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RELATED RESEARCH



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ABOUT SINTEZA 2020

International Scientific SINTEZA (SYNTHESIS) Conference provides an ideal platform for the exchange of information and dissemination of best practices, ideas and advancements in the state-of-the-art and technical improvements in the domain of Information Technology, its application and related innovations, as well as Data Related Research.

Rapid advances in Information Technologies over the previous decades have had a huge impact on numerous facets of everyday life and have created tremendous opportunities for economic, technological and social gains on a global scale. In particular, the advances in data-science, block-chain technology and optimization techniques are becoming the driving force behind many changes in both technology and business. New technologies and scientific breakthroughs have altered working and living environments making them safer, more convenient and more connected.

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, as well as their applications in a range of engineering and other fields of research.

Specific topics for this year are focused on artificial intelligence, machine learning, data research and analysis, as well as their application in solving practical real-life problems.

Due to the Covid-19 imposed pandemic, the conference has been held online this year, supported by the application of the Microsoft Teams Live Event software. The experiences we have gained are of precious value and could be extremely useful in the future – not only for conference organisers, but also for session moderators, speakers and all the participants.

Sincerely,

Organising Committee of Sinteza 2020



SINTEZA 2020

INTERNATIONAL SCIENTIFIC CONFERENCE ON INFORMATION TECHNOLOGY AND DATA RELATED RESEARCH

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ARTIFICIAL INTELLIGENCE ATLAS SESSION





AN END TO END LEARNING APPROACH FOR DISTANCE ESTIMATION TRAINED WITH ARTIFICIALLY GENERATED STEREO IMAGES

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Abstract:

This paper proposes a solution for distance estimation using stereo images. The solution is a convolutional neural network that takes two images as an input, and outputs the distance estimate, without the need for prior camera calibration or disparity map calculation. The dataset used for training consists of images generated from an artificially constructed 3D scene. The training algorithm used was stochastic gradient descent. Evaluation of the solution was conducted on a separate dataset. Mean absolute error after the evaluation was 1.59 m, while the median value of the absolute error was 1.2 m. These results show that the proposed solution is a valid proof of concept for the usage of convolutional neural networks for the distance estimation of objects in stereo images in a single step.

Keywords:

artificially generated data, convolutional neural networks, stereo vision.

INTRODUCTION

Distance measurement has applications in industrial environments and is an important component of obstacle avoidance systems used in autonomous vehicles. Some of the more usual approaches to distance measuring involve use of sonars, radars, LiDARs and cameras. Radars, sonars and LiDARs rely on time-of-flight to calculate distance of the object of interest [1]. Although radars and sonars can be used to accurately measure distance to single objects, they are not suited for high resolution measurements such as those required for construction of point clouds. Optical devices such as LiDARs do not suffer from this problem but their accuracy can be hindered by environmental conditions such as adverse weather [2]. Cameras, as another example of optical devices, can also be used to measure distance of single objects and to create point clouds. Accuracy of measurements acquired by cameras is largely dependent on environmental conditions and proper device calibration. However, an additional advantage of cameras, compared to the aforementioned devices, is that they can be used to collect more general information about the environment. In order to capitalize on the advantages of using

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cameras, while trying to mitigate their disadvantages, in this paper we propose a solution for distance estimation using cameras without the need for prior calibration.

This paper is composed of four chapters. In chapter 1 we will present work related to our research. The following chapter describes the proposed method. In chapter 3 we will present the results obtained by applying the proposed method to test data. Finally, in chapter 4, the conclusion, we will review the results and propose further improvements.

1. RELATED WORK

There is a significant amount of research on the subject of absolute distance measuring. Most of the research in this field describes methods relying on time-of-flight distance measurement or optical triangulation. In [3], the authors describe a high precision distance measurement method using an ultrasonic sensor to measure the time of flight of an ultrasonic pulse reflected by the target. Paper [4] describes a laser range finder for industrial distance measurements achieving a 2 mm absolute error in the distance range of 0.5 - 34.5 m. A different approach to measure distances is to use images, as proposed in [5], in which the authors use inverse perspective mapping to transform a forward-facing image, taken from an automobile-mounted camera, to a top-down view, which is then used to estimate the distance to an object. Camera tilt, change of velocity of the vehicle the camera is mounted on, and undulations of the road were a negative impact on accuracy. The authors of [6] use stereo images to create a 3D point cloud and calculate the distance to points of interest, which are tightly grouped clusters in the point cloud. This method has a maximum detection range of about 90 m, with optimal range being between 10 - 60 m. The achieved measurement error is higher than that of solutions using radar systems, but was comparably low for a vision-based system, ranging from less than 10 cm at 10 m to about 2 m error at 95 m distance. In [7] stereovision is used to construct 3D world coordinates of objects, calculated by using camera parameters and stereoscopic image data, with experimental results showing that, in the optimal range of 4 - 50 m, under reasonable illumination conditions, an error of 5% of the estimated distance can be expected. A method using stereo vision to generate disparity maps and extract stixels, which are then clustered into individual objects, for which the distance is measured is proposed in [8]. The method was not reliable at distances less than 5 m. At distances above this

threshold, the system achieved an accuracy of 92.51%. In [9, 10] the authors propose methods to generate disparity maps on image pairs using convolutional neural networks (CNN). The authors of [9] constructed two different models, one optimized for accuracy and the other for computation speed. The model optimized for accuracy achieved 3.89% pixel-wise error rate, while the fast model achieved an error rate of 4.62%. The model proposed in [10] achieved an error rate of 13% on the same dataset.

In the previously mentioned papers utilizing images to calculate the distance to an object, prior calibration of the cameras is necessary, and the camera parameters must be known. However, authors of [11, 12, 13] propose methods for automatic extraction of camera parameters.

2. PROPOSED METHOD

Papers presented in the previous section showed that neural networks can be used to generate disparity maps and to extract camera parameters. However, the proposed solutions never combined those tasks in order to estimate the distance to the target. Given these circumstances we propose a solution, in the form of a neural network, that not only integrates both tasks, but is also capable to estimate distance to a target object.

Neural network architecture

The neural network utilized in our solution is a feed-forward network consisting of a convolutional part and a fully connected part. The convolutional part is used to extract features from image pairs that are then forwarded to the fully connected part of the network. The convolutional layers are divided in two identical branches, each handling a single input image. The outputs of the convolutional branches are passed through an adaptive max pooling layer and then concatenated. These concatenated outputs form a 100x100x128 tensor which is then flattened into a 1D tensor and is passed as the input into a fully connected part of the network. This part is composed of 6 layers with the PReLU activation function between the first five, and a ReLU activation after the final layer. The detailed preview of the neural network architecture is given in Fig. 1.

Data acquisition

The data used for training and validation of the neural network consists of 10000 image pairs. The images were generated from artificial 3D scenes. The 3D scenes were modelled using Blender, an open source 3D modelling software.



The benefits of generating images from artificial scenes are the ability to acquire a large dataset with exact distance measurements and camera and scene parameters under our control without the need for manual data labelling.

The scenes themselves consist of 20 objects of which 19 are cubes serving as noise and a target object, of varying shapes and dimensions, to which the distance is measured. A cuboid enveloping the aforementioned objects is used as background of the scene. The target distance, i.e. the label, is calculated as the Euclidean distance to the center the stereo camera baseline. The focal length of the camera lenses is 50 mm, clip start is 0.1 m and clip end is 100 m. The cameras are positioned into a parallel configuration and are always facing the center of the target object. The baseline is set to 6.5 cm. A setup of the scene pre-render is shown in Fig. 2.

The materials applied to the objects are Physically Based Rendering (PBR) materials, used in order to achieve a higher level of detail while maintaining a low poly count for objects. PBR materials, consisting of the following textures: albedo, metalness, roughness, ambient occlusion, bump and normal maps, were used in this scene to create specialized shaders which enabled the altering of specific material properties such as color, reflectivity and surface imperfections. The lighting of the scene was realized by using a high dynamic range imaging (HDRI) texture, which allows for a greater range of luminosity than can be achieved with the standard lighting model in Blender.

The Cycles render engine, which is a ray tracing engine, was used to generate the image pairs. The engine was configured to use 3 light ray bounces, which allowed for the creation of photorealistic images while significantly reducing render times. In order to further optimize rendering times, while maintaining image quality, a lower sample value was used along with an active denoising component.

Parameters of the scene are randomized before each image pair is rendered. First, the HDRI texture is randomly chosen from a pool of 12 textures containing examples of interior, exterior, day and night lighting conditions. Then, the camera is positioned in the scene by randomizing its y coordinate in the range of 4 m to the left of its origin to 4 m to the right of the origin. The camera's z coordinate is randomized in the range of 0.5 m to 5 m above the origin. The target object is placed along the x axis, its x coordinate ranging from 8 to 68 m from the origin, which is the initial x coordinate of the camera. The scale and rotation of the target object are randomized along all axes, the scale in the range of 0.5 m

to 3 m and the rotation in the range of 0 to 2π . The shape of the target object is randomly chosen from a preset of 4 shapes: cube, sphere, cone, cylinder. The cubes used as noise are positioned from 5 to 10 m to the left and right of the x axis.

During the rendering process, a metadata file is formed. This file is composed of records describing each image pair. The records contain image names, the distance from the camera to the target object, and the coordinate of the point on the target object to which the distance is measured. The metadata file is used as the input into the training process.

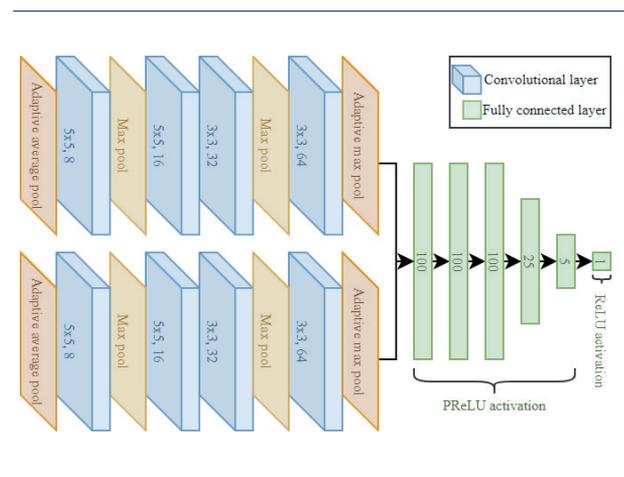


Fig. 1. Neural network architecture.

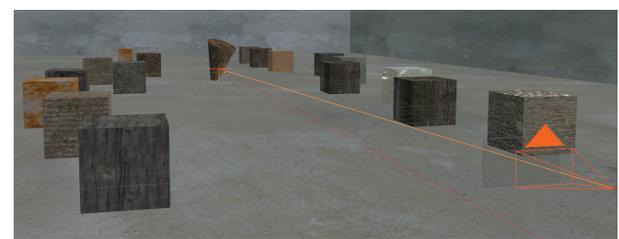


Fig. 2. Scene pre-render.

Training process

The neural network was trained using the stochastic gradient descent (SGD) algorithm. The learning rate of the algorithm was set to 1×10^{-5} , whilst the momentum was set to 0.9. Each training sample was composed of an image pair and the distance measured from the stereo camera to the target object. The training was done in batches, each batch contained 5 training samples. The batch size was chosen empirically with the goal of maximizing utilization of the graphics card and minimizing IO operations.



The dataset used to train the neural network was the previously acquired simple scene dataset. This dataset contained 10000 image pairs, divided into a training subset, containing 80% of the images and a validation subset containing 20% of the image pairs.

During training both the loss on the training dataset, and the average and median error on the validation dataset were monitored. The loss measure used during the training was the mean square error (MSE). The error measure used on the validation dataset is expressed as an absolute difference of expected and estimated value. Once the error measured on the validation dataset stopped changing significantly the training process was terminated. This happened after 12 epochs. The change of loss and validation error with respect to the number of epochs are shown in Fig. 3.

3. RESULTS

The neural network was tested on a separate dataset consisting of 2000 image pairs generated in the same manner as is described in II. These image pairs were not part of the training or validation subsets. Prior to testing, the neural network weights from the 12th checkpoint were loaded for the purpose of testing, as these scored the lowest error on the validation dataset. The mean absolute error on the test dataset was 1.59 m, while the median absolute error was 1.2 m. In order to facilitate further error analysis, the test results of every individual image were grouped into bins based on the value of the label, i.e. the real distance, in 10 m intervals. The mean and median absolute error values of each bin, as well as a boxplot of the errors per bin are shown in Table 1 and Fig. 4, respectively.

Detailed analysis of reported errors has shown that images generated from scenes using HDRIs with lower light levels have the largest difference between actual distance to object and the estimate. Similarly, a majority of objects sharing the same material as the background have shown to have a negative impact on results.

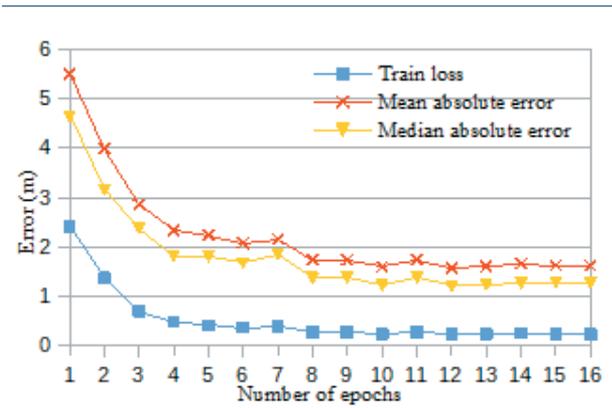


Fig. 3. Change of loss and validation error with respect to the number of epochs.

Table 1. MEAN AND MEDIAN ERRORS WITH RESPECT TO BINS

Bins	Errors (m)	
	Mean error	Median error
1	1.76	1.25
2	1.55	1.17
3	1.51	1.19
4	1.58	1.23

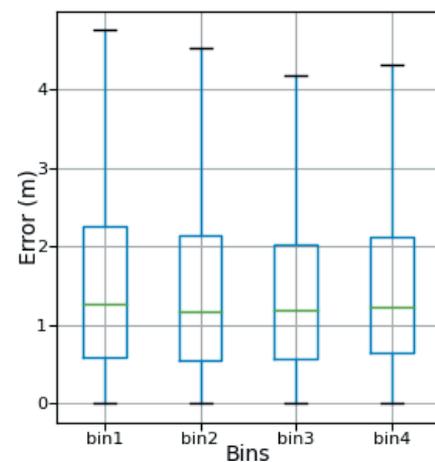


Fig. 4. Error distribution across bins.



4. CONCLUSION

Distance estimation from stereo images is a commonly used and well-known technique. While related works mainly focus on either disparity map generation or automatic camera calibration, the solution proposed in this paper unifies both into a single process in the form of a convolutional neural network. Stereo images were used as an input in order to estimate the distance to a target object in the images. The solution was trained, validated and tested using a dataset containing images generated from a 3D scene constructed using Blender. The training dataset consisted of 8000 image pairs, while the validation and testing datasets contained 2000 image pairs each. The neural network was trained for 12 epochs using SGD. Finally, the network was evaluated on the test dataset and achieved a mean absolute error of 1.59 m. Upon further examination of the results gathered from the evaluation, it was established that the network achieved similar performances across all distance ranges.

While the solution presented in this paper was shown to be a valid proof of concept, further research can be undertaken. One promising direction would be the construction of a more complex 3D scene for the generation of training data, as well as a larger dataset which would contain depth maps. Such a dataset could be used to train a depth map generating model or to improve the results of the solution presented in this paper. The viability of the solution for real-life application could be evaluated using manually labelled stereo images acquired with calibrated cameras. Transfer learning with the utilization of such images could prove as a promising direction for future research.

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REFERENCES

[1] T. Bosch, "Laser ranging: a critical review of usual techniques for distance measurement," *Opt. Eng.*, vol. 40, no. 1, p. 10, Jan. 2001, doi: 10.1117/1.1330700.

[2] R. Heinzler, P. Schindler, J. Seekircher, W. Ritter, and W. Stork, "Weather Influence and Classifica-

tion with Automotive Lidar Sensors," 2019 IEEE Intell. Veh. Symp. IV, pp. 1527–1534, Jun. 2019, doi: 10.1109/IVS.2019.8814205.

[3] A. Carullo and M. Parvis, "An ultrasonic sensor for distance measurement in automotive applications," *IEEE Sens. J.*, vol. 1, no. 2, p. 143, 2001, doi: 10.1109/JSEN.2001.936931.

[4] A. Kilpelä, R. Pennala, and J. Kostamovaara, "Precise pulsed time-of-flight laser range finder for industrial distance measurements," *Rev. Sci. Instrum.*, vol. 72, no. 4, pp. 2197–2202, Apr. 2001, doi: 10.1063/1.1355268.

[5] S. Tuohy, D. O’Cualain, E. Jones, and M. Glavin, "Distance determination for an automobile environment using inverse perspective mapping in OpenCV," pp. 100–105, Jan. 2010, doi: 10.1049/cp.2010.0495.

[6] S. Nedevschi et al., "High accuracy stereo vision system for far distance obstacle detection," in *IEEE Intelligent Vehicles Symposium*, 2004, Jun. 2004, pp. 292–297, doi: 10.1109/IVS.2004.1336397.

[7] Y. Huang, S. Fu, and C. Thompson, "Stereovision-Based Object Segmentation for Automotive Applications," *EURASIP J. Adv. Signal Process.*, vol. 2005, no. 14, p. 910950, Dec. 2005, doi: 10.1155/ASP.2005.2322.

[8] B. Lim, T. Woo, and H. Kim, "Integration of Vehicle Detection and Distance Estimation using Stereo Vision for Real-Time AEB System:," in *Proceedings of the 3rd International Conference on Vehicle Technology and Intelligent Transport Systems*, Porto, Portugal, 2017, pp. 211–216, doi: 10.5220/0006296702110216.

[9] J. Z’bontar and Y. LeCun, "Stereo Matching by Training a Convolutional Neural Network to Compare Image Patches," p. 32.

[10] T. S. Jordan and S. Shridhar, "Usings CNNs to Estimate Depth from Stereo Imagery," p. 6.

[11] M. Mendonça, "CAMERA CALIBRATION USING NEURAL NETWORKS," p. 4.

[12] Yongtae Do, "Application of neural networks for stereo-camera calibration," in *IJCNN’99. International Joint Conference on Neural Networks. Proceedings (Cat. No.99CH36339)*, Washington, DC, USA, 1999, vol. 4, pp. 2719–2722, doi: 10.1109/IJCNN.1999.833509.

[13] M. T. Ahmed, E. E. Hemayed, and A. A. Farag, "Neurocalibration: a neural network that can tell camera calibration parameters," in *Proceedings of the Seventh IEEE International Conference on Computer Vision*, Kerkyra, Greece, 1999, pp. 463–468 vol.1, doi: 10.1109/ICCV.1999.791257.



BENZENE SOURCE APPORTIONMENT USING BIVARIATE CORRELATION AND REGRESSION ANALYSES

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Abstract:

The aim of this study was to identify and characterize the individual sources of benzene in an urban area of Belgrade based on bivariate polar plot concentration, correlation, and regression analyses. The presented benzene behavior modeling relied on a weighted Pearson correlation coefficient, linear regression slope, and Gaussian kernel locally weighted by wind speed direction surface. The data, including the concentrations of volatile organic compounds (VOCs), inorganic gaseous pollutants and meteorological parameters, were obtained from a measurement campaign conducted at the Singidunum University (Belgrade, Serbia) during and after the heating season 2016. The results indicate the dominance of benzene, toluene, and NO local emission sources, as well as the significant impact of remote NO₂ sources located in the SW and SE. The strong interrelations between VOCs indicate the common origin of these compounds. High toluene to benzene ratio (>2) was almost independent of wind speed and direction, indicating that the entire area was severely exposed to fresh vehicular emissions. The absence of relationships between benzene and fossil fuel combustion gaseous pollutants including NO_x and O₃ suggests that evaporations from small chemical industrial complex situated in the S direction from the study site might be the main benzene and toluene emission source in the area. As regards inorganic gaseous pollutants, the relationship between benzene and NO in the N and NE might be related to the intensive anthropogenic activities in the central urban area of Belgrade and petrochemical industry in Pančevo. As presented herein, a combination of bivariate polar plot concentration, correlation, and regression analyses offers unique insight into the individual sources of air pollutants and their concentration dynamics.

Keywords:

benzene, volatile organic compounds, bivariate polar plot analysis.

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1. INTRODUCTION

In the recent years, volatile organic compounds (VOCs) became an important environmental issue because of their harmful impacts on human health and the environment. They originate from numerous natural and anthropogenic sources and are involved in a wide range of chemical reactions in the atmosphere including the formation of secondary



organic aerosols and tropospheric ozone. The most abundant VOCs in the atmosphere are hydrocarbons, organic alcohols, halogenated organic compounds, and sulfur compounds [1]. Four aromatic hydrocarbons - benzene, toluene, ethylbenzene, and xylene, commonly known as a BTEX group, are found to be abundant in the urban atmosphere and are considered the representatives of volatile organics [2, 3]. Natural sources of BTEX include crude oil evaporations and emissions from volcanoes and forest fires, while the primary anthropogenic emissions of BTEX compounds are related to motor vehicles, cigarette smoke, petroleum products, and the production and use of paints, lacquers, thinners, rubber, cosmetics, and pharmaceutical products [4].

Among the BTEX, benzene draws special attention because it is considered to be the most toxic and detrimental compound [5]. The International Agency for Research on Cancer (IARC), classified benzene as carcinogenic compound to humans (Group 1), while ethylbenzene has assigned as probably carcinogenic (Group 2). There is no evidence of the toluene and xylenes carcinogenicity in humans (Group 3), but toluene is more soluble in lipids than benzene, and therefore toluene exposure can lead to adverse neurological effects [6].

The research aimed at the investigation of VOC emission sources has been intensified over the last two decades, and many of these studies have been focused on the identification of sources by estimating the ratios of BTEX concentrations in the ambient air and calculating their correlations [7, 8]. Toluene to benzene ratio is commonly used to distinguish the impact of traffic and non-traffic emission sources, while ethylbenzene to benzene ratio, as well as xylenes to benzene ratio are often applied as indicators of photochemical reaction intensity [9].

This study considered the relationships and ratios between benzene, and toluene and inorganic pollutants, in the context of simultaneously measured meteorological parameters, wind speed and wind direction. The bivariate polar plot method in a combination with pair-wise statistics was used to indicate the most significant emission sources of benzene and investigate their characteristics in an urban area.

2. MATERIAL AND METHODS

For the purpose of this study, the measurements were conducted over the three-months period, at the Singidunum University building in the urban area of Belgrade (Serbia) during and after the heating season of 2016. The dataset comprised the concentrations of air pollutants and meteorological parameters [10].

University building is surrounded by large residential areas from W, SW, and NE side, some of which encompass households with individual fireboxes, while small scale industry referring to Road Institute of Belgrade, a building company and beverage factory stockroom are located in the nearest vicinity. In addition, confectionery factory, footwear factory, and several small-scale chemical plants are located 600 m in the NW and S direction, respectively. Approximately 800 m to the W and SW from the measurement site a large district heating plant and fuel oil heating plant of urban forestry organization used for the purposes of planting material production are situated. A boulevard with public transport and moderate vehicle flow passes by approximately 250 m in the SW direction, while a road with intense traffic is about 500 m away in the W-NW direction. The old city center and river confluence are located at the distance exceeding 2 km in the NW direction.

During the campaign, besides the other pollutants including polycyclic aromatic hydrocarbons, gases and metals, the concentrations of benzene, toluene, nitrogen oxides (NO , NO_2 , and NO_x), ozone (O_3), and meteorological parameters, including wind characteristics, were collected. The VOCs concentrations were measured in real time using a proton transfer reaction mass spectrometer (Standard PTR-MS, Ionicon Analytik, GmbH, Austria). A detailed description of the PTR-MS method is given elsewhere [11], while calibration procedure was done according to Taipale et al. [12]. Inorganic gaseous pollutant measurements were conducted by using Horiba 370 series devices which enabled continual pollutant concentration monitoring with a 2 minute-resolution data. The APNA-370 device was used for NO_x concentration measurements by a combination of dual cross-flow modulation type chemiluminescence principle and the referential calculation method according to SRPS EN 14211:2013 standard. Continuous monitoring of ozone concentrations was performed by the cross-flow modulated ultraviolet absorption method using APOA-370 device according to standard SRPS EN 14625:2013. Meteorological data were obtained by using Vaisala weather station (Weather Transmitter WXT530 Series).

The statistical data analyses included bivariate polar plots, and improved analytical method which combines bivariate polar plots with pair-wise statistics that provide information on how two pollutants are related to one another. The pair-wise statistics implemented include the weighted Pearson correlation and slope from two linear regression methods. More details about this method can be found in Grange et al. [13, 14].



The analyses were performed with the statistical software environment R [15], by the use of the Openair package [16].

3. RESULTS AND DISCUSSION

As indicated by the elevated pollutant concentrations at low wind speeds ($< 1 \text{ m s}^{-1}$), there is a dominance of local traffic emissions of benzene, toluene, and NO in the nearest vicinity of the sampling site (Fig. 1).

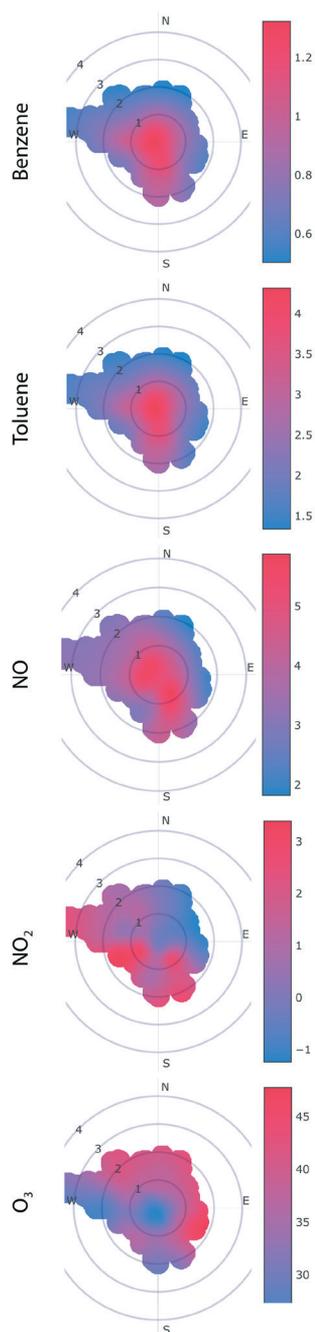


Fig. 1. Bivariate polar plot of benzene, toluene, NO, NO₂, NO_x, and O₃.

The highest concentrations ($> 3 \mu\text{g m}^{-3}$) of NO₂ were recorded during S and SW wind episodes which caused the air pollution transport from distant sources including the powerplants “Nikola Tesla” and “Kolubara” situated in Obrenovac and Veliki Crljeni [17]. In addition, several sources of O₃ were observed, and the dominant ones contributing to the concentrations higher than 40 $\mu\text{g m}^{-3}$ were identified in N, E, and SE direction of the measurement site.

Photochemical formation of O₃ in the troposphere is facilitated by the presence of sunlight and elevated levels of precursor pollutants including NO_x and VOCs.

The correlation matrix shows that the two organic compounds, benzene and toluene, were well correlated ($r=0.96$) (Fig. 2), which might suggest their common origin [18]. However, this type of analysis does not provide an indication of which type of source and to what extent contributes to total benzene concentrations. No significant relationships between benzene and NO, NO₂, O₃, and wind parameters were registered although very low values of Pearson’s correlation coefficient ($r=0.29$) between benzene and NO could be an indication of common pollutant emission sources, probably one of them being fossil fuel combustion.

When the benzene and other pollutant concentrations were plotted with a correlation statistic and slope binned by wind speed and direction (Fig. 3), the results were revealing more than the mean concentration polar plots and the correlation matrix together.

The strong relationship between benzene and toluene indicates the same dominant source of these compounds. The polar plot of the slope shows that the high toluene to benzene ratio (>2) was almost independent of wind speed and direction, indicating that the whole area was severely exposed to fresh vehicular emission sources [19]. Furthermore, during the N winds (NE and NW, more precisely), benzene and NO were highly correlated.

The zones of high correlation and the relationship between benzene and NO (slope > 6) in the N and NE indicate the impact of intensive anthropogenic activities in the central urban area of Belgrade and petrochemical sources near Pančevo [20].

The absence of a relationship between benzene and fossil fuel combustion gaseous pollutants including nitrogen oxides and O₃ indicated that benzene and toluene evaporations from small chemical industry complexes situated in the S direction from the study site can be considered the main pollution source in the area.

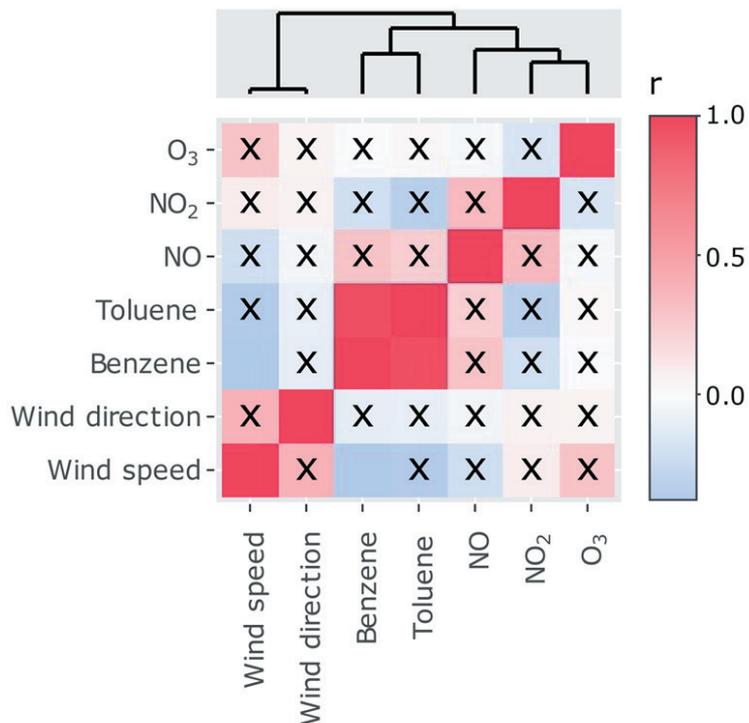


Fig. 2. Correlation matrix of pollutant concentrations and wind parameters.

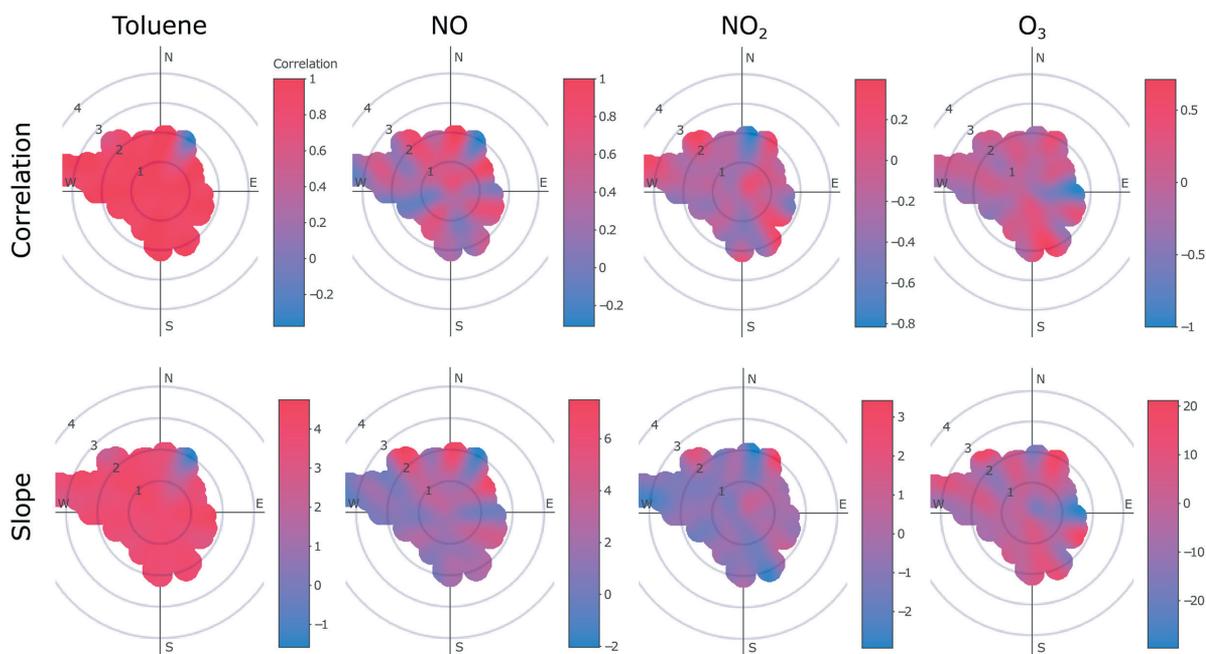


Fig. 3 Polar plot of the correlation (above) and slope (down) between benzene and toluene, NO, NO₂, NO_x, and O₃



4. CONCLUSION

In the field of atmospheric and environmental science, research on the relationship between chemical pollutants in the air and meteorological parameters is tremendously common, and there are diverse techniques of determination of the relationship and comparison. An analysis that also takes into account the correlation of the two pollutants can often be useful because it can lead to the identification of emission source characteristics.

Statistical analysis that includes wind characteristics – bivariate polar plot, applied to the concentrations of benzene, toluene, nitrogen oxides, and ozone, suggests that local sources of air pollution dominate in the study area. With pollutants mainly originating from local emissions, the elevated concentrations occur due to the lack of dispersion, in cases where wind speeds are low ($< 1 \text{ m s}^{-1}$). Polar correlations and slopes indicate that there were several types of sources that affected benzene concentrations in the investigated area, and the most important include exhaust from motor vehicles and emissions from industrial processes.

In addition to the statistical receptor modeling, analysis related to spatio-temporal variations and the contribution of other species and sources is required for reliable identification of benzene sources in complex atmospheric environments. The accompanying study should focus on factors such as the pattern of the weekend/weekday activities, regional and long-range transport, planetary boundary layer dynamics, and others meteorological parameters that significantly affect the observed VOC concentrations.

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REFERENCES

- [1] X. Zhang, B. Gao, A. E. Creamer, C. Cao and Y. Li, "Adsorption of VOCs onto engineered carbon materials: A review", *Journal of hazardous materials*, 338, 2017, pp.102-123.
- [2] R. Montero-Montoya, R. López-Vargas and O. Arellano-Aguilar, "Volatile organic compounds in air: sources, distribution, exposure and associated illnesses in children", *Annals of global health*, 84(2), 2018, pp. 225.
- [3] A. Mohammadi, Y. Ghassoun, M.O. Löwner, M. Behmanesh, M. Faraji, S. Nemati, ... and M. Miri, "Spatial analysis and risk assessment of urban BTEX compounds in Urmia, Iran", *Chemosphere*, 246, 2020, pp. 125769.
- [4] F. Hedayatade and N. Hassanzadeh, "Occurrence, Probable Source, and Health Risk Assessment of Benzene, Toluene, Ethylbenzene, and Xylene Compounds in Ambient Urban Atmosphere in Ahvaz, Iran", *Archives of Hygiene Sciences*, 9(2), 2020, pp. 152-167.
- [5] US EPA 2002. "Toxicological review of benzene (noncancer effects)", In Support of Summary Information on the Integrated Risk Information System (IRIS), U.S. Environmental Protection Agency, Washington, DC, October 2002
- [6] IARC, 2014, "Monographs on the Evaluation of Carcinogenic Risks to Humans", World Health Organization, International Agency for Cancer Research, Internal Report 14/002, Lyon.
- [7] M. Dehghani, M. Fazlzadeh, A. Sorooshian, H. R. Tabatabaee, M. Miri, A. N. Baghani, ... and M. Rashidi, "Characteristics and health effects of BTEX in a hot spot for urban pollution", *Ecotoxicology and environmental safety*, 155, 2018, pp. 133-143.
- [8] Z. Jiang, B. Grosselin, V. Daële, A. Mellouki and Y. Mu, "Seasonal and diurnal variations of BTEX compounds in the semi-urban environment of Orleans, France", *Science of The Total Environment*, 574, 2017, pp. 1659-1664.
- [9] B. T. Thera, P. Dominutti, F. Öztürk, T. Salameh, S. Sauvage, C. Afif, ... and A. Borbon, "Composition and variability of gaseous organic pollution in the port megacity of Istanbul: source attribution, emission ratios, and inventory evaluation", *Atmospheric Chemistry & Physics*, 19(23), 2019.
- [10] S. Stanišić, M. Perišić, G. Jovanović, T. Milićević, S. Herceg Romanić, A. Jovanović, A. Šoštarić, V. Udovičić and A. Stojić, "The PM_{2.5}-bound polycyclic aromatic hydrocarbons: the identification of emission sources and XGBoost pollutant level prediction in indoor and outdoor environment", 2020. (submitted for publication)



- [11] W. Lindinger, A. Hansel and A. Jordan, "On-line monitoring of volatile organic compounds at pptv levels by means of proton-transfer-reaction mass spectrometry (PTR-MS) medical applications, food control and environmental research", *International Journal of Mass Spectrometry and Ion Processes*, 173(3), 1998, pp.191-241.
- [12] R. Taipale, T.M. Ruuskanen, J. Rinne, M.K. Kajos, H. Hakola, T. Pohja and M. Kulmala, "Quantitative long-term measurements of VOC concentrations by PTR-MS? measurement, calibration, and volume mixing ratio calculation methods", 2008, hal. archives-ouvertes.fr.
- [13] S. K. Grange, A. C. Lewis and D.C. Carslaw, "Source apportionment advances using polar plots of bivariate correlation and regression statistics", *Atmospheric Environment*, 145, 2016, pp. 128-134.
- [14] W. Javed, M. Iakovides, E. G. Stephanou, J. M. Wolfson, P. Koutrakis and B. Guo, "Concentrations of aliphatic and polycyclic aromatic hydrocarbons in ambient PM_{2.5} and PM₁₀ particulates in Doha, Qatar", *Journal of the Air & Waste Management Association*, 69(2), 2019, pp. 162-177.
- [15] Team, R. C. (2012). *R: A language and environment for statistical computing*. 2012. Vienna, Austria: R Foundation for Statistical Computing, 10.
- [16] D. C. Carslaw and K. Ropkins, "Openair—an R package for air quality data analysis", *Environmental Modelling & Software*, 27, 2012, pp. 52-61.
- [17] M. Perišić, A. Stojić, S. S. Stojić, A. Šoštarić, Z. Mijić and S. Rajšić, "Estimation of required PM₁₀ emission source reduction on the basis of a 10-year period data", *Air Quality, Atmosphere & Health*, 8(4), 2015, pp. 379-389.
- [18] A. Stojić, S. S. Stojić, Z. Mijić, A. Šoštarić, and S. Rajšić, "Spatio-temporal distribution of VOC emissions in urban area based on receptor modeling", *Atmospheric Environment*, 106, 2015, pp. 71-79.
- [19] B. T. Thera, P. Dominutti, F. Öztürk, T. Salameh, S. Sauvage, C. Afif, ... and A. Borbon, "Composition and variability of gaseous organic pollution in the port megacity of Istanbul: source attribution, emission ratios, and inventory evaluation", *Atmospheric Chemistry & Physics*, 19(23), 2019.
- [20] A. Stojić, D. Maletić, S. S. Stojić, Z. Mijić and A. Šoštarić, "Forecasting of VOC emissions from traffic and industry using classification and regression multivariate methods", *Science of the Total Environment*, 521, 2015, pp. 19-26.



