing procedures and to test as many motor skills as possible in the shortest possible time, thus the new tests need to be as effective as possible. Therefore, this paper aims to propose a future modification of the 505 test to test other motor skills in addition to agility by using modern technology.

Keywords:

505 test, agility, speed, evaluation, validity.

INTRODUCTION

The upright body position, the movements of the body segments, and any human activity require a certain level of motor skills. They represent the human ability to establish movement and solve motor actions that are set as a task or need [1]. Motor abilities combine biochemical and functional processes, as well as psychological characteristics that are limited by the human neuromuscular system [2]. As a result, motor skills represent a wide research field. The quality of motor skills and the pace of their development (under the influence of training) directly affect human daily activities, as well as their health status. In contrast, in sports, they are directly related to achieving top results. Analytically, motor skills are described as abilities of strength, speed, power, endurance, coordination, flexibility, and agility [3].

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There is no consent in scientific publications about the definition of agility. Agility is traditionally defined as the ability to quickly change direction [4], but also the ability to change direction quickly and accurately [5]. In some publications, the authors have included in the definition a change of movement direction of the whole body, as well as rapid movements and a change of movement direction of the extremities [6].

Therefore, agility is not easy to define, since it represents a synthesis of almost all physical abilities that an athlete possesses. In accordance, agility is manifested in several forms, ie in (1) horizontal changes in the direction of the whole body, such as body maneuvers or avoiding the opponent; (2) vertical changes in the direction of the whole body, such as jumping and skipping, and (3) rapid movements of certain parts of the body that control props in sports, such as tennis, hockey, squash [7]… In the recent decades a more comprehensive classification of agility appears, as well as addressing the multiple factors included in the classification of agility. In more detail, they state that there are two main components of agility - (1) change of direction speed (CODS) and (2) perceptual and decision-making factors [8]. Within these two main components, there are sub-components, shown in Figure 1.

A critical review of the literature has proposed the following definition of agility: "... rapid movement of the whole body with a change of direction speed in response to a stimulus" [9, 10].

Externally, movements with a change of direction are characterized by acceleration of movement, deceleration of movement, and different degrees of change of direction. Since the movement is performed at the maximum possible speed, the most common features in the tasks for assessing agility (tests) are fast movements from the place (start), acceleration, deceleration to relative stop, and later changes of direction and acceleration after changes of direction. This sequence of changing movement characteristics is performed at least once (as in test 505, for example) or, depending on the task, repeated three to ten times (sometimes more than 10 times). From the aspect of motor abilities, the characteristics of strength (maximum strength and rate of force development) are important for the successful movement at the start, strength is important for acceleration and deceleration of movement, and coordination is important for the change of direction and movement technique. Success in agility tasks depends on different participation of strength and power, as motor abilities in changed movement conditions, ie it depends on coordination as a motor ability.

On the other end of the definition, in which agility is seen as a complex ability, suggest that it consists of: a) perceptual and decision factors - observation, prediction, and assessment of the situation and b) speed of change of direction - movement technique, speed, leg muscle characteristics and anthropometric characteristics [8]. In this determination, it can be noticed that for the successful manifestation of agility, in addition to perceptual factors, the characteristics of the leg muscles and morphological characteristics are also important. Based on the previously reported definitions, one can see the extreme complexity of agility as a motor ability because, in different scope and intensity, it includes the characteristics of morphological and psychological characteristics and motor abilities. The complexity of agility is reflected in the open character of motor skills [11], ie in the rapid change of direction in response to a stimulus [9].
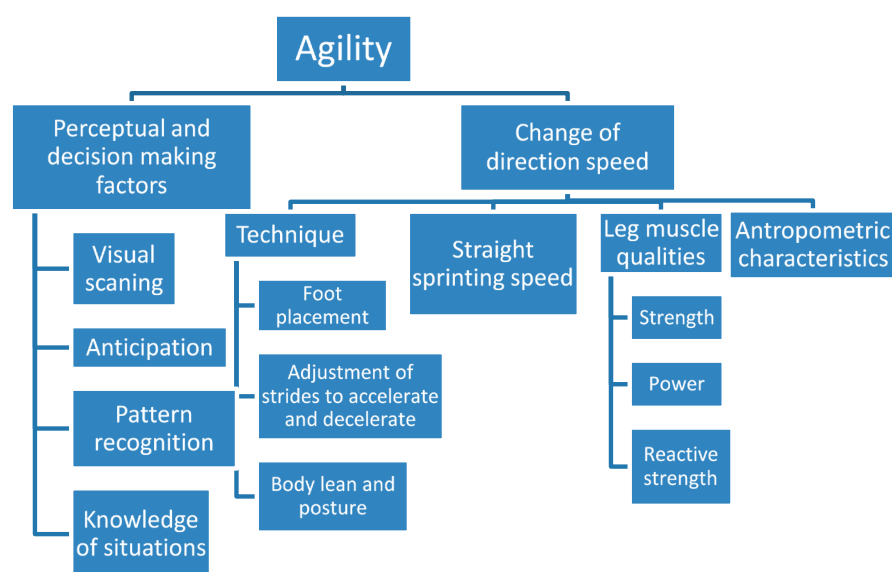

Figure 1 – Components of agility [8, 9, 10]

The assessment of agility is performed by various tests that contain acceleration, deceleration, and change of direction, and test protocols involve more or less specific patterns of movement (complexity of movement) concerning the movement characteristics in certain sports and disciplines such as football, basketball, handball, volleyball, tennis, etc. Examples of agility assessment protocols include 505 test, T-test, Step aside, Zigzag test, etc. [12]. It is clear that these tests contain the speed of running and changing direction, but the result obtained by measuring these tests is calculated as a result that shows us the agility of the subjects, although in all these cases we have given distances 5, 10, 15, 20 or 30 meters. The distance that the participant should run in the shortest possible time is different, primarily due to the sport in which the participant is engaged or his age.

Of all the agility tests mentioned, 505 test is the most commonly used in agility tests in both the junior and senior categories [7]. It is very efficient since the width of one athletic track and the length of 25m are enough for measurement. The test itself has the most possibilities for modification since only small corrections can take into account the specifics of the sports [13].

In this regard, this paper aims to propose a future modification of the 505 test to test other motor skills in addition to agility by using modern technology.

2. METHODS

For the purposes of this study, a bibliographic-descriptive method was used. Literature search was conducted with following services: PubMed, Google, Google Scholar and Kobson. The keywords for searching the appropriate literature were: *speed, agility, 505 agility test, running speed, human motor skills*.

3. RESULTS AND DISCUSION

The possibilities for modification of the 505 test are numerous. This test consists of parts that can be evaluated and that the specificity entered is crucial for research in a particular sport [14]. Viewed from the angle of change in the performance of participants after several consecutive repetitions of the same test, it can be determined how the measured ability changes [15]. In this regard, the speed at 5m or 10m, time to change direction, or response to an external stimulus may be introduced. The first part of the standard 505 test (10m), which represents the distance for increasing speed, and which is

not measured, provides a possibility for modification. For example, measuring the speed at 10m, as well as at the first 5m can be introduced. As a result, this modification would provide two results in the same attempt (test), namely the results of speed at 5m and 10m, while measuring agility.

Therefore, measuring two abilities in one test will reduce the testing time and consequently the workload of the participants (e.g. elite athletes). Such test should require further evaluation, as well as a new name (such as modified 505 test i.e. M505 test).

The following instruments would be used for testing: computerized photocell system, Martin anthropometer, In body 720 bioimpedance. On the first day, morphological characteristics would be tested, as well as speed testing at 10m with a checkpoint time at 5m and a standard 505 agility test results. The morphological characteristics that would be measured are body height, body weight, as well as body composition - muscle tissue, adipose tissue, and the ratio of mass to body height (BMI).

3.1. SPRINT TESTS

Assessment of the paticipants' speed would be performed by a 10-meter running test, within which the variables time at 5m and 10m would be monitored. In this test, the participants would have to run a 10-meter-long track by moving from a high start, in the shortest possible time. In addition to measuring the running time at 10m, this test would also measure the running time needed to cross the first 5 meters. Measurement of running speed at 5m and 10m, respectively, would be performed using a computerized system of photocells. Participants would begin the task at their convenience. Before the measurement, the subjects would have one pretest attempt, followed by two test attempts.

3.2. 505 TEST

Participants would have the task to cross the distance between the markers 15m apart in the shortest possible time. A computerized photocell system for measuring time will be placed at the tenth meter (Figure 2). Subjects will try to achieve maximum acceleration from the start line to the photocell (10m), then stop behind the line of the second marker, change direction for 180 degrees, and sprint again to the finish line (5m). The total distance in this task is 20 meters (10m run-up, and 2x5m measuring distance).
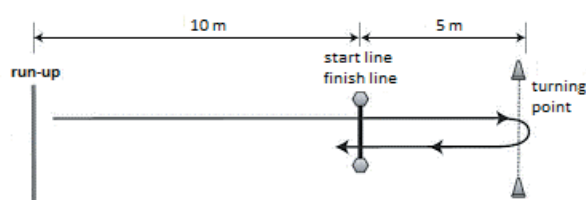
Figure 2. Movement of subjects during the performance of the agility assessment test in 505 test

Before measuring, the participants should have one pretest attempt, followed by two test attempts turning on the same leg. The second day of testing would take place after three days of rest, with a modified 505 test. These results would be taken to determine the validity of the test.

3.3. MODIFIED 505 TEST

Participants would have the task to cross the distance between the markers 15 m apart in the shortest possible time. A computerized photocell system for timing will be installed at the starting line, at the 5th meter, and at the 10th meter. Markers are also placed 15 meters from the start. Participants would move from the starting line after the sign that the system is ready and based on their own decision when to start the test. Participants would try to run their maximum from the start line, and then stop behind the line of the second marker, turn 180 degrees, and sprint again, maximally accelerating to the finish line (5 m).
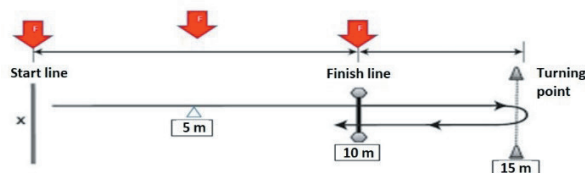

Figure 3. Movement of subjects in the modified M505 test with photocell positions (red arrows F)

The total distance in this task would be 20 meters. The time is recorded with photocells in the first 5m at 10m and then, as in the standard 505 test, the time of the last 5m, changing the direction by 180 degrees and returning to the second marker. Each participant would repeat the test three times.

4. CONCLUSION

For decades, testing has been a basic means of controlling the physical status of athletes. Over time, the tests were changed and evaluated following the needs or new technologies that both improved the quality and facilitated their performance. Testing that has been done with teams of athletes for several days has now been reduced to a couple of hours. It is expected that by evaluating this modified 505 test, a new test will emerge that will provide the results of speed and agility in only one measurement, thus shortening the testing time and strain on the athletes. The use-value of this test is reflected in the fact that in most sports games, basketball, football, handball, volleyball, distances of 5m and 10m are incorporated, which are important and the basis of movement in the game. In all mentioned sports except football, these are also the dominant distances.

The speed at these distances, as well as agility could be tested simultaneously in the modified 505 test. As a result, in some critical periods of the competition, the modified 505 test could provide answers to the coaches about these abilities that directly affect the team's game.

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IT APPLICATIONS IN SPORT SESSION

ELECTRONIC SPORTS AS A RESEARCH SUBJECT IN THE BIOPHYSICAL BRANCH OF SPORT SCIENCES

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Abstract:

The aim of this paper is to present to the scientific and broader professional public, particularly in the biophysical branch of sport sciences, the concept and development of eSport. Furthermore, an additional objective this paper is to present the results of the current studies of eSport within the biophysical branch of sport sciences, as well as to analyze its value and potential as a research subject in this field. For this purpose, the concept of eSport was defined, its roots, history, and development were presented, as were some key current research studies.

Keywords:

Movement, eSport, New media, Digitalization, Methodology.

INTRODUCTION

Although from the very name of the scientific discipline it could be assumed that sport is the basic research subject in sports sciences, there are a small number of researchers and theoreticians in this field who could agree with this assumption [1]. Concepts such as movement, human movement and the like are receiving wider support in this sense in the professional public, yet the debate on defining and limiting the subject of sports science as an autonomous research area is still open [2]. In today's world and society in whose shaping digital technology and new media play a crucial role [3] all traditional theoretical assumptions and concepts have undergone a significant transformation [4], which has important methodological implications [5,6]. Movement and sport [7] are among such concepts as well.

Electronic sport (eSport) as a higher term for all sorts of competitive playing of video games [2,8] is one of the most illustrative phenomena of the aforementioned influence of the digital twist [3] on the world of sports and sports science. The question arises whether eSport is a sport at all, and as such whether it can it be a legitimate research subject of sport sciences [9].

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The main reason for denying the sporting nature of eSports, and value of its research in biophysical sports science is the limited movement of players or athletes to that of the mouse, gamepads, joystick, or the pressing of buttons on the keyboard [2,9]. The global shift toward virtual reality relativizes the strength of this argument to a considerable extent.

The outbreak of the COVID-19 pandemic had a significant impact on all sorts of events organization [10], especially sporting events which lost their performance properties in competition without an audience [11]. Jet eSport events gained even more attention, popularity, and audiences under the conditions of social distancing and epidemiological measures.

This growing popularity can be one of the reasons why the value of eSport has also been recognized by the Olympic Committee. Although despite earlier announcements [12], its inclusion in the official program of the Olympic Games will still have to wait, eSport will be present at the Olympic Games in Tokyo in 2021 within numerous accompanying programs.

Having in mind the need for interdisciplinary and integrated scientific research [13, 14] the main aim of this paper is to present to the scientific and wider professional public, especially in biophysical branch of sport sciences the concept and development of eSport. Furthermore, the aim of this paper is to present the results of current studies of eSport in the biophysical branch of sport sciences, as well as to analyze its value and potential as a research subject in this field. The goals set in this way require the application of different review methods, such as background information gathering, critical appraisal of the topic, and systematic review.

2. DEFINITION OF ESPORT AND ITS HISTORIC DEVELOPMENT

Electronic sport, also referred to as Esport, E-sport, E sport or eSport, can be most generally defined as the playing of video games with the purpose of competition or, more precisely, as "a form of sports where the primary aspects of the sport are facilitated by electronic systems; the input of players and teams as well as the output of the eSports system are mediated by human-computer interfaces" [15]. Among the aforementioned abbreviations, eSport is most common in use, and most complementary to the acclaimed goals of this paper.

Esport is, simply put, a way to compete through the use of video games. Esports frequently involve organized, multiplayer competitions, and can be played both individually as well as in teams. Though video gaming culture has a long history of organizing competitions, prior to the late 2000's amateur players were in the majority-professional gaming only came into being when live streaming allowed for mass spectatorship [16]. It was at that point that many video game developers began to design and fund tournaments, as they recognized its potential in the industry.

The world of video games is expansive and ever-growing, with many different genres and sub-genres. The ones which are most popular among esports participants include MOBA (multiplayer online battle arena), FPS (first-person shooter), fighting games, card games, battle royale games and RTS (real-time strategy). There are, furthermore, multiple franchises which tend to have a loyal following. Much like other popular virtual events which bring people together both in person and online (Fantasy Football being the most obvious example), these competitions often involve the participation of leagues through sponsored teams.

Esport is big business-as the globe's access to the Internet-streaming services such as YouTube and Twitch being crucial here-increases exponentially, and with most of the developed world owning at least one device that connects to the Internet, this is to be expected. With an audience of over 450 million and revenues exceeding US$1 billion by the late 2010's [17], the assumption is that its popularity will only continue to increase. The stereotype of the young, male gamer does prevail-the division of the viewership skews far in the favor of male over female (85% to 15%, respectively), with most aged between 18 and 34, there are some female gamers who have performed professionally as well [18]. Unsurprisingly perhaps, initial recognition of esports was found in Asia, primarily China and South Korea. In fact, South Korea has already licensed professional players for over twenty years, and regulates esports through its Ministry of Culture, Sports and Tourism. Interestingly, despite Japan's well-known video game industry, its anti-gambling laws prevent it from allowing for professional gaming tournaments [19], which is why it lags behind the other two nations. Meanwhile, esports continue to grow in popularity in Europe and the Americas.