CONVERSATIONAL AGENTS FOR LEARNING FOREIGN LANGUAGES A SURVEY

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Abstract:

Conversational practice, while crucial for all language learners, can be challenging to get enough of and very expensive. Chatbots are computer programs developed to engage in conversations with humans. They are designed as software avatars with limited, but growing conversational capability. The most natural and potentially powerful application of chatbots is in line with their fundamental nature - language practice. However, their role and outcomes within (in)formal language learning are currently tangential at best. Existing research in the area has generally focused on chatbots' comprehensibility and the motivation they inspire in their users. In this paper, we provide an overview of the chatbots for learning languages, critically analyze existing approaches, and discuss the major challenges for future work.

Keywords:

language learning, conversational agents, survey, conversation, chatbot.

1. INTRODUCTION

Conversational agents (also known as chatbots) are becoming part of our everyday activities, such as Amazon Alexa [1] and Google Assistant [2]. These services employ a common technological metaphor - a personal, user-friendly assistant that provides a service by using a natural language [3].

The proliferation of technologies for learning languages aims at providing personalized services for gaining and maintaining language proficiency at any time, in any place [4]. Chatbots are becoming part of this paradigm shift as a cost-effective means to deliver such services. Besides, they try to ingrain positive working habits concerning language, such as repetition and follow-up exercises outside the classroom [5], [6]. The main benefits are ease of use and accessibility - the conversation metaphor using text- or voice-based interfaces make them more intuitive, available on smartphones in any place and at any time [7].

Recent research with various text-based human-chatbot interactions has consistently pointed to their potential benefits. Particularly concerning the motivation and engagement they inspire in their users [6], [7].

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These are critical requirements for technology-supported language learning. However, the potential of chatbots as language learning partners is yet underexplored. The evidence of the effectiveness and efficiency of the existing chatbot-like technologies for learning languages in terms of measurable outcomes (such as acquired knowledge, skills, and attitudes) is either missing or is non-consistent [4], [5], [6], [7], [8], [9].

This situation motivates our research to reflect on the previous work in chatbots for learning languages and formulate implications for their future. Due to their very nature, we believe that the chatbots' appearance and behavior are highly interdependent. Therefore, we look at them from technological (i.e., functional) and speaker (i.e., user experience - UX) aspects. In particular, this paper:

- ◆ gives an overview of the technology for learning languages,
- ◆ critically analyzes the chatbot technology against the proposed dimensions, and
- ◆ outlines the implications for future work on the chatbots for learning languages.

The paper is structured as follows: Section 2 situates our work in the context of the related technologies. In Section 3, we formulate the dimensions for analyzing relevant aspects of the chatbots for learning languages. Section 4 describes and compares the chatbots against the dimensions. Section 5 articulates the implications for future work. Section 6 proposes a conceptual architecture for the chatbots. Section 7 highlights the limitations of our work, and Section 8 concludes the paper.

2. ITECHNOLOGY FOR LEARNING LANGUAGES

Numerous applications for learning languages have been developed and used. We classify these applications into Web and mobile technologies and gamified technologies based on their underlying mechanisms and type of content delivery. Given their abundance, we do not aim to provide an exhaustive list of the technologies but analyze the representatives that demonstrate some shared properties.

Web and mobile technologies

A lack of time, numerous commitments and scheduling issues among others have led to people having to find ways around to learn foreign languages to maintain regular contact with the target language and practice to

become more fluent and proficient. In doing so, they seek assistance from diverse language learning programs that can be used on desktop computers, tablets, or smartphones and are always available to the user.

For this study, the authors have tested several popular language learning applications. HelloTalk [10] is a mobile application whose users learn foreign languages through a conversation with native speakers. The users can search for and chat with learning partners (autonomous learning), or join online group conversations moderated by teachers (collaborative learning). Duolingo [11] follows a more systemic and scaffolded approach in that it targets specific language skills (such as speaking, reading, listening, and writing skills) through a series of exercises. Rosetta Stone [12] is a universal platform for learning languages. To attract users, it implements different learning strategies. The strategies include topic-based learning (such as work, home, and similar), immersive experiences from rich multimedia content with high interactivity, skill-specific lessons (i.e., vocabulary, grammar, and others), or interactive storytelling on various topics. Memrise [13] facilitates language acquisition through learning by example (users can watch videos of native speakers conversing about the object they just saw or that came in their mind), learning by exploration (object identification in real-time so that a user can make a photo of an object and ask for a description in the chosen language from native speakers), spaced repetitions, or instant feedback on pronunciation. WordUp [14] is an application for learning English vocabulary. It aims to increase and maintain the user's vocabulary by prioritizing words based on their usefulness, putting words in familiar contexts, and repetition.

We explored English language learning opportunities. Given that the language of instruction could not be Serbian, we had to rely on our knowledge of either Russian, Croatian or Italian (as there is no English language instruction option for learning the English language). To gain a better understanding, especially when it comes to motivation to learn a foreign language, the authors of this paper, in addition to English, tested learning French and Italian at A1 level and Russian at B1 level.

All applications share some common features. Each application contains a brief grammar and/or vocabulary tutorial that serves as a preparation for or a reminder after the lesson has been delivered. The introductory test available in every application determines the user's language level, and following the results obtained, offer a course tailored to the learner's needs. However, it is unclear how the level of language proficiency is assessed,



since for the fluent speaker, the tasks come across as too easy, which in return may result in a quick loss of interest. We found that all the applications are largely intended for those whose level of knowledge corresponds to the basic or elementary level, and that for any advanced progress, relying on this kind of instruction is not sufficient. The tasks generally consist of translating from one language into another, listening and spelling out what is heard (clicking on the words offered), inserting verbs or nouns or articles into the appropriate form, and in the appropriate place with many repetitions. As the user progresses, the application adapts its content and functions to the users' language skills.

Maintaining continuity is certainly what every application insists on. In doing so, the applications employ the motivational elements of self-reflection (the users are continuously monitored and presented with their achievement), competition (comparison with peers), and digital nudging (regular reminders for the exercises). Except for WordUp, all applications support multiple languages. Most apps are free to some extent and charge their users for more advanced functions.

Gamified technologies

The term gamification is defined as using game elements in non-gaming contexts [15], such as learning foreign languages. These applications use elements of games to incentivize their users, where learning happens as a side effect of playing the game. The user incentives are internal and include fun, pleasure, satisfaction, challenge, achievement, reputation, and competition, among others [16], [17]. For example, Duolingo [11] employs aesthetical visual metaphors of hearts, badges, winning streaks, and leaderboards to motivate their users [18]. The Kahoot! [19] is an online educational platform used for gamified language learning [16]. The gamified components are multiple-choice and trivia quizzes that can be created and moderated by teachers. Ver-taal [20] follows a similar approach while using memory games and crosswords to facilitate learning foreign languages [16].

The study described in [17] provides a systematic review of digital games that follow a scaffolding approach to vocabulary acquisition of foreign languages. The games' genres vary and include storytelling games, problem-solving games, role-based games, virtual reality (VR) and body-motion games, adventure games, card games, and board games. While there is partial evidence of the games' positive effects on vocabulary acquisition, the issues of more sustained user engagement and a broader outreach remain. The issues are due to the inherent diversity of users' motivations to play games,

and the heterogeneity of user groups in terms of needs, preferences, and learning styles.

A similar analysis conducted in [16] shows that the digital game-based language learning induces positive emotions and attitudes of students. However, the games' positive effects are observed in a controlled environment (classroom). Furthermore, the games are biased towards the English language and mainly improve the vocabulary while having less influence on other language skills (such as reading, writing, speaking, and listening).

3. DIMENSIONS FOR ANALYSIS

We propose the dimensions to describe and compare existing chatbots for learning foreign languages (Table 1). The dimensions are extracted as themes from an emerging, inductive coding process on the existing solutions. The chatbots were obtained by an extensive search conducted by the authors from the available resources, including chatbots' websites (shown in Table 2), public collections and articles [21], [22], [23], [24], [25], and peer-review publications [4], [5], [6], [7], [8], [9], [26].

The dimensions are classified into *speaker* and *technology* aspects.

The *speaker aspects* include skill level, language diversity, domain, and interaction modality. The skill level tells whether the chatbot can adapt to the speaker concerning general language proficiency at a single or multiple levels of knowledge and skills. The language dimension indicates whether the chatbot supports learning one or more languages. The domain shows whether different thematic areas of knowledge are offered within a single language. The modality can be a text-based conversation (possibly including visual elements), speech-based conversation, or multimodal (combining the previous two).

Concerning the *technology*, the dimensions include dialog type, knowledge base, and availability. As for the dialog type, we adopted the existing taxonomy of chatbot dialog management systems as 1) predefined, based on the matching of a finite set of rules, and 2) statistical that generates responses dynamically from a larger dataset employing machine learning (ML) algorithms [27]. The knowledge base indicates the openness of the chatbot's data source of the linguistic concepts and terms for the language(s) it supports. Finally, the availability shows whether the chatbot is free to use or charges users for its services (fully or partially).



Aspect	Dimension	Value	Description
Speaker	Skill level (SL)	single	Single or not explicitly separated levels
		multiple	Multiple levels explicit for user
	Language (L)	single	Single target language
		multiple	Multiple target languages
	Domain (D)	single	Single knowledge domain
		multiple	Multiple knowledge domains
Modality (M)	text	Textual communication (with possible visuals)	
	voice	Speech communication	
	multimodal	Multimodal communication (e.g., text, voice, media)	
Technology	Dialog type (DT)	scripted	Predefined, rule-based dialog management
		statistical	Flexible, ML-based dialog management
	Knowledge base (KB)	open	Open, known language knowledge base
		closed	Closed, proprietary language knowledge base
	Availability (A)	open	Free service
	commercial	Paid service	

Table 1. ANALYTICAL DIMENSIONS

4. CHATBOTS FOR LEARNING LANGUAGES

The authors independently installed and probed the chatbots against the dimensions as of May 2020. The individual analyses were compared and reconciled in a series of discussions to reach an agreement on the chatbot's analytical evaluation shown in Table 2.

Looking at the table, we notice that the current chatbots mainly: offer multiple skill levels and languages to learn, combine knowledge from more domains, provide textual conversations, implement scripted user dialogs using proprietary linguistic knowledge bases, and charge their users.

Before we describe the examples, how they work, what functions they possess, their benefits and downsides, it's worth mentioning that even though the reference list of chatbots is longer, the number of real (proper) or active chatbots is much smaller. Namely, as seen in the table below, we have tested only 4 conversational agents that support real-time dialogue with users, providing immediate answers to prompts, and asking relevant follow-up questions. The curated chatbots [21], [22] including Edwin, Instant Translator, Translator ChatBot, Grammar Guru, CallMom, Tutor Mike, and Dave English Teacher were not available to test.

Mondly is a language learning application which is one of the few that, in addition to modern and interactive ways of learning languages through daily lessons that cover a plethora of topics (family, travel, restaurant to name a few) at the same time offers a voice-enabled chatbot. The application itself is partly free of charge, and in order to get access to all the chatbot's features - the user must subscribe to the content to unlock all the lessons. We only had a glimpse of the first lesson with instructions in the Croatian language - the lesson is called Hi, and the user is at liberty to go back to the same lesson over and over again. The communication starts with a greeting (e.g., "Good morning") and the user may select one of the three available prompts: "Hello/Good afternoon/Hi". Using Speech Recognition Technology (SRT), the user records his/her answer and begins a conversation with the chatbot. The conversation flows seemingly spontaneously, but when interrupting the series and asking a question (e.g., "How often do you play football?"), if the user is not quick enough to pose a question he/she will not get an answer. The reason being that the chatbot leaves insufficient amount of time to ask a question but rather moves on to the next one.

Chatbot	Speaker				Technology									
	SL	L	D	M	DT	KB	A							
	single	multiple	single	multiple	text	voice	multimodal	scripted	statistical	open	closed	open	commercial	
Mondly https://app.mondly.com/	-	+	-	+	-	+	+	+	+	-	-	+	-	+
Andy https://andy-chatbot.com/	-	+	-	+	-	+	-	-	+	-	-	+	-	+
Babbel https://it.babbel.com/	-	+	-	+	-	+	+	-	-	+	-	+	-	+
Lanny https://web.eggibun.net/	-	+	+	-	-	+	+	-	-	+	-	+	-	+

Table 2. ANALYTICAL EVALUATION OF THE CHATBOTS FOR LEARNING LANGUAGES.



The conversation neither comes across as very authentic (it is obvious that there is a script it follows very closely), nor does it evolve beyond the simple question answering sequence. If the user is an absolute beginner, or even starting over, Mondly is a great choice as it will teach a lot of useful vocabulary and phrases for a beginning language learner. It also works well with lower intermediate students. However, for a more fluent speaker, Mondly is not very challenging. Overall, it can help practice functional speaking skills, but other than that is fairly mundane and unimaginative. It also offers 33 different languages and targets different skills (speaking, listening, reading, writing). Among other qualities, we would single out personalization, leaderboards, and self-progress reports. The chatbot combines VR technologies as conversations with digital avatars (personas) in artificial environments (such as train, restaurant).

Andy is a phone application aimed at helping the user acquire new words/phrases and grammar by practical everyday conversation. The free trial period lasts for 7 days, and if the user wishes to keep practicing after it ends, it charges for more lectures. The Premium subscription gives access to additional learning functions such as grammar lessons and unlimited vocabulary practice for a price. The upside of the application is that the conversation, unlike with Mondly, appears to be spontaneous and extensive. The user almost does not have the impression of talking to a chatbot but rather conversing with a real person. It is quite engaging, and if the user wants to brush up his/her English and get the feel of talking to a real foreigner, Andy is a fairly good option. Speaking of the level, Andy offers greater diversity in that sense. Even though it does not provide a placement test, the impression is that the more fluent users are, the more dynamic and complex the conversational will become and vice versa. However, one of the major issues we had with the chatbot is that it had no voice-enabled function, which leaves the user no other option but to text. This is something that at times may appear as quite a wearisome activity that simply takes too long. Consequently, even despite the chatbot's attempts to keep the user engaged in the conversation, it is inevitable that even the most persevering users will ultimately yield. Another issue is that if the user does not subscribe to either its monthly or yearly package, the chatbot will ask to donate the money quite early on into the conversation, which does strike one as quite odd.

Babbel is a virtual assistant that speaks in 14 languages. The chatbot offers dynamic and flexible conversation threads. It supports scaffolded learning by moni-

toring the user's progress and providing level-based lessons. The lessons are contextual, bite-size lectures (10-15 minutes) covering different topics concerning everyday life situations. The assistant targets a variety of skills, including speaking, listening, reading, and writing. However, it is free only for the first month of use and charges its users after that.

Lanny is a live chat app created for people wishing to master the basics or advance their existing knowledge of Korean. One of the benefits of using this chatbot is that, in addition to conversing in Korean, the chatbot also uses English to answer and ask questions and clarify things. This makes Lanny ideal for people trying to grasp the basics of this language. Lanny is more than just a conversational partner, it is also a guide to Korean culture and its history. The application boasts the use of audio by native Korean speakers that will help learners with pronouncing, reading, speaking and writing Korean. The application is available for smartphone users and also has a Web version.

5. IMPLICATIONS FOR FUTURE WORK

Intelligent chatbots for learning languages are meant to work with professionals, not to replace them. The language experts have lots of knowledge and experience that the most sophisticated Artificial Intelligence (AI) algorithm today cannot match. In these applications and almost all AI applications, it is a major research challenge to study how humans and chatbots can work in synergy to improve the efficiency and effectiveness of technology-supported language learning.

We propose guidelines for future language-learning chatbot design and implementation that bring together language teaching experts, technology designers, and end-users. The reference architecture based on the guidelines identifies and connects critical components of such technology, their purpose and roles. This balanced design and development path can promote chatbots as successful language learning partners.

Implications for knowledge and education

We elaborate on three prospective directions as below.

A new methodology for a technology-supported language learning that builds on the paradigm of conversational agents. The methodology consists of theoretical, empirical, and technological components such as best practices, training materials, algorithms and programs. The methodology should focus on the following, crucial processes.



Chatbot's workflow design and implementation should develop techniques and algorithms for dialog management. The dialogue building approaches can be classified as using retrieval-based models (repository of predefined responses selected by rule-based expression matching) and generative models (creating responses using machine learning techniques and contextual information about the conversation) [27]. The former case may include the structured dialogues developed directly from the reference learning materials. In the latter case, the chatbot automatically learns through conversations [28]. At the moment, robust, but domain-specific dialog systems using handcrafted rules can be created accurately and straightforwardly using available tools such as Google DialogFlow [29] or ChatScript [30]. ML tools, such as Google TensorFlow [31], can improve the naturalness of such dialogs. However, the accuracy of the tools ultimately depends on the availability and quality of a language-specific training dataset (or model). The existing datasets are biased towards the English language, while other languages are underrepresented¹. It makes it more challenging to use ML algorithms to learn languages other than English. On the one hand, the creation of these datasets would require manual effort from proficient speakers. On the other hand, it would embrace the socio-cultural characteristics of the specific language speaking region, which is important when learning a foreign language.

Chatbot's user interface (UI) design and implementation should concentrate on its appearances and conversational styles (including gamification elements) to elicit positive attitudes (as the quantity of engagement) and outcomes (as the quality of engagement) [32]. For instance, simulating human languages with high message interactivity (conversational cues). It assumes engaging in back-and-forth message exchanges (mainly textual). Next, the use of human figures (visual cues) leads users to treat chatbots as human and act socially towards them. Finally, human-associated names or identity in the form of labeling a chatbot (identity cue) can be used since humans tend to perceive things by their labels. The form (usability) and function of an interactive product are equally important and cannot be separated. It is important to investigate how to combine the cues to influence user motivations and language proficiency. For example, how to combine them to compensate for the lack of face-to-face communication.

¹ There are 7,000 languages in use around the world - this is why they matter: <https://www.weforum.org/agenda/2020/02/how-some-endangered-languages-thrive> (Retrieved on 12.07.2020).

It is also relevant to examine the effectiveness of different input modes of the chatbot (speech and text). Implementing such methodology requires cross-cultural, longitudinal qualitative and quantitative studies with end-users. The studies should combine different instruments such as subjective, self-report ratings containing measures such as usefulness, usability, and emotions, and objective metrics such as the level of acquired skills in a foreign language, the amount of conversations, number of errors related to use, and dialogue time. These are all essential predictors of users' technology acceptance and adoption [33].

Technology for personalized language learning. A chatbot which keeps track of the users' past questions and level of language use, could, over a series of interactions, become familiar to users. The chatbot could reuse past language that has been successfully responded to, thereby enhancing users' self-perceived ability as support for interest development. Finally, it could remind the user of the necessity of practice and trying out new words or phrases. We envision defining particular scenarios that match specific language learning tasks and domains using co-design techniques [34].

A novel, online conversational service for learning languages at scale (L@S) by creating individual learning experiences, increasing learning outcomes, and supporting lecturers. This approach is especially useful for large-scale lecturers and massive online courses with more than a hundred students per lecture where individual support is not possible due to financial and organizational restrictions. The proposed methodology can deliver a blueprint of the technical infrastructure for developing and deploying such a service.

Implications for people and society

We describe how chatbots can support people in their everyday activities and transform our society.

Chatbots present an **affordable and ubiquitous source of language interaction** for many students learning English as a Foreign Language. It is, therefore, essential to understand how they can be put to use best, both inside and outside formal education. As a source of conversation practice and ubiquitous technology, they enable extra practice during independent study anywhere and anytime, inside and outside formal education.

The chatbot can offer some **language learning mechanisms** that many human language learning partners could not and/or would not. In particular, a broader range of expressions/questions and vocabulary, the scaffolded introduction of new vocabulary, grammar, and



expressions, or consistent understandable repetition which a human partner is unlikely to present (except language experts). It can also alleviate the issue of availability of native speakers or expert-speaking users, or even difficulty in finding a skilled and available speaking partner online.

An inclusive design and development strategy for language learning chatbot. The strategy is not about replacing lecturers with chatbots but creating a co-dependent and intelligent relationship between teacher and chatbot, utilizing their strengths and delivering the best student experience. The strategy should aim to improve chatbots' usability by following the principles of conversational UX design [3].

6. THE REFERENCE ARCHITECTURE

Based on the implications, we propose a blueprint of the technological architecture for designing and developing chatbots for learning languages (Figure 1).

The architecture aims to address the issues mentioned above by technology design. The *knowledge layer* contains linguistic concepts and terms necessary for the language content generation. Preferably in different languages, but at least two - a learner's native language and a second language. The existing knowledge sources can be exploited [35]. User-related information includes personal information, learning-related information, and dialog-related information. At the *language layer*, the information for learning languages concerning different language domain(s) and purpose(s) is created from the layer below. The layer's content serves as a basis for generating and maintaining conversations with the users through either interactive lecturing or examinations. The *dialog layer* creates and manages conversation threads. In particular, it accepts and interprets user input, makes the response contents with the specific semantics and syntax in one or several languages (dialog management), and creates the output as a natural language. The *UI layer* implements the agent's conversational appearance towards end-users as either text/visual, voice, or combination.

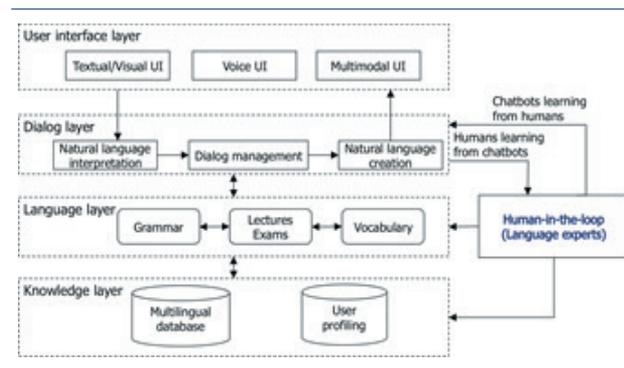


Fig. 1. The reference architecture for conversational agents for learning foreign languages.

Since automatically generated conversations still cannot match the ones created by people, human intervention is necessary. In this mutual relation, humans can learn from chatbots. For example, the new meaning of existing words or new words with new meanings (i.e., casual speech input by users from specific speaking regions or specific dialects). Vice-versa, chatbots can learn from humans through expert supervision. Such supervision may include the manual interventions in the automated natural language interpretation of the learners' input, creation of the responses, and natural language generation. This way, the chatbots can not only improve on their functions but capture the evolution of languages.

7. LIMITATIONS

Our goal was to conduct the survey with the analytical (heuristic) evaluation of the chatbots to identify critical aspects, understand their effects, and provide design implications for their improvements. This paper does not provide an exhaustive list of the chatbots for learning foreign languages. Instead, it extracts common examples that describe the current language chatbots' landscape. Besides, we did not assess the effectiveness of the chatbots on learning languages. These are the elements to be covered in future work.

8. CONCLUSION

This paper provides a critical reflection on the current state of the chatbots for learning languages and indicates some important directions for their future. A scarce, resulting sample of the available chatbots (N=4) reveals a complex picture of factors influencing the feasibility of the chatbots for learning languages.



Our analysis *informs* end-users of the available chatbot technologies, *communicates* their possibilities to language experts, and guides engineers for development. Will the future chatbots for learning languages be fully autonomous, or will the teachers remain as the humans who find out how to augment their practices using the chatbots? For the present, we opt for the latter - at least until AI makes significant advances in natural text and voice recognition, understanding, and generation to equip chatbots with greater effectiveness and autonomy.

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REFERENCES

- [1] Amazon Alexa voice assistant: <https://developer.amazon.com/en-US/alexa> (Retrieved on 26.08.2020).
- [2] Google Assistant services: <https://assistant.google.com/> (Retrieved on 26.08.2020).
- [3] R. J. Moore and R. Arrar, *Conversational UX Design: A Practitioner's Guide to the Natural Conversation Framework*, Morgan & Claypool, 2019.
- [4] S. Höhn, *Artificial Companion for Second Language Conversation*. Springer International Publishing, 2019.
- [5] L. K. Fryer et al. "Stimulating and sustaining interest in a language course: An experimental comparison of Chatbot and Human task partners," *Computers in Human Behavior*, 75, 2017, pp. 461-468.
- [6] L. K. Fryer, K. Nakao and A. Thompson, "Chatbot learning partners: Connecting learning experiences, interest and competence," *Computers in Human Behavior*, 93, 2019, pp. 279-289.
- [7] I. Hwang, Y. Lee, C. Yoo, C. Min, D. Yim, and J. Kim, "Towards Interpersonal Assistants: Next-Generation Conversational Agents," *IEEE Pervasive Computing*, vol. 18, no. 2, 2019, pp. 21-31.
- [8] S. Ruan et al. "BookBuddy: Turning Digital Materials Into Interactive Foreign Language Lessons Through a Voice Chatbot," In *Proceedings of the 6th ACM Conference on Learning @ Scale*, 2019, p. 30.
- [9] R. Winkler and M. Söllner, "Unleashing the potential of chatbots in education: A state-of-the-art analysis," 2018.
- [10] HelloTalk mobile application for learning foreign languages with native speakers: <https://www.hello-talk.com> (Retrieved on 25.08.2020).
- [11] Duolingo web and mobile platform for learning foreign languages: <https://www.duolingo.com/learn> (Retrieved on 25.08.2020).
- [12] Rosetta Stone web and mobile platform for learning foreign languages: <https://www.rosettastone.com/> (Retrieved on 25.08.2020).
- [13] Memrise web and mobile application for learning foreign languages from native speakers: <https://www.memrise.com/> (Retrieved on 25.08.2020).
- [14] WordUp mobile application for improving English vocabulary: <https://www.wordupapp.co/> (Retrieved on 25.08.2020).
- [15] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: defining "gamification"," In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 2011, pp. 9-15.
- [16] H. T. Hung, J. C. Yang, G. J. Hwang, H. C. Chu, and C. C. Wang, "A scoping review of research on digital game-based language learning," *Computers & Education*, 126, 2018, pp. 89-104.
- [17] D. Zou, Y. Huang, and H. Xie, "Digital game-based vocabulary learning: where are we and where are we going?," *Computer Assisted Language Learning*, 2019, pp. 1-27.
- [18] Duolingo - Translating User Research into Improved Design: <https://uxplanet.org/duolingo-e3e-47d2b41ba> (Retrieved on 23.08.2020).
- [19] Kahoot! web educational platform: <https://kahoot.com/>, Kahoot! gameplay access: <https://kahoot.it> (Retrieved on 25.08.2020).
- [20] Ver-taal language exercises for foreigners: www.ver-taal.com (Retrieved on 25.08.2020).
- [21] Botlist collection of chatbots for learning languages: <https://botlist.co/collections/@Taell/express-yourself> (Retrieved on 23.08.2020).
- [22] Chatbots for learning: https://chatbots.org/industry/learn_lookup/ (Retrieved on 23.08.2020).
- [23] 7 of the Best Language-Learning Chatbot Apps: <https://blog.vsoftconsulting.com/blog/7-of-the-best-language-learning-chatbot-apps> (Retrieved on 23.08.2020).
- [24] 5 Resources for Chatbots to Be Your Language Learning BFFs: <https://www.fluentu.com/blog/language-learning-chatbot/> (Retrieved on 23.08.2020).
- [25] 7 Powerful Chatbot Apps for Learning Languages: <https://www.tristatetechnology.com/blog/best-language-learning-chatbot-apps/> (Retrieved on 23.08.2020).
- [26] X. L. Pham, T. Pham, Q. M. Nguyen, T. H. Nguyen, and T. T. H. Cao, "Chatbot as an Intelligent Personal Assistant for Mobile Language Learning," In *Proceedings of the 2018 2nd International Conference on Education and E-Learning*, pp. 16-21.



- [27] J. G. Harms, P. Kucherbaev, A. Bozzon, and G. J. Houben, "Approaches for Dialog Management in Conversational Agents," *IEEE Internet Computing*, vol 23, no. 2, 2019, pp. 13-22.
- [28] A Trainable Spaced Repetition Model for Language Learning: <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/N8XJME> (Retrieved on 27.08.2020).
- [29] Google DialogFlow platform for chatbot development: <https://dialogflow.com/> (Retrieved on 27.08.2020).
- [30] ChatScript - an open source authoring tool for building textual chatbots: <https://en.wikipedia.org/wiki/ChatScript> (Retrieved on 15.08.2020).
- [31] Google TensorFlow Machine Learning platforms: <https://www.tensorflow.org/> (Retrieved on 27.08.2020).
- [32] E. Go and S. S. Sundar, "Humanizing chatbots: The effects of visual, identity and conversational cues on humanness perceptions," *Computers in Human Behavior*, 97, 2019, pp. 304-316.
- [33] D. Gursoy, et al. "Consumers acceptance of artificially intelligent (AI) device use in service delivery," *International Journal of Information Management*, 49, 2019, pp. 157-169.
- [34] M. Steen, "Co-design as a process of joint inquiry and imagination," *Design Issues*, 29(2), 2013, pp. 16-28, MIT Press.
- [35] Wordnet - the largest lexical database of English: <https://wordnet.princeton.edu/> (Retrieved on 27.08.2020).



EXPLAINABLE MACHINE LEARNING PREDICTION OF PCB-138 BEHAVIOR PATTERNS IN EDIBLE FISH FROM CROATIAN ADRIATIC

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Abstract:

Fish consumption, especially consumption of oily marine species, is globally increasing since it has been recommended by dieticians due to high content of polyunsaturated ω -3 and ω -6 (PUFAs) fatty acids in fish tissue. Health benefits of PUFA ingestion coincide with the risk of intake of hazardous lipophilic persistent pollutants including organochlorine pesticides (OCPs) and related polychlorinated biphenyls (PCBs). We examined the impacts of 18 fatty acids (FAs) and 36 toxic organic and inorganic contaminants on the behavior patterns of indicator congener PCB-138 in marine fish using eXtreme Gradient Boosting (XGBoost), SHapley Additive exPlanations (SHAP), and SHAP value fuzzy clustering. XGBoost indicated non-linear relationships between investigated variables that surpasses indications suggested by commonly applied correlation matrices. Ten extracted fuzzy clusters of SHAP values revealed that higher intake of saturated myristic-C14:0 and margaric-C17:0 acids followed by intake of nutritionally beneficial eicosadienoic acid (C20:2n-6) mostly contributed to the PCB-138 bioaccumulation. Important impacts on PCB-138 behavior patterns were also registered for chemically allied indicator congeners (-153 and -180) and organochlorines' metabolite *p,p'*-DDE. Less prominent were the associations between target congener and the most toxic dioxin-like PCBs.

Keywords:

persistent organic pollutants (POPs), (ω -3-6) fatty acids, heavy metals, Shapley Additive exPlanations (SHAP), fuzzy methods.

1. INTRODUCTION

Anthropogenic activities have led to several global, regional and local environmental issues related to air, water and soil pollution, gradual decrease of the stratospheric ozone layer, decrease in biodiversity, etc. Organic and inorganic contaminant emissions and dispersion caused by human activities refer to different classes of polychlorinated biphenyls (PCBs), polycyclic aromatic pollutants, trace metals and natural radioactivity. Organochlorine pesticides (OCPs) and PCBs are well-known as persistent organic pollutants (POPs). They are long-lived contaminants and possess numerous adverse effects on living organisms including humans and animals. Because of that their production and use is limited

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or forbidden in most countries. POPs bind tightly to particles in soil and sediment, which can act as a secondary sources of contamination for environmental media (water, air and living organisms).

At a global level, the oceans are the final sink/destination of POPs. The oceans act as a secondary source of contamination because POPs are slowly degraded and bioaccumulated in marine organisms, which are at the bottom of the food chain and represent a source of chemical hazards in human nutrition. The assessment of environmental exposure to marine toxins is based on POPs concentration data in the samples of water, plants and food. Small pelagic oily fish are highly recommended nutrient source worldwide due to their content of protein, minerals and healthy fats including omega-3 (ω -3) and 6 ω -6 polyunsaturated fatty acids (PUFAs) [1]. Benefits of the fatty acid consumption are associated with normal growth and development, the prevention of cardiovascular and inflammatory diseases, as well as cognitive decline and dementia. However, these FAs represent a very suitable matrix for bioaccumulation of highly lipophilic xenobiotics such as POPs. Although FAs profile and organochlorines content have been evaluated in numerous marine fish species worldwide, there are few data on their interrelations.

In this study, the presence of OCPs and PCBs has been investigated in small pelagic edible fish species: sardine *Sardina pilchardus* (Walbaum, 1792), anchovy *Engraulis encrasicolus* (Linnaeus, 1758), round sardinella *Sardinella aurita* (Valenciennes, 1847), chub mackerel *Scomber japonicus* (Houttuyn, 1782) and horse mackerel *Trachurus trachurus* (Linnaeus, 1758). We applied extreme Gradient Boosting (XGBoost), SHapley Additive exPlanations (SHAP), and SHAP value fuzzy clustering aiming to obtain a detailed insight into the distribution of indicator congener PCB-138 in the fish species. The impacts of the following factors including the level of OCPs, PCBs, saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), PUFAs and heavy metals were evaluated by SHAP since the method offers uniquely consistent and locally accurate solutions that have been confirmed in the previous investigations of environmental phenomena [2].

2. MATERIAL AND METHODS

Sampling

Fish samples were collected along the eastern Croatian Adriatic Sea during 2014 and 2016. Details about sampling were previously described [3]. Total of 107 fish samples were collected in various fisheries coastal (A, E, and F) and off-coast (B and C) zones. Approximately 50 specimens was sampled randomly using purse seine catches (mesh size: 8 mm/bar length) totaling 107 pooled samples from a fillet of specimen.

Chemical analyses

POPs

Chemical analysis of POPs was previously described elsewhere [3]. In brief, seven OCPs (HCB α -, β -, and γ -HCH, *p,p'*-DDT, *p,p'*-DDE, and *p,p'*-DDD), six indicator PCB congeners (PCB-28, PCB-52, PCB-101, PCB-138, PCB-153, and PCB-180), eight mono ortho congeners (PCB-105, PCB-114, PCB-118, PCB-123, PCB-156, PCB-157, PCB-167, PCB-189) and () PCB-60, PCB-74 and PCB-170] were analysed. High-resolution gas chromatography with electron capture detector (s) was applied for the compound identification and details are described previously [3].

The recoveries for the PCBs was in the range between 75% to 89% while relative standard deviation (RSD) between 1% to 11% was obtained. The recoveries for OCPs were in the range from 76% to 86%, with RSD from 1% to 11%. for both PCBs and OCPs, the determination limits were 0.01 ng g⁻¹ of fresh weight.

Elements

Sixteen macro- and micro-elements including toxic metals (Na, Mg, K, Ca, As, Cd, Co, Cr, Cu, Mn, Fe, Hg, Ni, Zn, Pb and Se) were analyzed. Homogenized fish samples (0.5 g) were basted by 5 mL of nitric acid (67% TraceMetal grade, Fisher Scientific, Bishop, UK) and 1.5 mL of hydrogen peroxide (30% analytical grade, Sigma-Aldrich, St. Louis, MA, USA). Afterwards, microwave digestion was performed as previously described [4]. Analysis of the elements was performed by inductively coupled plasma mass spectrometry (ICP-MS), (iCap Q mass spectrometer, Thermo Scientific, Bremen, Germany). The most abundant isotopes were used for quantification.

For five-point calibration, solutions of Fe, Zn, Cu, Mn, Se, Cr, Co, Ni, Na, K, Mg and Ca were prepared in the concentration range of 0.2–2.0 mg L⁻¹. The concentration of calibration-solution for Cd, Hg and As was in the range of between 0.2 and 2.0 μ g L⁻¹ and for Pb in the range between 2.0 and 20.0 μ g L⁻¹.



To check for the accuracy of the analysis, the certified reference material NIST SRM 1577c (bovine liver, Gaithersburg, MD, USA) was analyzed in the same manner as the fish samples. For all elements, the obtained results were within the satisfactory range of the certified values

Fatty acids

The concentrations of 6 SFAs (myristic, pentadecylic, palmitic, palmitoleic, margaric, and stearic acid), 3 MUFAs (oleic, paullinic and arachidonic acid) and 9 PUFAs, ω -6 and ω -3 families (linoleic, α -linolenic, icosadienoic, dihomo- γ -linolenic, eicosatrienoic, arachidonic, eicosapentaenoic, docosapentaenoic and docosahexaenoic) were determined according to procedure given in detail previously [5]. Prior analysis, the samples were partially thawed at +4 °C. Accelerated solvent extraction (ASE 200, Dionex, Sunnyvale, CA) using a mixture of n-hexane and iso-propanol (60:40 v/v) were applied for determination of total lipids for fatty acid content. The samples were analysed as FAME (fatty acid methyl esters) by gas-liquid chromatography (Shimadzu, Japan). Flame ionisation detector (GC/FID) and fused silica cyanopropyl HP-88 column were used. The chromatographic peaks were identified and quantified using Supelco 37 Component mix standard and internal standard (heneicosanoic acid methyl ester), respectively.

Data analysis

The relationships between PCB-138 and all other measured parameters were modeled by the XGBoost regression. The details on the method are given elsewhere [6]. In this study, we used Python XGBoost implementation. 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.

The explainability of the produced XGBoost model that operates with high-dimensional input data in a non-linear fashion was obtained by using explainable artificial intelligence method SHapley Additive exPlanations (SHAP) [7]. Based on the game theory, the Shapley explanations represent the only possible locally accurate and globally consistent feature attribution values. In this study, we applied the fuzzy clustering of absolute SHAP attributions to identify and characterize the relations among the measured parameters responsible for PCB-138 behavior.

2. RESULTS AND DISCUSSION

Pollutant toxicological profile

Small edible pelagic fishes live short at the bottom of the marine food chain (plankton < sardine species, anchovy < mackerel species), which are expected to bioaccumulate low levels of environmental contaminants. The transfer of accumulated hazards to the human body via fish intake is generally considered to be low. As shown by study results, inorganic compounds, macro-elements and toxic heavy metals, were prominently more abundant in the fish tissue than organic xenobiotics, OCPs and PCBs.

Biological effects of inorganic elements depend on the processes including absorption, accumulation, elimination and biotransformation into less or more toxic metabolites. Several minutes from absorption in the gut, the elements reach internal organs such as heart, liver, kidney and brain, while their penetration to muscles and adipose tissue occurs more slowly, up to several hours [8]. However, when they are present in low concentrations in the aquatic surrounding, their accumulation is less frequent as well. In the studied fish species, the concentrations of macro- (K > Na > Ca > Mg) and micro-elements (Fe > Zn > Cu) were within the normal physiological range, below the levels that could potentially cause pathological changes in tissues and organs, because of the absence of dominant well-known sources of pollution. In addition, the levels of the following elements: Hg, Pb and Cd, were lower than the maximum thresholds prescribed by the existing EU regulation [9].

Among POPs, *p,p'*-DDE, PCB-153, PCB-138 and PCB-180 were the most dominant. Although it is to be expected that larger, long-lived species, such as chub mackerel and horse mackerel, that are at higher trophic level, will uptake more organic contaminants than sardine species and/or anchovy, the values of the toxicological parameters such as the total quantity of indicator PCBs and WHO-dioxin-like PCBs toxic equivalents were below threshold concentrations of 75 ng g⁻¹ w.w. and 6.5 pg g⁻¹ [10]. As can be concluded, the examined fish species appeared to be safe for human diet with regards to the presence of toxic chemicals.

PCB-138 patterns

As represented by Pearson's correlation analysis, significant linear correlation coefficients ($r > 0.90$) were found between the following pairs of the investigated variables: *p,p'*-DDE-PCB-118; *p,p'*-DDE-PCB-138; *p,p'*-DDD-PCB-105; *p,p'*-DDD-PCB-180; PCB-138-



PCB-118; PCB-138-PCB-153; PCB-153-PCB-118; PCB-153-PCB-170 and PCB-156-PCB-180. The correlations between the POPs pairs: γ -HCH-PCB-170; γ -HCH-PCB-156; γ -HCH-PCB-118; γ -HCH-PCB-114; γ -HCH-PCB-180; p,p' -DDE-PCB-153; p,p' -DDT-PCB-170; p,p' -DDT-PCB-156; p,p' -DDT-PCB-118; p,p' -DDT-PCB-153; PCB-138-PCB-170; PCB-180-PCB-170; PCB-180-PCB-156; PCB-105-PCB-180; PCB-105-PCB-156 and PCB-105-PCB-170 were in the range from 0.80 to 0.90. As can be seen, the listed species with similar chemical structure and common origin display similar behavior patterns, as discussed below. We assumed that other methods apart from commonly applied correlation matrices could be further employed to describe the associations between POPs and FAs or inorganic contaminants in more details.

In this study, XGBoost has been successfully employed for the investigation of non-linear relationships between PCB-138 levels and key variables that shape its' behavior pattern in marine fish tissue. The predicted/observed calculated relative error was 11.2%, while the r^2 were 0.99 (Fig. 1).

Fuzzy clustering of SHAP values extracted ten groups (relative error < 10%) of similar variables that shape the dynamics of PCB-138 (Fig. 2. As labelled by red color, the constituents of six clusters, C2 and C6-C10, strongly positively impacted PCB-138 concentrations higher than 0.5 ng g⁻¹ and up to 1.5 ng g⁻¹. Dominant influences are attributed to the higher levels of myristic acid

(> 7%) and the following compounds: p,p' -DDE, PCB-101, PCB-118, PCB-123, PCB-153, and PCB-180, as well as to lower margoric content (\approx 1%). Although indicator congeners (-28, -52, -101, -138, -153, and -180), which are often classified as non-dioxin-like PCBs, dominated over dioxin-like PCBs, both classes were of significance when evaluating PCB-138 patterns. The relationships between PCB congeners and their presence at higher concentration levels are due to their structure referring to molecule rigidity and the number of attached halogen atoms, and consequently, perseverance and prolonged half-lives in marine environment.

Out of 18 investigated FAs, saturated myristic (C14:0) and margoric (C17:0) acid mostly contributed to the PCB-138 bioaccumulation followed by nutritionally beneficial eicosadienoic (C20:2n-6) and dihomo- γ -linolenic acid (C20:2n-3).

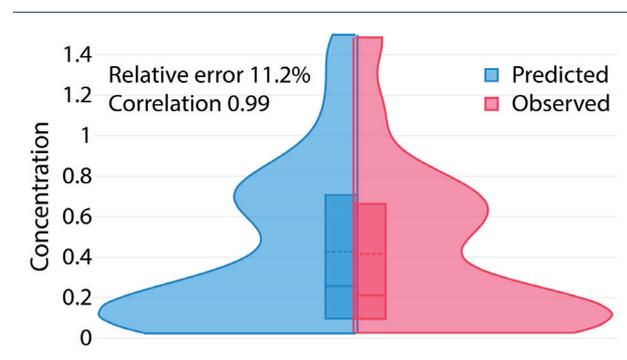


Fig. 1. XGBoost evaluation statistics.

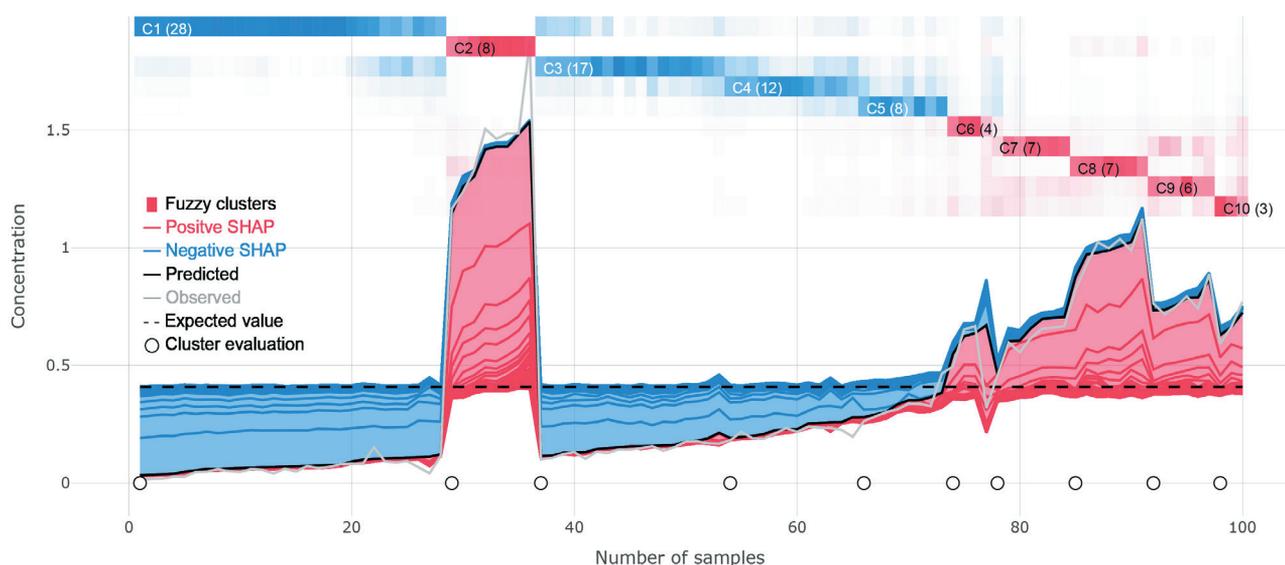


Fig. 2. PCB-138 SHAP force plot.



We have noted that these fatty acids were not the most abundant in the studied fish species, while the dominance of other FAs was recorded in the following order: palmitic > oleic > docosahexaenoic > stearic > myristic > eicosapentaenoic > palmitoleic > linoleic acid. Saturated acids such as C14:0 and C17:0 dominantly occurred as esterified polar phospholipids and therefore, SFAs and associated contaminants are more bioavailable than FAs presented in non-esterified free form. Eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3), are widely known as the most nutritionally relevant ω -3 PUFAs in oily blue fish, such as mackerel, sardines and anchovies. However, they appear to have no impact on the PCB-138 accumulation. Chub mackerel has been known to contain high percentage of the PUFAs in the form of free FAs, which are less efficiently absorbed than other lipid classes and easily eliminated from human intestines where they are dispersed into mixed micelles and bound to soluble lipid-binding proteins [11]. In addition, PUFAs are more susceptible to oxidative degradation when found as free FAs.

Four clusters (C1 and C3–C5, $\approx 70\%$) dominantly showed negative correlations with PCB-138 concentrations below 0.5 ng g^{-1} . The same parameters as discussed above shaped the clusters and negative relationships imply that low concentrations of SFAs do not add to PCB-138 uptake, or uptake of POPs from different sources, that are found to have variable impact, depending on the sampling time, seasonal and other fishery zone-related factors.

The plot in Fig. 3. shows the impact which each cluster has on output of the model. High levels of the cluster (C2, C6–C10) constituents, primarily PCB-153, *p,p'*-DDE, PCB-118, PCB-170, PCB-180 and myristic acid, has a high and positive impact on the PCB-138 patterns, as shown by right-oriented long distribution tail. Lower concentrations of these variables ($< 0.1 \text{ ng g}^{-1}$) are negatively correlated with the target variable, as indicated by negative relative SHAP value.

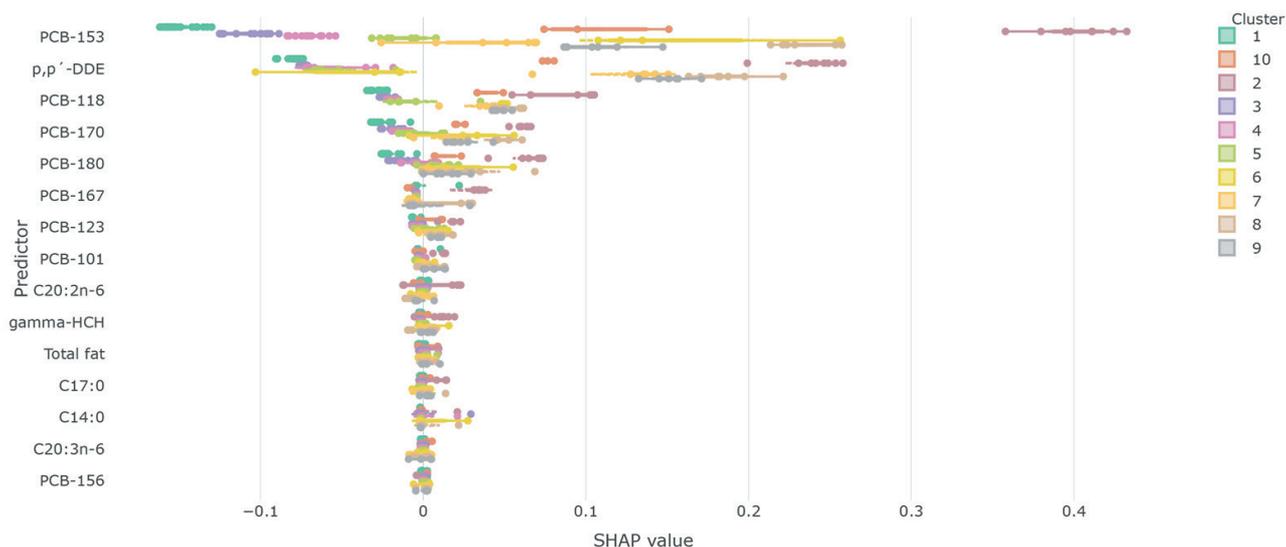


Fig. 3. PCB-138 SHAP value cluster evaluation.

4. CONCLUSION

Small edible fish species could be considered as both nutritionally valuable food source and sources of hazardous organochlorine pollutants, which negatively affect human health. Significant indications on relationships between POPs uptake and fatty acid in fish tissue has been reported worldwide. In this study, we presented a promising methodology, an explainable artificial

intelligence methods (XGBoost and SHAP), which was used with the aim of gaining better understanding of specific interrelations between fatty acid content and contaminants in consumable marine fish species. Out of 18 fatty acids, two saturated (myristic and margaric) and two ω -3 and 6 (eicosadienoic and dihomogamma-linolenic) acids were identified as crucial for the bioaccumulation of PCB-138 in sardine, anchovy and mackerel species. However, nutritionally beneficial EPA and DHA are



assumed to have no impacts on the contaminant uptake. The content of macro-elements and heavy metals is not related to PCB-138 chemodynamics in fish tissue, while influences of *p,p'*-DDE and both indicator and toxicologically congeners (-101, -118, -123, -153, and -180) were evident. Finally, methods have been successfully verified as a reliable means for examination of the relationships between POPs and FAs that overpowers commonly employed statistical approaches.

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REFERENCES

- [1] Food and Agriculture Organization of the United Nations (FAO), "The state of world fisheries and aquaculture worldwide 2018 - Meeting the sustainable development goals" 2018, pp. 1-227, ISBN 978-92-5-130562-1.
- [2] A. Stojić, N. Stanić, G. Vuković, S. Stanišić, M. Perišić, A. Šoštarić, and L. Lazić, "Explainable extreme gradient boosting tree-based prediction of toluene, ethylbenzene and xylene wet deposition." *Sci. Total Environ.*, 2019, pp. 140-147.
- [3] G. Vuković, S. Herceg Romanić, Ž. Babić, B. Mustać, M. Štrbac, I. Deljanin, D. Antanasijević, "Persistent organic pollutants (POPs) in edible fish species from different fishing zones of Croatian Adriatic." *Marine Pollut. Bull.* 2018, pp. 71-80.
- [4] J.M. Đinović-Stojanović, D.M. Nikolić, D.V. Vranić, J.A. Babić, M.P. Milijašević, L. Pezo, S. Janković "Zinc and magnesium in different types of meat and meat products from the Serbian market." *J. Food Compos. Anal.*, 2017, pp. 50-54.
- [5] A. Špirić, D. Trbović, D. Vranić, J. Đinović, R. Petronijević, V. Matekalo-Sverak, "Statistical evaluation of fatty acid profile and cholesterol content in fish (common carp) lipids obtained by different sample preparation procedures." *Anal. Chim. Acta*, 2010, pp. 66-71.
- [6] T. Chen, C. Guestrin, "Xgboost: A scalable tree boosting system", In *Proceedings of the 22nd acm sigkdd international conference on knowledge discovery and data mining*. 2016, pp. 785-794.
- [7] S. Lundberg, S. Lee, "A unified approach to interpreting model predictions". In *Adv. Neural Inf. Process. Syst.* 2017, pp. 4765-4774.
- [8] E. Brucka-Jastrzębska, D. Kawczuga, M. Rajkowska, M. Protasowick, "Levels of microelements (Cu, Zn, Fe) and macroelements (Mg, Ca) in freshwater fish." *J. Elementol.*, 2009, pp. 437-447.
- [9] European Commission, 2006. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs 20.12.2006 Off. J. Eur. Union, pp. L 364, 5-24.
- [10] European Commission, 2011. Commission Regulation (EU) No 1259/2011 of 2 December 2011 amending Regulation (EC) No 1881/2006 as regards maximum levels for dioxins, dioxin-like PCBs and non-dioxin-like PCBs in foodstuffs. Off. J. Eur. Union, pp. L 320, 18-23.
- [11] M. Á. Rincón-Cervera, V. González-Barriga, R. Valenzuela, S. López-Arana, J. Romero, A. Valenzuela, "Profile and distribution of fatty acids in edible parts of commonly consumed marine fishes in Chile." *Food Chem*, 2019, pp. 123-129.



MULTIFRACTAL CHARACTERISTICS OF CRITERIA AIR POLLUTANT TIME SERIES IN URBAN AREAS

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Abstract:

The complexity of spatial-temporal air pollutant concentration dynamics requires innovative modeling investigation approaches. The details of non-linear nature of pollutant behavior cannot be revealed by conventional approaches, but fractal and Hurst rescaled analyses allow the quantification of pollutant dynamics structure via self-similarity and scale invariance. In this study, we applied multiscale multifractal analysis (MMA) to investigate the complex time-series of criteria air pollutants (PM_{10} , $PM_{2.5}$, NO_x , SO_2 , CO and O_3). The results showed that PM_{10} and $PM_{2.5}$ concentrations are more stable compared to gaseous oxides and exhibit less prominent multifractality. Out of gaseous contaminants, CO is confirmed to be less chemically reactive than NO, NO_2 , NO_x , SO_2 and O_3 under the same atmospheric conditions in urban and semi-urban area. As concluded, the multifractal analysis presented herein can enhance our understanding of specific pollutant dynamic features and support relevant sectors to control the pollutant release and distribution.

Keywords:

multiscale multifractal analysis (MMA), suspended particle matter (PM), criteria air pollutants, air pollution, urban environment.

1. INTRODUCTION

Air pollution poses a major threat to health and climate, and it has been estimated to become the leading cause of mortality worldwide by 2050 [1]. Seven million premature deaths every year occur as a result of stroke, cardiovascular and respiratory diseases, all of which can be related to detrimental effects of high air pollutant concentration exposure [2]. Although the contaminant emissions have been reduced, about 30% of citizens in European urban areas are still exposed to air pollutant levels that exceed EU air quality guidelines defined with the aim of health protection [3]. Therefore, the research of air pollutant spatial-temporal behavior in urban areas appears to be one with highest potential to contribute to society.

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In the atmosphere, air pollutant lifetimes are in a range from hours to years, depending on air mass transport processes, undergoing transformations via chemical reactions and/or particle deposition. Although usually assumed to appear by a chance as a linear or a single-compartment processes, variations of air pollutant levels over time are neither simple nor random in their behavior. The factors like mutual pollutant interactions, meteorological parameters, and the emission source type and intensity, affect the air quality significantly and make the air pollutant temporal dynamics complex and difficult to analyze and understand.

The most striking feature of the pollutant concentration time-series refers to their long-term memory, which reflects how the pollutant past behavior patterns affects its future levels [4]. Self-similarity and scale-invariance are considered to be the memory characteristics of decisive importance concerning the pollutant time-series and therefore, vital for the estimation of long-range correlations and precise forecasting [5]. These structural properties can be captured by fractal and Hurst rescaled analyses that define fractals as self-similar shapes of the "structure holding the key to the whole structure" [6, 7, 8]. The multifractal approach has been applied for estimation of constitutional features and forecasting of air pollutant time-series [9, 10, 11, 12, 13].

In this study, we focus on the investigation of time-series of criteria air pollutants (PM_{10} , $PM_{2.5}$, NO_x , SO_2 , CO and O_3) across Belgrade with the aim to obtain more comprehensive understanding of the investigated species behavior and fate. Unlike the previous findings related to the Balkans, that were limited in terms of the result interpretations and sampling time, the findings presented herein are based on a long-term data and advanced investigation methods that enable pollutant temporal dynamics to be explored more profoundly.

MATERIALS AND METHODS

The data used for the analyses were obtained from the regular monitoring network of Institute of Public Health Belgrade and multi-year measurement campaign conducted from 2011 to 2016 at 9 sites covering 17 municipalities located in Belgrade (Serbia) urban, semi-urban and rural areas. The dataset comprised the concentrations of inorganic gaseous pollutants (CO , SO_2 , NO , NO_2 , NO_x and tropospheric O_3) and particulate matter (PM_{10} and $PM_{2.5}$) registered at the following locations: four of urban-traffic type (Institute of Public Health – IPB, New Belgrade – NBG, Zemun – ZEM and Slavija – SLA),

two of urban-industry type (Obrenovac – OBR and Lazarevac – LAZ), one suburban location (Ovča – OVC), and two locations classified as rural-industry sites (Grabovac – GRA and Veliki Crljeni – VC).

We applied multiscale multifractal analysis (MMA) [13] to investigate fractal characteristics of complex PM_{10} , $PM_{2.5}$, NO_x , SO_2 , CO and O_3 time series. MMA is a generalization of the standard MF-DFA, which adds the dependence on scale, providing a broader analysis of the fluctuation properties, as well as more general and stable results [14].

The aim of this study was to investigate the pollutant time-series, as described below. We delineated the strength of multifractality by the multifractal singularity, Q . The bigger the Q is, the more pollutant concentration time-series is influenced by Q interval fluctuations in negative or positive direction, while the absence of fluctuations results in Q equals to 0 and represents a mono-fractal behavior [10]. In addition, the span of multifractal singularity ($\Delta\alpha = \alpha_{\max} - \alpha_{\min}$) is an alternative way to study the strength of multifractality; the bigger $\Delta\alpha$ is, the stronger the multifractality degree is [5].

Besides, we considered Hurst exponent (H) which indicates the persistence level of the pollutant concentration time series denoted by the following values [5, 15, 16]:

- $H \geq 1.5$ represents brown noise uncorrelated processes with infinite memory;
- $H = 1$ refers to pink noise, i.e. the most prominent, stable and adaptable fractal phenomena with long-term memory;
- $0.5 < H < 1.5$ describe random walk processes with long-range correlated and persistent structure;
- $H = 0.5$ refers to white noise involving uncorrelated random variables with no memory;
- $H < 0.5$ is associated with the anti-persistent increments which possess anti-correlated structure.

RESULTS AND DISCUSSION

In general, a sharp negative slope of H versus Q surfaces clearly shows the multifractal behavior of all examined pollutant concentrations, which is opposite to the straight line with zero gradient, being an indicator of monofractal systems [15]. The H values above 0.5 suggest nonrandom pollutant fluctuations over time and reflect non-stationary signals with long-range dependent structure, which follow a power law.



The very few cases of $H < 5$, which indicate oscillating processes have occurred only at $Q=5$ for: O_3 being measured at urban-traffic and urban-industry sampling sites (NBG and LAZ), at scales between 50 and 130 hours; NO and NO_x registered at urban-ZEM location between 30 and 140 hours, and SO_2 being registered at urban and rural locations (OBR and GRA) impacted by the coal-fired power station emissions between 200 and 360 hours. Discrepancies in SO_2 dynamics in rural area could be attributed to intermittent pollution accidents related to the emissions from industrial sources and strong wind events. More comprehensive evaluation of O_3 and NO_x pathways in near-ground atmosphere, as well as the analysis of noted concentration deviations, would require more detailed investigation on volatile organic compounds (VOCs) and their interactions with NO_x and O_3 . Unlike many pollutants, ground-level O_3 is a product of photolytic decomposition of precursors rather than a component of primary emissions. Generation and removal of O_3 is strongly affected by the presence of NO_x , their type, lifetime and the way they interact with VOC , $HO\cdot$ and $ROO\cdot$ in a cycle of catalytic reactions. The interactions are impacted by location-specific factors, including pollutant sources and meteorological parameters.

As far as individual pollutants are concerned, H values between 0.70 and 1.5 showed the long-range persistent PM_{10} time-series at almost all sampling sites (Fig. 1). The most prominent variations of H values were apparent at lower and upper Q boundaries (-5, 5) exhibiting maximums at the small scales and in the scale range between 100 and 200 hours. Since PM_{10} represents a mixture of microscopic solid and liquid suspended matters involved in inherent condensation and nucleation, the registered cross-correlation behavior of meteorological factors and PM_{10} was not observed in the case of meteorological factors and the investigated gases [10, 17]. Hurst exponent exceeded 1.5 only at rural GRA and suburban OVC sampling sites, indicating pollutant concentration patterns which can be referred to a brown noise. These behavior pattern appeared at small temporal scales, up to 60 hours, and in the domain of negative Q values implying that the PM_{10} segments are more prone to small and large spatial-temporal variations. Air quality in rural areas being dominated by industrial emissions is more sensitive to fluctuations of meteorological factors compared to air quality in urban sites which is mainly burdened by alternating traffic emissions. After reached Brownian increments, the extremely steep slopes of H versus Q surfaces characterized the PM_{10} concentration behavior patterns at a time scale of up to 150 hours.

The results suggest a strong multifractal nature of PM_{10} which weakened over time and approached to the “healthy complex system” of pink noise.

Time-series of $PM_{2.5}$ were investigated at different sites, suburban OVC in residence area influenced by domestic heating, and VEL rural site in the coal mining industrial area. Strong multifractal nature of $PM_{2.5}$ referring to persistence and long-range correlations, was apparent in the scale range between 30 and 150 hours, as well as in the range between the 30 and 90 hours at OVC and VEL, respectively (Fig. 2). While multifractal features of $PM_{2.5}$ trend decayed with time, they were maintained in the area of negative Q domains.

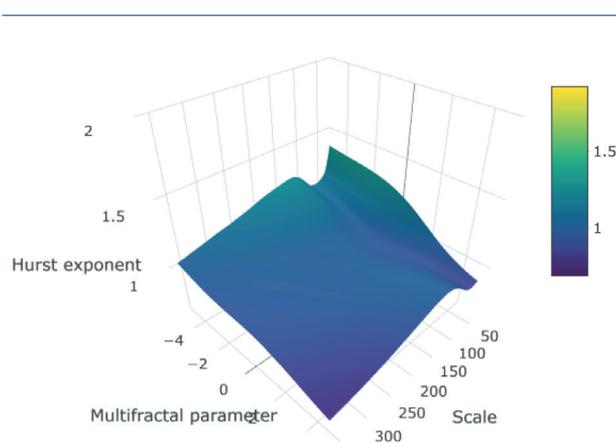


Fig. 1. MMA-derived Hurst surfaces for PM_{10} sampled at typical urban location in the Belgrade centre.

However, at a time scale from the 150 to 360 hours $PM_{2.5}$ concentration behavior patterns were different for $Q > 0$, reflecting the probable mono-fractal characteristics. $PM_{2.5}$ and PM_{10} multifractal patterns resemble for Q interval between 0 and 5, which illustrates their mono-fractal nature, whereas differences in their behavior are reflected in the Q interval between -5 and 0, which supports previous findings on dissimilarities among differently sized PMs in urban areas [18]. A strong multifractal behavior of PM sized below $5 \mu m$, and a weak and/or monofractal stochastic behavior of $PM > 5 \mu m$ was pronounced. In addition, the generalized distance coefficient (0.069), which was above threshold value of 0.065, indicated that the $PM_{2.5}$ and PM_{10} time-series are statistically different.

Multiscale multifractal analysis of SO_2 concentrations showed highly distinctive patterns depending on the sampling site (Fig. 3). The absolute similarities in the pollutant time-series between different sampling sites could not be expected due to numerous emission



sources, chemical reactions and meteorology, which are location-specific. Correspondingly to the findings for PM₁₀, the highest H values (from 1.64 at IPH to 2.37 at OBR) were observed at small time scales ranging from the 30 and 100 hours and in the area of Q negative domains (from -5 to -1).

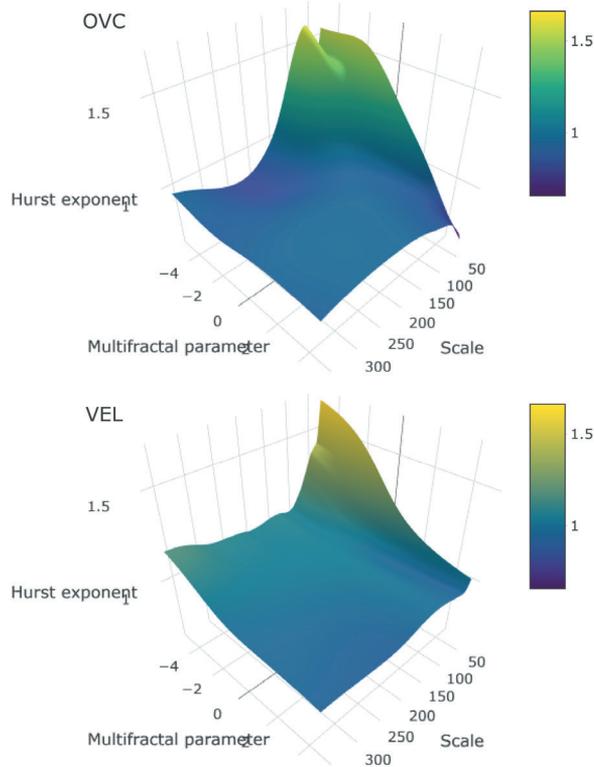


Fig. 2. MMA-derived Hurst surfaces for PM_{2.5} sampled at two rural/semi-urban sites in Belgrade.

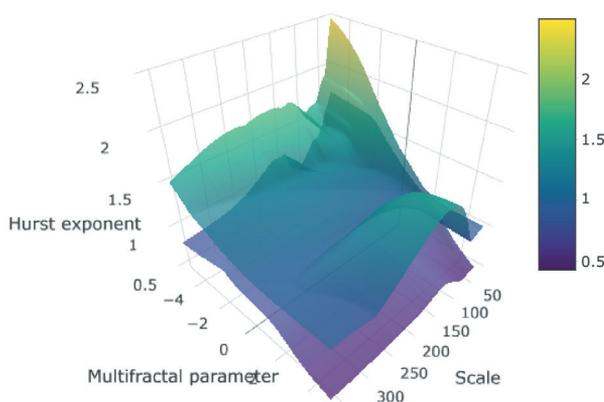


Fig. 3. MMA derived Hurst surfaces for SO₂ in Belgrade.

Such high H maximums induced steeper slopes of H versus Q surfaces implying unequivocal multifractality of SO₂ time-series. In addition, the results suggest that random fluctuations of SO₂ do not dissipate over time and possess brown-noise infinite memory. However, the most dominant characteristics of the SO₂ concentration behavior pattern are a long-range correlated structure and fast evolving fluctuations (H<1). Influence of PM₁₀ presence and potential SO₂ adsorption is a possible cause of SO₂ level variability, and therefore, multifractality. The studies aimed at chemical composition analysis identified material containing inorganic/black carbon and SO₂ as key constituents of PM₁₀ and PM_{2.5} [19, 20].

The time-series of nitrogen oxides (NO, NO₂ and NO_x) resemble each other at almost all sampling sites confirming the same origin and interrelations between these compounds (Fig. 4). Contrary to the PM₁₀ and SO₂ segments, H value reached plateau-shaped maximums higher than 1.5 at a larger scale from the 150 to 360 hours in the negative domains of Q interval (small fluctuations between -5 and ≈ -2). However, the dominant H values (0.5–1.5) reflect persistent/stable pollutant concentration behavior patterns and this trend is likely to be maintained over time. Chemical reactions with O₃ and volatile precursors in which nitrogen oxides are involved provide a possible explanation for the strong multifractality of NO, NO₂ and NO_x. The exceptions from described phenomenon are behavior patterns of NO, NO₂ and NO_x levels registered at two urban sites – SLA and LAZ.

In contrast to the other gaseous pollutants, CO showed less pronounced multifractality (Fig. 5) in urban areas. The highest peaks were observed at the time scale of 30 hours, and H exceeded 1.5 only between the 30 and 40 hours at an urban site – IPH. However, the multifractality in CO level behavior patterns weakened in the area of large fluctuations corresponding to positive Q domains approaching mono-fractal behavior between 100 and 360 hours, which reflects the stability of CO compared to NO, NO₂, NO_x and SO₂.

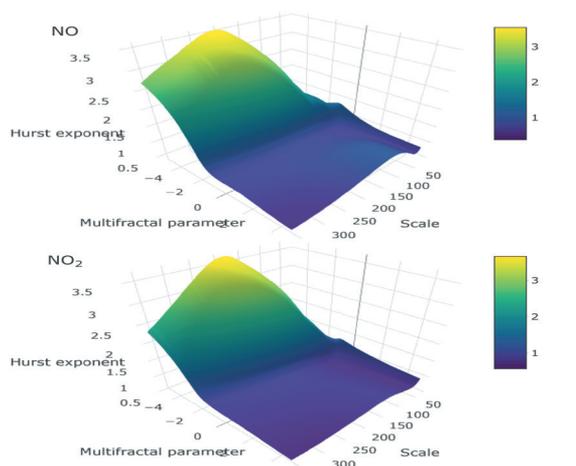


Fig. 4. MMA-derived Hurst surfaces for nitrogen oxides (IPH).

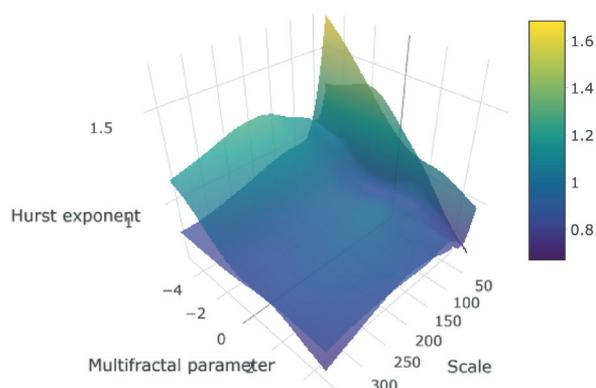


Fig. 5. MMA derived Hurst surfaces for CO in Belgrade.

CONCLUSION

The behavior of suspended particles (PM_{10} and $PM_{2.5}$) appeared to be more consistent in nature and exhibit less prominent multifractality than gaseous pollutants which is expected concerning the chemical reactivity of NO , NO_2 , NO_x , and SO_2 . Long-range correlated structure of PM_{10} time-series is likely to be driven by the variability of meteorological factors, while the corresponding patterns of SO_2 and nitrogen oxides could be a consequence of accidental pollution episodes and chemical reactions. Bearing upon the previously described complexity of the parameters affecting pollutant time-series, we emphasize that discussion above could not be used as a definite source of information regarding the pollutant behavior. However, what is of utmost importance is that given results are not biased by mean pollutant concentrations and may be regarded as representative for the studied

area. For this reason, the study could serve as a standpoint to evaluate pollutant predictability over urban/rural areas based on the pollutant multifractal nature. Beside commonly used methods of statistical analysis and source apportionment, the multifractal analysis presented herein could reveal specific pollutant pathways and support relevant economy and governmental sectors to control the pollutant release and distribution.

ACKNOWLEDGMENT

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REFERENCES

- [1] Organization for Economic Co-Operation and Development (OECD) Environmental Outlook to 2050: The Consequences of Inaction. Organization for Economic Co-Operation and Development (OECD); Paris, France: 2012.
- [2] WHO, https://www.who.int/health-topics/air-pollution#tab=tab_1
- [3] European Environment Agency (EEA) Air Quality in Europe—2017 Report EEA Report No 13/2017. European Environment Agency (EEA); Copenhagen, Denmark: 2017
- [4] A. Chelani, "Long-memory property in air pollutant concentrations." *Atmos. Res.* 2016, pp. 1-4.
- [5] T. Stadnitski, "Measuring fractality." *Front. Physiol.* 2012, pp. 1-13.
- [6] H.E. Hurst, "Long-term storage capacity of reservoirs." *Transactions of the American Society of Civil Engineers* 1951, pp 770-799.
- [7] B.B. Mandelbrot, J.R. Wallis, "Robustness of the rescaled range R/S in the measurement of noncyclic long-run statistical dependence." *Water Resour. Res.* 1969, pp. 967-988.
- [8] B.B. Mandelbrot, "The Fractal Geometry of Nature." New York: W.H. Freeman, 1977.
- [9] Q. Dong, Y. Wang, P. Li, "Multifractal behavior of an air pollutant time series and the relevance to the predictability." *Environ. Pollut.* 2017, pp. 444-457.
- [10] H.d. He, "Multifractal analysis of interactive patterns between meteorological factors and pollutants in urban and rural areas." *Atmos. Environ.* 2017, pp. 47-54.



- [11] T. Plocoste, R. Calif, S. Jacoby-Koaly, "Temporal multiscaling characteristics of particulate matter PM10 and ground-level ozone O3 concentrations in Caribbean region." *Atmos. Environ.* 2017, pp. 22-35.
- [12] A. Stojić, S. Stanišić Stojić, I. Reljin, M. Čabarkapa, A. Šoštarić, M. Perišić, Z. Mijić, "Comprehensive analysis of PM10 in Belgrade urban area on the basis of long-term measurements." *Environ. Sci. Pollut. Res.*, 2016, pp. 10722-10732.
- [13] A. Stojić, S. Stanišić Stojić, M. Perišić, Z. Mijić, "Multiscale multifractal analysis of nonlinearity in particulate matter time series." Paper presented at the sixth international WeBIOPATR workshop and conference, Serbia, Belgrade, September 6-8, 2017.
- [14] J. Gierałtowski, J.J. Żebrowski, R. Baranowski, "Multiscale multifractal analysis of heart rate variability recordings with a large number of occurrences of arrhythmia." *Phys. Rev.* 2012, p. 021915.
- [15] E.A.F. Ihlen, "Introduction to multifractal detrended fluctuation analysis in Matlab." *Front. Physiol.* 2012, pp. 1-18.
- [16] E. Molino-Minero-Re, F. García-Nocetti, H. Benítez-Pérez, "Application of a Time-Scale Local Hurst Exponent analysis to time series." *Digit. Signal Process.* 2015, pp. 92-99.
- [17] C. Zhang, Z.W. Ni, L.P. Ni, "Multifractal detrended cross-correlation analysis between PM2.5 and meteorological factors." *Physica A* 2015, pp. 114-123.
- [18] Y. Xue, W. Pan, W.Z. Lu, H.D. He, "Multifractal nature of particulate matters (PMs) in Hong Kong urban air." *Sci. Total Environ.* 2015, pp. 744-751.
- [19] N.P. Ivleva, U. McKeon, R. Niessner, U. Pösch, "Raman Microspectroscopic Analysis of Size-Resolved Atmospheric Aerosol Particle Samples Collected with an ELPI: Soot, Humic-Like Substances, and Inorganic Compounds." *Aerosol Sci. Tech.* 2007, pp. 655-671.
- [20] U. Pöschl, "Atmospheric Aerosols: Composition, Transformation, Climate and Health Effects." *Angewandte Chemie* 2005, pp. 7520-7540.