The roots of video game competition can be traced back to over fifty years ago, when computers were larger and games far less complex. The very first one is believed to have been held at Stanford University in 1972, specifically for the game Spacewar [20], wherein the prize for winning the tournament was a modest year's subscription to Rolling Stone magazine [21].

Several years later, as arcade video games entered their golden era, Space Invaders popularized the use of the high score option in which high-ranking players could input their own initials while contenders would attempt to defeat the score. The earliest large-scale video game competition was held in 1980, with over 10,000 participants taking part, ushering competitive gaming as a hobby with wide appeal [22].

Eventually, esports events began to get aired on television, as witnessed through the Starcade show in the United States, which aired over 100 episodes from 1982 to 1984 [23]. This show literally featured players trying to beat each other's high scores on an arcade game. Video game tournaments were even featured in mainstream movies, such as Tron, which was released in 1982. Still, at this point the games were still being played in person-it wasn't until the late 1980's that Internet games were designed to allow users to play against one other virtually-through the use of metaservers which located open game servers.

Street Fighter II, which came out in 1991, helped popularize tournament-level competition between two players directly [24], as opposed to depending on high scores which had earlier determined the outcome of who was the best player. By taking advantage of direct challenging, a whole new world was opening up for multiplayer and deathmatch modes. Indeed, it was the popularity of fighting games such as this one that likely provided the momentum for the creation of multiple esports tournaments in the 1990's, many organized by Nintendo. Meanwhile, internet connectivity began to contribute to the growth of the games industry, particularly for PC games.

Around the turn of the past century, South Korea began to stand out in the field of esports, likely as a combined consequence of the availability of broadband Internet networks and high unemployment rate. Internet cafes also began to sprout up worldwide, facilitating access to computers and connection for those who did not have the means to own either, as well as providing a safe haven for hardcore gamers.

Esports were televised in the 2000's, with some channels providing 24 hours coverage, but primarily in South Korea, as similar attempts made in Europe and in the United States were eventually shut down. In the 2010's, however, viewership and prize money both rose, which contributed to esports' popularity [25]. The online streaming platform Twitch, which was launched a decade ago, is known for regularly streaming popular esports competitions. Billions of minutes of content have been watched, which cannot be easily ignored. More and more tournaments are now being organized worldwide. Its popularity can no longer be ignored as a fringe interest. Multiple universities in the U.S. recognizing esports as a varsity level sport-to the extent of offering athletic scholarships and providing tuition funding for their players. As a culmination of life imitating art, the U.S. even opened up its very first Esports Arena in 2015.

3. ESPORT AS SUBJECT OF RESEARCH IN CONTEMPORARY BIOPHYSICAL SPORT SCIENCES

For the purpose of reviewing the current research results of studies on eSport in the biophysical branch of sport sciences, the PubMed electronic base was searched for relevant scientific scores. The following keywords for database search were used: "electronic sport*," "esport*," "e-sport*," "e sport*," or "eSport*." Search was performed for titles, as well as for abstracts. Initially, 148 results were found, ranging from the year 1988 until the present day. After filtering the irrelevant scores, which wouldn't fit under the proposed definition of eSport as competitive video games playing as the inclusion criterion, 83 scores were left. Among them, there were no books, no meta-analyses, one clinical trial, two randomized controlled trials, nine reviews, and two systematic reviews. The vast majority of the scores found deal with the issue of health and developmental risks associated with video games playing, and can only indirectly be related to the biophysical branch of sport sciences. Having in mind the exploratory nature of this paper, only two mentioned systematic reviews [26,27] will be presented with more details.

The study of Fanni Bánya and associates [26] deals with the psychology of eSport, and it is the first systematic review dealing with eSport which can be to some extent be considered related to the biophysical branch of sports sciences. Using similar methods of literature search as in this study, with the inclusion criterion of empirical studies published in a peer-reviewed journal related to competitive or professional video gaming, the authors found only eight valid studies. Those studies were grouped based on topic into three main groups.

The first group of papers dealt with the process of becoming professional video games player or an eSport athlete. The main concern of this paper was the motivation and reasons behind why ordinary video game players pursue professional careers, or how and why leisure and fun activities can become a profession.

The findings of the presented studies suggest that, according to this criterion, there is no major difference between professional athletes and eSport athletes.

The second group of studies dealt with the characteristics of eSport athletes. The main fields of interest were cognitive and conative traits, abilities and skills. It has been shown that success in eSport depends equally on the speed of information processing, focus, attention, and similar mental operations, as well as on the ability to continuously and strongly engage in a certain type of activity which, in this case, is video games. There does not seem to be any essential difference between traditional and eSport athletes regarding this issue, either.

The third group dealt with eSport spectators and their motivation for watching eSport competition. Although numerous similarities between traditional and eSports spectators have been observed, as this line of research cannot be classified as belonging to the biophysical studies of sport, it will not be presented in further detail.

The second found systematic review study dealing with eSport was that of Adam J Toth and associates [27]. This study dealt with the issue of the impact of eSports on the cognitive abilities of players, its specific nature related to the specificity of the activity, and its potential health risks and benefits.

Using the advanced dual systematic review method of literature survey, the authors started with 3,463 potential scores, and ended with 20 intervention and 50 groups in phase 1, and starting from 7,805 initial scores and ending up with 36 articles in phase 2. All included articles were rated as high- quality studies according to the strict inclusion criteria.

The main result of the intervention studies was that interventions of playing video games for about 25 to 50 minutes per day have a positive effect on attention, memory, information processing and task-switching abilities. The impact on memory was weak, the impact on attention and information processing was moderate, but the impact on task switching was strong.

Similar were the results of group studies in which the cognitive abilities and skills of gamers and non-gamers were compared. Gamers were superior to non-gamers when it came to attention, memory, information processing, and task switching abilities. This time, the difference was great when it came to attention, information processing, and task-switching abilities, and moderate when it came to memory.

In the third phase, the impact of traditional sport exercise, such as aerobic or anaerobic training on cognitive abilities was investigated. In these studies, some positive effect on attention, memory, information processing and task switching was uncovered, but the overall results suggest that this effect is low, or sometimes even negative.

Because this is a relatively new and uninvestigated area of research, with numerous of methodological issues and limitations, overall the clear conclusion to be drawn is only that there is a need for further research.

4. DISCUSSION AND CONCLUSION

For the purpose of presentation and analyses of the potentials of eSport as a research subject in the biophysical branch of sport sciences, the concept of eSport was defined, its roots, history, and development were presented, as were some key current research studies.

Although numerous authors are in disagreement when it comes to referring to eSport as a sport [9], it seems from the presented materials that it could easily fit the definition of sport as a competitive activity involving physical effort and skills, as well as being regulated by rules. All three criteria competition, rules and physical effort and skills can be found in eSport events [26, 27]. The main question over whether the mentioned physical effort and skills are by nature different to those in traditional sport is already obsolete. If chess, auto-moto sports, equestrian sports, bridge, nautical sports and the like can be regarded as sports, then why can't eSport as well? Furthermore, the inevitable movement toward virtual reality [28] will erase many of the differences between physical effort and skills needed for traditional sports and eSport. Again, if sport sciences research sport, or the biophysical nature of sport movement, then why should it not research eSport?

Instead of answering outdated questions, what is more important is to analyze the value and potentials of eSport research. First of all, it provides a greater possibility of laboratory research in a controlled environment than does traditional sport. The findings of such studies can be easily generalized and applied to traditional sport as well [2]. Secondly, comparing traditional and eSport athletes can bring us to a deeper and broader understanding of the nature of human movement, its informational and processing component in particular [27]. If sport sciences desire to be relevant for a future society, it should not discard the virtual world [14], rather, it should offer society relevant knowledge which can be used for prevention and development purposes [26].

Nevertheless, valid research of this complex phenomenon within the context of the biophysical branch of sports sciences requires an interdisciplinary and integrative approach [13], as well as open-mindedness of scientists to cooperate between different fields and methodologies. This kind of approach is already yielding results in the fields of health, creativity, and sports studies [29, 30, 31, 32, 33], and the potential for further development seems endless.

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STUDENT SESSION

MONITORING OF E-WASTE RECYCLING DATA

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Abstract:

Recycling of electronic and electrical waste (hereinafter E-waste) is becoming an increasingly important topic in Serbia, as well as in the world. Monitoring data on the quantities and types of e-waste that is recycled is important for recycling centers, but also for the Environmental Protection Agency and the Ministry of Environmental Protection. Regardless of the importance of this data in Serbia, a special program has not yet been developed to monitor and uniquely present this data. In the absence of a single program, recycling centers use a variety of accounting programs as well as Microsoft Office applications (mostly Excel).

Based on the data they generate in their programs, all recycling centers compile certain statistical and annual reports on waste movements at the end of the year. They also have the obligation of quarterly, monthly and daily reporting for certain types of E-waste.

Keywords:

Data monitoring, E-waste movement, E-waste, softver.

INTRODUCTION

In Serbia, as well as in the world in recent years, there is a growing trend of recycling of E-waste due to the faster obsolescence of electrical and electronic devices. The increase in recycling is good news, but larger quantities of recycled waste mean that it is becoming increasingly difficult to monitor them. In Serbia, a single software has not yet been developed to monitor the movement of waste, as well as the amount of collected and recycled E-waste. As a program that serves this purpose alone does not exist, recycling companies are forced to use and develop their own tools to track this data.

According to the Law on Waste Management, all recycling centers are obliged to report any movement of waste to the Environmental Protection Agency, as well as to confirm the movement of waste, confirming its movement, specifying data on the amount and type of waste, mode of transport and the like.

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These data are submitted by recyclers to the Agency electronically, as well as physically to the address of the Agency within 15 days from the end of the movement of waste. In order not to leave something out, recycling centers use various applications and software in which they enter data on the quantities of waste collected, treated and delivered. The most commonly used application for generating and tracking data is Microsoft Excel. In Excel, various tables are formed with precise data on the planned waste collection for the next week, on the type and amount of waste collected, treated waste, recyclables, daily reports, disposed waste and the like. In order to make data tracking as easy as possible, the bookkeeping programs that the company owns are also used.

These data are also entered in these programs and it is possible to obtain numerous reports based on them. Accepted Quantities of collected waste can be entered via Calculations, and quantities of treated waste using Requirements and Work Orders stating the result of recycling (recycling). Based on the entry of these data, it is possible to check the current waste warehouses, as well as the condition in all warehouses.

2. MONITORING OF E-WASTE RECYCLING DATA

E-waste recycling has made significant progress in Serbia in recent years. Recycled quantities are growing, and the number of Operators dealing with E-waste treatment is growing. Therefore, there is a greater need for both the state and the Operators themselves to monitor data on E-waste recycling. E-waste recycling companies have a legal obligation to notify each waste movement to the Environmental Protection Agency 48 hours in advance, as well as to confirm the movement when it is completed and to submit documents on waste movement to the Agency by mail. It is very important that the data is accurate, precise and delivered on time. In the computer age, companies use a variety of programs and applications to track all the necessary data and reduce the possibility of errors. Unfortunately, specialized software has not yet been developed in Serbia to serve this purpose, so recyclers use existing business software. By using business software to track the entire business, companies can generate various data that serve as a basis for monitoring business performance from year to year, as well as for various statistical reports. When it comes to recycling, one of the important parameters for monitoring business success is the amount of waste

taken over. Quantities of collected waste are observed separately for each class of waste. Another criterion by which the taken over E-waste is classified are the channels from which the waste is taken over. Recyclers, i.e. recycling employees, enter individual Calculations in the program, based on the documentation they receive after each waste movement. On that occasion, they enter the quantity and type of arrived and sorted waste, the date of collection, the data of the waste carrier and the data of the owner of the waste. Also, at the end of each shift, data on the amount and type of E-waste that is recycled and the amount and type of recycled waste are entered. Precise quantities of recyclables obtained (recycling result) are entered for each individual type of E-waste (so that it is possible after a certain time, to predict based on the amount and type of waste and the value related to recyclables). Based on the entered data, the program at any time provides information on the exact amount of waste collected, waste in the warehouse, as well as recyclables that can be resold and those that need to be disposed of.

Depending on the requirements entered, business software offers a large number of tabular reports. It is necessary to determine the time period for which the report is needed and define which data we want to consider in the report. So we can choose a specific category of E-waste or all downloaded E-waste. In addition, we can designate only one supplier or group suppliers, for example according to their location or according to whether the collection of E-waste is their primary activity or they are obliged by law to return waste from their own business for recycling, or in question. individuals and the like. The program also includes so-called ready-made, ie standard reports, which are often used and in which everything is defined in advance and it is only necessary to enter the period for which we need a report. These reports make it easy to track business and compare data at different time intervals.

The following is a report in the form of a table, showing the quantities of E-waste taken in a given year, sorted by waste classes, provided by one such program (Table 1).

Class	Quantity	Percentage of participation
Monitoring and control instruments	4,367,918 .00	17.03%
Toys and equipment for recreation and sports	314.00	0.00%
Automats	67,748.00	0.44%
CRT monitors	243,366.00	1.99%
EE tools	2,710,686.00	12.92%
IT and telecommunications equipment	759,341.00	4.31%
Small home appliances	168,096.00	0.72%
Medical assistive devices	28,483.00	0.10%
Consumer equipment	73,907.00	0.48%
Lighting equipment	83,919.00	0.15%
Other TV sets	104,189.00	0.38%
Air conditioners and refrigeration equipment	3,874,883.00	27.97%
CRT TVs	2,853,608.00	22.15%
Heating devices	22,323.00	0.16%
Large home appliances	809,198.00	11.21%
In total	16,437,977.00	100.00%

Table 1 – Amount of waste taken over in 2020

The data shown in Table 1 - Amount of waste taken over in 2020, represent one standard report in which the data are classified according to a certain criterion (in this case it is the E-waste class) for a time interval of one year with a percentage share in the total amount. The percentage of participation of individual classes of E-waste in the total amount of collected and recycled waste is very important.

Based on this percentage and data on the obtained recyclates (quantity of recyclates and their quality), we can conclude which is the optimal combination of E-waste, i.e. which combination of E-waste during recycling gives the highest quality recyclables.

In the same way, the data related to recyclables, quantities and types of E-waste that is in the temporary storage are presented, but the time interval is not determined, but the exact date for which the report is needed. Reports related to the quantities of recycled E-waste require the determination of the period for which the report is required and look similar. Based on these data,

it is possible to make decisions on a daily basis about the type of E-waste that will be recycled or, for example, about the sale of certain recyclables such as iron, copper, glass, plastic and the like.

There are many such reports, and it is possible to modify the requirements according to current needs. Modification of requirements is done if some specific data is needed, if we want to determine, for example, productivity in certain conditions or the quality of recyclables obtained by processing a particular waste, from a new supplier or E-waste that we have not treated so far (some specific tools, etc.).

By entering data, it is possible to monitor the operation of the recycling plant, i.e. the exact time of downtime. This provides the ability to analyze the causes of failures.

The following is another standard report, which is very often used. This is a report that monitors and compares the planned and actual quantities of collected E-waste. These data can be viewed on a daily, weekly, monthly, quarterly, semi-annual and annual basis. Monthly and annual reports are most often used. These data can be observed for all collected electrical and electronic waste, or for a certain class of waste. By selecting the appropriate parameters, the desired report is obtained.

Month	Realization	Plan	%Realizations
2021-1	164,662.00	161,000.00	102.3
2021-2	301,883.00	250,500.00	120.5
2021-3	416,574.00	312,500.00	133.3
2021-4	398,192.00	341,500.00	116.6
2021-5	54,922.00	341,500.00	16.1
2021-6		351,000.00	
2021-7		351,000.00	
2021-8		351,000.00	
2021-9		351,000.00	
2021-10		341,500.00	
2021-11		341,500.00	
2021-12		306,000.00	
Ukupno	1,336,233.00	3,800,000.00	35.2

Table 2 – Plan and realization of collected E-waste in 2021Advantages and disadvantages of existing data monitoring programs

Tracking data on recycled E-waste using existing commercial software has its advantages and disadvantages. As already mentioned, these are general accounting programs for comprehensive business monitoring. Their main advantage is that they are easy to use, so no additional training of employees is required to use it. These programs can be used by anyone who has been involved in bookkeeping or has been in contact with business software. Generally, companies that offer business software also offer free training to employees on how to use the software and support when using it. The advantage of these programs is that all data is in one place. [1] So that the financial data can be easily compared with the data on the movement of waste, or for example the data on the treated quantities can be compared with the data on recycled materials and in that way it is possible to easily detect errors if they occur. Centralized data storage also provides the possibility of various financial reports, makes it easier to monitor the productivity of workers in different conditions and the like. From a financial point of view, the use of standard business monitoring programs is a cheaper option than developing specialized software for the needs of recycling centers.