SHAPLEY ADDITIVE EXPLANATIONS OF INDICATOR PCB-138 DISTRIBUTION IN BREAST MILK

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Abstract:

Breastfeeding provides numerous health benefits for newborns by meeting the infants' nutritional needs and supporting associated immunological protection. Maternal milk is high in fat, and therefore, represents a very suitable media for the bioaccumulation of lipophilic pollutants such as organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs). This makes breast milk the primary source of the infant's postnatal exposure to persistent toxic xenobiotics. In this study, we applied a novel SHapley Additive exPlanations (SHAP) method to investigate the key parameters that govern distribution of PCB-138, an indicator of non-dioxin congeners, in the mother's milk. According to the accuracy metrics, the eXtreme Gradient Boosting regression was successfully employed, with relative error below 20% and high correlation coefficient ($r=0.97$), for finding the relationships between PCB-138 and other non-dioxin congeners, mother's age, and number of births. According to the results, PCB-156, PCB-180, HCB, HCH and PCB-118 have the major, while PCB-28, PCB-52 and PCB-189 have the minor impact on PCB-138 distribution in breast milk. Similar behavior of contaminants, which belong to the both indicator congener group (-28, -52, -180) and toxicologically relevant PCBs (-118, -189), was recognized. The SHAP conclusions were only partially consistent with the results of correlation analysis suggesting that POPs exhibit non-linear dynamics and interrelations. Therefore, the current knowledge on contamination of complex biomatrices would benefit from further detailed analyses of pollutant intermittent relationships.

Keywords:

human biomonitoring, persistent organic pollutants (POPs), organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs), Shapley Additive exPlanations (SHAP).

1. INTRODUCTION

Organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) belong to a group of compounds known as Persistent Organic Pollutants (POPs). Due to their common properties such as persistence, bioaccumulation, toxicity, and ability to be transported via air over long distances, the production and use of POPs are eliminated and/or restricted by the Stockholm Convention. Additionally, due to their persistence and lipophilic properties, they tend to accumulate in the fatty tissues of humans and animals.

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Research has shown that organochlorine compounds, as endocrine modulators, affect human health. The toxic potential of individual compounds is different, but the overall toxic effect is additive. According to epidemiological and laboratory studies, depending on the compound, these toxins can affect the development of cancer, cause allergy and hypersensitivity, as well as central and peripheral nervous system damage, reproductive disorders and immune system disorders. Humans and wildlife are exposed to PCBs and organochlorine pesticides in the polluted environment via air, water, sediment soil and food, by ingestion, inhalation or skin contact. Previous studies suggest that more of these compounds is introduced into the body by food intake than by inhalation or through the skin. It is also known that unborn children are exposed to organochlorine compounds that pass through the placenta. Biological monitoring of these compounds in the body requires invasive techniques referring to the surgical extraction of adipose tissue. The alternative monitoring approach and one of the mostly used non-invasive methods for the assessment of human exposure is the analysis of human milk POPs content.

A number of literature sources reported on POPs interrelations in the breast milk or/and their dependence on parameters like mother's age and weight loss, childbirth, dietary habits and occupation [1, 2, 3, 4]. Our previous investigations were aimed at investigating the presence of OCPs and PCBs in human milk as well as their mutual interrelations and associations with the mother's age and parity using machine learning (ML) algorithms [5, 6, 7]. In this study, we applied the additive feature attribution method – Shapley Additive Explanations (SHAP), which offers uniquely consistent and locally accurate attribution values in comparison with the conventional attribution methods and has become increasingly popular as a tool for predicting environmental phenomena [8]. We aimed to obtain a detailed insight into the parameters including organochlorine pollutants, mother's age and parity, that shape the PCB-138 distribution in the mother's milk. We chose this congener since it has been considered among PCB₆ group as indicator for the PCB behavior patterns in various samples and it has been also taken as the most suitable target compound for evaluating non-dioxin-like PCBs. The classification of non-dioxin- and dioxin-like congeners is used in the European food and feed regulation where dioxin-like PCBs resemble biochemical and toxicological characteristics of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD).

2. MATERIAL AND METHODS

Sampling

Breast milk samples were collected from 152 healthy primiparae, secundiparae and multiparae (third child delivery), aged between 19 and 45, living in Zadar (Croatia). The mothers had no history of accidental or occupational exposure to the analyzed POPs. More details about sampling were described previously [7].

Chemical analysis of PCBs and OCPs

The analytical procedure was described in details previously [5]. Briefly, two subsamples of each unfrozen milk sample (5 g) were extracted twice with a mixture of chloroform and methanol and dried under a nitrogen flow. Subsequently, milk fat was dissolved in n-hexane and purification and fractionation were performed.

Seven OCPs [hexachlorobenzene (HCB), hexachlorocyclohexane isomers (α -, β -, and γ -HCH), 1,1,1-trichloro-2,2-di(4-chlorophenyl)ethane (p,p' -DDT), 1,1-dichloro-2,2-di(4-chlorophenyl)ethylene (p,p' -DDE), 1,1-dichloro-2,2-di(4-chlorophenyl)ethane (p,p' -DDD)], 17 PCB congeners [PCB-28, PCB-52, PCB-101, PCB-138, PCB-153, PCB-180 (six indicator congeners), PCB-105, PCB-114, PCB-118, PCB-123, PCB-156, PCB-157, PCB-167, PCB-189 (eight mono ortho congeners), PCB-60, PCB-74 and PCB-170] were analysed. High-resolution gas chromatography with electron capture detector (s) was performed on a CLARUS 500 chromatograph using two capillary columns (Restek, Bellefonte, PA, USA) simultaneously: (1) 60m \times 0.25 mm, Rtx-5 film thickness of 0.25 μ m, and (2) 30m \times 0.25 mm, Rtx-1701 film thickness of 0.25 μ m. The LODs for the analyzed compounds were 0.5 ng g⁻¹ milk fat for PCB congeners, 0.1 ng g⁻¹ milk fat for α -HCH and HCB, 0.2 ng g⁻¹ milk fat for p,p' -DDE, 0.3 ng g⁻¹ milk fat for β -HCH, γ -HCH and p,p' -DDD, and 0.6 ng g⁻¹ milk fat for p,p' -DDT. The average recoveries for PCBs ranged between 58% and 86% and for organochlorine pesticides between 59% and 92%. Method reproducibility expressed as relative standard deviation was between 6% and 22%, and 7% and 24% for PCBs and OCPs, respectively.

Data analysis

The relationships between PCB-138 in breast milk and all other measured parameters were modeled by using XGBoost regression. The details on the method are given elsewhere [4]. In this study, we used Python XGBoost implementation. 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.

The explainability of the produced XGBoost model that operates with high-dimensional input data in a non-linear fashion was obtained by using explainable artificial intelligence method SHapley Additive exPlanations (SHAP) [5]. Based on the game theory, the Shapley explanations represent the only possible locally accurate and globally consistent feature attribution values. The captured attributed importance of a feature is visually presented as SHAP summary plot.

3. RESULTS AND DISCUSSION

The concentrations of organochlorines found in the milk samples of primiparae, secundiparae and multiparae aged between 19 and 45 (with an average age of 30 years) are given in Fig. 1. The most abundant pollutants were the by-products of lindane (γ -HCH and HCB), the organochlorine pesticide metabolites (p,p' -DDE and p,p' -DDD), and heavy hexa- and hepta-chloro non-dioxin like congeners (PCB-138, PCB-153, PCB-180 and PCB-170).

Significant linear correlation coefficients ($r \geq 0.90$) were found between the following pairs of the investigated variables: PCB-170-PCB-138; PCB-170-PCB-153; PCB-170-PCB-180; PCB-153-PCB-180 and PCB-153-PCB-138 (Fig. 2).

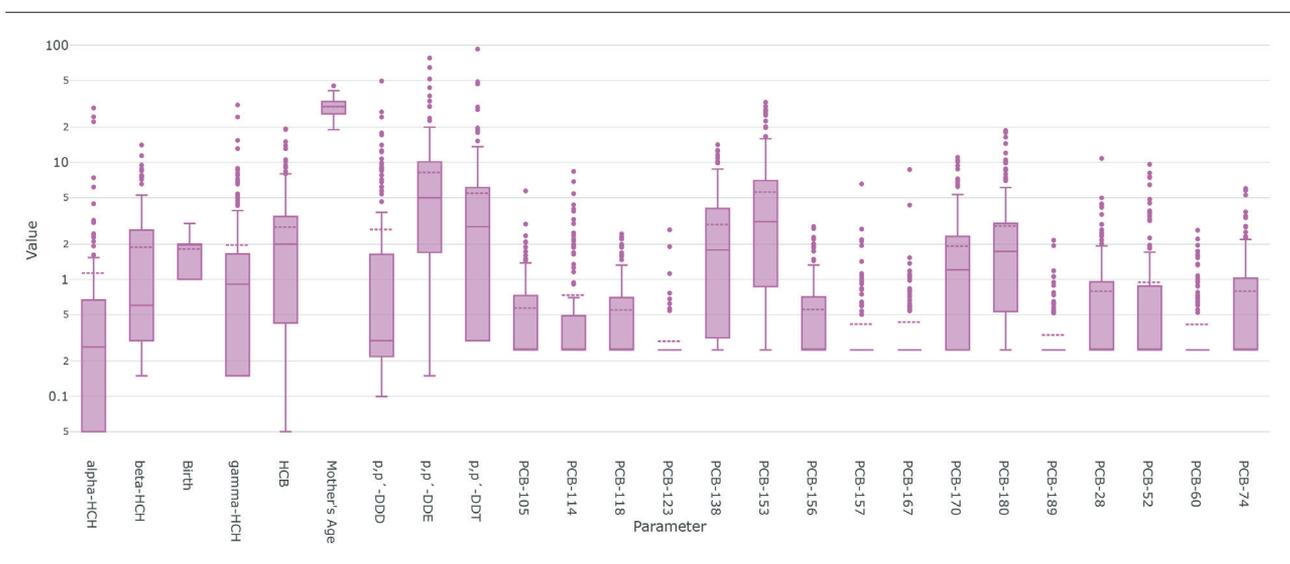


Fig. 1. Measured parameter box plots.

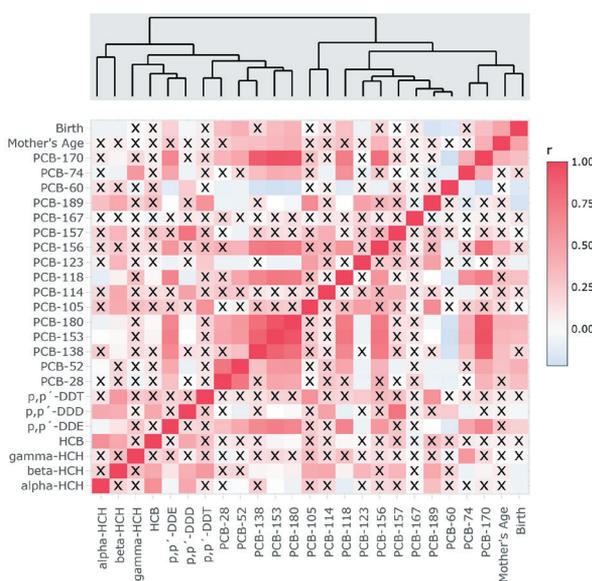


Fig. 2. Obtained parameter correlation matrix.



The results indicated that the listed pollutants have similar molecular structure and metabolic pathways, but we assumed that the advanced methods apart from commonly applied correlation matrices could be employed to deepen the current understanding of PCB-138 behaviour patterns in breast milk.

For investigating the non-linear relationships between PCB-138 and other congeners, mother's age, and number of births, the XGBoost regression analysis was successfully employed, with a relative error below 20% and high correlation coefficient ($r=0.97$) (Fig. 3). As shown by the highest positive (up to 4) and negative (up to -1.5) SHAP values, the most important variables that shaped PCB-138 behaviour pattern in the examined milk samples were PCB-170 and PCB-153 (Fig. 4).

The strongest influences were observed to be related to the elevated concentrations of the listed pollutants suggesting that mono-chlorine congeners are more prone to bioaccumulation in human milk compared to other PCBs.

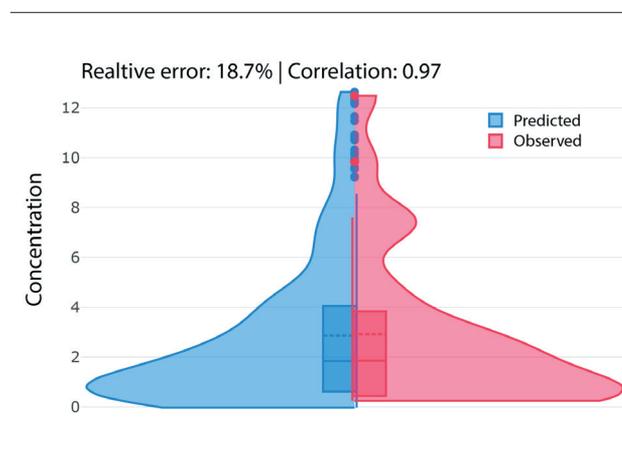


Fig. 3. XGBoost evaluation.

Position of the halogen substituting biphenyl ring of PCB-153, PCB-170 and PCB-153 provide such structure and rigidity of the molecules that facilitate PCBs' ability to pass from blood to breast milk. The other molecular properties including lipophilicity, molecular diameter and weight, and the number of attached halogens appeared to be less determinative for the PCB partitioning between blood and milk [9].

The SHAP analyses revealed less important impacts of PCB-156, PCB-180 and PCB-118 on the PCB-138 behaviour patterns in milk samples. The pollutants belong to non-dioxin-like/indicator congener group (-138, -153 and -180) and toxicologically relevant PCBs (-118 and -156), which elicit aryl hydrocarbon receptor-mediated

biochemical and toxic responses and resist in the food chain. Minor negative functional dependency was observed between PCB-153 and the elevated levels of low-chlorinated congeners (PCB-52 and PCB-28), which are more volatile and susceptible to metabolic breakdowns and excretion.

Numerous studies reported that POPs are eliminated from the body during the breastfeeding, which results in the lower levels of the pollutants in the breast milk of multipara. In addition, it has been usually reported that the milk of elder mothers contained higher concentrations of organochlorine xenobiotics [10]. As indicated by low SHAP values approaching zero, in this study, no significant influences of the mother's age and parity on the PCB-153 patterns was recorded (Fig. 3). For prediction of the POPs bioaccumulation in breast milk, the exposure routes including dietary habits, residential and working environment as well as the mother's childhood nursing history should deserve more attention in future research.

4. CONCLUSION

The health burden of organochlorines in breast milk represents an issue of global concern because of the POPs adverse impacts on human health, particularly sensitive sub-populations such as women and children. In this study, we presented promising explainable artificial intelligence methodology (XGBoost and SHAP) with the aim to investigate the organochlorine patterns as well as the PCB-138 dependence on the mother's age and child delivery. According to the results, similarly structured molecules, which belong to both non-dioxin-like/indicator congener group (-28, -52, -180) and toxicologically relevant PCBs (-118, -189, -156) as well as *p,p'*-DDT metabolite (*p,p'*-DDE) have impacts on PCB-138 distribution. No significant functional dependencies of the PCB-138 patterns and the maternal age and parity was observed suggesting that the impacts of dietary habits and health burden POPs in the residential and working environment should be more investigated in the future. The herein applied analyses could serve as a promising methodology for future epidemiological investigations and human health protection.

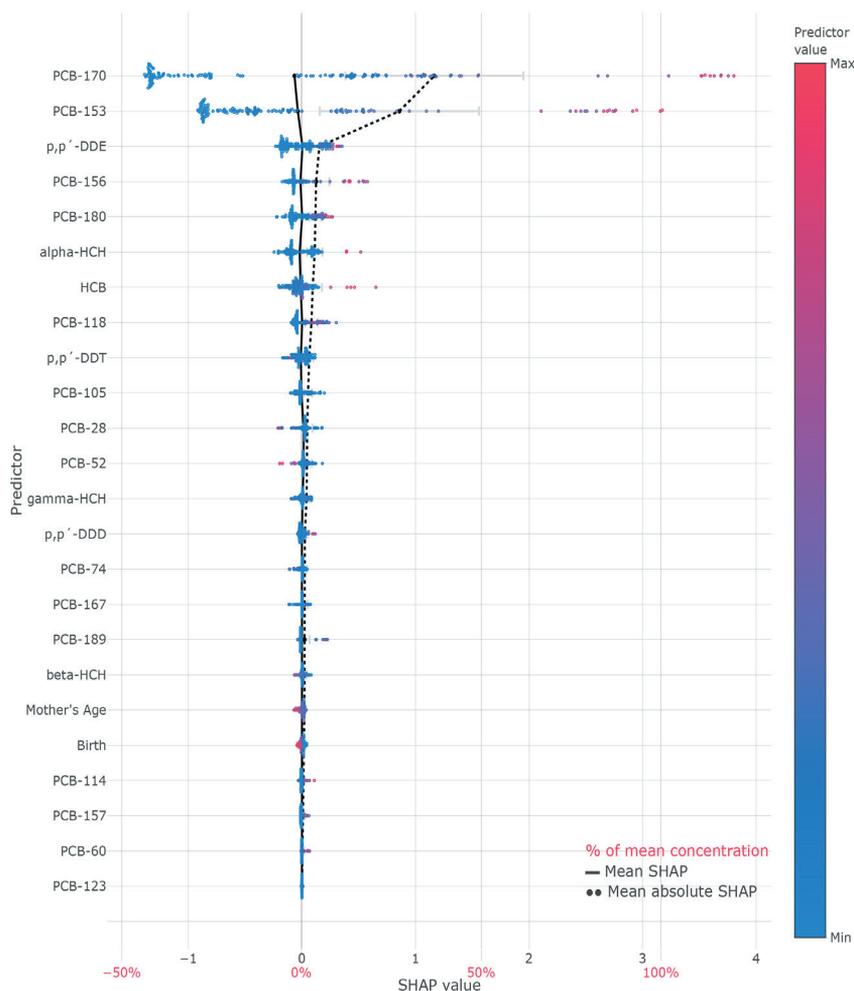


Fig. 4. PCB-138 SHAP summary.

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REFERENCES

- [1] J. Fång, E. Nyberg, U. Winnberg, A. Bignert, and Å. Bergman, "Spatial and temporal trends of the Stockholm Convention POPs in mothers' milk — a global review." *Environ. Sci. Pollut. Res.*, 2015, pp. 8989–9041.
- [2] United Nations Environment Programme, 2013. Results of the global survey on concentrations in human milk of persistent organic pollutants by the United Nations Environment Programme and the World Health Organization, Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants, Sixth meeting, Geneva, 28 April–10 May
- [3] S. Lignell, A. Winkvist, F. Bertz, K.M. Rasmussen, A. Glynn, M. Aune, and H.K. Brekke "Environmental organic pollutants in human milk before and after weight loss." *Chemosphere*, 2016, pp. 96–102.
- [4] A. Polder, J.U. Skaare, E. Skjerve, K.B. Løken, and M. Eggesbø "Levels of chlorinated pesticides and polychlorinated biphenyls in Norwegian breast milk (2002–2006), and factors that may predict the level of contamination." *Sci. Total Environ.*, 2009, pp. 4584–4590.
- [5] D. Klinčić, S. Herceg Romanić, M. Matek Sarić, J. Grzunov, and B. Dukić, "Polychlorinated biphenyls and organochlorine pesticides in human milk samples from two regions in Croatia." *Environ. Toxicol. Pharmacol*, 2014, pp. 543–552.
- [6] D. Klinčić, S. Herceg Romanić, I. Brčić Karačonji, M. Matek Sarić, J. Grzunov Letinić, and N. Brajenović "Organochlorine pesticides and PCBs (including dl-PCBs) in human milk samples collected from multiparae from Croatia and comparison with primiparae." *Environ. Toxicol. Pharmacol*, 2016, pp. 74–79.



- [7] G. Jovanović, S. Herceg Romanić., A. Stojić, D. Klinčić, M. Matek Sarić, J. Grzunov Letinić, and A. Popović, "Introducing of modeling techniques in the research of POPs in breast milk – A pilot study." *Ecotoxicol. Environ. Saf.*, 2019, pp. 341-347.
- [8] A. Stojić, N. Stanić, G. Vuković, S. Stanišić, M. Perišić, A. Šoštarić, and L. Lazić, "Explainable extreme gradient boosting tree-based prediction of toluene, ethylbenzene and xylene wet deposition." *Sci. Total Environ.*, 2019, pp. 140-147.
- [9] G. Vasios, A. Kosmidi, O.-I. Kalantzi, A. Tsantili-Kakolidou, N. Kavantzias, S. Theocharis, and C. Gigaginis "Simple physicochemical properties related with lipophilicity, polarity, molecular size and ionization status exert significant impact on the transfer of drugs and chemicals into human breast milk." *Expert Opin. Drug Metab. Toxicol.*, 2016, pp. 1273–1278.
- [10] R. Aerts, I. Van Overmeire, A. Colles, M. Andjelković, G. Malarvannan, G. Poma, E. Den Hond, E. Van de Mierop, M.-C. Dewolf, F. Charlet, A. Van Nieuwenhuysse, J. Van Loco, A. Covacci, "Determinants of persistent organic pollutant (POP) concentrations in human breast milk of a cross-sectional sample of primiparous mothers in Belgium", *Environ. Int.*, 2019, pp. 104979.



THE USE OF INNOVATIVE METHODOLOGY FOR THE CHARACTERIZATION OF BENZENE, TOLUENE, ETHYLBENZENE AND XYLENE SOURCES IN THE BELGRADE AREA

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Abstract:

The growth of urban population, economic development, urbanization and transport have a strong impact on environmental pollution. The increase in air pollutant concentrations over the last few decades has been in focus of contemporary science and research mainly for its adverse effects on public health, environment and climate change. In this paper, we are using the innovative integrated methodology for spatio-temporal air pollution modeling, based on receptor-oriented air circulation modeling and artificial intelligence implemented through machine learning methods for detailed characterization of toxic, mutagenic and carcinogenic representatives of volatile organic species – benzene, toluene, ethylbenzene and xylene, in the Belgrade area. Also, the study evaluates the possibilities of spatio-temporal forecast based on the integrated methodology. The results suggest that temperature and wind speed represent the main parameters which govern the spatio-temporal distribution of benzene, while the impact of other factors shows significant variations depending on the characteristics of receptor location.

Keywords:

Keywords – BTEX, artificial intelligence, machine learning, volatile organic compounds.

1. INTRODUCTION

Ambient air pollution accounts for an estimated 4.2 million deaths per year due to cardiovascular, malignant and chronic respiratory diseases [1]. Around 91% of the world's population lives in places where air pollution levels exceed World Health Organization limits [2]. Holgate (2017) emphasizes that 40,000 excess deaths in the UK annually can be associated with low air quality, and society would be much more aware of its significance if this mortality was the consequence of drinking polluted water [3].

Among the air pollutants that are of interest for current and future research due to their detrimental effects on both human health and the environment are volatile organic compounds (VOCs), a heterogeneous

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group of organic species with boiling points <250 °C. Their representatives are benzene, toluene, ethylbenzene and xylene, commonly referred to as BTEX. Over the last few decades in developed countries, reducing the levels of BTEX is still challenging [4], due to their enormous chemical diversity and abundance, their numerous emission sources, their complex atmospheric chemistry, insufficient funds for establishment and maintenance of monitoring networks, and the fact that abatement programs might have negative impacts on economic output.

The health effects of BTEX are diverse. For instance, the research has shown that long-term exposure to benzene increases the risk of developing malignant blood disorders, while long-term exposure to toluene causes renal tubular acidosis [5]. Furthermore, the studies have shown that after reduction of benzene, styrene, and tetrachloroethylene concentrations in industrial and urban areas, lifetime cancer risk decreased by one order of magnitude [6]. Populations in highly industrialized areas, socioeconomically deprived, as well as children, pregnant women and elderly people, appear to be more susceptible to pollution-related morbidity and mortality [7]. Apart from their impact on human health, BTEX and other VOCs are associated with climate change and increases in the oxidation capability of the atmosphere [8]. Not only volatile species directly and indirectly contribute to climate change, but their emissions and fates are expected to be influenced and increased by the forthcoming global warming.

Despite the fact that the big shifts in development and integration of different approaches in the area of environmental science have been made recently, spatio-temporal air pollution modeling remained a challenge. Two main approaches are typically employed to forecast air quality and to identify the factors that govern certain pollutant concentrations. The first approach relies on atmospheric diffusion models, while the second refers to statistical models that capture the essential relationships between the variables [9]. Thereby, multidimensionality and size of data sets, as well as the complexity of air pollutant processes and interactions, set too high requirements for conventional statistical methods. For this reason, methods of machine learning, a subfield of artificial intelligence that enables automatized big data analysis and development of learning algorithms, have been introduced into environmental science and research. In this paper, we used the innovative and integrated methodology for spatio-temporal air pollution modeling, based on artificial intelligence and imple-

mented through machine learning methods for detailed characterization of dominant and particular sources of BTEX in a wider region surrounding receptor site that was not covered by regular monitoring. The presented methodology has the potential to provide the basis for establishment of unique and sustainable system for air pollution source identification and enhanced air pollution data coverage that doesn't require additional investments in monitoring equipment. In long term, results of such an approach would provide a solid basis for establishing the sustainable system aimed at improved air pollution management and control.

2. METHODOLOGY

Machine learning algorithms are based on the extraction of patterns and selection of specific attributes from a large number of data, while eliminating irrelevant information. By identification of prediction most important attributes, machine learning methods acquire knowledge and define substantial relationships that exist between input and output parameters by placing a special focus on the data aspect that is most useful for efficient forecasting. The fact that methods based on decision trees, such as Gradient Boosting and Random Forest, have been shown to provide inconsistent attribute contributions, has led to the development of SHAP (SHapley Additive exPlanation), a method that estimates the contribution of each instance of an attribute, which further enables interpretation of the model outputs [10, 11].

EXtreme Gradient Boosting (XGBoost) can be assigned as ensemble method of supervised machine learning which combines the results of more than one decision tree approaches. The main feature of the XGBoost method is focus on obtaining more precise prediction, compared to the one that could be provided by applying a single constitutive decision algorithm. XGBoost method is based on boosting technique that sequentially defines smaller series of decision trees for classifying input data into two or more attribute-defined classes. Each consecutive decision tree is trained through iterations by taking into account the registered errors of previous classification.



3. RESULTS AND DISCUSSION

The variations of particular meteorological parameter affect the changes in other related parameters, which makes it difficult to distinguish between their particular impact on air pollution phenomena. Thus, the impact of meteorological factors is not observed as isolated impact of a single parameter and its variations, but rather as an impact of a certain weather type. In addition to this, a number of other factors can contribute to final impact of meteorological conditions, including the distribution of pollutant emission sources, local topography, street geometry and distribution of all elements and surfaces that can be of significance for air flow regime, pollutant dispersion conditions, their transport pathways and thus, the spatio-temporal variability of their levels. For instance, Liao et al. (2017) have identified ten typical air circulation types within one of the most polluted areas of China and explored their synergetic contribution with topography to local air quality [12]. Ning et al. (2019) have shown that air pollution forecast can be significantly impacted by the complexity of terrain areas because topographic features can to a certain extent limit pollutant dispersion under different weather conditions [13]. In addition to this, the consistency of meteorological conditions significantly affects the extent of volatile pollutant dispersion. For instance, previous study which has been dealing with the accidental benzene release risk assessment in an urban area using an atmospheric dispersion model has shown that benzene spreads over a much larger area during the nighttime due to a stable boundary layer, while during the daytime the enhanced vertical mixing results in limited dispersion of pollutant over the study area [14].

The results of this study suggest that low temperatures and weak to moderate wind represent the main parameters which govern the spatio-temporal distribution of benzene, while the impact of other factors shows significant variations depending on the characteristics of receptor location (Fig. 1). In a similar manner, the presented figures demonstrating TEX distribution can be interpreted (Fig. 2). As can be seen, the figures also include the relative errors and correlations between the observed and estimated BTEX concentrations, which can contribute to better XGBoost method performance evaluation.

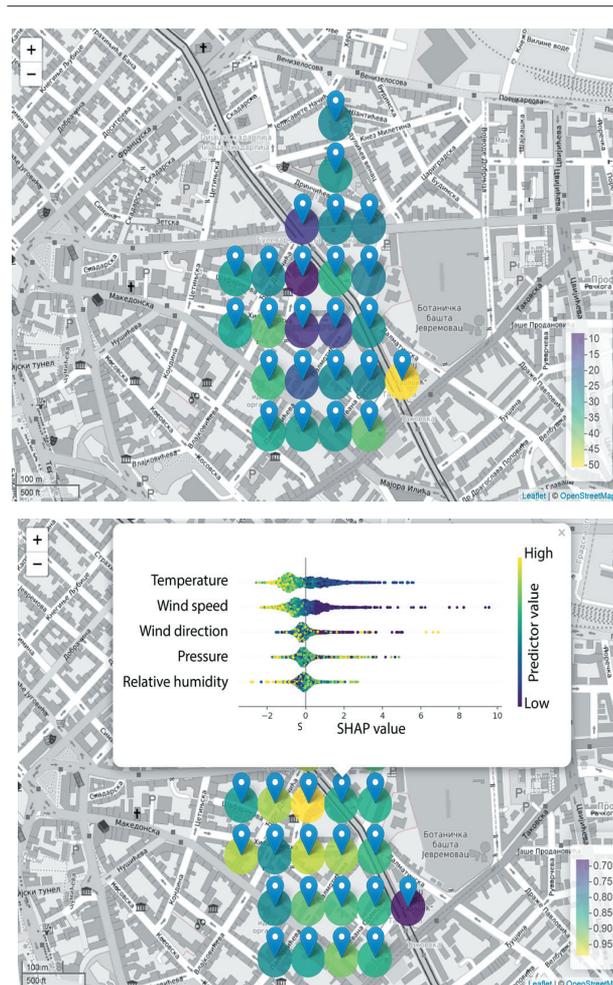


Fig. 1. Benzene forecast based on meteorological parameters – relative error [%] (above) and SHAP values and predicted/observed correlation coefficients (below).

Based on high correlation coefficients ($>0,80$) that were obtained for most of the analyzed data, it can be concluded that XGBoost can be rated as successful and efficient method for air pollution forecasting in the urban area. It should be emphasized that the estimated method errors are significantly lower than uncertainty (50%) which has been requested for evaluation of average annual benzene concentrations obtained by conventional modeling.

The results have also shown high correlations ($r>0,70$) between toluene and nitrate oxide concentrations, which can be considered as indicators of fossil fuel burning, which suggests the common origin of these pollutants in all locations being covered by the conducted analysis, except the old city area and Kalemegdan (Fig. 3), where the toluene concentrations most probably reflected the oxygenated air masses in some narrow canyon-type streets. Furthermore, high correlations ($r>0,70$) between benzene and inorganic oxides (NO_x , CO , SO_2) in western city region suggest the detrimental impact of remote air pollution sources, such as thermal plant Nikola Tesla A and B in Obrenovac (Fig. 4).



Fig. 2. Toluene (a), m,p-xylene (b), o-xylene (c), and ethylbenzene (d) relative error [%] forecasts based on meteorological parameters.

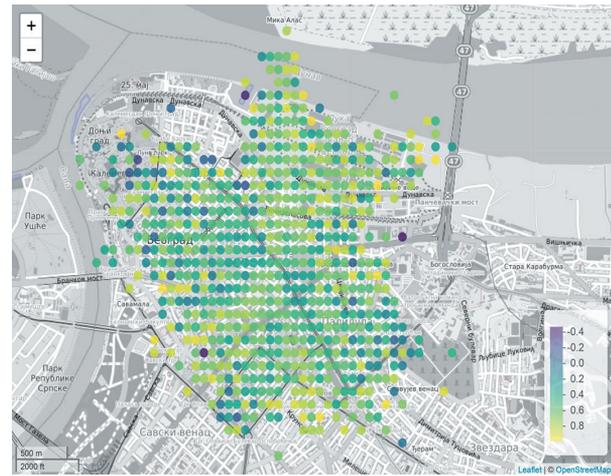


Fig. 3. Toluene and NO correlation coefficient.

Relatively low correlations between benzene and inorganic oxides in the northern and eastern city area suggest that benzene in this urban region can be related to evaporations and emissions coming from petrochemical industry, Oil refinery Pančevo and chemical industry Petrohemija.

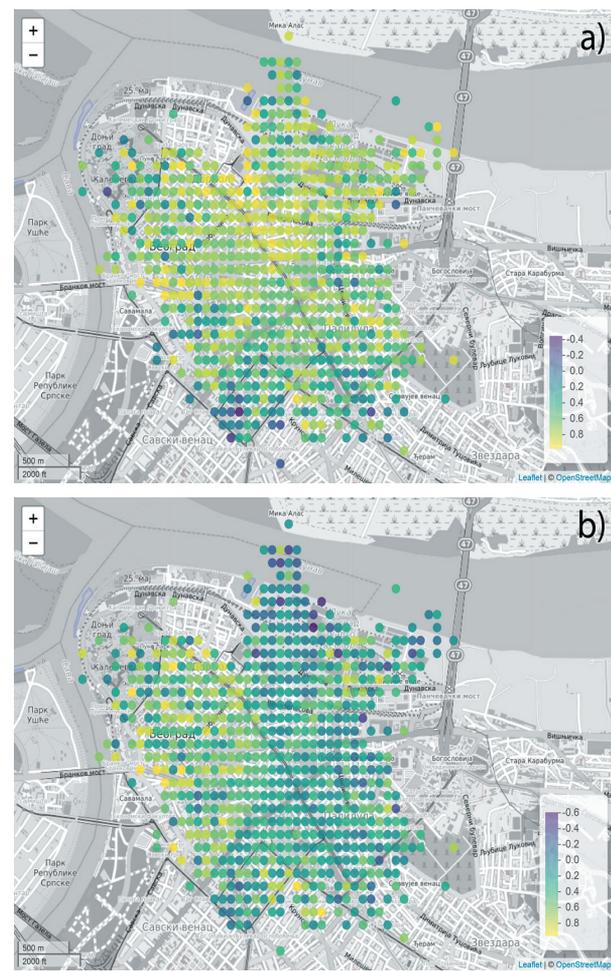


Fig. 4. Benzene correlation coefficients with CO (above) and NOx (below).



4. CONCLUSION

As can be concluded, we have demonstrated the use of efficient methods for spatio-temporal BTEX concentration modeling in the Belgrade area, based on receptor-oriented air circulation modeling and artificial intelligence implemented through machine learning and explainable artificial intelligence methods. The estimated method errors were shown to be lower than the requested uncertainty for conventional modeling. According to the results, temperature and wind speed represented the main parameters which governed the spatio-temporal distribution of benzene. In addition to this, the correlations between different air pollutant concentrations were considered for determination of their origin in all locations covered by the conducted analysis.

ACKNOWLEDGMENT

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REFERENCES

- [1] S. Rajagopalan, A-K. Sadeer, D. R. Brook, "Air pollution and cardiovascular disease: JACC state-of-the-art review," *J. Am. Coll. Cardiol.* vol. 72, pp. 2054-2070, 2018.
- [2] C. Y. Wright, D. A. Millar, "A global statement for air pollution and health," *Clean Air J*, vol. 29, pp. 1-2, 2019.
- [3] S. T. Holgate, "Every breath we take: the lifelong impact of air pollution—a call for action," *Clin. Med*, vol. 17, pp. 8, 2017.
- [4] M. J. Milazzo, J. M. Gohlke, D. L. Gallagher, A. A. Scott, B. F. Zaitchik, L. C. Marr, "Potential for city parks to reduce exposure to BTEX in air," *Environ. Sci. Process. Impacts*, vol. 21, pp. 40-50, 2019.
- [5] E. J. Werder, L. S. Engel, A. Blair, R. K. Kwok, J. A. McGrath, D. P. Sandler, "Blood BTEX levels and neurologic symptoms in Gulf states residents," *Environ. res*, 175, pp. 100-107, 2019.
- [6] J. E. C. Lerner, T. Kohajda, M. E. Aguilar, L. A. Massolo, E. Y. Sánchez, A. A. Porta, P. Opitz, G. Wichmann, O. Herbarth, A. Mueller, "Improvement of health risk factors after reduction of VOC concentrations in industrial and urban areas," *Environ. Sci. Poll. Res.*, vol. 21, pp. 9676-9688, 2014.
- [7] S. Bose, G. B. Diette, "Health disparities related to environmental air quality," *In Health disparities in respiratory medicine*, pp. 41-58, Humana Press, Cham, 2016.
- [8] P. Campbell, Y. Zhang, F. Yan, Z. Lu, D. Streets, "Impacts of transportation sector emissions on future US air quality in a changing climate. Part II: Air quality projections and the interplay between emissions and climate change," *Environ. Poll.*, vol. 238, pp. 918-930, 2018.
- [9] H. B. Ly, L. M. Le, L. V. Phi, V. H. Phan, V. Q. Tran, B. T. Pham, T. T. Le, S. Derrible, "Development of an AI model to measure traffic air pollution from multisensor and weather data," *Sensors*, vol. 19, pp. 4941, 2019.
- [10] M. V. García, J. L. Aznarte, "Shapley additive explanations for NO₂ forecasting," *Ecol. Inform.*, vol. 56, pp. 101039, 2020.
- [11] A. Stojić, N. Stanić, G. Vuković, S. Stanišić, M. Perišić, A. Šoštarić, L. Lazić, "Explainable extreme gradient boosting tree-based prediction of toluene, ethylbenzene and xylene wet deposition" *Sci Total Environ*, vol. 653, pp.140-147, 2019.
- [12] Z. Liao, M. Gao, J. Sun, S. Fan, "The impact of synoptic circulation on air quality and pollution-related human health in the Yangtze River Delta region," *Sci. Tot. Environ*, vol. 607, pp. 838-846, 2017.
- [13] G. Ning, S. H. L. Yim, S. Wang, B. Duan, C. Nie, X. Yang, J. Wang, K. Shang, K, "Synergistic effects of synoptic weather patterns and topography on air quality: a case of the Sichuan Basin of China," *Climate Dynamics*, vol. 53, pp. 6729-6744, 2019.
- [14] S. C. Truong, M. I. Lee, G. Kim, D. Kim, J. H. Park, S. D. Choi, G. H. Cho, "Accidental benzene release risk assessment in an urban area using an atmospheric dispersion model," *Atmos. Environ*, vol. 144, pp. 146-159, 2016.