What appears to be a disadvantage is the fact that these programs do not specialize in the recycling business, so additional use of Excel is necessary, for example, to avoid mistakes. In such programs, it is not possible to monitor the entire movement of waste, from the moment of announcing the movement to the Environmental Protection Agency to the moment of storage and confirmation of movement. There is no option to confirm the return of certified Waste Movement Documents that recyclers are required to keep and submit to the Agency under the Law on Waste Management. [2] Documents on the movement of waste are still submitted to the Agency, physically, by mail, which requires additional costs, both financial and unnecessary spending of paper (when printing documents).

These programs are diverse, there are many of them, so the reports of different recycling centers are not unified, which reduces the visibility of the reports and their comparison. Another problem is that these programs are not synchronized with the software of the Environmental Protection Agency, so that all data on the Agency's website are typed, ie data are first extracted from its own program, and then entered on the website. That way, there is a high chance that an error will occur, that something will be missed or that the wrong information will be entered. If an error occurs, some data can

be changed, while for some it is necessary to contact the Agency. These are just some of the disadvantages of using non-specialized software.

2.1. POSSIBLE DEVELOPMENT OF A RECYCLING DATA MONITORING PROGRAM

Monitoring data on the amount of recycled E-waste is of great importance not only for companies engaged in this activity, but also for the state itself. Namely, in order to develop its strategy, the state must have accurate and precise data on the quantities of collected and recycled waste. Also, based on these data, the state determines and allocates subsidies to recyclers, which is another reason for these data to be reliable. First of all, it is necessary to develop a program that would monitor the entire cycle of waste movement, from the very beginning (announcement of waste movement to the Agency) to the end (confirmation of movement, exact quantities of transported waste, data on the carrier, etc.). It would be good for the program to be used by all companies that deal with this activity, so that the reports would be unique.

One of the possible directions of program development is the use of QR code. By using a QR code on documents on the movement of waste, it would be possible to enter data into the program by simply reading it. In this way, important data such as the amount of waste, the date of movement of the waste, the conveyor and the like would be entered automatically.

Another possibility for development is for the program to be harmonized with the program on the website of the Environmental Protection Agency so that the data can be automatically submitted to the Agency by simply exporting data from the company's program. This would significantly reduce the possibility of errors when entering data and would reduce the time required to enter data. All of the above would increase labor productivity. It would be good to improve the Agency's software in terms of developing opportunities for document entry and create a centralized database of all documents entered in the field of e-waste recycling. [3, p. 34]

Taking into account the fact that recyclers are obliged to keep daily records of waste (to fill in DEO forms), as well as annual reports on waste (GIO forms), the program should generate these reports (in the form of prescribed forms) based on data are entered daily.

E-waste recycling is an important topic at the global level as well. However, there is no single program or single report in the world that could easily compare

recycling data from different countries. Quality and comparable data are needed in order to define a clear waste management policy at the global level, to develop E-waste statistics, as well as to reduce illegal trade in this area. [4] [5, p. 18]

3. CONCLUSION

Based on all the above, we can conclude that monitoring data in the field of recycling of electrical and electronic waste is difficult and underdeveloped. This stems from the fact that the recycling of E-waste itself, as well as the awareness of citizens and the state about the importance of recycling and the circular economy, is still not sufficiently developed. A program that would be used by recycling companies and that would be synchronized with the program of the Environmental Protection Agency has not been developed yet.

E-waste recycling companies are forced to use existing business monitoring software, which is not specialized, and to adapt it to their own needs. The main advantage is that there is no need to further train employees to use the program and that no additional costs are required. It is also important that all the data is in one place, so it is easy to compare them. What appears to be the main drawback is that it is not possible to monitor the entire flow of waste, but it is necessary to use additional applications and create tables and graphs for comprehensive data monitoring and error avoidance.

There is a strong need to develop a single specialized software that would be used by all operators involved in the collection and recycling of electrical and electronic waste. Such a program should make it easier to monitor and publish E-waste recycling data. The development of a specialized program would speed up and facilitate the submission of data to the Environmental Protection Agency and monitor the movement of waste from the announcement of the movement to the very end of the movement. All reports related to the recycling of electrical and electronic devices would be presented in the same way, which would contribute to better visibility.

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STUDENT SESSION

CRACKING COMPLEXITY IN MATERIAL DESIGN

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Abstract:

In an ever-evolving field, it would be appropriate to presume that the next best thing is always around the corner. This notion of continuous change although a natural herald of progress is sometimes taken for granted by some seasoned developers. In other words, change will happen, whether they want it to or not, or whether they are ready to accept it. In contrast, a newcomer to the field, at first, might be excused for not abiding by the conventions agreed upon in the immediate future following their introduction to the same, as they ought to bolster their knowledge with information already explored by their more experienced peers. At some point, though they too are expected to attain the competence and capacity to keep track of the numerous innovations as well as provide value in the form of their contributions. As the process of catching up is rather laborious and perhaps even stressful the goal of this paper is to attempt to demystify a topic that often gets deferred by topics that are considered to be of seemingly greater importance. No matter by which metrics one might characterize the state of their knowledge, the time comes when even the most loathed topics have to be explored. User Experience and User Interface Design fall under those topics some would rather do later than sooner as they view themselves as developers, not as designers. The paper will demonstrate that they are capable of being both.

Keywords:

Material Design, User Experience Design, User Interface Design, Design Language System.

INTRODUCTION

In order to set the stage for what is to come think of the following few cases. Put yourself in the shoes of a student attending some unnamed university being tasked with developing an application for an exam or a thesis. In the image, you are a lone wolf developer working on a software solution for an unnamed client. Lastly, think of you as a member of a small but diligent team in a startup company where all your coworkers belong to some subtype of software engineering.

In all before mentioned cases chances are you will be the one tasked with composing the interface design necessary for successfully finalizing the project.

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It seems only logical that in the assortment of tools under your belt as a developer you would hold certain knowledge of some Design Language Systems. If Android is your platform of choice, then Material Design is the Design Language System for you.

Before tackling the complexity of a specific it is always a good practice to at least familiarize ourselves with the definition of the universal and the reasoning behind its existence.

Namely, each company behind a specific Design Language System has given their version of the definition but ultimately they all mean the same. For example, Google and Airbnb, two well-known credible companies, define their Design Language Systems in the following manner:

- Google's Material Design is defined as an adaptable system of guidelines, components, and tools that support the best practices of user interface design [1].

- Airbnb defines its Design Language System (or DLS) as a collection of components defined by shared principles and patterns [2].

Design Language Systems provide value not only to the end-user by securing visual consistency but are also an effective catalyst for improving a team's productivity as they provide a ubiquitous language for accomplishing their tasks. Ultimately Design Language Systems serve as a valuable asset to the companies themselves for when used according to the principles set beforehand, they award them by accurately expressing their brand in products, communications, marketing, events, and digital experiences [3].

To summarize that which has been said so far. In order for the code implementation to be written down, developers should first consider the foundation of the design language itself. Short-term solutions at the cost of proper use of fundamental principles do not stand the test of time and have a great likelihood of costing us more in the future. Think long-term.

2. USER EXPERIENCE DESIGN

The term User Experience (or UX) is rather new compared to the history of mankind and language itself. It has been attributed to Don Norman who coined the term back in 1993 [4]. However as is the case with Design Language Systems there are various definitions provided by different entities, of which two shall be mentioned in this paper as the entities behind them hold great authority on the matter.

- Nielsen Norman Group, a world leader in research-based user experience founded by Don Norman and Jakob Nielsen gives us the following definition: "User experience encompasses all aspects of the end-users interaction with the company, its services, and its products" [5].

- International Organization for Standardization, defines User Experience as: "User's perceptions and responses that result from the use and/or anticipated use of a system, product or service" [6].

Note that UX design isn't only tied to software development, but rather it is a science in itself although in the design community itself there is disagreement about UX design being just design or rather art or science. One is certain without it the world of software development wouldn't be as it is today.

2.1. ASPECTS THAT GUIDE PRACTICE

The early period of UX design as it pertains to the development of smartphone applications might be described as being a period of lawlessness, a period of unintuitive user flows and inconsistent user interfaces. The wild west of application development. It is obvious to the conscious eye that plains have changed. Users are infatuated with the designs of the day.

At a time when markets are being saturated with applications competing for downloads, clicks, and views, of which some if not most are likely to dissipate not long after publishing for not abiding by the appropriate principles of UX design, it only seems logical to innovate the methods used to build them. In order to have a chance developers should incorporate into their designs some basic principles or aspects.

One of the most recognizable tools for encouraging the decision-making process and linking the requirements of various stakeholders is the User Experience Honeycomb by Peter Moreville [7]. The diagram is comprised out of seven qualities of user experience:

- Useful: If there is no purpose for the application to exist there is no need for it.

- Usable: The application has to enable users to effectively and efficiently achieve their goals as well as propagate the feeling of satisfaction while doing so.

- Desirable: Delivering positive experiences for users might just set a design apart from others.

- Findable: If you end up going to a store in search of a specific item, and once you are there you

spend a considerable amount of time looking for it, just to return home empty-handed you have just had a bad experience and you might decide to abstain from visiting that establishment again. The same is true for designing mobile applications. Users should be able to find the information they are looking for and also navigate to it on time.

- Accessible: Do the ethical thing and design applications so that they can be used by as many users as possible. Even those who might have certain disabilities deserve to have the same experience as others while using the application. Short-term profit doesn't justify the overall long-term positive user experience.

- Credible: Don't expect users to trust you. You ought to earn their trust.

- Valuable: At the end of the day if the application doesn't provide value to the user, in any of the before mentioned ways and in turn, doesn't provide value to the developer then it is bound to fail.

2.2. USER-CENTERED DESIGN

A third concept and further disagreement about defining it. User-Centered Design (or UCD) is often compared to, weighed against, and often used interchangeably with User Experience Design. This paper supports the opinion of Cennydd Bowles, a former design manager at Twitter, who in his article [8] states that UX design is the discipline (what is done), while the user-centered design is a process (how it's done).

Note that UCD isn't the only design process in use in teams today, nor is it the one that excels above all. According to Jared M. Spool, an expert on the subjects of UX Design strategy, Design, User experience, Usability, User Interface Design, UX design education (and others), those teams who are most effective are skilled in more than one style [9].

2.2.1. USER-CENTERED DESIGN IN PRACTICE

User-Centered Design is a form of iterative approach that generally iterates over four phases with accompanying methods and tools used for finalizing each phase before moving to the next one [10]. In practice, each team will interpret and adapt a methodology in the way most convenient to them.

For example, Mary Kennedy a User Experience, Product Design, and Management expert mentioned these five principles of UX design to apply to all design projects [11]:

1. Get to know your users;
2. Know your content;
3. Design your experience;
4. Test design assumptions; and
5. Continually validate.

There are various tools and methods in the market today that can be used to achieve each phase, nevertheless, it is always a good practice to keep it as simple as possible. Sometimes a simple pen and paper are more powerful than most high-tech solutions.

2.3. FOSTERING A UX CULTURE WITH MATERIAL DESIGN

Despite its comprehensive documentation Material Design allows for open interpretation when it comes to design implementation. Different designers might come up with unique ways of tackling complex problems but they should always consult the foundations and their own logic. The developer's job is to analyze problems and devise solutions with the use of logical thinking, which is why it wouldn't be far off to presume that if necessary even they could successfully accomplish the task of a designer provided they take the same approach.

Consistency is key for a usable and user-friendly design. Providing consistent experiences satisfies user expectations. Individual visual elements need to coexist in harmony. One should not deviate from the other. If a component is of one type, the other should be of the same. The mission, vision, and values of the organization should be reflected in the design. Most importantly if something doesn't seem right – iterate.

3. USER INTERFACE DESIGN

The world's most valuable resource is data and businesses that are able to manage the power of information drawn from it are clearly differentiated from those that manage it poorly. If developers are able to gather, analyze and present information effectively then they will be able to leverage the power as they choose. In the world of the design if they are able to maneuver the different methods of interaction that the user can utilize to access data and retrieve information in a way that doesn't disturb

the said process, then they have mastered the craft of designing user interfaces. Success cannot be achieved inadvertently. Deliberate action has to be taken to anticipate what users might need to do and to ensure that the interface has elements that are easy to access, understand, and use in order to facilitate those actions [12].

3.1. HEURISTIC PRINCIPLES GUIDING MOBILE USER INTERFACE DESIGN

During development, there is sometimes no progress without trial and error, while on the contrary there is no worse feeling than if the error occurs while in use by the end-user. It is for that reason that developers should adhere to some broad rules of thumb. The ten usability heuristics for user interface design [13] have been adapted in this paper to conform to use cases specific to the development of Android mobile applications. The constraints of the paper don't allow for detailed explanations concerning specifics of Material Design inside different platforms.

3.1.1. FEEDBACK AS AN OUTLET FOR CONTEXT

The tricky part about developing smartphone applications is that some content might be made to be hidden behind actions that might not be as obvious to the user as the developer had expected. The user even might not be aware that functionality exists. It is why developers are responsible for creating transparent components and elements that fit the context and provide immediate feedback upon use. But not only components but rather the whole intended flow of information. The users have to think that they are in control and that the decisions they have made so far and are going to make were reached naturally, without disturbances from the system, or that they have been in some way persuaded by the system either by withholding information or not accurately presenting the expected information. Equally feedback in the case of user error mustn't omit the context under which the error occurred.

3.1.2. DOMAIN-SPECIFIC LANGUAGE

The purpose of the application should be its focal point and the application must be designed in a way that accurately displays it. During the requirements gathering phase, developers need to get to know the system they are going to build so that later they can incorporate into it design decisions most familiar to the users.

Language, form, and concepts the users are used to in a specific domain should be incorporated into the design.

3.1.3. MEANING FIRST APPROACH

User interface design does not need to be overcomplicating. Instead of overthinking developers should try to keep it as simple as possible while preserving meaning perpetually. All the unnecessary information and functionality should be removed. Relevant information with adequate functionality is sufficient, albeit even if they conduct themselves in the mentioned way they mustn't take out information or functionality that provides users with options. Inadvertently prohibiting users to take a way out of an unwanted situation harbors a feeling of frustration in the user and ultimately chips away at the credibility of the company.

3.2. BATTLING EXPECTATIONS

Gone are days of reluctance. User experience and user interface design are not trends anymore. They have become staple sectors of the industry and are here to stay. One's attitude towards them could have been understood in their infancy, but in the world of today, they present expectations that need to be met. Understanding that they are tools of achieving the overall product strategy and measurable harbingers of product growth should be enough of a reason to look into investing in marketing and building products with them in mind.

4. MATERIAL DESIGN IN PRACTICE

Implementing mobile user interface designs demands adequate usage of appropriate material design visual components. Furthermore, individual components [14] are built to solve distinct manifestations of general design modules. In simpler terms, components are building blocks of responsibility. It can be said that a component is designed accurately if it combines best practices of UX and UI design respectively.

4.1. CONTROL COMPONENTS

Controls allow users to initiate functions, choose between options or they serve as visual representations of information that the user can micromanage to achieve certain functionality.

4.1.1. CALL TO ACTION

Buttons are functions a single click away from being initiated. Their importance is emphasized through their design. However no matter the scenario, they have to be designed to be legible to the user. If at first glance the user can't tell apart a button from other components then the design of the interface should be iterated. If the button doesn't properly convey meaning or isn't relevant in the context, the design should be iterated.

One notable button variation that can be utilized while designing is the floating action button (fab). Sometimes a single functionality might be awarded the highest level of emphasis. Often also called a primary action. On rare occasions, a single fab may be designed to act as a menu for related actions while keeping in mind that the functionality lacks scrolling functionality. A skilled practitioner will implement a transition of keeping the fab hidden while the user is scrolling through the contents of the screen.