ENVIRONMENTAL DATA SCIENCE SESSION



DATA SCIENCE ASSESSMENT IN EXPLORATION OF RADIOACTIVITY AND URANIUM DISTRIBUTION AT SUUJIN TAL STRUCTURE IN SOUTH-EAST MONGOLIA

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Abstract:

Suujin tal structure can be recognized from 500km in height by looking at Google Earth or SASPlanet orthophoto satellite imagery. The center of the structure is located 170 km north of Mongolia's southern border with China. It was developed on the central Mongolian fault. This tectonic activity created the Suujin tal structure, as well as some other objects such as the Han Bogd granite intrusion, Zuunbayan valley, Naarst uplift and other. Part of the aforementioned fault intersects Suujin tal in the direction of SSW-NNE in an almost straight line over 50 km. Within this area are historical radioactive anomalies 2453/529, 2453/530, 2453/531, 2453/511, 2453/512, and 2453/513 which were discovered by Soviet geologists during explorations carried out from 1979 - 1981. During a recent study of uranium at this site, a database was established, which include: raster and vector data - various maps, historic points of registered anomalies, recent field observation points, radioactivity measuring, airborne survey data, documentation photographs, and others[1]. In this paper, the main principles of procedures for mapping and database designing, which are using in this kind of explorations, will be presented.

Keywords:

radioactivity, tectonic activity, fault, Mongolia.

INTRODUCTION

The main objective of exploration activities at Suujin tal (Figure 1) was to find a uranium deposit. East and south-east Mongolia is, by its geological constitution, the potential for sediment-hosted uranium deposits. The bottom line is that Paleozoic granites and metamorphic rocks have been developed in this area, which by tectonic - uplift mechanism, build blocks that move conditionally "up" and graben systems built by blocks that descend. Granite and metamorphic rocks are decomposed by atmospheric conditions during millions of years and this material is deposited in descending systems. In this particular case, these are continental sedimentary processes and systems [2].

Granites worldwide (as well as their effluent equivalents rhyolite) carry uranium, thorium, and other radionuclide components. When decomposing these rocks in mild acids or bases, the stem (IV) uranium ion transfers to the migratory (VI) uranyl ion.

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Uranyl ion is transferred to surface and groundwater through the environment in an oxidizing environment (soil or soil colors are yellowish, reddish, brownish, etc.). When it encounters a reducing medium (sediment colors are gray, black, gray-bluish, greenish, or almost white) or so-called. redox. The uranyl ion usually carried by watercourses goes into insoluble uranium ion and thus forms concentrations at the boundary of oxidation and reduction conditions[3].

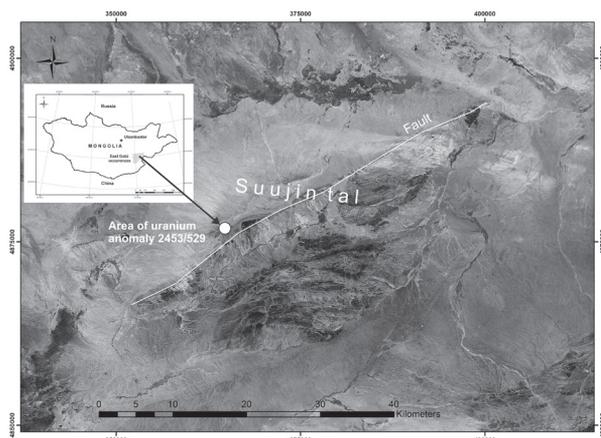


Fig. 1. Position of Suujin tal structure, radioactive anomaly 529 and fault line.

Groundwaters flowing through the sedimentation systems, which are influenced by intensive tectonics, carry different dissolved components. During tectonic movements, the positions of redox boundaries change place, and consequently uranium concentrations "travel" along with predisposed tectonic directions following the positions of the redox barrier.

The Suujin tal area has all characteristics for finding potential uranium deposit. In the far northeast of the structure were discovered two uranium deposits Dulaan ul [4] and Zovich Ovoo [5].

Based on historical Soviet data, and upon the establishment of an integral database of known positions and features of anomalies and zones, exploratory work was started in the area of interest.

METHODOLOGY

Investigative works were followed by methods of storing information in spatial databases.

Establishing a database system took several stages with is in close relation with operation exploration phases:

1. Collection and systematization of historical data;
2. Preparation of field research
3. Conducting field research
4. Airborne gamma survey
5. Organization of the final database and formation of layout.

Geology settings of Suujin tal structure

In historical data Suujin tal – it's a north-west part, is composed of the early Cretaceous huh teeg (K1ht) formation and late Cretaceous bayan shiree (K2bs) formation. During detail field geological exploration in July 2008 (mapping in scale 1:10.000, radiometric assaying, petrological and geochemical sampling) both sediment batches were explored in aim to define uranium distribution in a particular formation. In two layers of huh teeg (K1ht) formation, uranium grade is low - less than 10 ppm, but in sediments of bayan shiree (K2bs) formation uranium grade relatively high – up to 90 ppm. The main uranium content is in sub-layer built of medium-grained loose gravel conglomerate, brown to reddish-brown, strongly oxidized, and slightly silicified. This uranium potential layer is situated in the south-east part of the explored area, with a fall towards the north at an angle of 10 to 30°, rarely 40 to 50°. Uranium bearing sediment complex is thick mainly 5 to 10m and rarely up to 50m. During detailed mapping of uranium-bearing bayan shiree (K2bs) formation three layers were defined. Uranium was concentrated in the middle layer (medium-grained loose gravel conglomerate). In the lower muddy brown and upper reddish sandy layer, uranium was not found. Also, it was estimated that the bayan shiree (K2bs) formation which falls to the north, might create a synclinal structure, in which trenching and drilling should carry out, for possible uranium deposit, which is presumably is developed under the upper red sandy layer [6].

Collection and systematization of historical data

From the early 1950s to the end of the Soviet Union as coherent a state, intensive research was carried out in Mongolia by Soviet geologists and other experts from the states of the in that time existing Warsaw Pact. An enormous amount of data has been collected in the form of reports and studies stored in the territory of the present Russian Federation, and part of this material is also located in Mongolia at an institution called the Mongolian Mineral Resources Authority (MRAM).



Suujin tal space is described in the Reports of Airborne gamma and geological surveys No 2453 [7] and No 2428 [8] (MRAM nomenclature). In the mentioned reports, besides geological description, the results of geophysical radiometric and geochemical testing, there are also catalogs of radioactive anomalies that were translated from Russian into English and organized in an excel database. From this material, shapefiles were generated - points with attributes that represent radioactive anomalies as points and polygons which represent the zones, both with the following attribute which describes anomalies and zones.

These reports include geological maps as well as airborne radioactivity survey maps given as four maps: distributions of gamma counts, uranium distribution, thorium distribution, and potassium distribution. The maps were scanned, georeferenced, and organized into a system along with topographic maps in scale 1: 100,000 and base geological maps in scale 1: 500,000. The maps show spaces covered by specific areas of Soviet explorations. Upon the establishment of a preliminary database of historical data, areas of interest were identified that needed to be processed by field activities and sampling.

Example of historic data in Excel sheet:

- ◆ **Soviet number of anomaly** – 529;
- ◆ **Soviet Report number MRAM nomenclature** – 2453 O`ndurshil;
- ◆ **Location** - Unegetiin valley, Cagan-Suburgin plate 1,7 km from trigonometric point 979,7m;
- ◆ **Latitude** - 44.03611;
- ◆ **Longitude** - 109.32667;
- ◆ **Uranium grade range** 10^{-4} % - 62 U, 8 Th, 4% K;
- ◆ **Geology settings** – Anomaly is situated in fractured fault zone of Cagan Suburgin plate, strongly limonitic sandstone which is over conglomerate-clay layer; Dimensions – 0.5m thick layers in conglomerate at plate of 500 to 600 m²;
- ◆ **Potential status** – Anomaly is prospectiv sign for uranium ore;
- ◆ **Associated elements in %** - 0.0001 to 0.011 Th, 0.037 to 0.080 Pb, 0.015 As;
- ◆ **Background radioactivity in mcr/h** – 20;
- ◆ **Radioactivity at anomaly** – 30-62;
- ◆ **Origin** – secondary/sedimentary.

Thus, when preparing and processing historical data, the following was generated: Raster data in the following folders: Topographic maps 1: 100,000, Geological Maps

1: 500,000, Mineral map 1: 200.000. Shapefiles in folders: Uranium anomalies - points and Uranium anomalies - zones.

Preparation of field activities data

Accessing anomalies, especially 2453/529, turned out to be a logistically complex task because the anomaly could not be easily reached. We have known from experience that there is always a path or at least a trace to Soviet trigonometric points that were set up during the late 1940s and 1950s; however, the space is empty and not suitable for traditional Mongolian nomadic livestock farming. Considering that from 1957 to 2007/8 is 50 years of erosion. Still, the challenge was great. At the time of these activities - fall 2007, no detailed orthophoto images were available as today (2020). We had topographic maps 1: 100,000 with roads connecting the cities Khuvsgul and Sainshand (bigger settlements in the area), at a distance of 150km. On the topographic map was a road connecting two springs, one at the point where it would have to turn from the Huvsgul - Sainshand direction in the northwest to reach another spring that was in the area of interest. There were multiple attempts and all were unsuccessful. I participated in two, where in the second attempt we tried to "catch" the edge of horst, from the northeast of the structure, which is built of solid rocks, however, it was not possible to pass to the structure because the area between road and horst was filled with loose sand.

The conclusion was that we have to pass from the southeast side, built of Paleozoic metamorphic rocks, and carefully study the available satellite imagery. After considerable effort, a route with checkpoints was established. It was less than 20 kilometers - from a turn off the main road to the Soviet trigonometric point - orientation target, which we need to reach. With numerous stops, using GPS, a compass, printed satellite images, frequent stops, and pedestrian controls, we were able to reach the Soviet trigonometric point and anomaly 2453/529. After that, we made a GPS route and with this are possible to reach all points of interest. Following that, it was decided to establish a temporary yurt camp in the area of Suujin tal, with 4 geologists and two vehicles.

Fieldwork data

With the establishment of the driveway and temporary base, intensive measurement with the Exploranium GR135 Radiation Identification Device, mapping, and sampling began. Also, cross-sections and distribution of characteristic geological units of interest have been observed and mapped.



The structures that traverse this area and divide it into the south-east and north-west are precisely defined. All observation points and the structure mentioned are in the field database as shapefiles. At the contacts along the fault, a large number of points with elevated radioactivity (over 200cps) exist.

In the northwestern part of K1ss and partly K2bs, and along the spreading zone, a large amount of petrified and silicified bones (Figure 2) was found whose radioactivity was once up to 1200 cps. It turns out that the anomaly 2453/529 is the space where a silicified and fossilized tree was found with measured radioactivity of 700 cps in an area of 20m² approx. in size.



Fig. 2. Petrified and silicified bones with high radioactivity (up to 1200 cps).

During field research, the following data were generated:

- Raster data in next folders: Raster of the explored area - fact map in scale 1:100.000, Raster of the explored area on a digitized geological map 1:100,000, Excel data of observation points.
- Vector data in the following folders: Observation points fact data with coordinates, Radioactivity values in observation points with coordinates, Samples used for chemical assaying.
- Text data: Report which describes geological units, distribution character of U, Th, K and total count in cps, field diary, and a proposal for further work. Below is given the example of observation point in with photo documentation.

Example of Field work data in Excel sheet:

- ◆ Observation point No -198;
- ◆ Area - 8530X; Datum (ellipsoid) - WGS84;
- ◆ UTM Zone - 49T;
- ◆ Easting - 368902m;
- ◆ Northing - 4878431m;
- ◆ Latitude - 44.047328;
- ◆ Longitude - 109.363548;
- ◆ Radiometric Assay No - 1121;
- ◆ K (%) - 5.6;
- ◆ U (ppm) - 34.0;
- ◆ Th (ppm) - 11.0;
- ◆ TOT count (cpm) - 1519;
- ◆ K (cpm) - 286;
- ◆ U (cpm) - 128;
- ◆ Th (cpm) - 12;
- ◆ BGS (cps) background radioactivity - 530,
- ◆ Description - reddish-brown conglomerate cemented with fine-grained siltstone fragments, thickness 0,8m, strike and dip α 345/15-200;
- ◆ Photography No - 226; Elevation - 954m;

Airborne gamma survey data

Potential spaces were explored during May and June 2007 by airborne survey methods by contractor company Geosan LLC. A Cessna Caravan with two RSX-4 Gamma-Ray Spectrometers was used to measure radioactivity. The area of Suujin tal was numbered as Area 6. The distance between the routes was about 1000m; the average height was about 200m depending on the situation. The data processed indicate that the areas with the highest radioactivity are in places that is water under the sand and on a ridge.

During the Airborne gamma survey the following types of data were established:

- ◆ Numerical database;
- ◆ Shapefile database;
- ◆ Generated maps: Total gamma distribution map in cps (count per second), Uranium counts distribution map, Thorium counts distribution map and Potassium counts distribution map and
- ◆ Text files: Report of the airborne survey [9].



Organization of the final database

The final database is a coherent system from which is possible to generate Layout/maps, Numerical data, and values, Reports as text data, Define potential for a deposit, and future exploration estimation of costs. The schematic organization (algorithm) is shown in Figure 3.

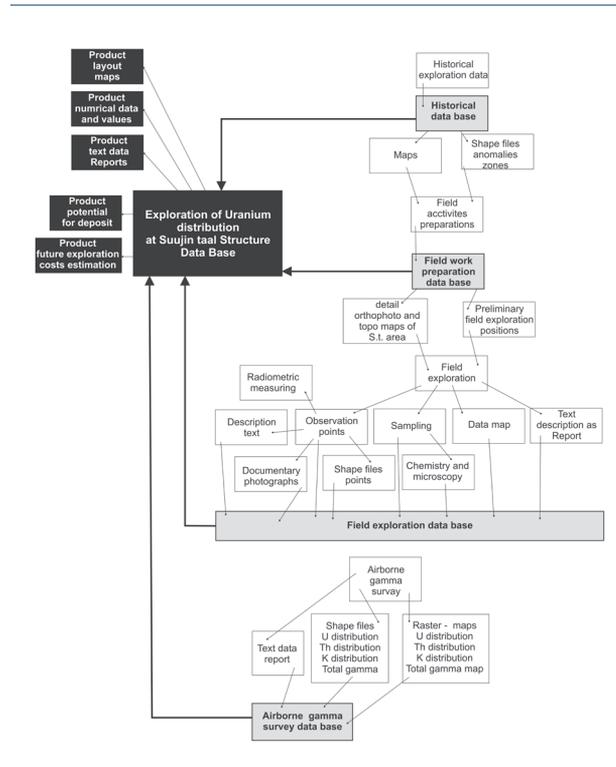


Fig. 3. Algorithm of final data base

CONCLUSION

When we started exploring the Suujin tal area, the main goal was an attempt to find a uranium deposit. After the first visit, I realized that the deposit may exist in the zone below the Quaternary sands in the central and northern part of the exploration License, below the Quaternary sediments, in Cretaceous package. The terrain is complex and possible drilling would be feasible, but with great effort. Instead of looking for uranium, this area should be protected as a world geological heritage. The fact is that it is a remote area, and it is not easy to get there, however, the presence of various rocks, faults, sediments, fossils, and other geological objects and features in a relatively small area is exceptional.

ACKNOWLEDGMENT

On this occasion, I would like to give great recognition to my Mongolian colleagues geologists Nurguli Raashkhan and Byambadrakh Bayarsaikhan.

REFERENCES

- [1] B. Vakanjac, P. Srna, V. Ristić Vakanjac, "Establishment of a database of uranium anomalies and zones in Mongolia", 161 – 168, September 2014. [Uranium – Past and Future Challenges, B.J. Merkel and A. Arab Eds. Springer, Freiberg, Proceedings of the 7th International Conference of Uranium Mining and Hydrology]
- [2] Yu.B. Mironov, "Uranium of Mongolia", Translated by Victor S. Popov, Centre for Russian and Central EurAsian Mineral Studies (CERCAMS), Natural History Museum, London, 2003/2005.
- [3] N.F. Rutherford, "Uranium Deposits: Geochemistry, Radiometrics and Models b". Notes to accompany workshop presented to: Batu Mining Monolia LLC and Gobi Coal and Energy LLC, Ulaanbaatar 94 p. September 2006.
- [4] <https://www.mindat.org/loc-297435.html>
- [5] <https://www.mining.com/areva-discovers-big-uranium-deposit-in-mongolia-23178/>
- [6] N. Raashkan, "Monthly report (Geological formation and mineral recourses of Suujin tal 8530X", Zaraiya Holdings LLC. Ulaanbaatar, p 4, 2008.
- [7] Yu. S. Shmelev, V.I. Panev, Yu.M. Gavrilov, V.D. Tataurov, A.V. Evstigneev, "Report on air geophysical and geological mapping at scale 1:200.000 carried out on O`ndorshil area", Ministry of Geology USSR, "Zarubezgeologiya", Mongolian Geological-Surveying Expedition, South Group. (MRAM No 2453) Legend, 12 p. Sverdlovsk. 1982.
- [8] U.V. Troitskii, V.A. Kaldishkin, V.S. Kormilicin, T.V. Kaldashkina, Report on Prospecting-Exploration on Uranium in East Gobi Area for 1978-1980" (Geological assingment MGSE-15), Ministry of Geology USSR, "Zarubezgeologiya", Mongolian Geological-Surveying Expedition. (MRAM No 2428), p76-81 and p171-217. 1981.
- [9] Geosan, Logistic Report, Mongolia Dornogovi Aimag, Sainshand Airborne Geophysical Srvey, August - September 2008 for Zaraiya Holdings LLC, p 1 – 9, 2008



MAPPING FOREST INFRASTRUCTURE – COMPARING DIFFERENT DATA ACQUISITION TECHNIQUES

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Abstract:

Forest resource information usually change over time, what is monitored by forest inventories using different methods. Forest infrastructures, such like roads, hydrographic network, other linear facilities are relatively stable in time. Nevertheless, conventional forest inventories in Lithuania map forest infrastructures every time the survey of forest resources takes place. Assuming, that different and rapidly developing forest stand inventory techniques are applied each time, there are significant changes in location of forest infrastructures observed. Repeated inventories of such objects usually assume increased inventory costs and introduce significant disorder when aiming for permanent forest management. This study investigates the opportunities of different data acquisition techniques for mapping relatively stable over time forest infrastructure objects. We compare classification and geometric accuracies of forest infrastructures achieved using (i) ground geodetic survey, (ii) available from state maintained geo-referenced background database, which has been created using interpretation of aerial images, (iii) extracted from 3D airborne laser scanning point clouds and (iv) very high-resolution World-View-1 satellite images. The key finding is that costly and time-consuming ground data collection approaches may be successfully substituted by remote sensing based data collection, which delivers compatible data contents for significantly lower costs.

Keywords:

remote sensing, forest infrastructure, mapping, accuracy.

1. INTRODUCTION

Forest of Lithuania, which cover more than 2 million ha, contribute significantly to the economy of country, thus, their management planning needs to base on timely and accurate inventory data. All state forests in Lithuania have been inventoried at least once in the 19th century and one of peculiarities of forest management planning was the division of forest tracts into usually rectangular blocks. Maps at a scale 1:5000 were produced since the 1930's, since the stand-wise forest inventories became routine procedures repeated on the same area approximately every decade, of course, disturbed by historical factors of the 20th century [1; 2]. After restoration of independency in 1990, Lithuania issued a Law of geodesy and cartography in 2001 [3].

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This legal act set detailed requirements for surveying and mapping, as well for developing GIS databases [4]. In 2004, the first version of georeferenced cadastre database GDB10LT was developed, which was considered as a mandatory dataset to develop all thematic GIS datasets, including the database originating from stand-wise forest inventories. Nevertheless, GIS in Lithuanian stand-wise forest inventories was introduced nearly a decade before the country-wide general-use datasets were created. This resulted in numerous overlaps and mismatches of the same features. More, the GDB10LT did not cover all information needed for stand-wise forest inventories and the Forest State Cadastre (FSC). All geographic data in FSC database are stored in state coordinate system LKS-94 [5]. Following the requirements for SFC database, the accuracy of clearly identifiable features, such as intersection points of roads, drainage canals, etc. may not exceed 5 m [6]. Even though there were formal requirements to update the FSC database permanently registering all changes due to silvicultural activities, in fact the solution used was to replace all information in the areas, where the stand-wise forest inventories took place, usually every 10 years [6]. Thus, it was soon realized, that the position of by-definition stable object in the forest, like the block lines, road infrastructures or hydrographic network changes with the stand-wise forest inventories [4]. In 2013, a project was carried-out to test the use of GPS technology to create accurately field surveyed forest geodetic network [7]. The methodology was tested and approved on 2014 and the product was named as the forest geo-reference background [8; 9]. There were set high quality requirements for field survey, however, it was also soon realised that development of forest geo-reference background is rather costly affair. Thus, the question was asked, what is the accuracy of forest geo-reference background and whether there are more economically sound alternatives to get the same product. General requirements for geospatial positioning accuracy are well known since 1998. [10]

The first validations of the forest geo-reference background indicated, that the accuracy of intersection points of forest block lines were surveyed with accuracies on X axis ± 3.1 m and ± 2.59 m on Y axis [11]. More detailed study was carried out in 2017 [4], which concluded, that the most accurate data was achieved on the block line intersection points and due the good forest block line condition and an appropriate choice of surveying techniques. The recommendation given was to carry out survey during the leafless forest condition in a mixed deciduous-coniferous stands [4]. Testing of alternative solutions to get the same product with lower

costs was rather episodic. Nevertheless, there are numerous opportunities to facilitate the development of forest geo-reference background utilising alternative solutions. In this study, we will focus on the potential of remotely sensed data to identify the same object, which are usually field surveyed to create the forest geo-reference background. As such solution may serve e.g. orthophotos, built on materials of aerial photography used in Lithuanian stand-wise forest inventory which possibilities to acquire the georeferenced information are detailed presented in 1996 [12]. Potential of high resolution (sub-meter) satellite images is also proven, as the information from usually used in stand-wise forest inventories in the areas where the aerial photos are not possible to acquire (e.g. over flight-restricted areas, near country borders with Russia and Belarus). Finally, airborne laser scanning techniques are coming to Lithuanian stand-wise forest inventory, too. [13]

The aim of study described in this paper was to investigate the opportunities of different data acquisition techniques for mapping relatively stable over time forest infrastructure objects. We compare classification and geometric accuracies of forest infrastructures achieved using (i) ground geodetic survey, (ii) available from state maintained geo-referenced background database, which has been created using interpretation of aerial images, (iii) extracted from 3D airborne laser scanning point clouds and (iv) very high-resolution WorldView-1 satellite images.

2. MATERIAL AND METHODS

The study was conducted in Dubrava forest in central Lithuania and its neighbourhood (Fig.1). Total area under focus was about 20000 ha.

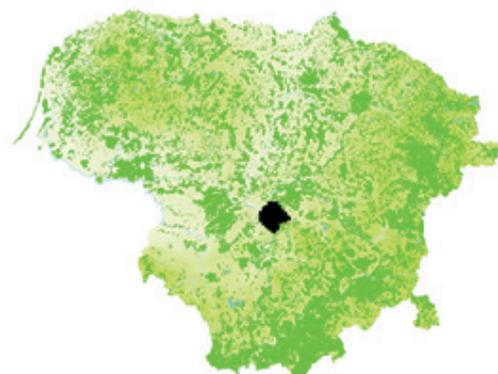


Fig. 1. Location of the study area



We compare the classification and geometric accuracies of four data sources to map forest infrastructures within the frames of stand-wise forest inventories. The data sources are:

1. Information, contained in forest geo-reference background (hereafter, FGB), which is created using the requirements of Specifications for forest management planning [14]. According to the Specifications, the FGB contains the information on relatively stable over time natural or human created objects in the forest, such like roads (≥ 4 m wide), linear hydrographic features (≥ 3 m wide), railways, other technological linear objects (≥ 4 m wide) and lines used to build forest blocks. The FGB is developed using ground survey methods by field measurements of points where the linear FGB objects intersect, as well as points where the block lines change their azimuth. The version of FGB used for our tests was developed in winter season of 2012-2013 by State company Lithuanian Forest Inventory and Management Planning Institute (LFIMPI) using Leica Smart station 1200 equipment, achieving positional accuracies of measured points inside 15 cm.
2. Information which is contained in a spatial data-set of Geo-reference data cadastre for Lithuania (hereafter GRPK), which is available from geportal.lt. This data set is aimed to record stable over time natural and anthropogenic origin land surface objects, related to the locations of water features, land covers, transport and communication infrastructures, elevations, location names, etc. This data set is permanently updated, usually using mono interpretation of orthophotos and is supposed to fit mapping standards at a scale 1:10000. For this study, we used version of GRPK downloaded 4-3-2020.
3. A geo-database, developed following the requirements for FGB, but conducting the measurements in 3D point cloud created using data from airborne laser scanning (hereafter, ALS) instead of field survey. Study area was scanned using ALTM3100 instrument from 1500 m altitude and 70 kHz pulse frequency or shooting density 1 point per m^2 (resulting in more than 2 responses per square meter) in summer of 2008. Features contained in FGB were interpreted using RGB visualizations based on the ALS point height percentiles: R – 90%, G – 60% and B – 30%. To support the interpretation, 3D visualizations of point clouds were also used.

4. A geo-data base of forest infrastructures based on the international cartographic standard MGCP, developed within the frames of MySustainableForest project by GMV AEROSPACE AND DEFENCE SA (hereafter, MSF). It is created by interpretation of Worldview-1 satellite images from 23-3-2019, aiming for feature representation at a scale 1:5000 and feature extraction – 1:2000. The thematic categories of the dataset are hydrography and waterways, transportation network, populated places, enclosures, industrial and energy objects and land cover.

Three types of points were identified independently on intersections of linear features, contained in all four data sources mentioned above: (i) intersections of forest block lines, (ii) intersections of forest block lines and roads and (iii) intersections of forest block lines and linear hydrographic features. Assuming formal requirement to use the FGB data set in stand-wise forest inventories, we considered it as the reference data set. All other data sets were considered as an alternative to create the FGB. So, we estimated geometric accuracies of points identified using other three datasets, comparing their cartesian coordinates with the ones achieved from FGB. Approaches established by Federal Geographic Data Committee of USA in National Standard for Spatial Data Accuracy [10] were used to compare the datasets. Horizontal accuracy was evaluated using root mean square errors for x and y coordinates:

$$RMSE_x = \sqrt{\sum (x_{data,i} - x_{FGB,i})^2 / n} \quad (1)$$

$$RMSE_y = \sqrt{\sum (y_{data,i} - y_{FGB,i})^2 / n} \quad (2)$$

Where: $x_{data,i}$ and $y_{data,i}$ are the coordinates of the i point in the dataset being evaluated;

$x_{FGB,i}$ and $y_{FGB,i}$ are the coordinates of the i point in the FGB dataset.

Horizontal error (HE) at point i is:

$$HE = \sqrt{(x_{data,i} - x_{FGB,i})^2 + (y_{data,i} - y_{FGB,i})^2} \quad (3)$$

Horizontal root mean square error $RMSE_r$ is:

$$RMSE_r = \sqrt{RMSE_x^2 + RMSE_y^2} \quad (4)$$

As the $RMSE_{min}/RMSE_{max}$ were in the range of 0.6 and 1.0, we calculated the circular standard error (at 39.35% confidence) as $0.5 \times (RMSE_x + RMSE_y)$, and, accepting that



the errors were normally distributed and independent, calculated the accuracy value:

$$Accuracy_r : 2.4477 \times 0.5 \times (RMSE_x + RMSE_y) \quad (5)$$

To evaluate clustering effects of errors, we calculated Global Moran's I statistic for point-wise horizontal accuracies. ArcGIS and MS Excel were used to process the data and elaborate the illustrations.

3. RESULTS AND DISCUSSION

There were 262 points located as the check points on the FGB, 84 representing the intersections of forest block lines, 108 – intersections of forest block lines and roads and 71 – intersections of forest block lines and linear hydrographic features. However, 79%, 58% and 73% of points identified on FGB, were located and identified on GRPK, respectively. Usually, the forest block lines were missing in the GRPK, due to specifics of nomenclature of GRPK. Only 38%, 34% and 23% of points were identified using intersection points of linear features, extracted from ALS data. Also, should be noted, that not the whole study area was covered by ALS data, and, similarly to the previous case, only block lines, which were clearly detectable, were used. 76%, 71% and 58% of points extracted using forest infrastructures based on Worldview-1 satellite images (MSF), were mapped. In all cases, the percentage of identified points would increase if using also virtual lines prolonging available linear features were used. However, we did not apply such approach because of the primary objective to evaluate geometrical accuracies of available intersection points.

Relatively largest horizontal accuracies were achieved using the GRPK as the source for constructing the database, which emulates the FGB (Fig. 2 and Table 1.). Nevertheless, the accuracies were below the requirements for mapping stable over time forest infrastructures. The lowest accuracies were achieved using ALS data as the input. Bearing in mind, that positional accuracies of points in the cloud were potentially more accurate than the accuracy of orthophotos to build the GRPK and MSF datasets, we explained this by imperfections in the methods, used to extract linear features in the ALS point clouds. If considering only GRPK and MSF dataset only, that the most problematic features to detect were the intersections of forest block lines and the roads, while the most precisely detected ones were the intersections of forest block lines and linear water features.

This contradicts a bit with our previous finding, that the hydrographic elements are the most difficult to identify on the image-based orthophotos in Lithuanian stand-wise forest inventories [8].

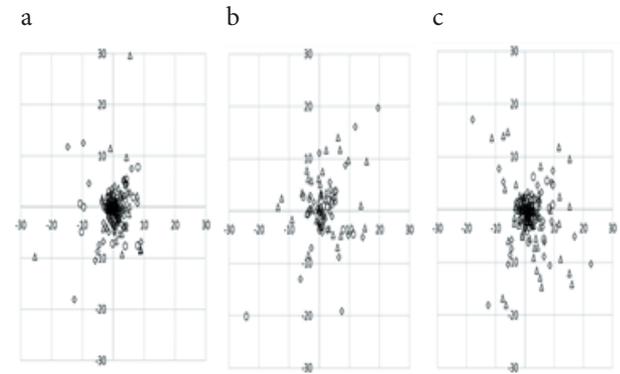


Fig.2. Magnitude (in meters) of horizontal errors of check points, depending on the input data source; a) GRPK, b) ALS, c) MSF. \diamond - block lines, Δ - block line x road, o - block line x linear water feature

Type of intersection	Number of points	RMSE _x	RMSE _y	RMSE _r	Circular standard error	Accuracy _r
Spatial dataset of Geo-reference data cadastre for Lithuania (GRPK)						
Block lines	66	3.921	4.502	5.970	4.212	10.31
Block line x road	63	4.297	5.264	6.795	4.780	11.70
Block line x linear water body	52	3.473	2.818	4.472	3.145	7.669
All	181	3.937	4.395	5.900	4.166	10.20
Forest infrastructures, created by interpretation airborne laser scanning 3D point cloud (ALS)						
Block lines	32	6.243	7.350	9.643	6.440	15.76
Block line x road	37	6.431	5.611	8.535	6.021	14.74
Block line x linear water body	16	7.512	5.481	9.299	6.500	15.90
All	85	6.580	6.301	9.110	6.440	15.76
Forest infrastructures, created by interpretation of Worldview-1 images (MSF)						
Block lines	64	5.929	5.017	7.767	5.473	13.40



Block line x road	77	5.645	6.190	8.378	5.918	14.49
Block line x linear water body	41	3.330	2.492	4.160	2.911	7.126
All	182	5.323	5.144	7.403	5.234	12.811

Table 1. Potential accuracy of identification of stable point-features in the forest, using different dataset as the input, all check points

Horizontal accuracies of all points extracted from the GRPK and MSF dataset, exhibit statistically significant clustering patterns (Fig.2). Visually, relatively poorer identification is towards the edges of forest tracts.

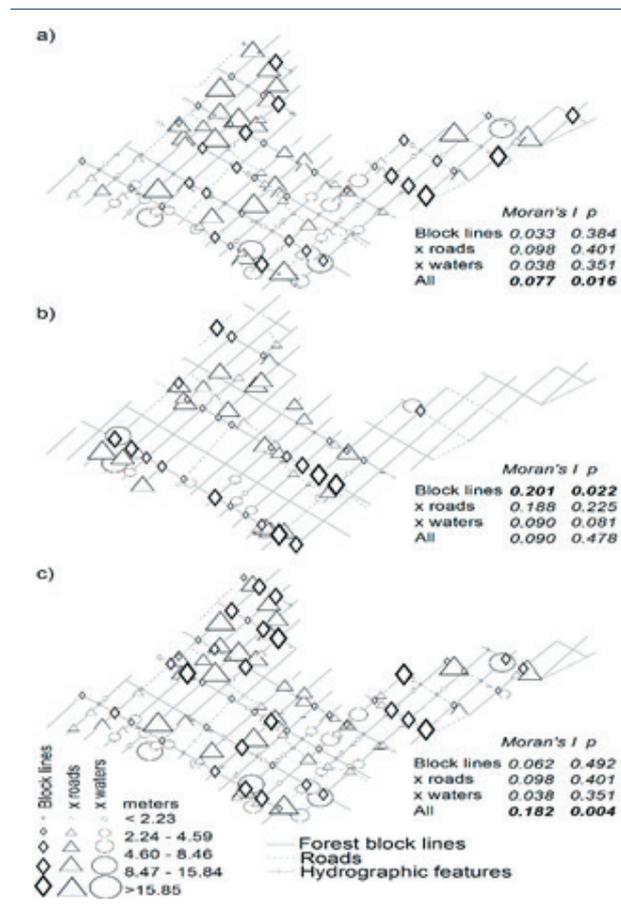


Fig. 2. Spatial pattern of horizontal errors, depending on the input data source; a) GRPK, b) ALS, c) MSF

All the above findings assume that the FGB dataset is free from errors. However, the identification of cross-roads in the specifications for FGB development [8] deviates from the practices used in photogrammetry. Also, it is very difficult to explain rather bit horizontal errors for some check points. Thus, we considered 5% of points with largest horizontal errors as outliers and removed from the calculations.

Another mandatory condition for the check point to be considered as an outlier were large horizontal errors (>10 m) on at least two data sources evaluated. Should be noted, that only intersections of forest block lines and block lines and roads were assigned to the outliers, i.e. never the intersections of block lines and water streams. After removed outliers, the accuracies improved notably (Table 2), suggesting that the GRPK may be used to build FGB, i.e. accuracies required in stand-wise forest inventory specifications are achieved without expensive field survey. Accuracies also improved for the MSF case, too, however, not for the ALS.

Type of intersection	Number of points	RMSE _x	RMSE _y	RMSE _r	Circular standard error	Accuracy _r
Spatial dataset of Geo-reference data cadastre for Lithuania (GRPK)						
Block lines	62	3.367	3.284	4.704	3.326	8.140
Block line x road	58	2.391	3.298	4.074	2.845	6.963
Block line x linear water body	52	3.473	2.818	4.472	3.145	7.669
All	172	3.108	3.155	4.429	3.132	7.666
Forest infrastructures, created by interpretation airborne laser scanning 3D point cloud (ALS)						
Block lines	31	6.342	7.459	9.791	6.901	16.89
Block line x road	33	6.021	4.699	7.637	5.360	13.12
Block line x linear water body	16	7.512	5.481	9.299	6.500	15.90
All	80	6.467	6.056	8.860	6.262	15.33
Forest infrastructures, created by interpretation of Worldview-1 images (MSF)						
Block lines	60	5.389	4.230	6.850	4.809	11.77
Block line x road	71	4.790	5.938	7.629	5.364	13.13
Block line x linear water body	41	3.330	2.492	4.160	2.911	7.126
All	172	4.716	4.720	6.672	4.718	11.55

Table 2. Potential accuracy of identification of stable point-features in the forest, using different dataset as the input, with 5% outliers removed



4. CONCLUSIONS AND RECOMMENDATIONS

- ◆ Costly and time-consuming ground data collection to build the forest georeferenced background, which is mandatory to build GIS databases in Lithuanian stand-wise forest inventories, may be supported by using information available from Geo-reference data cadastre for Lithuania.
- ◆ Forest infrastructures, extracted from Worldview-1 satellite images, may not substitute neither the field survey nor the Geo-reference data cadastre for Lithuania, however, they may contribute to validating and improving the forest georeferenced background.

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REFERENCES

- [1] A. Brukas, S. Jakubonis, A. Kuliešis, A. Rutkauskas. Lithuanian forest inventory and management and its evolution; (Lietuvos miškotvarka ir jos raida) Kaunas, 2002, p.187. ISBN 9955-03-130; In Lithuanian
- [2] G. Mozgeris, A. Galaunė, M. Palicinas, (2008). Systemy informacji geograficznej w zarządzaniu lasu na Litwie – dekada praktycznego stosowania. *Sylvan*, 1, p. 58-63
- [3] Law of geodesy and cartography (Lietuvos Respublikos geodezijos ir kartografijos įstatymas) Available:<https://www.etar.lt/portal/lt/legalAct/TAR.EFE69222D6BC/pjEhrFqfHv>
- [4] I. Bikuvienė, I. Živatkauskienė, A. Živatkauskas, M. Ogryzek, K. Kurowska, "Analysis of Geodetical Measurements' Accuracy for Forest Block Network in Tytuvėnai State Forest Enterprise" (2017) Proceedings of Baltic Geodetic Congress (BGC Geomatics), Gdansk, Poland; (p. 54-58); ISBN:978-1-5090-6040
- [5] State Land Management and Surveying Service under the Ministry of Agriculture of the Republic of Lithuania order on the procedure for introducing the national coordinate system (Lietuvos respublikos valstybinės žemėtvarkos ir geodezijos tarnybos prie žemės ūkio ministerijos įsakymas dėl valstybinės koordinacinių sistemos įvedimo tvarkos). Available online <https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.24435?jfwid=-19kda1ipcm> (accessed on 19 March 2020)
- [6] I. Bikuvienė, D. Tiškutė-Memgaidienė, "GIS in Lithuanian forest inventory – 20 years' experience". Proceedings of Sinteza 2016", Belgrade, Serbia; I SBN: 978-86-7912-628-3; p. 208-212.
- [7] Forest inventory and management scientific and technical council meeting; In Lithuanian (Miškotvarkos mokslinės techninės tarybos posėdis). Available online: http://musugirios.lt/images/files/Archyvas%202013%20zurnalai/MG_2013-11%20zurnalas.pdf
- [8] "Requirements for the development of forest georeferenced background, 31 Annex of Guide of forest inventory and management works", (Reikalavimai miškų georeferenciniam pagrindui formuoti" Miškotvarkos darbų vykdymo instrukcijos 31 priedas) Available online: https://e-seimas.lrs.lt/rs/las-supplement/TAD/e7affc50e3ba11e4a3f4c9665905a1b3/3c21dfd0480811e68f45bcf65e0a17ee/format/ISO_PDF/, in Lithuanian
- [9] A. Živatkauskas, I. Živatkauskienė, I. Kaulakytė, "Specificity of forming geodetical background and forest block network on example of Dubravos SFE" (Miškų georeferencinio pagrindo ir kvartalinių tinklo formavimo ypatumai VĮ Dubravos EMU pavyzdžiu). In proceedings Measurements engineering and GIS. 2013. Kaunas. p. 9-13. ISSN 2029-5790, in Lithuanian
- [10] Federal Geographic Data Committee, 1998. Geospatial Positioning Accuracy Standards. Part 3: National Standard for Spatial Data Accuracy. Available at: <https://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3> (accessed on 14 March 2020).
- [11] A. Galaunė, I. Bikuvienė, G. Mozgeris, "Research on Geometrical Accuracy of Forest Compartments Geographic Database" (Miško sklypų geografinių duomenų bazės geometrinio tikslumo tyrimai). *Vagos*. ISSN 1648-116X. Nr. 81 (34) (2008), p. 13-17. In Lithuanian
- [12] E.P. Baltsavias, 1996. "Digital ortho-images – a powerful tool for the extraction of spatial- and geo-information". *ISPRS Journal of Photogrammetry & Remote Sensing*, 51(1996), pp. 63-77.
- [13] I. Bikuvienė "Theoretical and practical improvement of forest inventory by using laser scanning", 2012, doctoral thesis, p.98, Akademijs, Kaunas. In Lithuanian
- [14] Specifications for Forest Management Planning, State Forest Service, 2010. Miškotvarkos Darbų Vykdymo Instrukcija. Available online: <https://www.etar.lt/portal/lt/legalAct/TAR.44E2BF82EF29/asr> (accessed on 8 March 2020). In Lithuanian



ENVIRONMENTAL DATA SCIENCE SESSION

MONITORING AND PREVENTION OF FOREST FIRES USING WIRELESS SENSOR NETWORKS

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Abstract:

Forest fires as a specific type of natural hazard are steadily increasing in recent decades in the world and Serbia. The most significant negative consequences are environmental (devastation of forest ecosystems), economic (resources loss and financial damage), and social (environmental pollution, loss of human lives). Due to the numerous factors that allow the occurrence and spread of forest fires, it is necessary to use modern methods for their early detection. Many methods and safety systems have been developed to prevent and to monitor forest fires. In addition to expensive remote-sensing monitoring systems (expensive specially equipped aircraft and satellites), there are more practical solutions. Satellite system networks technology has its drawbacks, data collection is difficult or impossible due to bad weather (cloudiness, smoke). Wireless network sensors have their advantages: low cost, reliability and easy installation, wireless data transfer, and low power consumption. The system is applicable in various fields such as medicine, agriculture, security, forest fire-prevention, etc. Wireless network sensors system monitor forest fires even when they are forming, regardless of the accessibility of the terrain, the size of the space of interest, or its distance. The information collected allows for taking quick and effective action to suppress and extinguish forest fires.

Keywords:

orest fires, natural hazards, sensors, real-time assessment.

INTRODUCTION

Today, technologies are developing at a high speed, so that they have become available and popular for monitoring and prevention of natural hazards in the environment [1]. Creating and connecting to databases provides real-time data that is crucial. Data transfer is fast and high quality and is used for monitoring purposes, in smart buildings, agriculture, traffic, earthquake research, environmental protection, etc. Application in the field of environmental protection is of great importance due to the constant anthropogenic pressures that grow from year to year. The need to protect property, material goods, and nature has become a daily need of society.

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1. FOREST FIRE

One of the natural hazards that are especially dangerous for the environment are forest fires and if they are detected within 6 minutes of their outbreak, they are relatively easy to extinguish (NFDRS - National Fire Hazard Assessment System). Numerous techniques for early detection of forest fires have been developed.

The organizations, "The Center for Research on the Epidemiology of Disasters (CRED)" and "Munich Reinsurance Company (Munich RE)", based on cadastres of natural disasters and definitions, classified forest fires into a group of natural climate disasters [2], [3]. It is important to emphasize that this type of natural hazard is most common in the territory of the Republic of Serbia [4] (Table 1).

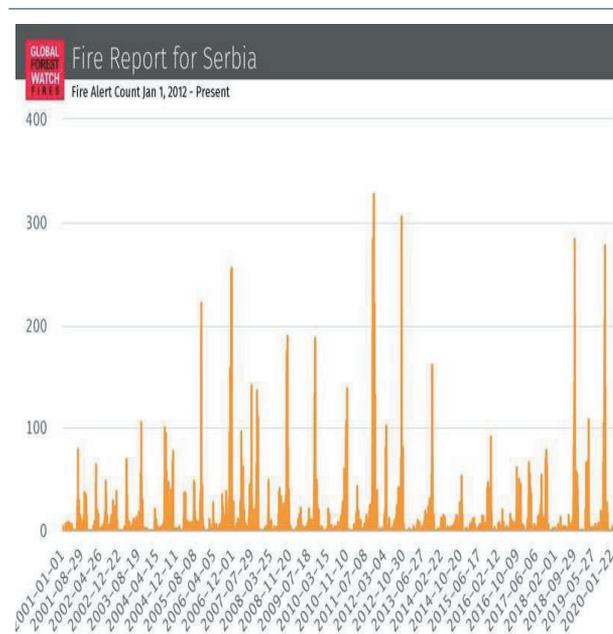


Table 1. STATISTICS ON FIRES IN THE REPUBLIC OF SERBIA FROM 2001 TO THE PRESENT (GLOBAL FOREST WATCH FIRES)

Without forest ecosystems, there would be no life on the planet as we know it today. The role of forest systems in gas exchange is well known. During the process of photosynthesis, forests absorb carbon dioxide, produce oxygen, and release it into the atmosphere. Forests are also a natural filter of the atmosphere and slow down climate change. 30% of the earth's surface (4 billion hectares) is covered by forests, while in Europe the forest cover is about 34% (193 million hectares, excluding Russia) [5]. As for the Republic of Serbia, it is considered

a medium-forested country with 29.1% under forest cover (2.25 million hectares) according to data taken from the site Serbia Forests (www.srbijasume.rs). Serbia is therefore close to the global average of 30%, but it is, therefore lower than the European average, ie. of 46% (Table 2).

		Period	2014	2017
Indicator	Territory - NSTJ			
Forested land - total [Hectare]	REPUBLIC OF SERBIA		2168746	2237511
	SRBIA – North		185436.65	193440.11
	Beogradski region		61625.27	61987.21
	Region Vojvodine		123811.38	131452.9
	SRBIA – South		1983309.35	2044070.89
	Region Šumadije i Zapadne Srbije		963740.88	980213.35
	Region Juzne i Istočne Srbije		1019568.47	1063857.54
	Region Kosovo i Metohija	
State-owned forested land [Hectare]	REPUBLIC OF SERBIA		953218	963458
	SRBIA – North		133986.07	135746.06
	Beogradski region		15242.31	15455.26
	Region Vojvodine		118743.76	120290.8
	SRBIA – South		819231.93	827711.94
	Region Šumadije i Zapadne Srbije		400580.42	403731.19
	Region Juzne i Istočne Srbije		418651.51	423980.75
	Region Kosovo i Metohija	
Privately-owned forested land [Hectare]	REPUBLIC OF SERBIA		1215528	1274053
	SRBIA – North		51450.58	57694.05
	Beogradski region		46382.96	46531.95
	Region Vojvodine		5067.62	11162.1
	SRBIA – South		1164077.42	1216358.95
	Region Šumadije i Zapadne Srbije		563160.46	576482.16
	Region Juzne i Istočne Srbije		600916.96	639876.79
	Region Kosovo i Metohija	

Table 2. THE TERRITORY OF THE REPUBLIC OF SERBIA UNDER FOREST (REPUBLIC STATISTICAL OFFICE, REPUBLIC OF SERBIA).

Suorce: www.stat.gov.rs

With the increase of the human population and the need for resources, the anthropogenic impact also increases, which creates favorable conditions for the outbreak of forest fires and uncontrolled combustion of combustible material in rural areas.

Fires are caused by a combination of physicochemical processes. The so-called "fire triangle" is formed by a combination of combustible material, air, and heat sources. The following factors have a decisive influence on the formation and movement of fires: climate, flammable material, and topography (altitude, exposure, terrain slope, terrain configuration) [6].

Forest fires are an increasingly common occurrence across the planet and are mainly responsible for anthropogenic factors (95%), although they can also occur naturally (5%) [7], [8]. Wildfires are unpredictable and difficult to control because you are usually admitted late. Forest fires occasionally have a regulatory role and contribute to the establishment of ecological balance,



but they also cause devastation within ecosystems. In addition to soil and water pollution, fires also lead to the loss of nutrients and microorganisms in the soil. When they expand, they are difficult to control. Environmental, economic, and cultural losses are difficult to compensate [9], [10].

Forest fires during the outbreak on the ground floor are mostly without a large flame, they create smoke and generate heat. For that reason, modern sensors are needed to detect this type of fire, which can detect even the smallest temperature oscillations and the presence of smoke. If ground forest fires are not detected in time, they spread and form crown fires with a strong flame. At high temperatures, the sensors are destroyed.

Forest fires are the most extreme type of forest devastation, and therefore a global problem that requires the involvement of all relevant institutions in the fight to prevent and combat them. Over 50,000 fires occur worldwide each year, leaving behind devastation. 40 million hectares of forests are destroyed in fires, leading to a reduction in the population of wildlife and large casualties [11].

Monitoring sites of interest is often not practical and possible due to the configuration of the terrain and large expanses. Therefore, the need for monitoring using modern technologies is necessary for taking measures to warn and prevent damage from forest fires. With the help of these technologies, information is quickly transmitted in real-time from inaccessible locations. By monitoring sudden temperature rises, steps can be taken effectively to prevent the spread of forest fires. The collected data can be displayed using a GIS program in the form of maps [12].

2. FIRE MONITORING TECHNOLOGIES

An overview of available technologies singled out five, with the best parameters: Wireless Network Sensors, Image and Image Processing, Satellites, Unnamed Flying Objects / Aircraft, and Radio Acoustics.

The parameters used when comparing technologies are as follows: cost, real-time convenience, mobility, energy consumption, fire spread prediction, terrain coverage, data transmission delay detection, false alarms, fire location error (Table 3).

Comparison	Wireless sensor Networks	Image and Video Processing	Satellite	UAV/ Airborne	Radio-acoustic
Cost	Low	High	Very High	High	Medium
Practicality	High	Medium	Very High	High	Very Low
Detection device mobility	Fixed	Fixed	Mobile	Mobile	Fixed
Battery power provided through	Rechargeable Devices	Rechargeable Devices	Solar	Rechargeable Devices	Rechargeable Devices
Information about fire behavior	Yes	No	Yes	Yes	No
Region of Interest	Can be extended	Limited	Complete Forest	Can be extended	Limited
Detection-notification delay	Small	Long	Very Long	Long	Small
False Alarm	Low	Medium	Very Low	Medium	High
Fire localization error	Low	High	Very High	High	High

Table 3. COMPARISON OF DIFFERENT TECHNOLOGIES FOR FOREST FIRE DETECTION BY PARAMETERS

- According to the parameter "Costs", this technology can be divided into three groups:

Taking into account the parameters of the mentioned technologies for installation and operating costs, we divided the technologies into three groups: cheap, medium, and expensive.

- 1) Cheap (Wireless Network Sensors)
- 2) Medium (Radio Acoustics)
- 3) Expensive (Image and video processing, Unnamed flying objects/aircraft, Satellites)

- According to the parameter "Practicality", this technology can be divided into three groups:

Taking into account the parameters of the mentioned technologies we divided the technology (according to the possibilities of their practical installation and use) into three groups: impractical, medium practical, and practical.

- 1) Impractical (Radio Acoustics)
- 2) Medium practical (Image and video processing)
- 3) Practical (Satellites, Wireless Network Sensors, Unnamed Flying Objects / Aircraft)

- According to the parameter "Mobility", this technology can be divided into 2 groups:

Taking into account the mobility parameters of the mentioned technologies, we divided the technologies into two groups: stationary and mobile.

- 1) Stationary (Wireless network systems, Image and video processing, Radio acoustics)



2) Mobile (Satellites, Unnamed Flying Objects/Aircraft)

• According to the parameter "Energy consumption", this technology can be divided into 2 groups:

Taking into account the parameters for the energy consumption of the mentioned technologies, we divided the technologies into two groups: rechargeable devices and solar devices.

1) Rechargeable devices (Wireless network systems, Image and video processing, Unnamed flying objects/aircraft, Radio acoustics)

2) Solar devices (Satellites)

• According to the parameter "Fire spread prediction", these technologies can be divided into 2 groups:

Taking into account the parameters of technologies for the prediction of the behavior of forest fires, we divided the technologies into two groups: anticipate the spread of fire and do not predict the spread of fire.

1) Anticipate the spread of fire (Wireless network systems, Satellites, Unnamed flying objects/aircraft)

2) Do not predict the spread of fire (Image and video processing, Radio acoustics)

• According to the parameter "Ability to cover the terrain", these technologies can be divided into 4 groups:

Taking into account the parameter for the ability of the technology to cover the terrain, we divided the technology into four groups: cannot be spread, limited, expandable, and all-terrain.

1) Cannot be spread (Wireless network systems)

2) Limited (Image and video processing, Radio acoustics)

3) Expandable (Unnamed Flying Objects / Aircraft, Radio Acoustics)

4) All-terrain (Satellites)

• According to the parameter "Detection-data transfer", this technology can be divided into 2 groups:

Taking into account the parameter for the ability of the technology for detection-data transfer, we divided the technology into two groups: a short time and a long time.

1) A short time (Wireless network systems, Radio acoustics)

2) A long time (Satellites, Unnamed flying objects/aircraft, Image, and video processing)

• According to the parameter "False alarms", this technology can be divided into 3 groups:

Taking into account the parameter for the ability of technologies to detect false alarms, we divided the technology into three groups: low, medium, and high level.

1) Low (Satellites, Wireless Network Systems)

2) Intermediate (Unnamed flying objects/aircraft, Image and video processing)

3) High level (Radio acoustics)

• According to the parameter "Fire location error", these technologies can be divided into 2 groups:

Taking into account the parameter for the ability of technologies to detect fire locations, we divided the technology into two groups: low and high.

1) Low (Wireless Network Systems)

2) High (Image and video processing, Satellites, Unnamed flying objects/aircraft, Radio acoustics)

3. WIRELESS NETWORK SYSTEMS

Based on the review of all parameters, the technology of Wireless Network Systems is derived from the others.

Wireless network sensors were developed as one of the key technologies in the twenty-first century for monitoring and tracking, data collection, and processing. Systems that use orthophotos (satellites) in detecting forest fires have their drawbacks such as weather conditions (cloud cover) and installation and technical costs. The sensor network consists of devices distributed in the field with various sensor accessories that accurately monitor the state of the environment. Data transmission is wireless, and the technology is reliable, requires low energy consumption, and is financially available to the general public [13]. It is used in hard-to-reach locations. Due to their characteristics, these systems are used in various fields - from security, medicine, agriculture, to the monitoring of the already mentioned forest fires.

The installation of the sensor is simple and there is no need for frequent human interventions. The technology is affordable. By connecting a large number of sensors, a stationary network is formed. Each sensor within the network has its identification number and is capable of wireless communication, but also of collecting, processing, and forwarding information. False alarms rarely occur due to sensor failure. Thanks to the network arrangement of sensors, we can quickly and efficiently determine wind speed, air pressure, humidity, smoke, CO₂, direction, and direction of forest fire [14].



Depending on the need, there are two types of wireless sensor networks: a system for occasional data collection (air temperature) and a system for detecting hazards (forest fire). Timely detection of forest fires is crucial to reduce damage.

The location is chosen based on the natural resource we want to protect and the potential risk of forest fires. Fires can be classified by size, frequency, shape, speed, intensity, etc. [15]. All the mentioned parameters become irrelevant if the fire is identified at the very beginning. Therefore, it is important to place the sensors at the optimal distance (about 400 sensors per square kilometer). Wireless sensors are placed along with the site at a distance of 50-150 m [16]. Each sensor within the network measures the set parameters (attributes). The sensors detect physical or chemical readings and convert them into a signal that they send to the control panel. After installation, the sensors are adjusted to the desired parameters for monitoring temperature, humidity, and wind speed. The temperature change is monitored in four ranges (20-30 °C green risk zone, 30-40 °C yellow risk zone, 40-50 °C orange risk zone, and 50-60 °C red risk zone) [17]. After calibration of the wireless sensor networks, the system connects to the database (application) with the help of which information is collected and stored. After receiving information based on real-time data processing and attributes, the competent person (Employee in charge of monitoring the database) monitors all the characteristics of the forest fire and based on them contacts the competent services (National services in charge of emergency interventions due to natural hazards). After fulfilling all the above conditions, the system is put into operation.

To establish successful monitoring of natural hazards, ie protection against forest fires, it is necessary to fulfill the following steps:

- Site selection and sensor installation
- Sensor calibration according to desired parameters
- Connecting to a database (application)
- Real-time data processing
- Direct connection with the headquarters of the competent services
- Commissioning of the system

4. CONCLUSION

The paper deals with available technologies for monitoring and prevention of forest fires. By comparing the pros and cons of the available parameters, we have singled out the technology of Wireless Network Systems. Wireless network systems allow us to monitor forest fires in real-time with the help of remote detection, regardless of the accessibility of the terrain and the size of the area of interest and its distance. Installation and commissioning of the system are extremely affordable. By monitoring the protocols, important information can be efficiently submitted to the competent services, which can act on time in crises. Natural wealth and human lives are protected in a technologically innovative way with reduced real-time risk.

REFERENCES

- [1] J. Zhang, W. Li, N. Han, J. Kan: Forest Fire Detection System Based on a Zigbee Wireless Sensor Network, *Front. For. China*, Springer Verlag, pp.369-374, 2008.
- [2] VIIRS 375m NRT - NRT VIIRS 375 m Active Fire Alert product VNP14IMGT. Available on-line [<https://earthdata.nasa.gov/firms>]. DOI: 5067/FIRMS/VIIRS/VNP14IMGT.NRT.001.
- [3] MODIS Collection 6 NRT - MODIS Collection 6 NRT Hotspot/Active Fire Alert Detections MCD14DL. Available on-line [<https://earthdata.nasa.gov/firms>]. DOI:5067/FIRMS/MODIS/MCD14DL.NRT.006
- [4] Lukić, T., Gavrilov, B. M., Marković, B. S., Komac, B., Zorn, M., Mladan, D., Đorđević, J., Milanović, M., Vasiljević, A. Đ., Vujičić, D. M., Kuzmanović, B., Prentović, R. (2013): Classification of natural disasters between the legislation and application: the experience of the Republic of Serbia. *Acta geographica Slovenica*, 53-1, pp. 149-164.
- [5] Aleksić, P., Krstić, M., Jančić, G. (2009): Forest fires – an ecological and economic problem in Serbia. *Botanica Serbica*, 33 (2), pp. 169-176.
- [6] Aleksić, P., Jančić, G. (2011): Zaštita šuma od šumskih požara u Javnom preduzeću „Srbijašume”. *Šumarstvo*, broj 1-2, strana 95-110.
- [7] E. Zervas, O. Sakkas, S. Hadjiefthymiades, C. Anagnostopoulos, Fire detection in the urban-rural interface through fusion techniques, in *Mobile Ad-hoc and Sensor Systems*, 2007. MASS 2007. IEEE International Conference on, 2007, pp. 1–6.
- [8] Radovanović, M., Pereira Gomes, J.F., (2008): Sunčeva aktivnost i šumski požari. *Geografski institut „Jovan Cvijić” SANU*, knjiga 71, Beograd.



- [9] Kre, P. Ymir, I, B. Hrvoje, V. Marin, Early forest fire detection with sensor networks: Sliding window skylines approach, 1430151 725-732 (2008).
- [10] M. Hefeeda, M. Bagheri, Wireless sensor networks for early detection of forest fires, in *Mobile Adhoc and Sensor Systems*, 2007. MASS 2007. IEEE International Conference on, 2007, pp. 1–6.
- [11] Lukić, T., Marić, P., Hrnjak, I., Gavrilov, M.B., Mlađan, D., Zorn, M., Komac, B., Milošević, Z., Marković, S.B., Sakulski, D., Jordaan, A., Đorđević, J., Pavić, D., Stojavljević, R. 10 Researches Review DGTH | 45-1, 1–10, 2016 (2017): Forest fire analysis and classification based on a Serbian case study. *Acta geographica Slovenica*, 57-1, pp. 1-13.
- [12] [12] B. S. Lee, M. E. Alexander, B. C. Hawkes, T. J. Lynham, B. J. Stocks, P. Englefield, Information systems in support of wildland fire management decision making in Canada, *Computers and Electronics in Agriculture* 37 (1-3) (2002) 185–198, DOI: 10.1016/S0168-1699(02)00120-5.
- [13] I. Kurtis Kredo, M. Prasant, Medium access control in wireless sensor networks, *Comput. Netw.* 51 (4) (2007) 961–994, 1223795.
- [14] J. Lloret, M. Garcia, D. Bri, S. Sendra, A wireless sensor network deployment for rural and forest fire detection and verification, *Sensors* 9 (11) (2009) 8722–8747.



THE CHALLENGES OF QUALITATIVE DATA SYNTHESIS FOR SOCIO-ENVIRONMENTAL ASSESSMENTS

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Abstract:

Available data regarding environmental sciences represents an extremely complex set of inputs since that field of science became one of the most dynamic areas of scientific research. Data science has a huge impact on environmental analysis, offering an abundant scope of new techniques that are used to understand even the most seldom environmental processes. There is no doubt that it is a multidisciplinary challenge because it deals with many fields such as statistics, artificial intelligence, social sciences, psychology, economics, health, etc. Environmental studies forced societies to try to answer questions regarding processes of climate change, human pressures, negative impacts on land, water, and air quality, energy efficiency, health, and food safety, biodiversity and many other aspects. In order to answer those questions, the results of qualitative data analysis must be taken into account when assessing the situation and defining measures for the improvement of particular ecosystems. The aim of this paper is to emphasize a necessity for qualitative data collecting and analyzing through presentation of some assessment examples aimed to define importance of social dimensions in environmental sustainability.

Keywords:

multidisciplinarity, processes, social dimensions, environmental sustainability.

1. INTRODUCTION

Data science is not mainly focused on understanding and managing analyzed data in the environment. Many processes and challenges in environmental science need new techniques and ways to process data. Especially when the most critical topic in today's world is climate change and its impact on life in general. This paper has a goal to determine the potentials of using data science in environmental research, and additionally to highlight crucial challenges for qualitative data analysis in environmental science.

A metonym for data science is a "big data", which gives us a complex data connotation. However, the real test is when dealing with a diversified/heterogeneous source of data. There is a great potential for data science in the environmental field, and that potential is filled with challenges that can be overcome with new techniques and approaches [1].

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Understanding the environment represents a multidisciplinary task which includes ecologists, hydrologists, pedologists, biologists, chemists, physicists, and analysts, along with political science which enhances the impact of social sciences in the processes. How big of an impact social science have, can be shown by an example of natural capital and ecosystem services [2].

Natural capital is mainly focused on water, soil, air, energy resources, and living beings, while ecosystem services are primarily focused on sustainable and integrated management of complex ecosystems and all of their aspects, including ecological, social and economical [3].

This shows how much environmental science depends on data [4] (like most other science fields), which leads to a transparent and exact science approach.

It is essential that environmental science effectively integrates data science in its work process, and to look up to branches of science which are more advanced in collaborating with data science, e.g. physics [5] and bioinformatics [6].

These suggestions open up a lot of questions and can start a lot of debates. Most of those questions are related to the integration of the complex sets of data, which have to be transformed in an agreeable collection of new findings which can be later applicable in practice. Most of the practice includes strategies, frameworks, policies, management plans and possible solutions for a series of challenges that environmental science deals with every day.

It is obvious that the relationship between data science and environmental science should be strengthened, and there is no doubt that they should become a symbiotic entity.

2. HETEROGENEOUS DATA CHALLENGES

Challenges and obstacles in data usage are different and can depend on the area of the science studied, however, the main factor which determines that level is diversity in main sources, along with the type of the data involved. Data science most often is identified with data's four Vs: volume, velocity, variety, and veracity [7].

Data from environmental science comes from many different sources, and the processes are supported by many innovations during the collecting:

1. A large number of data is collected through a remote sensor, by observing the environmental area without interfering in one's life flow. It is usually done by using satellite imaging, airplane

imaging, and pilotless aircrafts imaging. These types of research include passive activities such as photo and infra-red images, and active actions like LIDAR or Radar, LandSat NASA, and many others [8].

2. Systems and technologies for observing the Earth which uses sensors for collecting data from all layers of the atmosphere: lithosphere, biosphere, hydrosphere, and cryosphere. System based on these technologies is occasionally obtaining the data, although today more often is a real-time obtaining through long-distance transfer. Internet of Things (IoT) is playing a big role in observing the natural environment by using the sensors for real-time data [9].
3. Data obtained through fieldwork is kept growing. The precision of the collected data during the field trip is high in accuracy and a good example is a mobile application in a field of biodiversity called Big Garden Bird Watch [10].
4. Historical records are of great importance for environmental sciences because many of them are digitalized. However, there is still a lot of data that is not digitalized especially on the local level.
5. The analytical approach in the research regarding modern ecology is extended through web platforms such as social media. Many examples show how social media can be used to inform the community about potentially dangerous events like floods, severe weather storms, and many other natural disasters.

Reliability of the data in environmental science is under a question mark. That is the case, especially when dealing with the data collected from local communities. That kind of data can differ based on the common knowledge of the participants of the survey. Also, it is very important to mention that sometimes data obtained through satellite imaging can be less accurate than the data obtained during the fieldwork. Another problem arises from cheap equipment which becomes less and less reliable but easy to acquire.

Diversity of the data in environmental science indicates that we need a way to creatively use data sources, on the other hand, it urges us to connect different sets of findings. The challenge of data in environmental science is the most prominent when one's trying to reach a higher level of the interfering of a couple of sources during the data collection.



Eionet - European information and observation network, which works alongside with EEA (European environmental agency), has a great role in Serbia for integrating the monitoring and reporting on the field. The EEA web of the agencies is made of many European centers, 900 experts from 37 worldwide countries, over 300 national agencies along with other entities which deal with environmental issues.

One of the most significant focuses of information systems is collecting data based on indicators in the environment and their impact on human health, as well as connecting with the World Health Organization (WHO) and their Environmental Health Information System (ENHIS). One of the goals of that department of WHO is to estimate the effect of climate change on human health as well as creating protection measures.

ENHIS is mostly focused on the connection between human health and environmental issues. One of the greatest challenges in this area of interest is the fact that indicators of the status of the environment can differ from the general health conditions of the population.

There are potentially useful, but insufficiently used, qualitative data collected through surveys conducted within local communities with the aim of assessment of social issues relevant for environmental protection and human health [11].

3. QUALITATIVE DATA ANALYSIS EXAMPLE

Research conducted was focusing on professional opinions regarding ecological and economical instruments along with systems of environmental protection. The research was carried through with online surveys sent to 300 e-mail addresses. In the end, 236 surveys were returned filled [12].

Participants are representatives of local government offices, civil society organizations, scientific and research institutions in Serbia.

All the data was collected using Google Forms and stored into Google tables. Cookies were used to ensure that one IP address can deliver one survey.

Questions with numeric (ranking) answers were analyzed in Microsoft Excel, while all answers on open-ended questions were analyzed in NVivo 12 Plus¹ software. It was a useful tool for presenting all kinds of answers for open-ended questions. In that software, answers were coded into categories and analyzed based on the obtained results.

1 NVivo 12 Plus - <https://www.qsrinternational.com/nvivo/nvivo-products/nvivo-12-plus>

For example, one open-ended question in this survey was: *Who should finance environmental protection?*

All the answers were coded in a category relevant to respondents' opinions. In the end, there were seven categories including government, polluters, local community, non-governmental organizations, international organizations, all together and others.

Fig. 1. shows the results for this question, analyzed using NVivo 12 Plus software and presented as a word cloud.

The analysis shown above cover only one open-ended question. Not only that it presents us with the complexity of the research, but also it illustrates how difficult it is to plan appropriate measures for improvement in the field of environmental protection.



Fig. 1. -Who should finance environmental protection?

The analysis of quality data show that 71.6% of stakeholders think that the expenses for the protection of the environment should be financed by all members of the community (polluters, government, local communities, international organizations, NGOs and others).

Other questions from the survey, which are not shown in this publication, clearly point out the fact that this answer is far from reality. Financial support is currently obtained from polluters and the government for most of the environmental issues. In order to declare responsibilities for each individual to finance protection of the environment in exchange for gaining profit through certain production or processing, it's necessary for quantitative data of environmental impact to exist, especially in the area where such action is happening. Monitoring of the environment is a necessary part of the process of determining the financial obligations of certain parties for the needs of protection of the environment.



On the other hand, existing data regarding the status and intensity of pollution, which are emitted by certain parties, (even the ones who are pretty well systematized) does not necessarily mean much, especially if the local community did not get them serious and accepted them as relevant. The current government stand is that parties who pollute the most should be the ones who finance the protection of the environment.

However, local communities, civil sector and scientists all agree that financing for the protection of the environment should be the responsibility of everyone in that community or country. The ultimate goal of each research is to create a summary for policymakers, which will give a proper pathway for them, but only if they are based on integrations of quantitative and qualitative data of socio-environmental researches.

4. QUANTITATIVE DATA ANALYSIS EXAMPLE

For the purpose of getting better insights on how different reality can be, quantitative analysis was conducted with questions which include ranking series. These kinds of questions were able to draw the answers which will eventually show the real difference between subjective feelings and objectives of the reality.

Quantitative data analysis shown in the Fig. 2. included participants from many different educational backgrounds. From individuals with secondary education to individuals with Ph.D. degree.

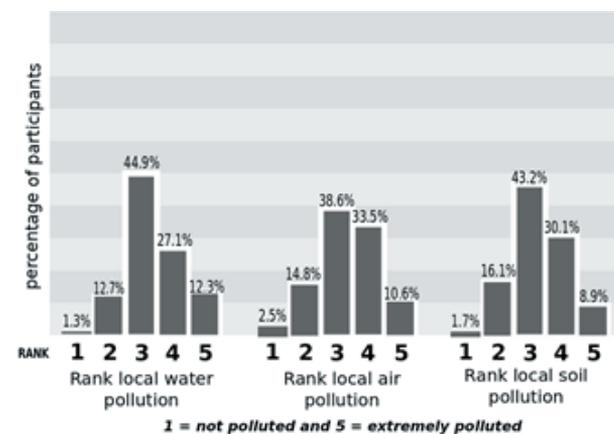


Fig. 2. – Participants ranking the water, air and soil pollution, in their own opinion.

Results were, as expected, an overlap between subjective feelings and objectives of the reality. As it can be inferred from the Fig. 2., greater percentage of participants

ranked water, air and soil pollution to be in the higher level of 3 and 4 on a scale of 5. On the other hand, just a few participants marked levels of 1 on the scale, and levels 2 and 5 were marked approximately in the same percentage.

These results were really important to show the awareness of the people in Republic of Serbia, regarding environmental protection. It shows just how much global influence through mass and social media sculpts the minds of society. However, information given by the public institutions is most of the time rare and with a lack of details. Field of environmental studies should focus more on improving the channels for distributing valuable and accurate information regarding, if possible, real time data for all people interested in current status on environmental issues, whether those individuals are environmental professionals or citizens.

There is a huge data, measured from different environmental branches, but most of those results are not analyzed and therefore the real picture and status of the environment can not be established.

Fortunately, the difference between today's assumptions regarding status of the environment and real-time results is not significant. Still, there needs to be better cooperation between data science and environmental science in order to obtain and publicize results with certain scientific weight. Better and more improved data science technologies can help with that, so this kind of surveys can be taken on another level where all results will have a bigger impact on the subject.

5. CONCLUSIONS

Environmental science, along with physics, chemistry, biology, geosciences, biophysics, physical chemistry, etc., belongs to the basic natural science sector [13]. What makes it even more complex is the fact that it is a multidisciplinary science, which brings a certain level of responsibility to properly answer most of the miscellaneous questions. To answer those questions, researchers need to use a wide spectrum of analytical instruments. Those instruments can include processes such as data collecting, processing, and analysis, management and diagnostics.

Furthermore, it can be concluded that modern ecological reality requires a high level of understanding of the systems of the environment, which brings us back to the multidisciplinary approach for this branch of science [14].



The great challenge still remains to be the management of complex data, including interaction, crossing and using data from many different systems and fields of study.

The integration of data from environmental science is exceptionally important because we have a diversity of inputs from different sources. A new type of science emerged, which will have new approaches to overcoming those challenges [15].

The road towards a new type of science demands new incentives, which can be important for developing in a field of research. That included adaptive approaches in sampling and data collection. Furthermore, it will include adaptive modelling along with new techniques that are going to correspond with more complex and diverse environmental data, including data streaming in real-time [16].

Above all, the integration of qualitative data analysis into an environmental quality monitoring system is very important for assessing the socio-ecological status of a particular area.

To strengthen the symbiotic connection between data science and socio-environmental science takes time, however, that relationship could be a basis for further improvement of environmental policy making process.

REFERENCES

- [1] D.A. Reed and J. Dongarra, "Exascale computing and big data", *Commun. ACM* 58, pp.56–68. doi: 10.1145 / 2699414, (2015).
- [2] M. Potschin, R. Haines-Ioung, R. Fish, and R. Kerri Turner, "Routledge Handbook of Ecosystem Services", New York, NY: Routledge, (2016).
- [3] F. Muller, R. de Groot, and L. Villemen, "Ecosystem Services at the Landscape Scale: the Need for Integrative Approaches", doi: 10.3097 / PO.201023, (2010).
- [4] T. Hey, S. Tansley, and K. Troll, (eds.). "The Fourth Paradigm: Data-Intensive Scientific Discovery", Microsoft Research, (2009).
- [5] C.L. Philip Chen, and C.I. Zhang, "Data-intensive applications, challenges, techniques and technologies: A survey on Big Data", *Inf. Sci.* 275, 314–347. doi: 10.1016 / j.ins.2014.01.015, (2014).
- [6] C.S. Greene, J. Jie Tan, M. Ung, J.H. Moore, and C. Cheng, "Big Data Bioinformatics", *J. Cell. Physiol.* 229, 1896–1900. doi: 10.1002 / jcp.24662, (2014).
- [7] H.V. Jagadish, J. Gehrke, A. Labrinidis, Y. Papakonstantinou, J.M. Patel, and R. Ramakrishnan, "Big data and its technical challenges". *Commun. ACM* 57, 86–94. doi: 10.1145/2611567, et al. (2014).
- [8] E.S. Langley, A.A. Leeson, C.R. Stokes, and S.S.R. Jamieson, "Seasonal evolution of supraglacial lakes on an East Antarctic outley glacier", *Geophys. Res. Lett.* 43, 8563–8571. doi: 10.1002/2016GL069511, (2016).
- [9] V. Nundloll, B. Porter, G.S. Blair, B. Emmett, J. Cosby, and D. Jones, "The design and deployment of an end-to-end IoT infrastructure for the natural environment", *Future Intern.* 11:129. doi: 10.3390/fi11060129, et al. (2019).
- [10] M.A. Godard, A.J. Dougill, and T.G. Benton, "Scaling up from gardens: biodiversity conservation in urban environments", *Trends Ecol. Evol.* 25, 90–98. doi: 0.1016/j.tree.2009.07.016, (2010).
- [11] D. Indić, M. Terzić, and M. Ivanković, "Informacioni sistemi u upravljanju rizicima u životnoj sredini", *Vojnotehnički glasnik*, Vol. LXI. No. 1, pp. 210-225, DOI: 10.5937/vojtehg61-1678, (2013).
- [12] M.R. Adžemović, A.Z. Šašić Ivanović, D.M. Nikolić, J.D. Aleksić, and R.M. Stevanović, "Redesigning current instruments as a precondition for a more effective environmental protection", *Chemical Industry*, 71(4):343-350. DOI: 10.22987HEMIN-D160620045A, (2017).
- [13] E.D. Ender and B.F. Smith, "Environmental Science – A Study of Interrelationships", 11th edition, Mc Graw-Hill International Edition, New York, (2008).
- [14] A. Mihajlov, A. Jovanović, F. Jovanović and Hristina Stevanović-Čarapina, "Reporting by selected Analytical Tools for Environmental Management: Hazardous waste management in South Eastern Europe", *Journal of Environmental Protection and Ecology*, 12(2), pp. 565-569, (2009).
- [15] S.L. Cornford, D.F. Martin, D.T. Graves, D.F. Ranken, A.M. Le Brocq, R.M. Gladstone, and W.H. Lipscomb, "Adaptive mesh, finite volume modeling of marine ice sheets", *J. Comput. Phys.* 232, 529–549. doi: 10.1016/j.jcp.2012.08.037, et al. (2013).
- [16] G.S. Blair, P. Henrys, A. Leeson, J. Watkins, E. Eastoe, S. Jarvis, and P.J. Young, "Data Science of the Natural Environment: A Research Roadmap", *Front. Environ. Sci.* 7:121. doi: 10.3389/fenvs.2019.00121, (2019).