4.1.2. SELECTION CONTROLS

Whether applications are capable of prompting the users to choose between a few options when gathering data, or allowing them to change item state by a single click, developers have to be mindful that each individual item in the list of options has to be readable when viewed as separate entities, but also the list as a whole has to be easily scannable. With a single glance, users have to be able to discern the options they had chosen previously. If the application allows users to choose one option from a list of options Radio Buttons should be used to implement such functionality. On the other hand, if the users are capable of selecting multiple choices from a single list of options, then developers should use Checkboxes instead. Switches at first glance could be used interchangeably with Radio Buttons or Checkboxes, where the latter would just represent a different design alternative, but it is not so. Each component conveys some meaning when viewed in context. Switches represent state. Light being turned on or off, not a choice between dim or bright light.

4.1.3. INPUT CONTROLS

Acquisition of data from the user by the system is a vital part of any application. The end result, the output can usually be displayed as simple text that when put into context conveys meaning, while the input depends on the functionally that the developer wants to achieve. Entering an email via a Text field, a Date or Time via the respected Pickers, or alternatively allowing users to make selections from a range of values with the help of adjustable Sliders should be done efficiently. The design should be intuitive and the input indicative of the context.

4.1.4. DYNAMIC CONTROLS

To allow users to trigger actions, select, filter, or input data while dynamically changing the provided options depending on the context should be done with the use of Chips.

4.2. NAVIGATION COMPONENTS

Navigation refers to the interactions that allow users to navigate across, into, and back out from different pieces of content [15]. Choosing between the different navigation components of Material Design can sometimes be a challenge as most can be used interchangeably, which is also the reason they all conform to the same base quality norms, although each component might have slight additional nuances. For example, the way in which the destinations are displayed within the Navigation drawer (top to bottom) and Bottom navigation (equal) in terms of importance.

When using components like App bars, Bottom navigations, Navigation drawers, Menus or Tabs developers should take adequate precautions that their design throughout the application stays consistent. Furthermore, their positioning needs to reflect their purpose of being navigational components. They should be easy to read and ergonomic to use.

4.3. INFORMATIONAL COMPONENTS

A previously mentioned principle for interaction design suggests that feedback should be provided to the users whenever they interact with the system. Informational components are used to inform users about a task. They can contain basic or critical information and or one or multiple tasks that are optional or required. Only in the case of the Dialog component should the user experience be interrupted, although the user will still retain the choice to simply close the dialog box.

Dialogs, Snackbars, Badges, Tooltips, Toasts, Progress Indicators, and Banners should be used in an informative way. The goal of the component is to be helpful, which is why its content has to be relevant to the

context. The amount of text should be short enough to accurately convey the message. Finally, informational components have to be placed in the most suitable area of the UI where the users will be able to see them and interact with them in an efficient and comfortable manner.

4.4. COMPOSITIONS

The term Container can be used to represent the left-over components, although that term omits the content from the equation. As the primary reason for a Container's existence is to group related elements of a single context, it wouldn't be incomprehensible to relate to the union of the Container and its content as a Composition. Once they are considered as a distinct unit developers can proceed with their design. The reason why, at least in this paper, they aren't placed into the other classifications is that their function is dependant upon their content. Cards, Sheets, and Lists are distinct members of this classification. If one word could be used to guide the design of Compositions then that word would be consistency.

4.5. BEST PRACTICES

As with maturity comes experience the following list is a collection of some additional best practices to use while implementing Material Design that have proven themselves useful over the years at cutting down on build-time, cost, and overall resource management:

- Follow appropriate resource naming conventions.
- Use colors.xml, dimens.xml, styles.xml, strings.xml references to avoid repetition and support subsequent smoother change handling. Avoid hard-coding.
- Don't overestimate the power of simple design.
- Don't overuse color.
- Use low-fidelity prototypes for early-stage testing, while spending more energy and time on high-fidelity ones later [16].
- If repeated use of a component is observed, the component should be placed in its own resource file and subsequently imported into the desired locations.

4.6. LEARN FROM EXAMPLE

Figure 1 is used to illustrate best practices of UX/UI design. The following mistakes can be easily discerned :

- Section headers are of the same font type as the text within the section.
- Section headers are of the same font size as the text within the section.
- The use of icons is inconsistent.
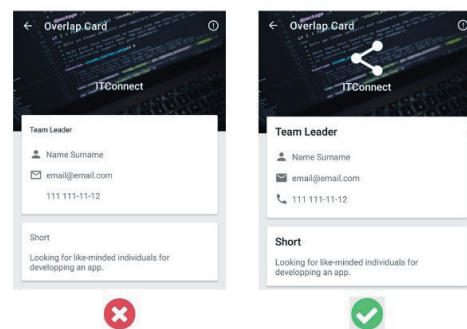- The user has to guess that 111 111-11-12 is the phone number of the shown team leader.

Figure 1 - An example of bad and good design

5. CONCLUSION

With this paper, we set out to bring to a developer's attention the importance of being self-sufficient. Understandably knowledge doesn't come overnight, nor is this paper intended to be overly comprehensive. Cracking the surface of a topic, in this case, Material Design is sometimes adequate enough to catch someone's interest and jumpstart their own research into the matter. Practice makes perfect. Remember, if something doesn't seem right – iterate.

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CHALLENGES IN WIRELESS SENSOR NETWORKS - OVERVIEW

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Abstract:

Wireless sensor networks can be found almost everywhere. They consist of small devices, known as sensor nodes, which are arranged in the desired environment. They collect information and send it to the client through a network gateway using a routing protocol. These networks have many good characteristics like quality of service (QoS), reliability, low power consumption, flexibility, scalability, etc. Despite these good characteristics, many problems and challenges are plaguing these networks. Challenges depend on the type of network, and each network has its problems. Connecting wireless sensor networks to the Internet of Things also leads to new challenges. Security is one of the main problems plaguing these networks, but it is also one of the most difficult challenges due to network limitations. In addition to safety, the biggest challenge is still consuming energy because it is not always possible to charge the battery, so the sensor nodes die. Another more serious challenge is the real-time transmission. Traditional wireless sensor networks do not work in real-time, and even if they need to work in real-time, they avoid it. The Internet of Things works in real-time, so it needs real-time wireless sensor networks.

Keywords:

Wireless sensor networks, Sensor node, Challenge, Issues, Characteristics, Internet of Things, Energy, Security.

INTRODUCTION

Wireless sensor networks are one of the most important technologies of this century. These networks are applicable in almost all areas of human activity. Because of their great potential, those networks are of considerable help in so many fields. The most important fields of application are military, health, environment, industry, traffic, ecology, etc. The main advantages of wireless sensor networks are low cost and low energy consumption, which explains such widespread application. The role of wireless sensor networks is to track or monitor the environment, in which they succeed through collection, processing, and transmission of data. Wireless sensor networks ensure their survival in the Internet of Things, as they are the main component of the Internet of Things. Smart cities, smart homes, and others are being developed with the help of the Internet of Things.

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These developments are where the sensor networks play their main role. Nowadays, sensor networks can connect to the internet. But these networks still have many problems and flaws, making them so challenging that we are constantly working on improvement. Despite all the research that has been conducted on how to avoid the limitations of these networks, there are still too many challenges and issues in this field. There are challenges in all types of networks, network characteristics, design, architecture, protocols, security, Internet of Things, etc.

2. WIRELESS SENSOR NETWORKS

A wireless sensor network is a large group of sensor nodes. This network consists of sensor nodes, gateway, communication protocols, and client. Sensor nodes can collect and process data and then send the data to other nodes until it reaches the gateway. The task of the gateway is to send data to the client. Communication protocols organize data transfer and ensure that data arrives at its destination.
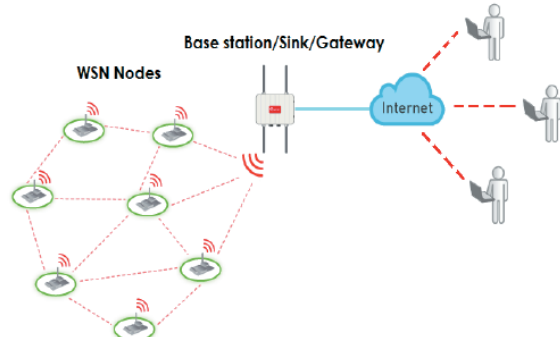

Figure 1 – Wireless sensor network

Wireless sensor networks usually don't have any infrastructure. Many sensor nodes are randomly placed to monitor the environment without an infrastructure, which is called an unstructured network. In unstructured networks, sensor nodes can self-organize. In structured networks, the seniors are placed according to a previously devise plan.

2.1. SENSOR NODE

The main components of the sensor node are:

- sensor
- microcontroller
- transceiver
- memory
- power supply

Sensors collect data, the microcontroller processes the data, and the transceiver forwards or receives data from other nodes. The memory is used to store data, and the power supply is a battery. Sensor nodes are small and limited, which is why they are cheap [1]. Yet, they know how to be energy efficient because the batteries are small.

Optional components of the sensor node are a GPS location receiver and a power generator if the sensor needs more power.

2.2. CHARACTERISTICS

For wireless sensor networks to be well implemented, the best possible characteristics are needed. It is necessary to make a lot of compromises for a better network, although with better quality comes a higher price. The characteristics of these networks are:

- Robustness
- Low price
- Reliability
- Mobility
- Dynamic network organization
- Low energy consumption
- Network heterogeneity
- Quality of service (QoS)
- Real-time transmission
- Flexibility
- Scalability

These characteristics are a good fit for applications in various areas. Still, wireless sensor networks have so many issues and challenges. Among the challenges is the improvement of the main characteristics of these networks.

3. CHALLENGES

Sensor networks have advanced a lot, but there are still issues and challenges for researchers and scientists. Figure 2 shows the challenges that are now being considered or have yet to be considered by researchers.
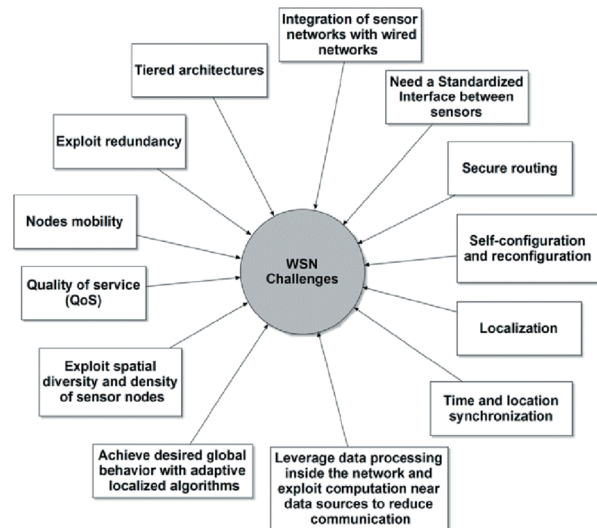

Figure 2 – Challenges in wireless sensor networks

This picture shows some challenges, although of course, there are many more. The most important challenges are real-time transmission without delay, power management with good energy utilization, more secure and private protocols, high quality of service, scalability, heterogeneity, complexity, and better self-management. A large number of proposed architectures emerged recently that target some of the mentioned challenges. For instance, energy-efficient architecture that also incorporates security aspects is proposed in [2].

Generally speaking, challenges in wireless sensor networks can be divided based on network type, network components, network characteristics, the Internet of Things applications, and security [3], [4].

3.1. CHALLENGES BY NETWORK TYPE

Wireless sensor networks are installed everywhere, both underwater and underground, as well as on land. Every environment has its challenges [5] [6].

Types of wireless sensor networks are:

- Terrestrial
- Underground
- Underwater
- Multi-media
- Mobile

Terrestrial wireless sensor networks can have a significant number of sensor nodes. The nodes can be deployed in two ways in the area. The first way is ad hoc, where sensor nodes are randomly dropped in the area. The second deployment way is according to the previous plan, for example, using optimal placement. The main challenge in those networks is energy saving. To overcome that challenge, we can minimize delays, eliminate data redundancy, use multi-hop optimal routing, and use a short transmission range.

Underground wireless sensor networks are located underground to monitor caves, mines, or other activities. For the data to reach its destination, the gateway is above ground, which ensures that the data will reach the user. The main challenges are communication and energy consumption. In communication, signal attenuations occur, and often the signal is lost completely. There are problems with energy consumption because there is no way to recharge the batteries. More batteries are installed, but when the batteries run out, the sensor node dies. To solve these challenges, minimal energy consumption and the best possible communication protocols are necessary.

Underwater wireless sensor networks are much more expensive than conventional terrestrial networks. Fewer sensor nodes are set up, and underwater vehicles are used for information gathering and research. Acoustic waves are used for communication. Communication challenges include signal loss, limited bandwidth, and high delay. Preventing sensor node failure due to water conditions is the biggest challenge of these networks, they must be well equipped for the environmental conditions.

Multi-Media Wireless Sensor Networks are used to monitor multimedia content such as video, images, and audio. In these networks, the sensor nodes consist of cameras and microphones.

They are set according to previously conceived plans. The main challenges are power consumption, data processing, quality of service (QoS), the need for high bandwidth, compression, and cross-layer design. High bandwidth and high-power consumption are required for video transmission. The quality of service (QoS) is difficult to achieve due to delays [7].

Mobile wireless sensor networks consist of movable sensor nodes. Sensor nodes change their location and organize themselves. A node can only communicate with nodes within its range. These sensor nodes use dynamic routing protocols. The main challenges are coverage of the required area, energy consumption, control and navigation, localization, placement, data processing, and self-organization.

3.2. CHALLENGES BY NETWORK COMPONENTS

The main challenges associated with wireless sensor network components are their low cost and the fact that they are as small as possible. Sensor nodes are the most important components of these networks.

The challenges of sensor nodes are:

- Node costs
- Design constraints
- Deployment
- Energy consumption
- Fault-Tolerance

Since wireless sensor networks are usually huge, the price of one sensor node must be as low as possible. The goal is for the price to be less than one dollar. The low cost of nodes ensures the greater application of sensor networks as in that case they are not financially demanding.

When designing a sensor node, the goal is to make small devices that are cheap and efficient. As a result, software and hardware limitations arise. Hardware is limited by price and size, and then the software is limited by hardware components. A lot of compromises are needed to get efficient sensor nodes. Hardware constraints also affect the protocols and algorithms that can be used. Due to the small memory, the software must be limited to storing only truly important information. The software has advanced a lot and manages to deal with hardware shortcomings, but a great number of improvements are still needed. The most difficult challenges are with the hardware.

Deployment of sensor nodes is a crucial challenge. Network complexity, as well as some other problems, can be reduced by a good deployment scheme. A huge number of sensor nodes are always placed in these networks, so it is necessary to use valid techniques. There are two types of deployment of these networks: dynamic and static deployments.

In static deployment, the sensor nodes are placed in predetermined locations. Dynamic or Ad Hoc deployment is used with mobile sensor nodes, as they organize themselves. Sensor nodes place them in the best possible locations, but they often change location due to network needs and environmental conditions. These sensor nodes must be able to do everything themselves, without consuming too much energy.

Energy consumption is one of the most important challenges with sensor nodes because battery life most often determines the life of a sensor node. Some sensor nodes can charge their batteries, and some can even replace the battery. However, the most common case is where the node dies when the battery is discharged, so the sensor node must save its battery as much as possible. The development of smaller batteries with a larger capacity is going very slow, so it is necessary to find other solutions to maintain the sensor node. Some sensor nodes use several different modes of operation depending on whether they transmit information or not. If they do not transmit data, it means that they are in sleep mode, which is how they save the battery.

Fault tolerance is a very complicated challenge. The sensor node can fail quite easily in the event of any damage or low battery. It is necessary to improve the sensor nodes to cooperate better with failures, but this is not an easy task. In the event of a sensor node failure, the network must continue to operate smoothly, which is why the network needs anti-failure techniques to be maintained. Fault-adapted protocols are also needed.

3.3. CHALLENGES BY NETWORK CHARACTERISTICS

Wireless sensor networks have many characteristics, as we saw in Chapter 2.2. Each of these characteristics is challenging and needs to be improved. The main challenges of this type are real-time transmission, quality of service (QoS), scalability, heterogeneity, and power management.