UTCI BASED ASSESSMENT OF URBAN OUTDOOR THERMAL COMFORT IN BELGRADE, SERBIA

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Abstract:

The main purpose of this research is to assess the outdoor thermal comfort (OTC) of Belgrade, in order to investigate how distinct bioclimatic conditions influence on the human organism during the summer in urban environments. Universal Thermal Climate Index, which represents the heat stress of the human organism caused by meteorological conditions, was used as an indicator of thermal comfort in the study. The main goal was to monitor changes in the index values, as well as the frequency of various categories of thermal stress during the hottest part of the year (months June, July, and August). For this research, mean daily meteorological data from the Meteorological Observatory Belgrade have been collected for the period from 1999 to 2018. The obtained results show a gradual change in the bioclimatic conditions, which are generally more adverse in July and August. Results also indicate that OTC in Belgrade was considerably reduced, especially in 2007, 2012, 2015, 2017, and 2018..

Keywords:

UTCI, outdoor thermal comfort, urban environments, Belgrade .

INTRODUCTION

Extreme weather conditions are one of the most common consequences of climate change, as a global threat [1]. It is followed by the severe biometeorological conditions that can have a strong impact on public health and quality of life in urban areas. In addition, it has a serious impact on thermal comfort (which can be outdoor or indoor). The generally accepted definition of thermal comfort is: "it is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation" [2].

Findings of Geletič et al. [3,4] have shown that in Central Europe and other European regions, heat-related hazards such as extreme temperatures, heatwaves, tropical days and nights will become more frequent during the 21st century. Cities, as the areas where the increase in population density is pronounced and in which a larger amount of heat accumulates due to various anthropogenic factors, are prone to the emergence

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of urban heat islands (UHI) and heat-related hazards [4]. That is the main reason why the issue of outdoor thermal comfort (OTC) in urban areas has become the subject of numerous studies. Among currently conducted studies and applied indices, the Universal Thermal Climate Index (UTCI) is increasingly popular [1]. UTCI is claimed to be a universal thermal index that can be successfully applied in the evaluation of open spaces in different geographical areas [5]. According to Binarti et al. [6] the UTCI multi-node model is very precise “in replicating the human dynamic thermal response under a wide range of thermal environments”.

OTC in urban environments, its perception, and its varieties due to different climate zones fascinate and attract many authors worldwide, and as a consequence significant improvement was made and achievements were noticed in this science field after the year 2000 [7]. The application of UTCI for this purpose is very common. Kolendowicz et al. [8] have applied this index in order to evaluate bioclimatic conditions in the area of the southern Baltic coast, for the period 1981–2014. Lam and Lau [7] have examined the divergence in thermal perception and way of dressing between inhabitants from two different climate regions (Melbourne and Hong Kong) over similar UTCI ranges in summer. Bröde et al. [9,10] have applied this index to assess the outdoor urban thermal comfort of the city of Curitiba (Southern Brazil). Abdel-Ghany et al. [11] have studied different thermal indices (among them UTCI) to assess the arid environment of the central region of Riyadh, Saudi Arabia. In a study conducted by Mölders [12], hourly UTCI values were determined, based on meteorological data from 456 stations in Alaska, eastern Russia, and northwestern Canada over a period of 38 years (1979-2017). The UTCI based assessment of bioclimatic conditions of urban areas in Europe has been the subject of numerous research papers and projects so far [1,6,13,14,15,16]. In recent years, urban OTC in Western Balkan countries was investigated in several studies, and its perception in many cases was evaluated through UTCI [15,17,18,19,20].

This scientific field is in a phase of accelerated development, because of the increasing consequences of climate change, the negative effect of global warming, and the worsening of living conditions in big cities. As Pantavou et al. [16] have mentioned, the estimation of urban thermal comfort is pivotal in the foundation of efficient health warning systems and planning public spaces in cities.

1. STUDY AREA

Belgrade, the capital and largest city of Serbia, is located on the Balkan Peninsula in Southeast Europe. Geographically, it lies on the Sava and Danube river bank (Fig. 1), near the Mountain Avala (511m) and it belongs to a continental climate region. Summers are warm and maximum temperatures are most commonly recorded during July and August, while the minimum temperatures are most commonly recorded in January [21]. Belgrade's climate is considered to be a Cfa type (a humid subtropical type of climate) according to the Köppen-Geiger climate classification. An average annual temperature observed in the city for the period from 2000 to 2017 was 13.4°C [22]. The increase in daily temperature in Belgrade is evident, and it is additionally influenced by the existence of an urban heat island [17].

According to the Statistical Office of the Republic of Serbia [23], the city municipality of Vračar, which covers an area of just 3 km², is the most densely populated part of Belgrade, with 19 285 inhabitants/km² (in total 57 856 dwellers in 2019). It is also a highly urbanized zone, characterized by a lack of open green spaces (Fig. 2). Placed in this environment, the meteorological station Meteorological Observatory Belgrade (western Vračar, 44°48'N, 20°28'E, 132m) gives us meteorological data which best reflects the bioclimatic conditions that occur in the central urban areas [19].



Fig.1. Central urban zone of Belgrade - City municipalities Vračar, Stari grad and Savski venac



Fig. 2. The city municipality of Vračar

One of the most significant results of scientific cooperation within the “European COST Action 730” network is the presentation of the Universal Thermal Climate Index, which has significantly improved human biometeorology as a science [10]. The advantages of this index were also recognized by the World Meteorological Organization (WMO) [8]. Since then, the application of the UTCI has become increasingly common, both in scientific and epidemiological researches and in fields such as the development of health warning systems, urban and spatial planning, etc. Thanks to that, this index is slowly gaining the status of “an internationally standardized instrument for the assessment of thermal environments” [24].

The UTCI (°C) combines both meteorological and physiological parameters for the determination of thermal comfort through the evaluation of human energy balance [25]. All physiological parameters used in this study were determined and defined by international standards and previously conducted scientific tests. As for the physiological parameters, they refer primarily to the metabolic processes in the human body. This kind of process produces heat in the organism that is continuously exchanged with the immediate surroundings. By virtue of this capability, the human body manages to maintain constant body temperature [13,14,17,18,24,25].

According to the ANSI/ASHRAE Standard 55 [2,18] “MET” is defined “as a measure of physical activity and it corresponds to the release of human heat of $58.2\text{W}\cdot\text{m}^{-2}$ from an average skin surface area of an adult (1.8m^2), i.e. it is equivalent to the energy rate generated per unit surface area of an average person at rest. Further, ISO 8996 [26] has defined the standardized value of the metabolic heat energy (M) which amounts to $135\text{W}\cdot\text{m}^{-2}$ (2.3MET), for a person moving at a speed of $1.1\text{m}\cdot\text{s}^{-1}$ ($4\text{km}\cdot\text{h}^{-1}$).

In this research, the UTCI-Fiala multi-node model of human thermoregulation integrated with an adaptive clothing model was used for the simulation of the human reaction [18,27]. UTCI can most easily be explained as “the air temperature of the reference environment which produces an equivalent dynamic physiological response under a set of reference conditions” [9,10,18]. This model actually helps us to understand and then simulate the reactions that take place in human skin and lead to the sweat production, e.g. during excessively warm periods when the body tries to maintain balance and constant temperature [13,25]. In addition, UTCI is “the air temperature of a reference environment that would cause in the human body the same UTCI-Fiala model’s response as the genuine environment” [14,18]. It is also important to mention that the conditions of the reference environment used in this paper are confirmed in previously conducted research by various authors [10,13,14,18,24,25,28].

According to this model, there are 10 categories of cold and heat thermal stress, which are shown in Table I. The UTCI equation (1) is:

$$UTCI = f(t, f, v, t_{mrt}) \quad (1)$$

In this function, “ t (°C)” represents air temperature, “ f (%)” is relative humidity, “ v (m/s)” is wind speed, and “ t_{mrt} (°C)” is mean radiant temperature. For this occasion, we additionally included another one meteorological parameter – cloudiness “ N (in % or in octants)”, in order to obtain more precise calculations.

UTCI thermal stress classification	
UTCI (°C)	Stress category
$UTCI > 46$	Extreme heat stress
$38 < UTCI < 46$	Very strong heat stress
$32 < UTCI < 38$	Strong heat stress
$26 < UTCI < 32$	Moderate heat stress
$9 < UTCI < 26$	No thermal stress
$0 < UTCI < 9$	Slight cold stress
$-13 < UTCI < 0$	Moderate cold stress
$-27 < UTCI < -13$	Strong cold stress
$-40 < UTCI < -27$	Very strong cold stress
$UTCI < -40$	Extreme cold stress

Table 1. UTCI thermal stress classification

Source: [13,25]



Determination of a certain UTCI thermal stress was based on the meteorological data set, which was retrieved from the Republic Hydrometeorological Service of Serbia. The data set consisted of twenty Meteorological Yearbooks (from 1999 to 2018). Each Meteorological Yearbook was the source of the mean daily values of meteorological parameters (t, f, v, N) used in this study [29]. The mentioned data were recorded at the Meteorological Observatory Belgrade (the station is located in the area called “western Vračar”). Software Bioklima 2.6, developed by Prof. Krzysztof Błażejczyk, was used as a tool for UTCI calculations [30].

3. RESULTS

Abdel-Ghany et al. [11] have defined human thermal comfort “as a condition of mind, which expresses satisfaction with the surrounding environment”. Additionally, they singled out high temperatures and humidity as the main reasons that cause heat stress [11]. These microclimatic indicators are those that determine outdoor thermal comfort. How people feel in the environment, has a strong impact e.g. on working performance, lifestyle, health, etc. Under the influence of intensive urbanization, morphological characteristics and other factors, the air temperature in cities is almost always higher in relation to the temperature measured in the surrounding rural areas [31]. Battista et al. [31] have estimated that for the medium-sized cities difference in air temperatures amounts between 0.5°C and 3°C . This can reduce OTC, provoke health problems, and reduce the energy efficiency of buildings [5,32]. Furthermore, reduced OTC may have an indirect impact on indoor environments, interfering with indoor thermal comfort or enhancing/reducing energy loads for air conditioning [9,10].

As already mentioned, Belgrad’s climate belongs to the Cfa climate type (a humid subtropical climate). According to Binarti et al. [6] the humid tropical and subtropical climate covers a vast area of the globe, which is inhabited by more than 33% of the world’s population. Berger [33] has noted that UHI occurs in cities belonging to this climate twice as much as cities in other climatic zones. That is the main reason why Belgrade was chosen as a study area for the research.

The research was conducted in two phases. First, authors have observed the different index values and categories of thermal stress on a daily basis, year after year. In the second part, we have analyzed separately the first (1999-2008) and second decade (2009-2018) to gain insight into what long-term changes of OTC can be expected in the future.

Figure 3, 4, and 5 show the ratio of the total number of days for each category of thermal stress during the investigated period (June – August, 1999–2018). Fig. 3 distinctly shows that in June outdoor thermal comfort is the most favorable during the summer season in Belgrade. June is the only month where the results showed the presence of the cold thermal stress. The minimum value of the index was recorded on 9th June, 2005 ($\text{UTCI} = -3.75^{\circ}\text{C}$). After 2005, cold stress during summer in Belgrade was not recorded (regarding the mean daily values of meteorological parameters that were used in this study). On a mean daily level, the prevalent category of thermal stress (during all three months) is the one where the values of UTCI are between 26°C and 32°C , which means that people outdoors feel „moderate heat stress“. Comparing these three months, we can also conclude that during June, the days with „no thermal stress“ most often occur ($9 < \text{UTCI} < 26$).

At first glance, we can see that the OTC in Belgrade has been noticeably reduced, mainly in July and August (Fig. 4 and 5). It can be concluded that the weather conditions during July and August lead to unfavorable bioclimatic conditions, and as a result of that in many cases, UTCI value on a daily level belongs to the categories of “moderate” ($26 < \text{UTCI} < 32$) and “strong” ($32 < \text{UTCI} < 38$) heat stress. However, the presence of strong heat stress varied over the years, especially in August 2018, when 16 days with “strong heat stress” were recorded (of which 5 and 7 consecutive days), while in August 2002, 2004 and 2005 only 2 days were recorded (in each year). According to this category of thermal stress as adverse years 2017 (14 days), 2015 (12 days), and 2012 (12 days) also stand out.

Prolonged periods of high temperatures in July 2007, enabled the occurrence of the longest heat stress event during these 20 years, with 10 consecutive days when the daily index value was over 32°C . In July 2007, there were 15 such days in total. The second-longest heat stress event, with 8 consecutive days in the category of thermal stress between 32°C and 38°C , occurred in July 2012. In total, in July 2012, there were 14 such days. According to the Republic Hydrometeorological Service of Serbia [29], the year 2012 was the second hottest year since 1951. What is even more interesting, since 2007, an obvious reduction in the number of days without thermal stress was registered, i.g. in 2012 and 2016 there were just 3 days in that category. In 2017, only 1 day with “no-thermal stress” was registered, while in 2018 there was no such day.



Analyses of input data and obtained results have shown the increasing frequency of extreme summer temperatures. Also, an increase in UTCI values was noticed over a 20-year period. As regards the thermal stress category of “very strong heat stress” (where the index value is between 38°C and 46°C), there were five cases when UTCI has overstepped its threshold: in 2000 (UTCI=38.3°C, 4th July), in 2002 (UTCI=38.17°C, 24th June), in 2007 (UTCI=39.38°C, 22nd July), in 2013 (UTCI=38.49°C, 29th July), and 2017 (UTCI=38.47°C, 5th August). The mean daily values of UTCI were also high in 2012 and 2015, when they almost reached 38°C. The highest UTCI value during the whole investigated period was registered on 22nd July 2007 (39.38°C). As stated by Tošić et al. [22] just two days later, on 24th July 2007, a record temperature of 43.6°C was registered, which was the highest recorded temperature in Belgrade in the past 120 years.

The findings in this paper are in keeping with the other papers which have studied different phenomena connected with weather conditions. For instance, in terms of extreme weather conditions in Serbia, Unkašević and Tošić particularly singled out the heatwave that lasted from 14th to 27th, July 2007 [34]. Unkašević et al. [21] have been investigated trends in extreme temperatures in Belgrade from 1975 to 2003 to estimate how an increase in the mean summer temperatures is linked to changes in the extreme maximum and minimum temperatures. It is believed that the rising average seasonal temperatures are connected with a significant increase in the occurrence of extreme maximum temperatures [21]. Furthermore, the findings of Unkašević et al. [21] show that the average summer temperature in Belgrade has increased by 0.1316°C/yr. As Đorđević claims [35], in observed period from 1957 to 2006 the rise of an average, maximum and minimum annual air temperature in Belgrade was significant. In addition, Tošić et al. [22] recognized the year 2012, followed by 2007, 2011, and 2017, as a year with a maximum number of fires within a period of 18 years (2000–2017). Moreover, a high possibility of fire contingency in Belgrade was present almost every year after 2007 (with the exception of 2014) [22].

Comparing two decades 1999–2008 and 2009–2018, the results showed a decline in the number of days defined as days “without thermal stress“, when UTCI mean daily value was between 9°C and 26°C. On the other hand, there was an increase in all other categories distinguished by a higher degree of thermal discomfort. If we look at the data obtained for August (Fig. 5), we can see that the number of days in “strong heat stress” category rose from 64 (1999–2008) to 91 (2009–2018)

which means almost 30% of the increase. Simultaneously, the number of days with “no-thermal stress“ (9<UTCI<26) in August decreased by more than 50%, from 80 (1999–2008) to only 36 (2009–2018). In addition, we have registered, for the first time in these 20 years, a day with “very strong heat stress“ in August, and what is more important is that it was the maximum summer value of UTCI in 2017.

We have similar results for July. For example, UTCI in “moderate“ and “strong heat stress“ category records a constant growing tendency - from 149 (1999–2008) to 161 (2009–2018) for moderate, and from 79 to 104 for strong heat stress (increase of 24%). Concurrently, there was a 47% drop in the total number of days with “no-thermal stress“ (from 80 to 42 such days) (Fig. 4).

Slightest changes were observed in June. The number of days with “moderate heat stress“ is almost the same - 157 such days in the first decade, and 158 in the second. Some changes can be noticed regarding the days without thermal stress, where a decrease was recorded (from 98 to 92). Also, in the category of strong thermal stress, an increase was registered (from 42 to 50 such days).

All of the above gives us a verification that the OTC in Belgrade has been reducing in the last 20 years.

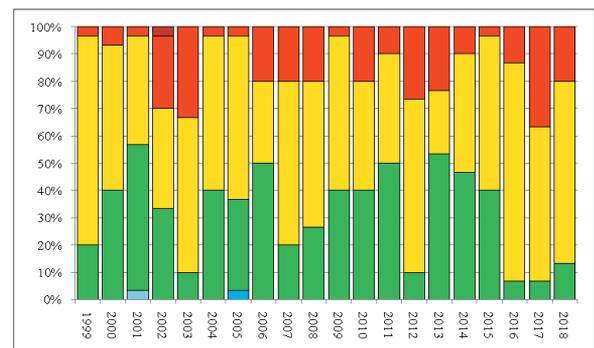


Fig. 3. UTCI thermal stress categories in total, June 1999-2018

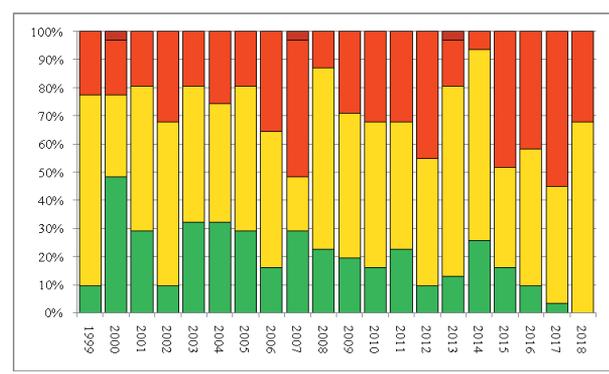


Fig. 4. UTCI thermal stress categories in total, July 1999-2018

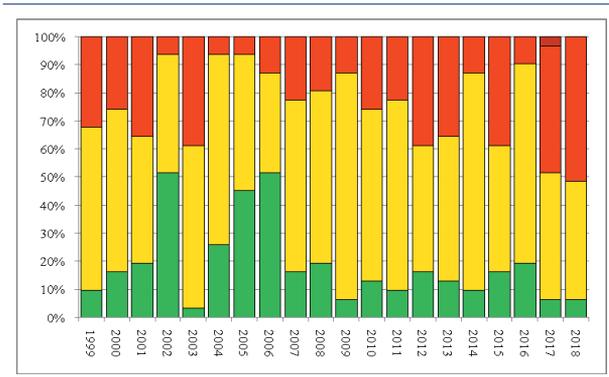


Fig. 5. UTCI thermal stress categories in total, Aug 1999-2018

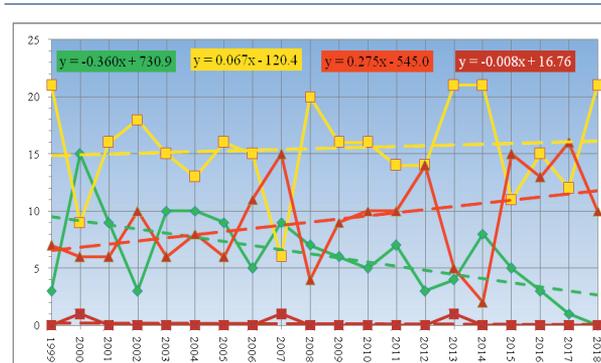


Fig. 6. Trendline - number of days for each thermal stress category of UTCI, Belgrade, July 1999-2018

Considering that some of the most significant changes in terms of outdoor thermal comfort in Belgrade have occurred in July and August during the period from 1999 to 2018, these two months were further analyzed. Fig. 6 and 7 show the trendline of the number of days for different categories of thermal stress according to UTCI. Table II shows the annual values of the growing or descending trend of a particular thermal stress indicator. By analyzing the obtained graphs, the following can be concluded: the crucial changes of OTC in Belgrade are connected to the “no-thermal stress” and “strong heat stress” categories. The green trendline shows a constant decline in the number of days without thermal stress from 1999 to 2018, with an annual trend of -0.36 days/yr in July, and -0.272 days/yr in August. On the other hand, the highest growth trend was recorded in July in the “strong heat stress” category (red trendline), amounting to 0.275 days/yr. August follows, with a growth trend of 0.229 days/yr. During August, the category “very strong heat stress” manifests a slight growing tendency (0.012 days/yr), which confirms that the bioclimatic conditions in Belgrade are subject to change, leading to more uncomfortable OTC.

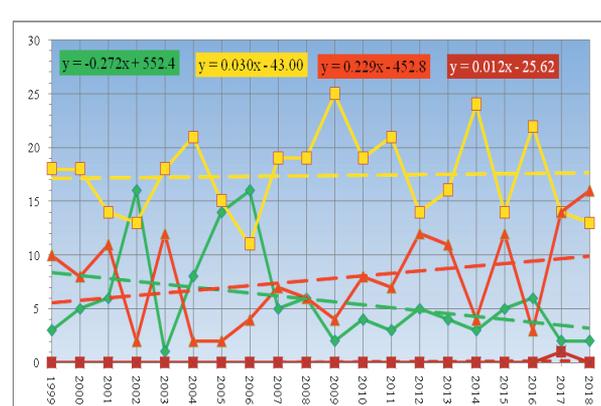


Fig. 7. Trendline - number of days for each thermal stress category of UTCI, Belgrade, August 1999-2018

Annual trend (days/yr) for July and August, 1999-2018		
Heat stress category	July	August
No thermal	-0.36	-0.272
Moderate	0.067	0.03
Strong	0.275	0.229
Very strong	-0.008	0.012

Table 2. Annual values of the growing or descending trend of a particular thermal stress indicator, Belgrade, July and August

4. CONCLUSION

The primary aim of this study was to evaluate the OTC of the central urban zone of Belgrade during the hottest summer months. Outdoor thermal comfort assessment, for the period from 2009 to 2018, was conducted by using UTCI, a heat budget index, which represents the heat stress of the human organism caused by meteorological conditions. The obtained results enable better insight and understanding of how climate change affects local bioclimatic conditions in urban areas. We can also see how outdoor thermal comfort in Belgrade becomes more and more unpleasant, year after year, especially after 2007.

The increasing temperature (annual and mean daily) and extreme summer temperatures, prolonged heatwave periods, Belgrade’s UHI phenomenon, aerosols, air pollution (cause of the greenhouse effect), lack of “green architecture” and open green spaces in the central part of the city, high urbanization and other anthropogenic impacts lead to reducing of OTC. All of this has a strong



and negative impact on the human organism, public health and the quality of life in Belgrade. OTC causes discomfort predominantly during July and August. In the twenty-year period, 2007, 2012, 2015, 2017, and 2018 stands out as the most adverse ones. The year 2007 can be marked as a “turning point”, because after this year days without thermal stress are in permanent decrease, with an annual trend of -0.36 days/yr in July, and -0.272 days/yr in August, while the number of days that belongs to other categories of heat stress is on the rise. The highest growth trend of 0.275 days/yr was observed in July. The maximum index value during the investigated period was 39.38°C (22nd July 2007), while the minimum value was -3.75°C (9th June, 2005). That was an isolated case of “moderate cold stress“, and after 2005, cold stress during summer in Belgrade was not recorded.

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REFERENCES

- [1] A.M. Tomczyk, and M. Owczarek, “Occurrence of strong and very strong heat stress in Poland and its circulation conditions”, *Theor. Appl. Climatol.*, vol. 139, pp. 893-905, 2020.
- [2] ANSI/ASHARE Standard 55: Thermal Environmental Conditions for Human Occupancy, ANSI/ASHRAE Approved, available at: <http://www.techstreet.com/ashrae/standards> (last access: 21st April 2020), 2017.
- [3] J. Geletič, M. Lehnert, P. Dobrovolný, and M. Žuvela-Aloise, “Spatial modelling of summer climate indices based on local climate zones: expected changes in the future climate of Brno, Czech Republic”. *Clim. Chang.*, vol. 152 (3–4), pp. 487–502, 2019
- [4] J. Geletič, M. Lehnert, and M. Jurek, “Spatiotemporal variability of air temperature during a heat wave in real and modified landcover conditions: Prague and Brno (Czech Republic)”, *Urban Climate*, vol. 31, pp. 100588, 2020.
- [5] R. Aghamolaei, M. Mehdi Azizia, B. Aminzadeha, and P.A. Mirzaei, “A tempo-spatial modelling framework to assess outdoor thermal comfort of complex urban neighbourhoods”, *Urban Climate*, vol. 33, pp. 100665, 2020.
- [6] F. Binarti, M.D. Koerniawan, S. Triyadi, S.S. Utami, and A. Matzarakis, “A review of outdoor thermal comfort indices and neutral ranges for hot-humid regions”, *Urban Climate*, vol. 31, pp. 100531, 2020.
- [7] C.K.C. Lam, and K.K. Lau, “Effect of long-term acclimatization on summer thermal comfort in outdoor spaces: a comparative study between Melbourne and Hong Kong”, *Int J Biometeorol.*, vol. 62, pp. 1311-1324, 2018.
- [8] L. Kolendowicz, M. Półrolniczak, K. Szyga-Pluta, and E. Bednorz, “Human-biometeorological conditions in the southern Baltic coast based on the Universal Thermal Climate Index (UTCI), *Theor Appl Climatol.*, vol. 134, pp. 363-379, 2018.
- [9] P. Bröde, E.L. Krüger, F.A. Rossi, and D. Fiala, “Predicting urban outdoor thermal comfort by the Universal Thermal Climate Index UTCI - a case study in Southern Brazil”, *Int J Biometeorol*, vol. 56 (3), pp. 471-480, 2012.
- [10] P. Bröde, E.L. Krüger, and D. Fiala, “UTCI: validation and practical application to the assessment of urban outdoor thermal comfort”, *Geographia Polonica*, vol. 86, pp. 11-20, 2013.
- [11] A.M. Abdel-Ghany, I.M. Al-Helal, and M.R. Shady, “Human Thermal Comfort and Heat Stress in an Outdoor Urban Arid Environment: A Case Study”, *Advances in Meteorology*, 2013.
- [12] N. Mölders, “Outdoor Universal Thermal Comfort Index Climatology for Alaska”, *Atmospheric and Climate Sciences*, vol. 9, pp. 558-582, 2019.
- [13] K. Błazejczyk, M. Kuchcik, A. Błazejczyk, P. Milewski, and J. Szmyd, “Assessment of urban thermal stress by UTCI – experimental and modelling studies: an example from Poland”, *ERDE*, vol. 145, pp. 16–33, 2014.
- [14] C. Di Napoli, F. Pappenberg, and H.L. Cloke, “Assessing heat-related health risk in Europe via the Universal Thermal Climate Index (UTCI)”, *Int. J. Biometeorol.*, vol. 62, pp. 1155–1165, 2018.
- [15] J. Dunjić, “Outdoor Thermal Comfort Research in Urban Areas of Central and Southeast Europe: A Review”, *Geographica Pannonica*, vol. 23 (4), pp. 359-373, 2019.
- [16] K. Pantavou, G. Theoharatos, M. Santamouris, and D. Asimakopoulos, “Outdoor thermal sensation of pedestrians in a Mediterranean climate and a comparison with UTCI”, *Building and Environment*, vol. 66, pp. 82-95, 2013.
- [17] M. Pecelj, A. Đordđević, M.R. Pecelj, J. Pecelj-Purković, D. Filipović, and V. Šećerov, “Biothermal conditions on Mt. Zlatibor based on thermophysiological indices”, *Archives of biological sciences*, vol. 69 (3), pp. 455-461, 2017.



- [18] M. Pecelj, M. Lukić, D. Filipović, B. Protić, and U. Bogdanović, "Analysis of the Universal Thermal Climate Index during heat waves in Serbia", *Nat. Hazards Earth Syst. Sci.*, vol. 20, pp. 2021-2036, 2020.
- [19] M. Lukić, "An analysis of the influence of air temperature and humidity on outdoor thermal comfort in Belgrade (Serbia) using a simple heat index", *Archives for Technical Sciences*, vol. 21 (1), pp. 75-84, 2019.
- [20] B. Basarin, T. Lukić, and A. "Matzarakis, Quantification and assessment of heat and cold waves in Novi Sad, Northern Serbia", *Int. J. Biometeorol.*, vol. 60 (1), 139-150, 2016.
- [21] M. Unkašević, D. Vujović, and I. Tošić, "Trends in extreme summer temperatures at Belgrade", *Theor. Appl. Climatol.*, vol. 82, pp. 199-205, 2005.
- [22] I. Tošić, D. Mladjan, M. B. Gavrilov, S. Živanović, M. G. Radaković, S. Putniković, P. Petrović, I. Krstić Mistrizelović, and S. B. Marković, "Potential influence of meteorological variables on forest fire risk in Serbia during the period 2000-2017", *Open Geosci.*, vol. 11, pp. 414-425, 2019.
- [23] Statistical Office of the Republic of Serbia: Profile of the municipality of Vračar, available at: http://devinfo.stat.gov.rs/SerbiaProfileLauncher/files/profiles/sr/1/DI_Profil_Vracar_EURSRB001001001003.pdf (last access: 9th August 2020), 2020.
- [24] G. Jendritzky, R. De Dear, and G. Havenith, "UTCI – Why another thermal index?", *Int. J. Biometeorol.*, vol. 56, pp. 421-428, 2012.
- [25] K. Blazejczyk, G. Jendritzky, P. Bröde, D. Fiala, G. Havenith, Y. Epstein, A. Psikuta, and B. Kampmann, "An introduction to the Universal Thermal Climate Index", *Geogr. Pol.*, vol. 86, pp. 5-10, 2013.
- [26] ISO 8996: Ergonomics of the thermal environment – Determination of metabolic rate, available at: <https://www.iso.org/standard/34251.html> (last access: 2nd April 2020), 2004.
- [27] D. Fiala, G. Havenith, P. Bröde, B. Kampmann, and G. Jendritzky, "UTCI-Fiala multi-node model of human heat transfer and temperature regulation", *Int. J. Biometeorol.*, vol. 56, pp. 429-441, 2012.
- [28] P. Bröde, D. Fiala, K. Blazejczyk, I. Holmér, G. Jendritzki, B. Kampmann, B. Tinz, and G. Havenith, "Deriving the operational procedure for the Universal Thermal Climate Index (UTCI)", *Int. J. Biometeorol.*, vol. 56, pp. 481-494, 2012.
- [29] Republic Hydrometeorological Service of Serbia: Meteorological Yearbook for the period from 1998 to 2017, available at: http://www.hidmet.gov.rs/latin/meteorologija/klimatologija_godisnjaci.php, (last access: 15th May 2020).
- [30] Institute of Geography and Spatial Organization, Polish Academy of Science: BioKlima 2.6 - Universal tool for bioclimatic and thermophysiological studies, available at: <https://www.igipz.pan.pl/Bioklima-zgik.html> (last access: 10th August 2020).
- [31] G. Battistaa, R. De Lieto Vollaroa, and M. Zinzib, "Assessment of urban overheating mitigation strategies in a square in Rome, Italy", *Solar Energy* vol. 180, pp. 608-621, 2019.
- [32] R. Aghamolaei, M.H. Shamsi, M. Tahsildoost, J. O'Donnell, "Review of district-scale energy performance analysis: outlooks towards holistic urban frameworks", *Sustain. Cities Soc.*, vol. 41, pp. 252-264, 2018.
- [33] M. Berger, "Urban heat-balling: a review of measures on reducing heat in tropical and subtropical cities", In: Sheng, T., Hing, P. (Eds.), *Sustainable Future Energy 2012: International Energy Conference, Brunei Darussalam & 10th Sustainable Energy and Environment (SEE) Forum Proceeding*. Universiti Brunei Darussalam, Brunei Darussalam, pp. 445-451, 2012.
- [34] M. Unkašević, and I. Tošić, "The maximum temperatures and heat waves in Serbia during the summer of 2007", *Climate Change*, vol. 108 (1-2), pp. 207-223, 2011.
- [35] S. Đorđević, "Temperature and Precipitation Trends in Belgrade and Indicators of Changing Extremes for Serbia", *Geographica Pannonica*, vol. 12 (2), pp. 62-68, 2008.



**MODERN TECHNOLOGIES IN
LANGUAGE TEACHING SESSION**



GOOGLE TRANSLATE ACCURACY EVALUATION

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Abstract:

Google Translate (GT), as the most used language translation application, has been significantly improved when artificial neural network (ANN) based Neural Machine Translate System was introduced. The purpose of this paper is to evaluate the translation accuracy of the GT system when used for education purposes. The text in the English language is translated into two languages, by professional human translators and by GT. It is IT related text and refers to computer networks. Students' comprehension of the given text is evaluated regarding language fluency, adequacy, meaning and severity.

Keywords:

Google Translate (GT), machine translate (MT), accuracy, human interpreter, education.

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1. INTRODUCTION

Automatic translation to designated languages offered to website users is the trend that is visible for the last couple of years. Google Translate (GT) is one of the most frequently used tools of the MT system. The services provided by GT are free of charge, and in line with official data from Google, GT is used by over 500 million users [1]. Due to its necessity and rapid progress in the development of machine translation, it is expected to process not only texts but also audio and video files.

GT architecture has changed and improved over time (Figure 1). At the beginning, MT was rule based (*Rule-based Machine Translation*) which worked on the morphology, syntax and semantic of both languages. Then, *Statistical Machine Translation (SMT)* was developed, based on two statistical models, language model and translation model.

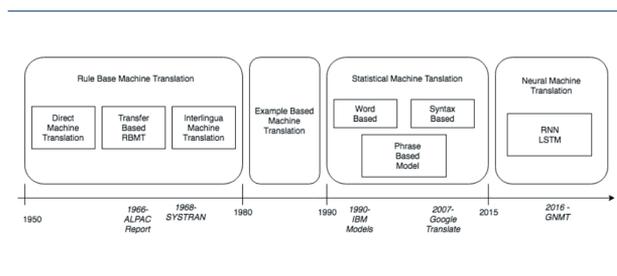


Fig. 1. GT architecture development over time [2]

One of the flaws of this architecture is that massive parallel corpuses are created. Today, GT architecture is based on artificial neural networks, thus the model is called Neural Machine Translation (NMT). This model uses Recurrent Neural Networks algorithm. This Google NMT model has some limitations, namely: lexical, format, expertise and accuracy [3].

Since Google NMT (GNMT) algorithm has been recently introduced, the question that arises is GT accuracy. Khoong et al. [4] have assessed the use of GT to translate emergency department discharge instructions into Spanish and Chinese. Results showed that 92% sentences were accurately translated into Spanish, and 81% into Chinese. Aiken in 2019 [5] showed that translations between English and German, African, Portuguese, Spanish, Danish, Greek, Polish, Hungarian, Finnish and Chinese tend to be the most accurate.

Yamada [6] in his study in 2019, investigated college students' post-editing potential when using Google SMT, and Google NMT of the same source text. NMT showed better results in terms of its final product, which contained fewer errors. However, there were no significant difference in cognitive effort or error correction rate. Guldal and Isisag [7] analysed the translation errors of GT outputs conducted from Turkish to English. The errors were classified into: Lexical Errors, Morphological, Syntactic, Semantic and Pragmatic Errors. The results show that even though GT provides faster translations, there is still a need for human assistance.

Jabak [8] conducted the assessment of Arabic-English translation produced by GT. Results showed that GT made lexical and syntactic errors, therefore GT cannot be used as a valid translation tool for Arabic-English translation. Rensburg et al. [9], assessed GT in a South African higher education environments. One document was translated from African into English and another form English into African. The results showed that a user would not have to spend much time correcting translations.

Chen et al. [10] evaluated the accuracy of GT when translating health information from English to Spanish, and English to Chinese. Results showed that Google provided accurate translation for simple sentences.

The goal of this paper is to evaluate to what extent the quality of translation of Google Translate is satisfactory in order to be applicable in learning professional language, in our case, in the area of IT.

The authors took the text from Wikipedia on computer networks that was originally in English, that was subsequently translated to Italian and German by human translator and GT. The interpreter evaluates the text translated by GT on the basis of Trujillo scale which includes intelligibility and accuracy. The intelligibility scale is a five-degree, and the accuracy scale is a seven-degree scale. Further research will include students who will be given both translations, based on which they will do a task regarding reading comprehension.

Based on the questions about the text responded by students we will measure the level of understanding of one and the other text, based on which it will be concluded whether GT can be used in learning foreign languages in the field of informatics and computer science.

It is assumed that the level of comprehension of the text translated with the use of Google Translate will be surprisingly high and that it will not deviate significantly from the text translated by human interpreter. The authors of this paper rely on research confirming multiple utility of Google Translate, especially in relation to costs compared to a professional translator [11].

It is expected that despite a significant number of errors regarding syntax and style, the level of understanding of our text will be surprisingly high. It is assumed this is due to the structure of the sentences of special purpose language.

1. MACHINE TRANSLATION

Machine translation (MT) entails automatic translation using a computer program that is designed to translate text from one language (source) into another (target) language without the aid of a human [12] [13].

MT dates since the World War II when a connection was noticed between the translation and cryptography during decoding of the messages in computers [14]. During the 60ies, MT was criticized due to its inaccuracy and slow performance, but in the late sixties it became success, especially in Canada where it is used today in translating weather reports [14].



With the onset of World Wide Web, MT blooms later on, when it becomes available online as Babel Fish [15]. After this period a number of tools emerged for machine translation, including Google Translate that is easily available to users and free of charge.

Google explains that according to the previous translated text by human translators, the GT looks for patterns in millions of documents and makes intelligent guesses to create an appropriate translation [16].

Google launched Google Translate in 2009 enabling users of websites to translate, instantly, the content of the website into more than sixty languages. A new feature for the Website Translator was launched in 2012. In this way, the website administrators were enabled to edit translations and users were allowed to propose a better translation. The suggested translation could have been accepted or rejected by the web administrator [17]. With the aim of improving the quality of the translation it is possible to post-edit the MT output. Even though it facilitates the process of translation, a number of studies show that MT is efficient in case when it is corrected by the human factor [18].

Traditional phrase-based translation systems have executed their tasks by breaking the source sentences to parts, and then, translating them phrase by phrase. This manner of translation is nothing similar to human translation. A man would read the source sentence first, understand it, and then translate. This is the manner of translation imitated by Neural Machine Translation, the NMT.