Real-time transmission is the transfer of data in real-time with time constraints on when the data is due to arrive. Small delays are allowed, and the data must arrive before the deadline. This transmission may cause more delays or data loss. The problem is that not enough attention has been paid to this challenge by researchers and protocols have not been developed for real-time transmission. The development of real-time transmission protocols is just beginning. Ordinary protocols either ignore real-time or send data as quickly as possible so they may arrive on time.

This characteristic of wireless sensor networks is very important for the future of these networks and therefore a lot of attention must be paid to this challenge.

Many new challenges and problems will only arrive when it comes to real-time transmission development.

Quality of service (QoS) is very important for sensitive data, so this challenge is of great importance for wireless sensor networks. Therefore, the quality of service parameters must match the transmission requirements. If the parameters are bad, the data will not arrive at the destination at the agreed time and they will be lost. The RAP and SPEED protocols have been proposed to improve the quality of real-time services. The RAP protocol measures the required packet transmission rate based on the path and deadline. However, there is no guarantee that the package will arrive on time. The SPEED protocol controls the delay in the nodes based on the feedback, but even here we have no guarantee due to various interferences that can occur.

Scalability is the ability to check the number of sensor nodes without affecting the network. This is a very challenging task, as with the increase of the network the number of problems and failures increases, but also because the cost of maintaining the network is higher. Protocols are then prone to major errors, so work needs to be done to improve the protocol. For the network to withstand the addition of more nodes, we need fault protection techniques and better transmission control.

Heterogeneity is the ability to connect different types of sensor nodes within a single network. Different interfaces between different sensor nodes are required. Heterogeneous wireless sensor networks can be installed in different applications thanks to the variety of sensor nodes, which is what makes these networks quite powerful. Of course, there are many challenges with these networks due to the need for complex protocols and better characteristics like robustness and flexibility.

Power management is a challenge that can be solved by intelligent use of energy and power. To achieve this, we need efficient use of energy, efficient collection of energy, as well as storage and conversion of energy. Network performance must not suffer from power management. One solution is to use ultra-small chips that consume little energy. Another solution is to collect energy. Collecting energy is a big challenge because each type of energy is collected differently. Energy collection can be divided into bursters and ticklers. An example of bursters energy collection is a micro-generator, and an example of ticklers energy collection is a solar cell.

Recently, a popular approach is the application of nature-inspired approaches to tackle some of the challenges imposed by the WSN. These challenges include localization of the sensor nodes [8], optimization and prolonging the network lifetime [9], [10] , and energy efficiency [11].

3.4. CHALLENGES OF THE INTERNET OF THINGS

For the Internet of Things to function properly, a lot of improvement of wireless sensor networks is required. Many challenges arise with the advent of the Internet of Things applications. The various changes are in architecture, in how to advance access for more devices, high real-time transmission, and semantic representation and processing.

Wireless sensor networks are the infrastructure of the Internet of Things [12]. The changes in the network architecture are needed to adapt to new tasks. There are many differences in the Internet of Things applications, so there is no single architectural solution. There is also the problem of connecting different architectures if there is a need for them. It is necessary to work on this challenge to improve architectures and facilitate their use.

The number of devices connected to wireless sensor networks and the Internet of Things is constantly growing. Due to the increase in the number of devices in the networks, it is necessary to develop networks that can withstand the constant addition of new devices. Therefore, it is necessary to improve routing protocols, as well as to improve network access. When a new device is connected to the network, it is necessary to gain access to the network to be able to exchange information. There are scheduled-based and contention-based access technologies.

The Internet of Things works in real-time, which is why wireless sensor networks must transmit in real-time. Since traditional sensor networks do not work in real-time or avoid it, it is necessary to improve the network substantially in order to obtain high real-time transmission. This problem is often divided into a distributed and a centralized solution. The distributed solution is based on the division of tasks by levels. This solution is very robust, but it lacks perspective. A centralized solution manages heterogeneous networks in a simple way, although the complexity is the weakness of this solution.

Semantic technology is a relatively new technology from which much is expected. The main advantage of this technology is the sharing of knowledge through a wireless sensor network. Semantic representation and processing are very important for the development of intelligent Internet of Things systems. The main challenges of this field are the technology of semantic representation for terminal devices, query-based semantic platforms, and semantic analysis and management of sensor information.

3.5. SECURITY CHALLENGES

Security is one of the most important challenges in all technologies, so it is also important in wireless sensor networks. The data is often sensitive and of great importance. Unattended sensor nodes are much more sensitive to attacks. Wireless communication is also sensitive to attacks. There are many network defense techniques, but sensor networks do not have enough resources, which is why there is a problem with the implementation of defense. Some of the solutions are key distribution, cryptography, and node authentication [13]. Connecting wireless sensor networks to the Internet of Things increases security. A lot of people are entering the security of the Internet of Things, and thus into wireless sensor networks. There are many threats, and the damage they can cause is often enormous.

The biggest challenge of security is to make strong routing protocols. Such protocols can well protect the network from malicious attacks, and they can handle limited resources. It is necessary to design new and powerful protocols that will solve many security challenges. One solution is to use trust relations. If trust is high, there is little need for cryptographic keys. This way we save energy and network performances are improved.

4. FIELDS OF RESEARCH

There are many fields of research into the challenges and issues of wireless sensor networks, and there are fields that are still only in theory. Some of the challenges and issues we did not cover or mentioned are:

- Localization
- Middleware
- Synchronization
- Database Centric and Querying
- Calibration
- Geographic routing
- Programming Models
- Medium Access Schemes

One of the most interesting research fields is the use of wireless sensor networks in machine learning and artificial intelligence. Wireless sensor networks can be adapted to neural networks to save energy and facilitate tasks.

Another interesting research field is smart buildings; the basic challenges are energy and security. In addition to these challenges, there is also the cost of hardware, wireless connectivity, system architecture, and programmability.

Fields of research such as medicine, pharmacy, and biology are critical for human health. Therefore, the application of wireless sensor networks is of great importance for improving healthcare applications. These networks can accelerate the work of health care, and in the future may completely replace humans. To achieve this, it is necessary to improve challenges such as interoperability, real-time data acquisition and analysis, reliability and robustness, and new node architectures.

Agriculture is also a field in which the use of wireless sensor networks is becoming necessary. Monitoring the amount of water, soil quality, as well as the action of plant protection products is of great importance. That is why it is important to work on researching wireless network networks for this field.

5. CONCLUSION

The challenge area in wireless sensor networks is huge and not at all easy to handle. This paper summarizes all the major challenges in wireless sensor networks. Of course, numerous challenges exist, as so are not even mentioned. Challenge divisions were made based on network type, components, characteristics, Internet of Things, and security. It is possible to make more divisions, but here they are briefly summarized in this way. Several important challenges are mentioned in each section. Finally, there are a few words about the fields of research that are particularly interesting and important, as well as some indications of what will be worked on in the future.

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CRYPTOCURRENCY FORECASTING USING OPTIMIZED SUPPORT VECTOR MACHINE WITH SINE COSINE METAHEURISTICS ALGORITHM

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Abstract:

Predicting the market behaviour is a crucial task for cryptocurrency investors. Based on the prediction, they make decisions that will either bring profit or loss. The prediction is typically involves the historical data that is used to forecast the future behaviour of the prices on the market.

Prediction is based on the machine learning approach. The nature-inspired algorithms have been successfully applied in optimization of numerous machine learning models in the recent years. Swarm intelligence metaheuristics, a family of nature-inspired algorithms, have proven to be excellent optimizers not only in the machine learning domain, but in various other practical domains as well. This paper proposes one such approach, more precisely the enhanced version of the sine cosine algorithm to optimize the support vector machine, and use it to predict the cryptocurrency prices. The basic SCA was improved with a simple exploration mechanism, and then compared to other approaches executed on the same datasets.

The results obtained from the performed experimental simulations indicate that the proposed method achieved better performances than other approaches included in the research.

Keywords:

Cryptocurrency, Blockchain, Machine Learning, Sine and Cosine Algorithm, Support Vector Machines.

INTRODUCTION

The biggest challenge that cryptocurrency investors face is predicting and forecasting the market behaviour and making the right decisions that bring high profit. Cryptocurrencies differ from other currencies by being independent and wholly based on peer-to-peer transactions. The possibility that cryptocurrencies can replace today's online payment methods encourages people to invest and support cryptocurrencies which provides more secure online transactions.

Financially, the market of cryptocurrency is called the stock market. Market prediction plays the primary role to maximize profit in the field of cryptocurrency. Therefore, the market prediction has grown and advanced significantly, including machine learning technologies to predict DIPs and HODLs [1].

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Cryptocurrency is entirely on blockchain technology that makes it more secure and faster than any other system. The main advantages of blockchain, transactions are processed instantly, and people cannot trace them.

Bitcoin (BTC) is considered to be the leading cryptocurrency by the community. It requires a digital signature from all participated parties (sender and receiver) [2]. It uses cryptography techniques performed by networks to verify transactions and record them in a public distributed ledger known as a blockchain.

In 2011 Litecoin (LTC) was launched with a faster transaction rate as fast as less than 1 minute and enough intelligence to deal with more significant volumes than Bitcoin [3]. Litecoin creators developed network technology to ensure repeated block creation, and the block creation time was reduced. Before building a block, it takes 10 minutes to create a block, with Litecoin decreased to 2.5 minutes each block with a new hashing algorithm.

Ethereum is a decentralized, Turing-complete blockchain framework for building and executing intelligent contracts and circulating systems [4]. Ethereum has no limits on circulation, and it may be sold on cryptocurrency exchanges, not as one of the methods of payment, but only as part of the network of Ethereum [5].

NEM is also known as the 'peers' or P2P blockchain notarization, a network of computers joined and used to pay for online transactions and perform the online message function. NEM has a registered NEM version called Mijin and then makes NEM the first blockchain public or private combination [3].

Ripple is an open-source digital technology and a peer-to-peer (P2P) system created by Jed McCaleb and his colleague, Chris Larsen. The Ripple is governed by one institution. In its transactions, Ripple provides another safety mechanism. The Ripple development is based on the Byzantine Consensus Protocol, which now has a maximum of 100 million. One of the most remarkable things about the Ripple payment transaction is that it only takes 4 seconds [3] [6].

1.1. OBJECTIVE

This paper aims to use an enhanced since cosine algorithm (eSCA) to improve support vector machine and use that to predict cryptocurrency prices. This process requires finance experts, also requires much time from the experts and non-experts in this field to do the research needed for price prediction, which cannot be very accurate.

1.2. PAPER STRUCTURE

The remaining sections are arranged as follows. Section 2 examines similar research conducted in the blockchain area of study and gives a short summary of the swarm intelligence approaches and application. Section 4 gives details on the information collected and the experimental outcomes. Finally, the conclusion and future study are provided in Section 5.

2. OVERVIEW OF RELATED WORK

Metaheuristics begin with random training circuit solutions and, with time, improve the solution to minimise inaccuracies. In the SVM training phase, metaheuristic algorithms were applied, and it was stated that these methods outperformed a gradient algorithm when the issue was more challenging and multi-dimensional.

The collective actions of decentralised, self-organising, natural or artificial systems are swarm intelligence (SI). Swarm intelligence algorithms are the most popular method of resolving numerous NP-hard problems [7]. There are many Swarm intelligence algorithms like ant colony optimization (ACO) [8], particle swarm optimization (PSO) [9], bat algorithm [10], and Artificial Bee Colony (ABC) [11]. A variety of issues, including wireless sensor networks [12] [13] [14] [15], cloud computing [16] [17] [18], prediction, machine learning [17], MRI brain tumour classification [19], COVID-19 [20] [21] and global optimisation issues [22], have also been solved using SI approaches.

Analysis of earnings forecast of blockchain financial products based on PSO [23], in estimating the return rate of blockchain financial products, researchers attempted in this work to tackle a wide variety of problem areas, restrictions, and poor fitting effects of traditional methods. In this study, BP neural network with SVM and PSO was employed by researchers. The results demonstrate that their method is better than the other algorithms being evaluated in price prediction.

A study of financial investment based on the algorithm of the deep learning network was conducted [24]. The researchers tried to utilize the technology of deep learning to anticipate financial data for this study, with promising results. Finally, the ABC metaheuristic algorithm was used to optimise blockchain investment profile [25]. The researchers wanted to improve the security of asset securitisation and lower investment risk with their study.

The results also show that the ABC algorithm has successfully optimised the investment portfolio and reduced the risk of decision-making.

3. PROPOSED ALGORITHM

Mirjalli presented the Sine Cosine Algorithm (SCA) technique in 2016, providing a mathematical model using the functions of the sine and cosine [26]. The SCA produces multiple initial, random solutions and enables them to swing towards or outwards the optimal solution. This approach additionally integrates several random and adaptable variables to emphasize the exploration and exploitation of the search space at different phases of optimization. And it was demonstrated that SCA is able effectively to explore different areas of a search area while avoiding local optima at a time when it converges to the global optimum and exploiting promising regions of an inquiry space during optimization.

In the exploration phase, an optimization algorithm rapidly combines the random solutions into a group of solutions with a large degree of diversity in order to find potentially interesting areas of the search space. However, throughout the exploitation process, there are increase changes in random solutions, and random differences are considerably less than within exploration.

The position update equations are as follows for exploration and exploitation:

$$X_i^{t+1} = X_i^t + r_1 \cdot sin(r_2) \cdot \left| r_3 P_i^t - X_i^t \right| \tag{1}$$

$$X_i^{t+1} = X_i^t + r_1 \cdot con(r_2) \cdot \left| r_3 P_i^t - X_i^t \right| \tag{2}$$

Equation 1 position updating equations for the exploration and exploitation

Where X_i^{t+1} symbolize the current position of the solution in the i-th dimension, at t-th iteration. Also r_1, r_2 and r_3 are three randomly generated numbers between 0 and 1, P_i^t symbolize the position of the i-th dimension, and $||$ to symbolize that only the positive value will be used of $r_3 P_i^t$-X_i^t.

These two equations are combined as follows:

$$X_i^{t+1} = \begin{cases} X_i^t + r_1 \cdot sin(r_2) \cdot \left| r_3 P_i^t - X_i^t \right|, & r_4 < 0.5 \\ X_i^t + r_1 \cdot con(r_2) \cdot \left| r_3 P_i^t - X_i^t \right|, & r_4 \geq 0.5 \end{cases} \tag{3}$$

Equation 2 Combined equations of sine and cosine algorithm

Where r_4 shows a random number generated between 0 and 1.

As Equation 2 shows, SCA uses four primary parameters, and the parameters are accountable for the position of the destination. The search procedure, therefore, achieves a balance between solutions to coordinate well towards the optimal result. The cyclic architecture of the sine and cosine algorithm guarantees that the space between two solutions is exploited. In order to explore the search region, the solutions should be able to search throughout the area between their respective destinations. The sine and cosine algorithms are adjusted to do this. The sine and cosine range has to employ a solution to update its place outside the area between itself and another solution in order to guarantee the search area is investigated. Randomness can also be produced by finding a random number between 0 and 2π for r_2 in Equation 2.

To balance the exploration phase with the exploitation phase, the SCA uses the following formula:

$$r_1 = a - t \frac{a}{T} \tag{4}$$

Equation 3 balance the exploration and exploitation

Where a symbolize a constant, T symbolize the maximum number of iteration, and t symbolize the current iteration number.

However, it was shown that metaheuristic exploration might be enhanced by doing original SCA tests using basic CEC unconstrained benchmarks. In order to solve this, the basic SCA was introduced to a simple exploration mechanism: the lowest solution from the population is replaced each time in the lower and upper boundaries of the search space by randomly generated individuals using the following equation:

$$X_{rnd}^j = L^j + \varnothing \cdot \left(U^j - L^j \right) \tag{5}$$

Equation 4 update worst solution

Where X_{rnd}^j is the j-th component of the random solution newly produced, $\varnothing$ in the other hand present a number chosen from a uniform distribution, and U^j is the upper boundary, and L^j is the lower boundary of the j-th parameter.

The proposed improved SCA metaheuristics are known as enhanced SCA (eSCA). Algorithm (1) displays pseudo-code.

Algorithm 1 - Pseudo-code of proposed eSCA

```
Initialization. Generate the starting random population
of N individuals X within the boundaries of the search
space and calculate its fitness.
Initialize the maximal number of iterations T.
Do
 for all X in the generated population do
  Evaluate utilizing the fitness function.
  if f(X) better than f(P) then
   Update the position of the best solution (P = X*).
  end if
 end for
 Update r1 parameter using Equation 3.
 Update r2; r3 and r4 parameters.
 Update the positions of search agents using Equation 2.
 Replace the worst solution with a random one using Eq. 4.
while (t < T)
return P the best solution found.
```

3.1. SUPPORT VECTOR MACHINE

SVM is a technology for machine learning, developed by Vapnik and Cortes in 1995, founded on the VC dimension and the idea for structural risk reduction. It includes maximum interval hyperplanes, convex, slack variables and mercer's kernel. The technical theory is particularly ideal for small simple, high-dimensional and non-linear problems and has a significant capacity for generalization and machine learning [27].

SVM is used for two things: selecting the appropriate kernel function and fine-tuning their parameters. Searching for the best decision plane is an optimization challenge from a computational point of view. By using a non-linear transformation, the kernel function assists in the creation of linear decision planes. This section explains the foundations of SVM for classification problem.

Let us consider a dataset and its class labels, denoted by $S = x1,...xn$ and $G = y1,...yn$, respectively. SVM aims to find the best hyperplane H to separate two data samples and create the most extensive interval r between them. The ideal hyperplane H is represented as:

$$W^T x + b = 0 \qquad (6)$$

Equation 5 Ideal hyperplane

Where W indicates the weight vector and b refers to the bias.

The problem has now been turned into an optimum problem of W and b as the following:

$$\begin{cases} min_{\omega,b} r(\omega) = \frac{1}{2}\|\omega\| \\ y_i\left((\omega \cdot x) + b\right) \geq 1, i = 1,2,...,n \end{cases} \qquad (7)$$

To meet the Karush Kuhn Tucker (KKT) criteria, the previous equation can be simplified by inserting Lagrange multipliers. The goal function is simplified to:

$$min_a \frac{1}{2}\sum_{t=1}^{n}\sum_{j=1}^{n} y_i y_j a_i a_j \left(x_i \cdot x_j\right) - \sum_{j=1}^{n} a_j$$

$$s.t.\sum_{t=1}^{n} y_i a_i = 0, 0 \leq a_i \leq C$$

According to the experimental results, the bigger the value of C, the bigger the separation interval, but the more significant the generalization risk. The ultimate classification function is as follows:

$$f(x) = sgn\left\{\left(\sum_{t=1}^{n} y_i a_i k\left(x_i \cdot x_j\right)\right) + b^*\right\}$$

Equation 6 Ultimate classification function

By translating the nonlinear data into a high-dimensional feature space, kernel functions may be utilized to separate it linearly. The kernel function is defined as follows:

$$K(x_i, x) = \left(\varphi(xi), \varphi(x)\right)$$

Equation 7 Kernel function

As a result, the final classification function can be expressed as:

$$f(x) = sgn\left\{\left(\sum_{t=1}^{n} y_i a_i k\left(x_i \cdot x_j\right)\right) + b\right\}$$

Equation 8 Final classification function

The Gaussian kernel (radial basis function, RBF) is one of the most often used kernels for high-dimensional non-linear data, and it is expressed as the following:

$$k(x, y) = exp\left(-y\|x - y\|\right)^2$$

Equation 9 Gaussian kernel

The classification performance of SVM is mostly determined by these two parameters, C and, which must be modified.

4. EXPERIMENTAL SETUP AND ANALYSIS

In the conducted experiments, the eSCA was tested with five years of daily prices from 2013 until 2018 for six types of cryptocurrency. Furthermore, this dataset includes open and close prices, also the highest and lowest price during the day (Table 1).

Variable	Description
Open Price	The opening price of a certain cryptocurrency on a given trading day.
Close Price	The closing price of a certain cryptocurrency on a given trading day.
Low Price	The lowest price of a certain cryptocurrency on a given trading day.
High Price	The highest price of a certain cryptocurrency on a given trading day.

Table 1 Description of variables

The training and testing dataset are provided in Table 2, with the number of training and testing simple for each cryptocurrency that has been used in this experiment. It should be highlighted that the number of training simples is different between the cryptocurrencies, but all of them have the same number of testing simples which is 364.

Training dataset				Testing dataset		
Crypto currency	From	To	Number of samples	From	To	Number of simples
BTC	28/Mar/2013	16/Jan/2017	1388	17/Jan/2017	16/Jan/2018	364
ETH	07/Aug/2015	16/Jan/2017	526	17/Jan/2017	16/Jan/2018	364
LTC	28/Apr/2013	16/Jan/2017	1358	17/Jan/2017	16/Jan/2018	364
XRP	04/Aug/2013	16/Jan/2017	1262	17/Jan/2017	16/Jan/2018	364
XEM	01/Aug/2015	16/Jan/2017	657	17/Jan/2017	16/Jan/2018	364
XLM	05/Aug/2014	16/Jan/2017	896	17/Jan/2017	16/Jan/2018	364

Table 2 Dataset used for training and testing process

In Python environment, the SVM-eSCA model was constructed by leveraging popular keras machine library and scikit-learn tools. On the Nvidia 1080 with 8GB of RAM 6X GPU tests are run. The experiment begins with observing and controlling performance measurements for different sorts of cryptocurrencies by classification.

Tables 3 and 4 illustrate the accuracy rate of the cryptocurrency market cap classifications. Table 3 illustrates several classifiers performance metrics, whereas Table 4 displays the support vector machine, support vector machine standard with optimized particle swarm optimization parameter selection and support vector machine standard with enhanced sine cosine algorithm.

Classifiers	Performance Accuracy (%)					
	BTC	ETH	LTC	XRP	XEM	XLM
SVM [28]	**78.90**	95.50	82.40	70.00	**47.70**	58.70
Optimized SVM-PSO [28]	90.40	**97.00**	**92.10**	82.80	57.80	64.50
SVM-eSCA	**91.21**	**97.44**	**92.31**	**84.07**	**58.86**	**66.23**

Table 4 Comparison to find the best classifier

Several classifiers with the same data have been trained. The data sets were tested using the accuracy of classifications on this occasion. The identical set of data is used to compare all classifiers.

5. CONCLUSION

This paper proposes an enhanced SCA approach that was applied to optimize the SVM. The proposed method was tested on the cryptocurrency prediction problem, and compared to the standard SVM method and SVM-PSO method.

Classifiers	Performance Accuracy (%)					
	BTC	ETH	LTC	XRP	XEM	XLM
ANN	**79.40**	78.00	75.80	81.40	**77.80**	89.80
DL	61.90	69.40	62.80	60.90	57.20	70.70
SVM	78.90	**95.50**	**82.40**	70.00	47.70	58.70
BoostedNN	81.20	81.60	72.20	**81.50**	77.40	**92.80**

Table 3 Classifiers performance accuracy

The conducted experiments clearly indicate that the proposed SCA approach obtained the best accuracy of all methods included in the analysis.

The future work in this domain will include testing of the other SI metaheuristics, in improved or hybridized versions on the same SVM optimization problem, and also the application of the eSCA method to other practical problems as well.

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CONVERSATIONAL SURVEY CHATBOT: USER EXPERIENCE AND PERCEPTION

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Abstract:

The aim of the paper is to explore two directions, one is the use of conversational chatbots for the purpose of data collection, and the other is the analysis of user experience in the usage of chatbots when it comes to various customer services. Regarding survey chatbot, the paper discusses existing obstacles of static online surveys, and through the presented steps of chatbot design, demonstrated the ease of designing and distributing chatbot for research purposes. On the other hand, through the conducted research, which included 200 respondents from the Serbian market, research shows that chatbots are not so widely used (only 44% have used chatbot), and even 88% of respondents would use human rather than Chabot. However, through analysis of existing research that involved other markets, results have shown that most respondents feel more relaxed and have fun when using a chatbot. Still, the main obstacle, in general, is the lack of social capabilities of chatbots.

Keywords:

Conversational Agent, Online Survey, Chatbot, Chabot Builder, Landbot.

INTRODUCTION

Today, with the advent of AI-powered technologies, there are several methods to collect data. One traditional way is to conduct a static online survey, which is still widely used. Another way is by using chatbots, or lately biometric sensors that provide precise insights into human behaviour such as Eye Tracking, Facial Expression analysis, EEG, ECG and other techniques. However, these newer biometric technologies are still not so accessible. Therefore, in this paper, we will focus on chatbots and demonstrate how researchers can use existing chatbots platforms to create their survey. Besides, we have used a conversational survey chatbot to investigate the user experience and perception of today chatbot capabilities.

The lack of static online surveys is the difficulty to interpret users' natural language responses and manage complex interactions. [1] For example, users are usually offered predefined answers, and on questions like "What do you think about the service?", users' responses could be:

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"I've never used it", "I am satisfied" etc. If free-text format is offered, then the problem is how to interpret answers, since natural language processing (NLP) algorithms are not so easy task. Even if a system has implemented NLP algorithms on free-text responses, the problem is how to manage further interactions with users.

Besides these difficulties, the main problem today is that users are not willing to respond to online surveys anymore, or they will spend a max of 5 min answering the questions regardless of the size of the survey. [2] The main reasons are decreasing human attention span, and due to the bad overall survey design (relevance, format, structure and so on), the respondents get bored very fast. [3] For example, grid questions cause 80% more drop-out than any other question format.

On the other hand, chatbots are changing the patterns of how humans interact with computers today. [4] Chatbots are conversational software systems based on artificial intelligence (AI) techniques with which users interact through natural language dialogue, by text or voice. [5]

Today, the growth of chatbots in customer service, education, health, travel, entertainment, personal assistance and other areas, has changed how companies engage with their customers, students with learning platforms, tourists with travel systems and many other applications.

A chatbot survey or "conversational survey" is an online survey presented in a form of conversation where respondees, instead of answering static questions, are engaged in a conversational exchange with a bot persona.

While chatbots were initially designed to mimic human-to-human communication, current chatbots are typically task-oriented, assisting users to complete a certain task or achieve specific goals. For example, Siri or Alexa dialogue agents can provide concrete answers, such as to find restaurants, pay bills, make phone calls or texts etc.

Despite the benefits, there is a lot of issues. Recent research shows that chatbots still fail to meet users' expectations because of the lack of social capabilities [4]. Also, people are afraid of chatbot could use some of their private data for unknown purposes. People are also expecting that chatbot can answer questions like a human. Besides, people are usually dissatisfied when they realize that a chatbot can provide them with false answers.

In this paper, we have designed a chatbot survey to investigate user experience when interacting with it, and in general, to find out do they still prefer human over Chabot agent. For chatbot design, we have used the open-source chatbot framework "Rasa.ai". Dialogue flow is directed by Rasa Core. In this study, we have used Landbot platform to create the rule-based chatbot. The study involved 200 respondents from Serbia, aged 18-55 years which have responded to 12 questions by using a chatbot survey.

The paper is structured as follows: first, a relevant background of chatbots and related studies are presented. In the next section, the process of chatbot design using an open-source chatbot builder is shown. Finally, the research results of the survey chatbot are analysed, which are followed by a conclusion and further perspectives.

2. LITERATURE REVIEW

Human-computer interaction (HCI) field implies technologies that allow usage of natural language among human and computers.

An AI-based chatbot is a conversational system that is designed to emulate human communication with capabilities to understand natural language, identify meaning, emotion, intention, and provide meaningful responses.

In the era of cognitive computing, personal smart devices come with pre-installed conversational agents (CAs), such as Siri, Microsoft Cortana, Google Assistant, Alexa, and others. Based on the mode of interaction, CAs can be categorized into [6]:

1. Speech-based CA (e.g., Siri, Alexa)
2. Text-messaging based CA (e.g. Messenger bots, Google Assistant)
3. Multimodal CA.

The first developed CA was a text-messaging based agent, called ELIZA, that emerged in 1966 from MIT. ELIZA worked on simple declarative rules to mimic the responses of a psychotherapist in a therapy session. When text messaging gain popularity in 2015, chatbots have received significant attention. Over 30.000 chatbots have been developed on Facebook's Messanger Bot platform. [7] The recent interest in chatbots can be attributed to the development of advanced AI techniques, especially with a combination of machine learning and deep learning algorithms.

Chatbots can be classified into various categories based on their purpose, mode of interaction, usage, design techniques, knowledge domain etc. According to the design mode or level of understanding the type and purpose of the conversation, chatbots can be broadly classified based on the following criteria [8]:

1. Interaction mode (text or voice/speech-based)
2. Chatbot application (task or non-task oriented)
3. Rule-based or AI (Machine or deep learning)
4. Domain-specific or Open-domain.

According to the purpose, chatbots can be grouped into the following categories [8]:

1. Service chatbot – designed to respond to customer requests or queries.
2. Commercial chatbot – designed to streamline purchases or other customer behaviours.
3. Entertainment chatbot – designed to engage customers with games, movies, sports, favourite brand, and other events.
4. Advisory chatbots – designed as recommendation systems, provide suggestions etc.

A chatbot can be classified as [9]:

1. Task-oriented chatbots – assist the customer to complete certain tasks (e.g. find location), by using a supervised or unsupervised approach.
2. Non-task-oriented chatbots – focus on customer conversation to find the right solution or to entertain.

Nuruzzaman & Hussain (2018) proposed taxonomy of the Chatbot application, divided it into four groups, such as [10]:

3. Goal-based chatbot – setup to have short conversations to get information from the user to complete the task.
4. Knowledge-based Chatbot – access the knowledge from the underlying data sources.
5. Service-based Chatbot – provide personal or commercial services.
6. Response Generated-based chatbots – based on what action they perform in generating the response.

Instead of answering static questions when conducting a traditional online survey, when using chatbot survey respondents are more engaged in conversation, and have more fun. Some advantages of using survey chatbots are [10]:

- Free the users' email inbox
- Transform the user experience into something more enjoyable
- Higher survey response rates
- React in real-time (for example, in the middle of the survey chatbot can offer discount voucher)
- Analyze conversation flow and follow customer behaviour throughout the questionnaire.

Radziwill & Benton (2017) provided quality attributed of chatbots and conversational agents, according to the quality assessment method. [11]

3. RELATED WORKS

Kim et al. (2019) conducted a 2 (platform: web vs. chatbot) x 2 (conversational styles: formal vs casual) experiment. The results show that participants in the chatbot survey provided higher-quality data. [3]

In the research of Xiao et al. (2020), 300 participants took a typical online survey on Qualtrics, and the other 300 interacted with an AI-powered chatbot to complete a conversational survey. Results show that chatbot drove a significantly higher level of participant engagement and better quality responses measured by Gricean Maximus in term of informativeness, relevance, specificity and clarity. [1]

Lee et al. (2020) revealed that chatbots are a low-cost, effective tool that supports people's self-disclosure. They run a study with 47 participants that were divided into three groups to use different chatting styles. The results show that chatbot self-disclosure also had a positive effect on participants enjoyment over the study period and improved perceived intimacy. [12]

Colace et al. (2018) have contributed to the chatbot prototype in the education domain. The purpose of the chatbot is to provide support to university students on some IT courses. Generally, students find that chatbot is easy to use and it is user friendly, and that is simple and effective. [13]

Folstad & Brandtzaeg (2020) analysed users' experiences with chatbots. [7] They conducted a questionnaire study that involved more than 200 chatbot users. Participants reported a set of positive experience, and usage of chatbots on different platforms: Messenger (79%), Skype (54%), Kik (38%), Viber (12), Slack (10%) and Telegram (4%). However, 65% of respondents reported that using a chatbot weekly or daily, 48% of them reported using a chatbot for 3 or more years, and 40% of respondents had experience with Google Assistant, according to (Folstad&Brandtzaeg, 2020). [7]

In the study "Why people use chatbots", authors Brandtzaeg & Folstad have investigated people's motivations and reasons for using chatbots. Conducted research, that involved 146 participants, aged 16-55, reported that productivity is the main motivational factor. Chatbots help users to obtain timely and efficient assistance. Besides, other motivational factors are entertainment, social and relational factors, and curiosity. [14]

In the research paper, titled "Millennials: attitude towards chatbots" by Cicco et al. (2020), 193 Italian millennials participated. The study suggested that millennials are the ones that definitely will give a chance to AI and chatbots. [15]

4. STUDY METHOD

4.1. CHATBOT DESIGN USING OPEN-SOURCE CHATBOT BUILDER

For designing conversational software, the open-source framework called Rasa.ai was used. [16] Dialogue flow is directed by Rasa Core and that corresponds to the following intentions (rasa.com) [17]:

1. Greeting (User greets chatbot)
2. Affirm (User confirms the chatbot statement)
3. Deny (User rejects chatbot statement)
4. Thankyou (User expresses his thanks)
5. Inform (User informs the chatbot about an entity)
6. Byebye (User exits the chat)

Today there are many no-code platforms that chatbot development makes an intuitive and easy task. In this study, we have used Landbot to create the rule-based chatbot.

With the Landbot platform, two main types of conversational assistants can be created [18]:

1. NLP chatbots – use Landbot's Dialogflow (API. AI) integration. This type of chatbot is ideal for creating an assistant for WhatsApp, plain text messages or another messaging platform with a limited user interface).
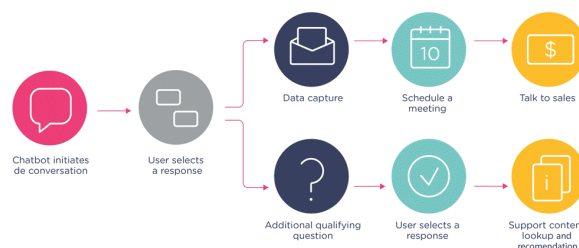2. Rule-based chatbots - user can decide about his/her path (Fig. 1).

Fig. 1. Example of a rule-based chatbot decision tree [19] (Source: https://landbot.io/chatbots)

With Landbot also conversational application, that consists of rich user interface (UI) elements and combine NLP with rule-based elements, can be created.

Process of designing Landbot conversational chatbot include [20]:

1. **Choose the type of channel** - After setting up the chatbot builder account, which is free, and selected the "Build a Chatbot" option, the next step is to choose the type of channel. Available options are Website, Facebook Messenger, WhatsApp, or any messaging platform with Application Programming Interface (API).
2. **Choose the template of start from scratch** – Chatbot for this survey has been made from the beginning.
3. **Optimization of the Welcome Message** – personalisation of the welcome message can incorporate text or media messages such as images, gifs, videos etc.
4. **Adding the first sequence** - The main point of designing a chatbot is to connect questions and answers.
5. **Preview** – in any step the user experience and quality of the connections can be checked.
6. **Chatbot Branding customization** – including design the theme, choose the background colour scheme, select the logo and avatar, choose the fonts.
7. **Publish, share with a link or embed a chatbot on the website** – select embed options (full page, popup, embed or live chat).

After the design phase, another step is to send a chatbot survey to participants addresses via Facebook, Twitter, e-mail or WhatsApp. In this survey, chatbots are created using WhatsApp.

4.2. DATA COLLECTION

Data are collected by using the WhatsApp channel. A chatbot survey was distributed to randomly selected people. Among 200 respondents, there were students and employees, aged from 18 to 55 years. Participants responded to 12 questions by using a chatbot survey.

In the Landbot platform, under the section "Users", the answers of the respondents can be tracked. In the section Metrics, the results of the chatbots can be analysed.

4.3. RESULT ANALYSIS

This study aims to understand users experience and perception when interacting with chatbots. After reviewing the results of the research, we came up with unexpected results, and some of them will be presented below.

On the question "Do you know what a chatbot is?", 87% of participants said Yes, and 13% responded "No" (Fig. 2).
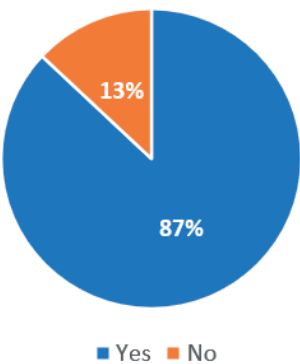
Fig. 2. Results of the question "Do you know what chatbot is"

On the question "Have you ever chatted with a chatbot?", only 44% have used it, and 56% did not (Fig. 3).
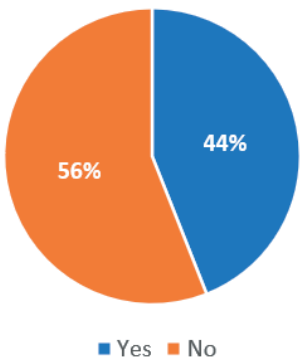

Fig. 3. Results of the question "Have you ever chatted with a chatbot?"

On the question "Would you use a brand again if you knew that they do not have a human agent?", 48% said that they would, 35% is not sure, and 17% wouldn't (Fig. 4).
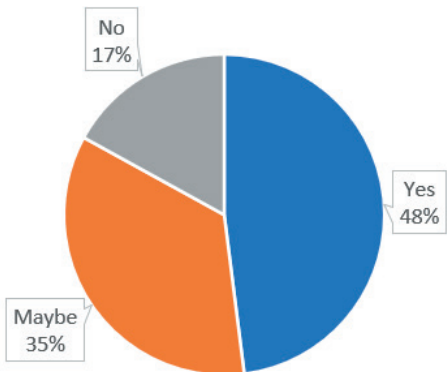

Fig. 4. Results of the question "Would you use a brand if you knew that they do not have a human agent?

However, on the question "Would you rather receive help from a chatbot or human agent even if you have to wait for a human agent?", surprisingly 88% of respondents said that they rather prefer a human agent (Fig. 5).
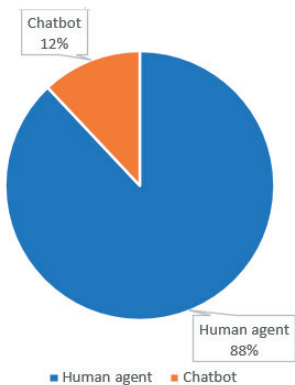

Fig. 5. The main result of the research

Most respondents explained that they have more trust in humans. Besides, the advantage of human agents is a natural and confidential way of talking. They also said that human can, logically, understand their needs.

On the other side, a smaller percentage of respondents said that chatting with the chatbot is just an easier and better way to get information since human agents are usually very busy with a lot of calls.

5. CONCLUSION

Conducting online survey by conversational chatbots, have never been so accessible, and easy to design. One of the main purposes of this paper is to demonstrate the design steps of a chatbot survey by using the free Landbot platform. Another purpose is to investigate the user experience when interacting with chatbots.

Although it is easier today than ever to create a chatbot for different needs, this study, which is applied to the Serbian market, shows that there is still dissatisfaction and mistrust when using chatbots. When it comes to other markets, research shows that chatbots are more interesting, available, enjoyable, effective and simple to use. However, in general, the pain point of existing chatbots are still missing social characteristics that cohere with users expectations, avoiding frustration and dissatisfaction. However, research shows that regarding conducting a survey it is preferable to create a conversational survey chatbot instead of a traditional, web or email survey.

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ALGORITHM FOR SORTING NON-NEGATIVE INTEGERS

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Abstract:

This paper presents an algorithm for sorting non-negative integers. The algorithm solves the sorting problem recursively. There are numerous sorting algorithms available today, however this paper suggests a different approach to solving this problem using a binary representation of integers. The paper graphically presents comparative tests that were executed with already existing sorting algorithms. The test results show in which situations it is best to use this algorithm. Possible further directions of development of this algorithm, as well as other algorithms that can use this approach to problem-solving, are also presented.

Keywords:

sorting algorithm, binary number, recursion.

INTRODUCTION

Data sorting is one of the basic problems in programming. Tremendous amounts of data that require to be analyzed and processed are produced daily. Sorting can facilitate and speed up the process of data analysis and processing. A large number of applications use sorting algorithms to solve a particular problem in the fastest and easiest way. Sorted data are simpler to work with and enable users better data display as well as faster search. Dozens of algorithms that solve this problem have been written to date. Most of these algorithms work very quickly for small amounts of data, but if the data amount is large, the performing time of the algorithm can vary drastically. Therefore, one ought to choose the best possible algorithm that will provide the best and fastest solution to the problem. The sorting algorithm can be used to sort both simple (integers, decimal numbers, characters) and more complex data types (objects). Data sorting order can be ascending or descending.

Modern web, mobile and desktop applications use some of the existing sorting algorithms. Sorting problem is present in variety of domains in the modern computer science as well. Because of that, sorting algorithms are one of the basic algorithms in programming.

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There is always the need to find new algorithms, even if they work for just a specific input data (such as positive integers), because even slightest improvement in the performances could lead to reducing the costs drastically.

This paper is organized as follows. Section 2 provides a short overview of already existing solutions. Section 3 proposes the new algorithm, while section 4 yields comparison with other approaches. Finally, section 5 concludes the paper.

2. EXISTING ALGORITHMS FOR SOLVING SORTING PROBLEMS

Several algorithms that solve the sorting problem have been written to date. Algorithms use various techniques to come up with solutions [1] [2]. Some algorithms come to the solution by an iterative procedure, others by recursive, as well as by using different types of data. Some of the basic algorithms are bubble sort, selection sort, insert sort, merge sort, quick sort.

Bubble sort is a simple sorting algorithm that works by comparing two adjacent elements of an array and changing their places if they are in the wrong order [3]. After each pass through the array, one element, the largest or the smallest, takes its position in the sorted array. The average time complexity of the algorithm is O(n^2). Therefore, it belongs to the group of slower algorithms [4].

Selection sort is a more efficient algorithm than bubble sort, although the average time complexity is the same as with bubble sort O(n^2) [5]. The idea of the algorithm is to find the smallest element after one pass through the array and place it in the proper position. After the first iteration, the smallest element of the array will be in the first place, after the second iteration the second smallest element of the array will be in the second place and so on. After the *i*-th iteration, the i smallest elements of the array will be sorted in ascending order.

Insert sort is practically a more efficient algorithm than the previously mentioned ones. Its average time complexity is O(n^2). Sorting is done by adding a certain element of the array to the previously sorted part of the array [6]. Initially, only the first element belongs to the sorted part of the array and after that, the other elements are added to that part of the array at the positions so that the array remains sorted.

Merge sort was invented by John von Neumann in 1945. Unlike the aforementioned algorithms that use an iterative approach of passing through an array, merge sort uses a recursive method of passing through an

array. The average time complexity of this algorithm is O($n \log n$) and it, therefore, belongs to the group of more efficient algorithms. This algorithm is much more effective than those previously mentioned. The idea of this algorithm is to divide the array which is to be sorted into two halves, i.e. two smaller arrays, which are further divided by a recursive call until an array of one element is obtained. After that, the smaller sorted parts are merged and sorted and thus a sorted initial array is obtained [7].

Quick sort was developed by Tony Hoare in 1959. The average time complexity of this algorithm is O($n \log n$). Although in the worst case the algorithm is no better than slow, square, sorting methods, in practical applications it has proven to be amongst the most efficient ones. The idea is to choose one element, called a pivot, based on which the other elements will be sorted. At the end of one pass through the array, the exact position of the pivot element in the sorted array is found and the array is divided into two parts, into elements smaller and larger than the pivot element, which are further sorted by a recursive call [8].

3. IMPLEMENTATION OF THE PROPOSED ALGORITHM

Unlike the previously mentioned algorithms, the proposed algorithm performs sorting based on the binary presentation of numbers. The paper presents an algorithm that sorts non-negative integers in ascending order. The algorithm solves the problem using recursion.

The idea of the algorithm is to regard each number as a binary number and to perform sorting based on the value of a certain bit.

The idea of the algorithm will be presented below.

Let unsorted array integers 9,6,6,1,8,9,9,7,4,3 be given. Each of these numbers can be represented in binary notation (Figure 1).

	9	6	6	1	8	9	9	7	4	3
3	1	0	0	0	1	1	1	0	0	0
2	0	1	1	0	0	0	0	1	1	0
1	0	1	1	0	0	0	0	1	0	1
0	1	0	0	1	0	1	1	1	0	1

Figure 1 - Unsorted array

First, sorting is performed based on the value of the highest bit using two pointers. One pointer points to the first element of the array (lowPointer), while the other points to the last (highPointer). If the value of the highest bit pointed to by the lowPointer is equal to 0 (zero), the pointer moves to the next element of the array (lowPointer++). If the value of the highest bit pointed to by the highPointer is equal to 1 (one), the pointer moves to the previous element of the array (highPointer--). If the value of the highest bit pointed to by the lowPointer is equal to 1, and the value of the highest bit pointed to by the highPointer is equal to 0, then the replacement of the value of the elements pointed to by these two pointers is performed. The lowPointer and highPointer continue to move through the array until the highPointer points to an element with a smaller index than the lowPointer.

3	1	6	6	4	7	9	9	8	9
0	0	0	0	0	0	1	1	1	1
0	0	1	1	1	1	0	0	0	0
1	0	1	1	0	1	0	0	0	0
1	1	0	0	0	1	1	1	0	1

1	3	4	6	6	7	9	9	8	9
0	0	0	0	0	0	1	1	1	1
0	0	1	1	1	1	0	0	0	0
0	1	0	1	1	1	0	0	0	0
1	1	0	0	0	1	1	1	0	1

1	3	4	6	6	7	8	9	9	9
0	0	0	0	0	0	1	1	1	1
0	0	1	1	1	1	0	0	0	0
0	1	0	1	1	1	0	0	0	0
1	1	0	0	0	1	0	1	1	1

Figure 3 - Other steps for sorting an array

The pseudocode of this algorithm is given below (Listing 1). The *bitSort* algorithm has 4 parameters: the array to be sorted (*arr*), the low pointer (*low*), the high pointer (*high*), the bit position based on which the sorting is performed (*bitPosition*). The algorithm uses the *getBit* helper function for returning the bit value at a certain position (*bitPosition*) of a certain number (*number*).

3	6	6	1	4	7	9	9	8	9
0	0	0	0	0	0	1	1	1	1
0	1	1	0	1	1	0	0	0	0
1	1	1	0	0	1	0	0	0	0
1	0	0	1	0	1	1	1	0	1

lowPointer   highPointer

Figure 2 - The arrangement of elements after one pass through the array

After one pass through the array, the arrangement of elements as in Figure 2 is obtained. The grouping of elements based on the value of the bit at position 3 can clearly be seen. Elements starting with 0 are grouped to the left, while elements starting with 1 are grouped to the right.

The next step is sorting the left and then the right part of the array. This sorting is performed based on the value of the bit at position number 2. The same method of sorting using two pointers is used. After the elements are grouped based on the value of the bit at position 2, the sorting is moved to the lower bit positions until the bits at the lowest position are reached (Figure 3).

```
getBit(number, bitPosition){
    return (number>>bitPosition)&0b1;
}

bitSort(arr[], low, high, bitPosition){
    if(low==high or bitPosition<0){
        return;
    }

    left = low;
    right = high;

    while(low <= high){
        if(getBit(arr[low],bitPosition)==0){
            low++;
        }

        while(low<=high and
              getBit(arr[high],bitPosition)==1){
            high--;
        }

        if(low<=high){
            swap arr[low] and arr[high];
            low++;
            high--;
        }
    }

    if(high>=0){
        bitSort(arr,left,high,bitPosition-1);
    }

    if(low<=right){
        bitSort(arr,low,right,bitPosition-1);
    }
}
```

Listing 1 - Pseudocode of the proposed algorithm

The value for the *bitPosition* parameter can be predetermined depending on the length of the binary record of the largest number in the array.

The time complexity is O(kn) and it can therefore be classified into a group of faster-sorting algorithms. The constant k represents the length of the binary record of the largest element of the array, while n represents the length of the array.

The advantage of this algorithm is that the recursion depth is limited by the number passed through the *bitPosition* parameter during the first function call.

4. COMPARISON WITH EXISTING ALGORITHMS

In this chapter, comparative tests of MergeSort, QuickSort and the proposed BitSort algorithms will be presented. All examples were tested in the Java programming language on a PC (Intel i5-3337U 1.8GHz).

Figure 4 shows how the performance time of the algorithm changes depending on the change in the range of values of the elements of the array. The example uses an array of 1,000,000 elements.

While the range of values of the elements of the array is [0, 1000000), [0, 100000), [0,10000), [0, 1000). The performance time shown is relative and depends on the performance platform.
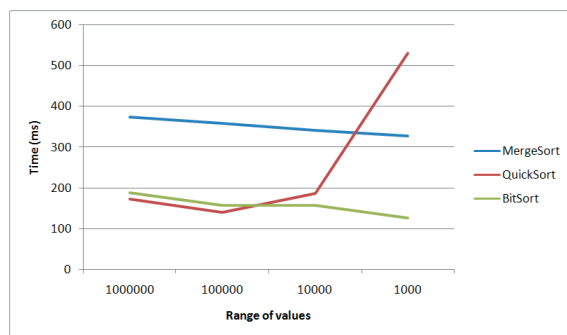
Figure 4 - Performance time depending on the range of values

The graph shows that the performance time of the BitSort algorithm is approximately the performance time of the QuickSort algorithm for array elements whose range is [0, 1000000) and [0, 100000), while it is much faster for a smaller range of values.

Figure 5 shows the performance time of array sorting algorithms depending on the number of array elements for array elements whose range is [0, 100000). The performance time shown is relative and depends on the performance platform.
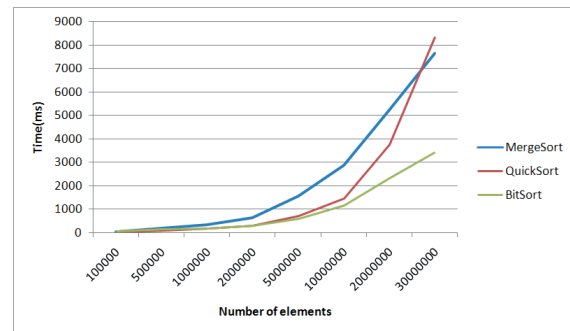
Figure 5 - Performance time depending on the number of array elements

For small amounts of data, all three algorithms perform relatively quickly. As the amount of data increases, it can be seen that the BitSort algorithm is faster than the MergeSort and QuickSort algorithms.

Figure 6 shows the number of checked array elements depending on the range of values of the elements of the array for a constant array length of 1,000,000 elements.
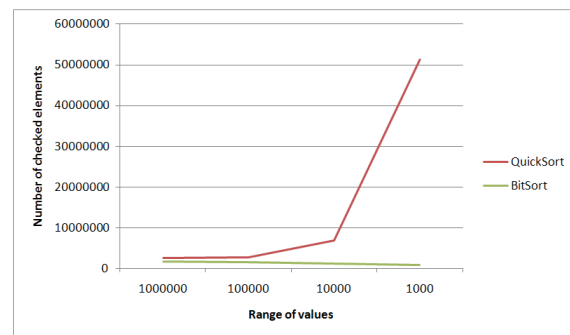
Figure 6 - Number of checked elements depending on the range of value

The graph shows that the BitSort algorithm uses a smaller number of array element approaches during sorting.

Figure 7 shows the number of checked array elements depending on the number of array elements for a constant range of element values [0, 100000).
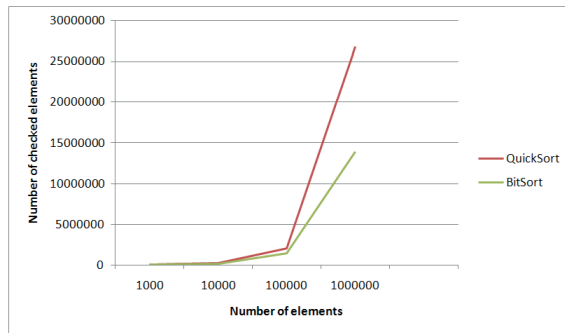
Figure 7 - Number of checked elements depending on the number of array elements

The graph shows the BitSort algorithm checking a smaller number of array elements than the QuickSort algorithm.

5. CONCLUSION

This paper presents a sorting algorithm that sorts non-negative integers based on a binary representation of an array element. Based on the time complexity of the algorithm, as well as comparative tests with already existing algorithms, it is shown that the algorithm belongs to the group of faster-performing algorithms. The proposed algorithm performs relatively quickly for large amounts of data and can therefore be used in today's world where huge amounts of data are produced daily. The advantage of the algorithm is that the number of recursive function calls is known in advance.

Since the algorithm sorts only non-negative integers, it is possible to continue with the further development of this algorithm. The next steps in the development of this algorithm are sorting negative integers, as well as other data types. Since the algorithm uses binary data presentation, it is possible to lower the algorithm to a level as close as possible to the hardware and thus further reduce the performance time. One can use this way of developing an algorithm, using binary data presentation, on other algorithms and thus attempt to improve the existing ones or write new ones.

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STUDENT SESSION

BLOCKCHAIN APPLICATION IN RFID DOMAIN

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Abstract:

Many people associate Blockchain technology exclusively with the payment system and earnings via the Internet, but its application is much greater. In this paper, after exploring chapters related to blockchain technology and microchips (RFID chips), we will be able to see how wide the application of blockchain technology is and the full extent of its capacity and possibilities for use in a variety of different areas of life. The paper aims to show the possibility of applying blockchain technology for object tracking. The idea of the application in a retail chain has been proposed.

Keywords:

Blockchain, RFID, chip, tag, reader.

INTRODUCTION

Mankind has always needed to have accurate information about the origin and history of any valuable object. Nowadays, however, as technology advances and the number of hackers increases, the number of counterfeit goods has grown and become easily available in the supply chain all over the world. Where the prevalence of the product is high, proof of the authenticity and the integrity of the goods is becoming increasingly difficult to prove. A possible solution to this problem is reflected in the application of blockchain technology to the source of and authenticity of many goods/products [1].

Combining blockchain technology with RFID chips gives us the ability to keep the data stored in the chip permanently, unchanged, and easy to read. RFID technology is characterized as reliable and can be easily adapted to the user's needs.

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2. BLOCKCHAIN

To better understand this new technology of marking and tracking products, we need to understand what a blockchain system is. This system can be described as one in which a record of transactions/information is maintained across several computers that are linked in a peer-to-peer network. A blockchain is a constantly growing ledger that keeps a permanent record of all the transactions that have taken place in a secure chronological and immutable way [1].

It is a database that is shared among network participants. It was created by connecting a P2P network (peer to peer) and a distributed server, which allows all transactions to be time-marked. This database is not stored in one central location (server), alternatively, it is distributed (decentralized) and represents a public book (Ledger) where all transactions that have ever occurred in respect of the product or goods are recorded and stored online. The database is public (rather than privately owned) and effectively is owned by all participants in the network [2].

The system of approval and acceptance of what is valid/accurate or not is based on group trust and consensus. Since the system is decentralized, all transactions and information contained in the ledger must be unchanged or agreed upon before any changes can occur. Data immutability is the essence of the system and the blockchain system itself differs from classic private databases, where changes and deletions of data are allowed [2].

As the information is stored in blocks (these blocks are put together to form a chain) and their distribution is done via the Internet where all nodes in the network have access to the blockchain itself. Nodes effectively form the infrastructure of a blockchain. All nodes on a blockchain are connected and they constantly exchange the latest blockchain data with each other so that all the nodes stay up to date with the same correct information and data. They store, spread and preserve the blockchain data, so theoretically a blockchain exists on nodes [2].

By allowing these nodes to access the blocks, all parties can get validation at any time of the information contained within that particular block. The first block in any blockchain is called the genesis block and each block in the chain contains the hash value of that data as well as the hash value of the previous transaction [2].

The securitisation and protection of the blockchain system itself is done by applying cryptographical methods and algorithms. For the blockchain system to function, cryptographical mechanisms are used:

- Hash functions;
- Public and private keys;
- Digital signing.

The inability to change the data contained within the blockchain is provided by the hash function and the consensus of the nodes in the network is required for any validation of the block. The immutability of data leads to trust in the system because it is difficult for any single individual or group of people to influence the data in any way. Data changes can occur only under the condition that most nodes in the network are represented by a group that wants to forcibly change the data, which is difficult to achieve [2].
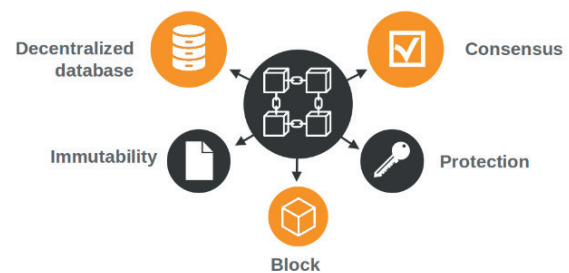

Figure 1 Blockchain technology architecture

3. MICROCHIPS

Microchips (chips) are widely used today, we can find them in computers, telephones, they have also been used for tracking pets. Scientists are still developing microchips, researching their applications, and today, microchips are produced that are barely noticeable to the human eye. The chip can receive millions of bits, which are usually grouped in groups of eight bytes [3].

Memory chips play a basic role in storing data that a microprocessor can access immediately. Since memory chips are mainly used in computers, we can divide them into two types [3]:

- RAM (Random Access Memory) - also known as the internal memory is where the data on a computer remains stored until the computer shuts down. There are two types of RAM as follows:
  - SRAM (Static Random Access Memory);
  - DRAM (Dynamic Random Access Memory);

◆ ROM (Read Only Memory) – is data stored in memory that is not subject to change. Flash memory is a removable ROM memory, the data on it remains stored even after the computer is shut down. To remove data from ROM memory, developers must to reprogram parts of the chip.

3.1. RFID CHIPS

Radio Frequency Identification (RFID) is a technology that is highly developed today and is one of the most commonly used technologies. It allows the identification of objects, without the need for physical or visual contacts, using radio waves. The critical parameters of the identification process are the memory space and the time required for identification [4].

The RFID system can be represented by two components:

- Transceiver (transmitter / receiver) and antenna this combination is an RFID reader;
- Transponder (transmitter) and antenna represent RFID tag.

Communication between the tag and the reader is done using radio signals that transmit data. Data transmission can be one-way or two-way [5].

The data used in RFID technology is not strictly defined, which allows users to customize it to their own needs. These can be some measurements of the environment, products, timestamps, location of the facility… RFID technology can also be used in combination with cryptographical methods to increase data security [5].

3.2. RFID TAGS AND READERS

The reader has the role of delivering the downloaded information from the label to the computer in digital form. It consists of an antenna and a decoder. Readers can be portable (handheld terminals) or fixed [6].

An RFID tag can be represented as a small piece of material made up of an antenna and a microchip. Used to store data. Labels can be read-only or read-write, depending on the user's needs [5]. There are two types of labels [6]:

- Passive RFID tag does not have its own energy source, it relies on energy emitted by the reader.
- The active RFID tag has its own power source that they use to generate signals to respond to the reader. They are connected to the propulsion

infrastructure or use the energy stored in the integrated battery. Active tags contain not only the battery but also some form of transmitter on the tag.
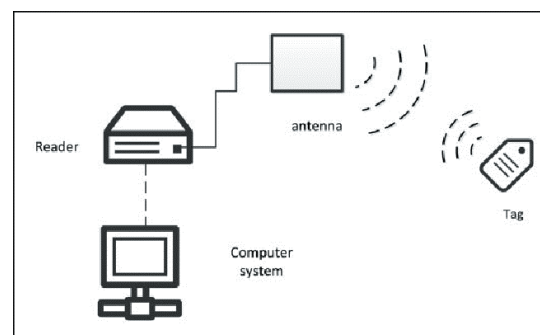
3.3. RFID CHIPS

Figure 2 Working principle of RFID system [7]

The principle of operation of the RFID system is shown in Figure 2. When the tag reaches the reading zone, its data is transmitted to the reader via the antenna and the antenna transmits radio signals and thus activates the mark.

When contact is established between the antenna and the tag, data in the tag can be written or read.

When the RFID tag passes through the electromagnetic zone, a reader activation signal appears and it then decodes the data encoded in the integrated circuit tag (silicon chip) and transmits it to the computer. The data stored in the tag can identification data, location data, specific product data, et cetera.

RFID quickly attracted attention because it can be used to track moving objects [6].

4. A COMBINATION OF RFID AND BLOCKCHAIN

By combining blockchain technology with RFID technology, it is possible to achieve real-time monitoring of objects. The role of blockchain technology in this combination is reflected in the security and accuracy of data. The RFID system is used for the purpose of fast and accurate data transmission.

By combining these technologies, we can create supporting documentation that will be difficult to falsify. It is recommended to use multiple signatures, which prevent one party from independently creating records and changing the information entered in the documentation [5].

Smart contracts are programs that are stored on a chain of blocks and run when pre-set conditions are met and they are usually used to automate the execution of agreements so that all participants can be immediately sure of the outcome, without any involvement of intermediaries or waste of time. In fact, it is a collection of code and data located at a specific address on a chain of blocks [8]. Smart contracts in a combination of blockchain and RFID systems are also called triggers.

Automatic or semi-automatic data entry leads to time savings, increased accuracy, reduced labor needs, increased trust among users, and reduced false information. Time data and precise locations can be entered automatically [5].

An example of using a combination of these technologies can be found in a retail chain. The goal is to ensure trust between the buyer and the seller so that the buyer will have access to all relevant information about the desired product. Buyer can find out the place and time of production, delivery conditions, method of storage, information about the supplier, distributor,… [5] Through this example of application it is possible to avoid the purchase of counterfeit, unverified and unreliable products.

However, the actual application of RFID technology and blockchain is still limited due to technical and economic barriers [5].
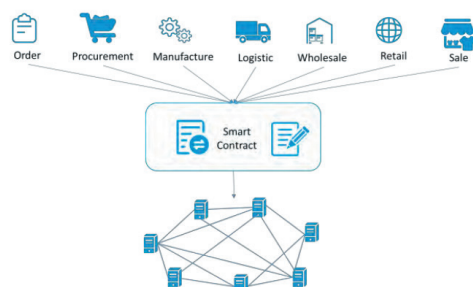

Fig. 3 Clothing Logistics Management

Figure 3 A retail chain that used RFID technology and blockchain [9]

A logistics management system based on the application of blockchain and RFID technology can be represented through a four-layer structure including an application layer, a blockchain data processing layer, and a data collection layer.
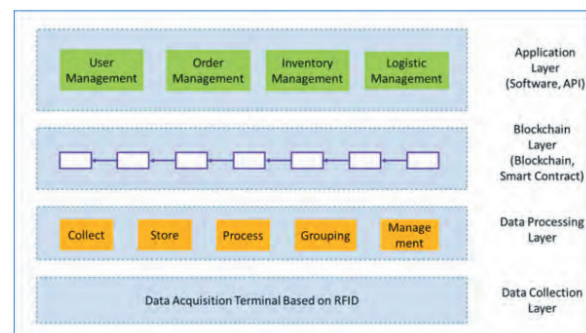

Figure 4 Logistics management system architecture [9]

The data collection layer is based on the application of RFID technology, which means that all data processed in the system are collected from objects that have an RFID tag and they are transmitted to a computer using a reader [9].

A data processing layer is also required. It is responsible for collecting, processing, transmitting, verifying the collected data, filtering information, removing redundant data (duplicates),… Data is first processed and then transferred to the blockchain layer [9].

The role of the blockchain system is reflected in the storage of data, but also the entire system. It enables the use of smart contracts that are built into the system and enables their execution regardless of external factors [9].

The application layer manages software functions, inventory, processes, and distributes orders. It is responsible for the user interface [9].

5. CONCLUSION

The first blockchain however was originally conceptualized by a person (or group of people) known as Satoshi Nakamoto who significantly improved the design by using a new methodology to time stamp blocks without requiring them to be signed by a trusted party and introducing a difficulty parameter to stabilize rate with which blocks are added to the chain. The design was implemented as a core component of the cryptocurrency bitcoin where it serves as the public ledger for all blockchain transactions on the network.

Its potential, however, has extended beyond financial currency usage and does not exclusively exist in that field. Using this system in combination with other technologies opens up new possibilities for its application. Specifically, this paper discussed the combination of blockchains with RFID chips for tracking an object or product, which provides security to system users.

The convenience of using RFID technology is reflected in the high degree of reliability of reading data from the tag, the ability to read data if the reader and the tag do not have direct contact with each other Blockchain in this combination of technologies provides data security, ensures that all set conditions (if any) are met.

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