In 2016, Google implemented the Google Neural Machine Translation model (GNMT). This GNMT system loads the source sentence first in order to produce the vector of “thought”, that is, the sequence of numbers representing the meaning of the sentence and the decoder that is processing the vector of the sentence and translates it to target language. GNMT is based on encoder-decoder architecture of the system using Recurrent Neural Network (RNN) (Fig. 2).

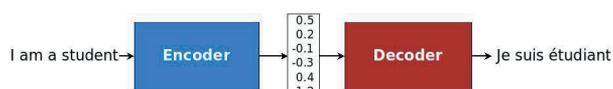


Fig. 2. GNMT system encoder-decoder architecture [19].

Based on artificial neural network, it was supposed to improve the quality of translation to great extent. GNMT (Neural Machine Translation System) has improved the quality of the two most commonly used language pairs – Spanish-English and French-English. The accuracy of translation improved by 85%. In 2017, Google launched a survey among GT users. They are asked to evaluate three translating options: machine statistical, neural and human. The results were a surprise – it turned out that the translation relying on neural networks was almost perfect in certain language pairs [16].

2. RESEARCH METHODOLOGY

Choice of sentences

It was decided to focus on IT related text. The authors selected the text from Wikipedia on computer networks. The original English text contained 10 sentences translated by the translator and GT. An example of chosen sentence in its original form and translated by a professional translator and GT are shown in Table 1.

Table 1. An example of chosen sentence and its translations

Original sentence	„A computer network or data network is a telecommunications network which allows computers to exchange data”
Translated by professional translator in German	„Ein Computernetz oder Datennetz ist ein Telekommunikationsnetz, das Computerdaten austauschen können.”
Translated by GT in German	“Ein Computernetzwerk oder Datennetzwerk ist ein Telekommunikationsnetzwerk, mit dem Computer Daten austauschen können.”
Translated by professional translator in Italian	“Una rete di computer o rete di informazioni è una rete di telecomunicazioni che permette lo scambio di dati informativi.”
Translated by GT in Italian	“Una rete di computer o una rete di dati è una rete di telecomunicazioni che consente ai computer di scambiare dati.”

Language selection

Even though GT offers a wide spectrum of translations from English to other languages the authors of this paper focused on two languages, Italian and German due to a large number of students of the faculty for IT that select these languages.



Method for Machine Translation Evaluation

A common evaluation technique is used, where four expert translators gave ratings based on Trujillo's scale of intelligibility as well as accuracy. Research steps are drawn in the figure 3.

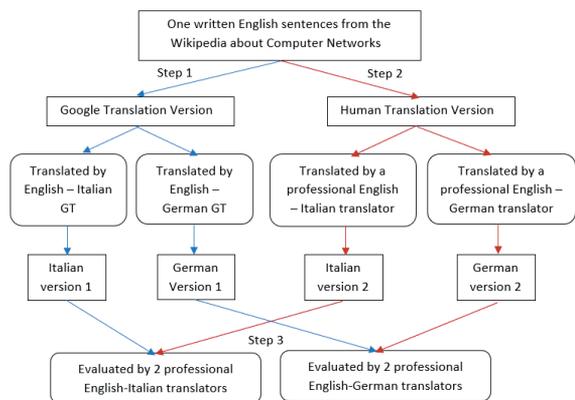


Fig. 3. Research steps

When evaluating the text translated using Google Translation the human factor is the only valid one to judge the quality of the text translated. Translated text is evaluated based on intelligibility and accuracy, using appropriate scales [20], [21], [12,13].

Intelligibility is the level of fluency and grammar accuracy of the text translated using the MT system, as well as the text translated by the human factor [20]. Also, it represents a level of comprehension of the text [12,13].

It was noticed that the text translated by GT did not decrease in the quality on the scale of intelligibility as well as accuracy, but there were changes in the style and syntax of the sentence.

After the examination in the form of a test based on the translated text, which will include students in terms of measuring the intelligibility and accuracy of both translations, it will be concluded which text has a higher score. The further step will be to examine which language pair has a greater degree of intelligibility and accuracy. Future research will be based on expanding the number of languages (including Spanish, Russian, French and Arabic), on the basis of which of the mentioned languages has the largest database and thus the largest score.

The test contains 15 multiple-choice questions. An example of the test questions in German and Italian language is shown in Table 2.

Table 2. An example of the test questions in both languages

Test question in German	Ein Computernetz oder Datennetz ist ein Telekommunikationsnetz, das Computer ermöglicht: _____.” a) Datenaustausch b) Verbindungen zwischen den Knoten c) Kommunikationsprotokol
Test question in Italian	Una rete di computer o rete di informazioni è una rete di telecomunicazioni che permette ai computer _____.” a) lo scambio di dati informativi b) nodi di rete c) protocollo di comunicazione

Intelligibility

The term intelligibility includes clarity, fluency and sometimes, ease of reading [16]. Regarding intelligibility the style may or may not be considered [21]. Intelligibility is an important factor of evaluating translation quality due to the fact that even when a text is accurately translated but the spirit of the target language is neglected, certain level of intelligibility is lost [1]. In order to avoid subjectivity when evaluating a translation by one of the assessors, objective evaluation may be received using statistical methods, through the combination of assessments of several different assessors [20]. Arnold et al. suggest at least four assessors and point out they should be related to the area [21].

Accuracy

Accuracy or “adherence” to the original text is a measure determining the level to which the translated text retains the meaning of the original text [20]. In order to receive a broader image of the translation quality, intelligibility and accuracy must be observed in pair. After the measured level of intelligibility, the accuracy must be measured [21]. When assessing accuracy, it is important that the assessors have necessary language skills and knowledge. If the issue of objectivity is considered, since some of the assessors are stricter than others, including a large number of assessors will result in a clearer image of accuracy level. Additionally, this may bring front an issue of one assessor understanding a sentence in different context than the others.

Scale selection

In order to evaluate the comprehension of MT system results, a number of scales has been developed. Intelligibility scales range from two to five level ones [21].



In these scales the sentences that are understood the best get the highest marks, and vice-versa. One of the renowned scales is the Trujillo five-point scale that includes clear, unequivocal descriptions for each scale point [20]. The scale measures how much an examiner agrees or disagrees with a specific statement. Scale points measure grammar, word usage and style in term of whether rewriting is needed or not. If there are some problems regarding scale points the examiner needs to look at the original sentences to interpret the meaning. The final score will depend on examiner's grades regarding abovementioned scale points [20] [1].

Trujillo's seven-point intelligibility scale [20] [1] measures the degree to which a native speaker understands the sentence and the degree to which the content of the source language sentence is clearly passed on. Word order, the use of tenses, subjects and predicates relationship are also graded by the examiner. The final score depends on the overall understanding by a native speaker and examiner.

Profile of evaluators

According to Arnold et al. [21] it is necessary to include at least four examiners in the examination. Thus, we selected four professional translator. Each of them had native command and knowledge of the target language. Also, they were required to have excellent language skills in order to understand the given instructions and the original English text in order to determine the intelligibility and accuracy scores. The research included expert translators who worked as foreign language lecturers at Singidunum University.

Before starting research, the examiners received detailed instructions regarding the intelligibility and accuracy of the translation, as well as explanations regarding the scales and the method of assessment. In order to achieve objectivity regarding the evaluation of the translated text, the examiners had a day off between the evaluation of the text translated by GT and the text translated by the translator. It was also required not to discuss or express an opinion regarding translations.

For the purpose of this paper the authors evaluated the intelligibility and accuracy of translations based on evaluations conducted by interpreters.

3. CONCLUSION

Based on the text taken from Wikipedia that has been translated from English to Italian and German with the aid of Google Translate and professional translators, multiple choice questions were prepared. We will determine a level of comprehension of both texts based on these responses. The expected result is that students understand the text translated with Google Translate better, regardless of whether it is German or Italian. This may be explained by the fact the text is from the IT area and the level of intelligibility is higher due to sentence structure and syntax. Technical language is, in its structure and style, significantly different that literary language that demands wider context when it comes to translation, so these results are expected.

Research will be performed for other languages (French, Russian, Spanish and Arabic) and we will measure the level of intelligibility and comprehension regarding language pairs.

Since translation by translators requires certain amount of time, knowledge, skills and effort; time and resource saving concerns are increasingly significant, hence, the use of MT expects to grow in a very short period of time. Regarding the development of MT, it is very likely that the grammatical accuracy of translations will be improved, especially in language pairs mostly used. If we consider increase in use of advance technologies in foreign language studies, it is up to the academic community to accept or reject such form of cooperation. MT will surely not replace the adoption of a foreign language in the close future but the method of communication using advance technologies will be of great assistance to the teachers and students alike. The human factor is of the most importance when it comes to skills of inter-cultural, inter-personal communication that will be difficult to master using technology.

REFERENCES

- [1] A. Tobin, "Is Google Translate Good Enough for Commercial Websites?: A Machine Translation evaluation of text from English websites into four different languages," *Computer Science*, pp. 94-116, January 2015.
- [2] C. Lungu, (2020) Tutorial on machine translation. Available at: [http://www.clungu.com/machine%20translation/tutorial/Tutorial-on-Machine-Translation/\(13/09/2020\)](http://www.clungu.com/machine%20translation/tutorial/Tutorial-on-Machine-Translation/(13/09/2020)).



- [3] A. Baloiu, (2020) Neural Machine Translation: an insight. *Ad Verbum*. Available at: <https://www.ad-verbun.com/en/blog/nmt> (13/09/2020).
- [4] E.C. Khoong, E.Steinrook, C. Brown, A. Fernandez, "Assesing the Use of Google Translate for Spanish and Chinese Translations of Emergency Department Discharge Instructions", *JAMA Internal Medicine*, 179(4): 580-582, 2019.
- [5] M. Aiken, "An Updated Evaluation of Google Translate Accuracy". *Studies in Linguistics and Literature*, Vol. 3, No.3, 2019.
- [6] M. Yamada, "The impact of Google Neural Machine Translation on Post-editing by student translators", *Journal of Specialised Translation*, 2020.
- [7] B.K.Guldal i K.U.Isisag, "A comparative study on google translate: An error analysis of Turkish-to English translations in terms of the text typology of Katherina Reiss. *RumeliDE Dil ve Edebiyat Arařtırmaları Dergisi*.
- [8] O.O.Jabak, "Assessment of Arabic-English translation produced by Google Translate", *International Journal of Linguistics, Literature and Translation (IJLLT)*, Vol. 2, Iss. 4, 2019. Available at: <https://publication.ijllt.org/media/290334-assessment-of-arabic-english-translation-581a8141.pdf> (18/09/2020)
- [9] A.V. Rensburg, C. Snyman, and S. Lotz, "Applying Google Translate in a higher education environment: Translation products assessed. *Journal Southern African Linguistics and Applied Language Studies*, Vol. 30, Iss.4, 2012.
- [10] X. Chen, S. Acosta, A.E. Barry, "Evaluating the Accuracy of Google Translate for Diabetes Education Material". *JMIR Diabetes*, Vol. 1, Iss. 1, e3, 2016.
- [11] F. Sheppard, "Medical writing in English: The problem with Google Translate," *La Presse Médicale*, 40(6), pp. 565-566, 2011.
- [12] W.J. Hutchins and H.L. Somers, *An Introduction to Machine Translation*. London: Academic Press, 1992.
- [13] W.J.Hutchins, H.L.Somers (1992) *An Introduction to Machine Translation*. Academic Press, Cambridge, GB.
- [14] P. Koehn, *Statistical Machine translation*, Cambridge: Cambridge University Press, 2010, pp.15
- [15] J. Yang and E. Lange, "Going live on the internet," in *Computers and Translation: A Translator's Guide*, H. Somers, Eds. Amsterdam-Philadelphia: John Benjamins, 2003, pp. 191-200.
- [16] <http://www.isi.edu/natural-language/mteval/> [Accessed 10 September 2020]
- [17] J. Chin, 2012. Now you can polish up Google's translation of your website. *The Official Google Translate Blog* [Online], 30 May. Available from:<http://googletranslate.blogspot.jp/2012/05/now-you-can-polish-up-googles.html> [Accessed 7 September 2020]
- [18] M. Groves, and K. Mundt, "Friend or foe? Google Translate in language for academic purposes." *English for Specific Purposes*, 37, pp. 112-121, 2015.
- [19] T. Luong, E. Bredo, R. Zhao (2019) *Neural Machine Translation (seq2seq) Tutorial*. *Readme.md*. available at: <https://github.com/tensorflow/nmt> (13/09/2020).
- [20] A. Trujillo, *Translation Engines: Techniques for Machine Translation*. London: Springer-Verlag, 1999
- [21] D. Arnold, L. Balkan, R. Humphreys, S. Meijer and L. Sadler, *Machine Translation: An Introductory Guide*. Oxford: NCC Blackwell, 1994



MODERN TECHNOLOGIES IN TEACHING LITERATURE

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Abstract:

The aim of this paper is to identify and analyze the latest technologies in second language teaching, notably teaching English literature to 'digital natives', the modern generations of students raised in media-saturated world who need the instructors and educators in good command of the most recent teaching methods in order to excel academically. The paper sheds a new light on the second language acquisition in the context of reading and interpreting both contemporary and classic literary texts by using digital tools, social media and other sites of Internet. By offering a thorough analysis of the impact of modern technologies on teaching literature, we endeavor to determine the position of literature in the 21st century and point to its significance for students' mental, emotional and moral development.

Keywords:

literature, digital era, digital tools, social media, Facebook.

1. INTRODUCTION

In the era in which being digitally literate is no longer a luxury or a matter of choice but a necessity, it is important for teachers to consciously realize the benefits of information and communication technologies in order to use them adequately in the process of transmission of both theoretical and practical knowledge to students. Teachers should, therefore, be able to create the environment that successfully promotes a practical usage of new technologies in education, particularly in language teaching, as this field has always been regarded as the one in line with the ongoing innovation processes in the world of IT. If properly encouraged to use Internet, digital tools, social media and similar sources, the students will be able to gain and evaluate additional knowledge needed for interdisciplinary research lying in the core of successful business ethics, intensify their mental functions and develop a team-building spirit. Deployment of Bloom's Taxonomy Map and online educational tools

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such as Popplet, Facebook, Voicethread, Google Search and Trello in the course of Applied Linguistics and Language Teaching 2 at the Faculty of Philology at Sinergija University in Bijeljina proved to be particularly efficient and effective since the students successfully demonstrated the use of all higher-order thinking skills [1].

The 21st century has equipped students with a variety of online resources such as community-based and collaborative-knowledge-exchange systems [2] and an easy access to various digital platforms. Rather than passively consuming information, the students create personal information networks and connect with various learning communities. As digital natives prone to multitasking and fast information processing, the students are in constant demand of more sophisticated teaching methodologies that challenge traditional education systems. Language teaching is perhaps the most open and adaptable to the integration of the latest technologies since it is interdisciplinary in its nature and as such more ready to embrace the novelties originating from distinctive scientific fields. Teaching literature under the umbrella of language teaching is even more challenging if considered in the light of its adjustment to the latest developments in the IT world, since it may be quite challenging to bridge the gap between love of technology and love of a written/spoken word as a part of the artistic expression.

Compared to other subjects and courses, teaching literature has proved to be most resistant to the integration and use of modern technologies, as literature was predominantly associated with deeply spiritual, emotional and mental notions that could hardly be linked with the utilitarian world of technology. If we make use of technology in teaching literature despite the fact that we know that technology is intimately bound with the dehumanization of society, how can we successfully and adequately “identify, explore and interpret the human values lying in the core of any literary work”? [3]. Taking this into consideration, there is a strong need for a redefinition of the goals set and methodologies used in teaching literature, in order to harmonize the traditional and conventional approaches with the innovative and more modern ones. Many scholars address the question of how new media influence the way we read and understand the literature written prior to the digital age. They mostly agree that literature teachers need to include new media such as periodicals, films, images, digital texts, blogs, Web sites, online videos, etc. into the literature classroom and point to the importance of acknowledging the fact that these texts are being woven into both our culture and literate experience [3] [4]; [5]; [6]; [7].

Conversely, the question that arises from the need for IT integration in teaching practices is the following: how can the teachers balance academic loads and maintain high standards of instructions while keeping pace with new technologies?

2. INNOVATIVE WAYS OF READING AND INTERPRETING LITERARY TEXTS

The use of new forms of media – video games, graphic novels, interactive hypertexts, language platforms or digital tools – in teaching literature inspires students to think critically as the skills they develop by analyzing these media forms can be applied to studying traditional literary texts. Also, teaching a traditional literary text can go along with its reinterpretation in newer media, as [8] notices in his blog about the use of technology in teaching literature by taking as an example ‘choose-your-own-adventure-style’ game /<http://gamebookadventures.com/gamebooks/to-be-or-not-to-be/> based on Shakespeare’s *Hamlet*. Namely, in this game entitled ‘To Be or Not to Be’ the players are allowed to decide what happens next in the narrative by choosing between three Shakespeare’s characters. They can ‘play as Hamlet and revenge their father’s death’, ‘play as Ophelia and make scientific discoveries’, and ‘play as King Hamlet, Sr. and die on the first page’. The game features tiny Yorick skulls that mark the choices Shakespeare took in his play. The players may opt for following these skulls for the original story or create their own adventure. The game combines time travel, pirate fighting and murder investigation with specially composed soundtrack and sound effects. The players can listen to the narration as they play the game, learn new words and phrases and look for secret messages hidden throughout the gamebook. Also, the game uses dyslexic friendly font support to aid readers with dyslexia. The use of such media form adds new meanings to the already existing interpretations of Shakespearean play and triggers new discussions arising from the textual analysis.

If used adequately, Internet can be an immensely significant source of creativity, notably when it comes to opening discussions and debates regarding moral dilemmas that are in the core of the greatest literary works. By setting up a forum or ‘comment section’ for discussing the novels analyzed during the literature classes, the students may feel free to ask and answer questions regarding the book they are reading and the teacher can anytime challenge the students by assigning various problem-solving tasks regarding the book in question.



Posting comments and replying to them anytime can save time and make teacher's efforts to help students get the gist of the book less intense. In addition to this, the teacher should restrict access to the forum or comment section to students and remind them of privacy concerns. Also, for the sake of the privacy protection, the students should be encouraged to use nicknames rather than their real names and provide as little information about themselves as possible.

Technology in literature is also used to enhance traditional reading experience. One of the language platforms used for such purposes is the 'Actively Learn' platform /<https://www.activelylearn.com/>, which makes use of e-books that are now widely used in literature classes. The platform extends the learning process that takes part in the classroom beyond the walls of the institution and offers the teacher's constant support to students. Namely, by using this platform the teacher is allowed to embed comments, questions and annotations into an e-book's text anytime he or she finds suitable. The teacher sends his or her own notes through the internet directly to the students' copies of the e-books. Simultaneously, the students are allowed to write their own notes, ask questions or comment on the notes that other students have written, thus creating a strong bond regarding the student-student or student-teacher relationship.

The use of digital tools can be quite beneficial and inspiring in reading and interpreting both traditional and modern literary texts. The use of technology at literature classes is explored in the text written by Mark Lieberman who lists some of the most innovative ways of using digital tools that has already been put into practice by various teachers at Universities across America [9]. For the purpose of this paper we singled out the use of story maps by Allison Fagan, associate professor of English at James Madison University in Virginia, who encouraged students to use 'Esri Story Map' tool during the course on literature regarding undocumented immigration. Due to the limited length of this paper, we will briefly explain how this web tool works in context, without providing a detailed procedure.

Esri Story Map /<https://www.esri.com/en-us/about/about-esri/overview/> is a digital tool that enables students to combine maps, places, locations, geography and narrative text for creating engaging stories that may contain a variety of multimedia materials such as videos, images, shapes, etc. This digital tool is particularly useful for making a link between a work of fiction and a current real life situation. For instance, the migration process that occurs both in real time, i.e. the problems

with illegal entries at the U.S.-Mexico border explored by Fagan and her students, and in a work of fiction, may be successfully explored by using this digital tool. During the semester-long project conducted by Fagan, the students used this tool to get a deeper understanding of the impact of a character's location on their experience. The students needed to conduct a thorough research into historical events and place them on the same map. Though struggling at first, towards the end of the course, as Fagan notices, the students began to feel more comfortable with the use of the web tool and opted for more sophisticated tasks than the program would allow.

Exploring such undergoing processes that affect the modern society (i.e. migration, global warming, climate change) and linking them with those the characters face within a work of fiction (i.e. the story of Rjepnin, a Milos Crnjanski's tragic hero, a Russian immigrant who settled in London /*A Novel about London*, 1971/, warns about difficulties the immigrants face in their process to fit into the world different from theirs, or Margaret Atwood's story of a mad scientist /*Oryx and Crake*, 2003/ that warns about the disturbing effects of technology on the science-driven society) by using the story maps might be immensely beneficial in literature teaching. Even the simplest story maps activate deeper levels of thinking and raise students' awareness of the current social, cultural and political issues.

Apart from iPads that enable the circulation of information and promote the exchange of ideas in literary classes, the use of e-clicker questionnaires challenges traditional approaches to reading and reviewing a literary work. As they shorten the time needed for reviewing the content of a literary work, the e-clicker questionnaires have proven to be an effective and very popular tool among the students [10]. Instead of raising their hands when the teacher asks a question, the students press the buttons on the e-clicker and their answers are analyzed by the computer. With the use of e-clickers in the classroom the literature classes become more interesting. This device ensures the relative anonymity of the students' answers. If one e-clicker is given to a group of students, discussion may be easily triggered among them. However, since e-clickers require a simple form of answers (Yes/No or multiple choice), it is advisable to use them occasionally or in combination with other tools that stimulate critical thinking in literature classes.



3. SOCIAL MEDIA IN LITERATURE TEACHING

Since social media sites are widely used for promotion and networking by contemporary literary authors, there are various ways in which teachers may engage students in the process of gathering information about the authors and their literary works so that they could better understand their fiction. Following the contemporary author's posts and activity on social networks may give students an insight into the themes that generally interest the author in question since they usually serve as a bounteous source of inspiration for his or her fiction. For example, Margaret Atwood's concern for the environment and global warming, the recurrent themes in her writings (i.e. exploring eco-fiction in her MaddAddam trilogy), is apparent if you check her Facebook page https://www.facebook.com/pg/MargaretAtwoodAuthor/about/?ref=page_internal/, since she posts frequently about the fatal consequences of pollution and inadequate use of plastic bags. Her concern for the environment is seen in constant promotion of 'Ecosia', a search engine that donates 80% or more of its profits to nonprofit organizations that focus on reforestation, on her Facebook page. In light of this, we chose to present the assignment set by Wiseman and Wagler, the teachers at University of Nebraska, since it provides a good example of how similar use of social media works in practice. The main goal of their assignment is helping students to develop critical thinking skills about media consumption as they participate in literary communities and explore new venues for writing [11].

Task 1 For the purpose of this assignment students use smartphones with access to social media sites in order to analyze and gain access to posts written by contemporary writers. For a six-week time, students are asked to participate on a social media site of their choice (Facebook, Twitter, etc.) as they follow an author of their choice who frequently posts content. Namely, the students are encouraged to think about their reading and writing interests and the authors they love (e.g. a Margaret Atwood fan might follow her on Facebook or Twitter <https://twitter.com/MargaretAtwood/>, visit 'Atwood Society' <https://twitter.com/atwoodsociety/>, or visit her website (<http://margaretatwood.ca>), while a Harry Potter fan might enjoy exploring 'Pottermore' <https://www.wizardingworld.com/>). Then, the students are advised to focus on the author's posts and his or her interactivity with followers. It is also expected from the students to post and interact with others at the site.

Students are asked to document their findings and reflections and evaluate the author's site (its purpose, audience, genre and style, and cultural context). The evaluation involves one- to two-page analysis of a given aspect of a social site or on author's use of that site. Alternatively, the teachers may offer an analysis as a guided, in-class writing activity, where students write down what they are noticing on their sites. Also, small and large group discussions may be organized together with workshops to help students relate their peers' findings to their own. After a final workshop, students are to give five-to-seven-minute presentation of their portfolio. The portfolio including screenshots or other artifacts that support students' findings is later translated into PowerPoint presentation.

Apart from learning more about the authors they admire and discovering new ones, this assignment offers students an excellent opportunity to explore the innovative ways in which authors, readers and presses use new technologies to communicate, discuss and explore literature. This assignment gives students an insight into digital reading and writing communities and encourages critical thinking as the students consume and produce content in an online environment [11]. Finally, the workshops that are part of the assignment encourage idea exchange and help students develop skills in revision, argument and peer feedback.

Facebook with its Timeline feature can also be a useful tool for an in-depth analysis of a chosen literary text, since it allows students to visualize events from the plot, the author's life, or socio-historical context of the literary work. The assignment set before the second-year students attending the course of Victorian literature at the Faculty of Philology at Sinergija University during the school year 2017/2018 consisted in creating a page of the chosen literary character (or its corresponding film character) while logged in on their Facebook accounts (Page name and category were requested) and filling in all the necessary information concerning the character's life. Since the Timeline feature allows an exact tracking of the plot developments, as well as the significant turning points in his/her life and the interactions among characters within the fictional world set in the specific socio-historical context, recreating the identities of the students' characters was neither time-consuming nor a complex task.

Task 2 This assignment was used instead of oral presentations the students were asked to give in order to earn extra points. The students worked in groups of 4 to 5 during a two-week long period. Each student was asked to choose one literary character from the book



we were reading at that time [12], create the character's profile as a page, complete the information section and 'become Friends' with other fictional characters in order to interact on Facebook. At this point, the students chose the main characters of Oscar Wilde's novel: Dorian Gray, a painter Basil Hallward, a notorious instigator Lord Henry Wotton and Sybil Vane, an actress in love with Dorian. In order to make their characters more convincing, the students were also asked to watch one of the two film versions based on Wilde's novel: a 1945 American horror-drama film directed by Albert Lewin and a 2009 British fantasy-horror drama directed by Oliver Parker.

Filling in the information section of a character's profile was quite purposeful, since it assumed the students' engagement with finding the concrete facts and information about the character's life, such as Basic Info, Work and Education, History by Year, Relationship Status, etc. At the same time, the students classified the information they discovered and decided what should be revealed and hidden to the public. The deeds and events that the characters (i.e. Dorian Gray) were unwilling to reveal since they damaged their reputation (the deteriorating portrait of Dorian Gray showing his true nature) might be exposed by other characters (i.e. Basil, who finds out the truth about Dorian's changing portrait) by tagging the character in an incriminating photo or posting on his wall (in this concrete case, the narrative would take an unexpected turn that would lead to surprising versions of the novel's ending).

The students as creators of the character's page are given the opportunity to decide what their character should 'Like' or add to his or her list of 'Favorites', including books, people they admire, music, events, etc. This Facebook feature proved to be quite useful as it encouraged the students to go deeper into the analysis of the original text and search for information supporting their decisions what to like on the social network (i.e. Dorian Gray liked the pages about fashion, style and art and all newfangled magazines; he was also 'interested' in the events such as 'dinner parties', 'cocktail parties', 'theatre going', or the events that suggested 'a life of debauchery'). By considering what Dorian Gray would like, who he would interact with, what events he would choose to visit, the students are subconsciously dragged into the process of constructing the character's identity in the context of social media behaviors. Also, since some of the options that Facebook offers are unavailable to character pages, the students had to find the way how to express their disliking or antipathy towards

certain characters (i.e. Lord Henry's disliking of Sybil Vane was expressed by Lord Henry's observations concerning her poor acting).

In addition to this, the students made use of 'status update' option on Facebook, where they were able to engage in conversations with multiple characters chosen from the book, share their view of key events or specific scenes from the text and trigger discussions in real time. As the narrative unfolds, the students update their status and engage themselves in the process of character development. They search for interesting conversations in the original text and share their character's views on many issues. For instance, Lord Henry's derogatory view of women is expressed by posting the following conversation between Lord Henry and Dorian: "My dear boy, no woman is a genius. Women are a decorative sex. They never have anything to say, but they say it charmingly. Women represent the triumph of matter over mind, just as men represent the triumph of mind over morals" [12]. Simultaneously, by uploading a photo or video, another feature offered by Facebook, the students demonstrated their creativity in a variety of ways. While some students opted for creating the characters following the information given in the text itself, others chose to do the 'remake', that is, to transform their nineteenth-century characters into their twenty-first century counterparts by creating and uploading photos or videos showing how they thought their characters would dress, talk and behave if they existed in digital era.

In one of the versions created by the students Dorian Gray's photo that revealed his moral deviance was exposed on his Facebook Timeline by revengeful James Vane, a brother of deceased Sybil Vane, while he was attending the party organized in his honor for winning the first prize in 'Beauty Award Online Competition'. As people at the party, Dorian's connoisseurs, followers and 'false' friends, were constantly online, they could immediately see the post on his wall, which resulted in damaging Dorian's reputation to such an extent that repair was not possible. Despite the fact that our Dorian immediately deleted a compromising photo, his dark secret had been revealed. As a consequence, this triggered fast reactions of the people (and characters) who were eager to leave comments or emoticons expressing their shock, surprise or disgust beneath the photo. At that very moment, the profile picture of 'forever' young and beautiful Dorian that he chose for himself was changed into the portrait of an old, gruesome and despicable man whose soul was as rotten as the face on his changed profile picture.



By translating the literary work into the language of social media familiar to them, the students are invited and encouraged to discuss unfamiliar and often complex literary perspectives and add new meanings to the literary works interpreted from multiple perspectives.

4. CONCLUSION

Nowadays it is expected from the teachers to provide the environment that will enable students who have grown up using a multitude of digital platforms to access information easily, communicate across platforms dispersed in a wide range of media and understand information shared online. To what extent will the teacher be able to activate the learning process within the framework of new technologies depends on the competences of the teacher and his or her readiness to implement new technologies in teaching, the complexity of learning itself and the complexity of the available teaching tools. In view of this, some scholars started to use the term 'transliteracy' defining it as "the ability to read, write and interact across a range of platforms, tools and media from signing and orality through handwriting, print, TV, radio and film, to digital social networks" [13]. The integration of interactive media as a teaching tool into the literature classes proves to be a stimulating and engaging way of addressing various communication concepts and challenges of the 21st century.

Innovative ways of reading and interpreting literary texts identified and explored in this paper trigger the students' motivation, initiate discussion, and raise the students' awareness of the current social/political/global issues. By setting up forums and 'comment section' for online discussion of moral dilemmas within literary texts the students are more willing to actively participate in problem solving tasks set by the teachers. The use of 'Actively Learn' platform that enables students and teachers to embed comments, questions and annotations into an e-book's text anytime, enhances the learning process since the students are able to clarify whatever they find confusing within the literary text, while Esri's Story Map establishes the relation between a written word and a real life experience.

The tasks set before students as a way of implementing social media in literature teaching presented in this paper proved to be quite effective. In Task 1 it is showed that the use of Facebook, Twitter or other social media network for the purpose of assessing and evaluating the contemporary authors' posts and checking their interactivity with followers gives students an insight into

digital reading and writing communities and encourages critical thinking. The students' findings presented during the final workshop in the form of a portfolio and PowerPoint presentation helped students develop skills in revision, argument and peer feedback. The Task 2 dealing with the use of Facebook with its Timeline feature for the purpose of creating a page of the chosen literary character turned out to be quite beneficial to the second-year students attending the course on Victorian Literature at the Faculty of Philology at Sinergija University. Translating the traditional text into new media offered multiple perspectives and added new meanings to the literary text. The students tackled the complex issues that appeared in the text without much trouble. By transforming the nineteenth-century novel into the twenty-first century story the students were able to detect the timeless themes and questions that obsess the people regardless of their age or the time they live in.

Therefore, it can be concluded that, by adequate implementation of social media in teaching literature that includes the students' consuming and producing content in an online environment, teachers may help students think critically about their surroundings and make thoughtful, critical and analytical inquiries about social media in general.

REFERENCES

- [1] M. Nikolić and T. Dabić, "The Bloom's Taxonomy Revisited in the Context of Online Tools," in *International Scientific Conference on ICT and E-Business Related Research, Singidunum University, Belgrade, Serbia, 2016*.
- [2] S. T. d. Zepetnek and A. L. Azcárate, "Mapping the World, Culture, and Border-crossing.," in *Education, Interculturalism, and Mapping a New Europe*, Kaohsiung, National Sun Yat-sen UP, 2010, pp. 38-49.
- [3] M. Škobo and B. Đerić-Dragičević, "Teaching English Literature in the Digital Era," in *Sinergija 2019 - XX International Scientific Conference, Sinergija University, Bijeljina, Republic of Srpska, 2019*.
- [4] R. Scholes, "The English Curriculum After the Fall," *Pedagogy Critical Approaches to Teaching Literature Language Composition and Culture*, pp. 229-240, 2010.
- [5] E. Cushman, "New Media Scholarship and Teaching: Challenging the Hierarchy of Signs," *Pedagogy Critical Approaches to Teaching Literature Language Composition and Culture*, pp. 63-79, 2011.
- [6] J. Parks, "A Digital Approach to Teaching Postmodern Literature," in *Teaching Literature with Digital Technology*, Boston, MA: Bedford/St. Martin's, 2016, pp. 110-121.



- [7] M. Nikolić, "The use of audio and video recordings in English language teaching," in *Sinergija 2017 - XVIII International Scientific Conference, Sinergija University, Bijeljina*, 2017.
- [8] D. Spencer, "Prestwick House," July 2015. [Online]. Available: <https://www.prestwickhouse.com/blog/post/2015/07/using-technology-to-teach-literature>.
- [9] M. Lieberman, "How Technology Enhances Literature Learning," 31 January 2018. [Online]. Available: <https://www.insidehighered.com/digital-learning/article/2018/01/31/technology-tools-work-literature-classrooms..>
- [10] G. Boruszko, "New Technologies and Technologies and Teaching Compar eaching Comparative Literature Literature," *CLCWeb: Comparative Literature and Culture and Culture*, 2013.
- [11] L. M. Wiseman and A. Wagler, "Shaking the Magic 8 Ball: Social Media for Readers and Writers," in *Teaching Literature with Digital Technology*, Boston, MA: Bedford/St. Martin's, 2016, pp. 3-20.
- [12] O. Wilde, *The Picture of Dorian Gray*, Ware, Hertfordshire: Wordsworth Editions Limited, 2001.
- [13] S. Thomas, C. Joseph, J. Laccetti, B. Mason, S. Mills, S. Peril and K. Pullinger, "Transliteracy: Crossing Divides," *First Monday: Peer-Reviewed Journal on the Internet* 12, pp. 2-3, 2007.



TEACHERS' PERCEPTION OF THE USE OF ICT IN FOREIGN LANGUAGE TEACHING AT A HIGHER EDUCATION INSTITUTION

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Abstract:

The objective of this paper is to analyse and present the attitude of language teachers of a private higher education institution towards the use of ICT in the process of teaching foreign languages. Furthermore, the aim of the paper is to find out if teachers believe they have the skills and abilities necessary for the implementation of ICT tools. For this purpose, the authors have designed a questionnaire in order to examine if foreign language teachers feel motivated and prepared to implement new technologies as an integral part of their lectures. The results show a positive attitude of foreign language teachers regarding the incorporation of ICT tools in their classes, though they do not state that ICT tools are mandatory and/or essential in the language classroom. The research results also indicate that teachers use both traditional and ICT methods, which they find to be a perfect combination. These research results are very similar to the results of the previous research conducted by the same authors, but from students' perspective, regarding the usage of ICT tools in foreign language classroom.

Keywords:

Foreign language teaching, language teachers, ICT teaching methods.

INTRODUCTION

Foreign language courses have always been considered one of the fundamental aspects at Singidunum University in Serbia, due to the importance of foreign languages that may enable students to develop necessary linguistic competences and communication skills in order to obtain better employment and academic opportunities in different professional sectors or educational fields. Increasing access to new technologies¹ in the modern media culture of the digital society has promoted the usage of technological tools in the classroom. Internet and technological devices take part in almost every class at each educational level.

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¹ In this paper, the term new technologies will be used to refer to a variety of concepts such as ICT (Information and Communication Technologies), digital technologies, modern technologies or emerging technologies, regarding technical innovations and communication technology supported with multi-functional devices that enable easier, faster and better communication and functioning of modern society.



When it comes to foreign language teaching, new technologies also became an indispensable part of teaching practice due to multiple benefits of the usage of ICT tools and digital media for developing and practicing language skills [1]. On the other hand, the integration of ICT in the educational process should rely on teachers' pedagogically grounded and responsible use with clear educational goals, the real impact on teaching practice, the relevance for the objective needs and interests of students, and it is important to avoid their use as a fashionable practice [2]. In that context, the opinion and perceptions of both protagonists in the learning-teaching process (students and teachers) regarding the impact of the usage of new technologies in a foreign language classroom is a fundamental aspect to know and analyse for further improvement of a language teaching process. The methodology used in this paper was based on the analysis of literature related to teacher perception, the impact of ICT and its level of use. The information was collected from university language teachers of foreign languages, through the application of a questionnaire that enabled the authors to identify the opinion of teachers. It is also relevant to determine which tools bring benefit to the language teaching process in the classroom and what kind of teaching dynamics can be applied with a positive impact on learning in a physical classroom, but in the virtual classroom² too, in an online teaching environment. For this paper, the authors have designed a questionnaire as a research instrument. The questionnaire consists of a series of questions whose aim is to gather information from teachers of foreign languages at university level, in order to know their opinions based on teaching experiences regarding the use of new technology in teaching practice, and to identify the relevance for the needs and interests of students. The questionnaire was shared with eighteen teachers, who are all employed at Singidunum University. This research follows the study which was conducted last year regarding students' perception of the ICT oriented work in a foreign language classroom vs traditional methodology of teaching/learning at the same university context [3]. In other words, the same aspects are covered, but a different sample is used.

2 The main difference between the physical and virtual classroom is based on students' and teachers' possibility to share the same physical space, to see and hear each other, on the fact that the whiteboard and learning materials are in real time, as well as on the difference regarding collaborative work in direct contact. In a virtual classroom, a student can see, hear and interact with their teacher and other students in real time via the video-audio stream.

1. STUDENTS' AND TEACHERS' PERCEPTIONS ON ICT IN A LANGUAGE CLASSROOM

The implementation of ICT has a significant and dynamic increase, especially when it comes to higher education [4] [5]. A teacher as a subjective critic of ICT can highlight the deficiencies, but also recognize ICT potential in the teaching and learning process. According to the definitions of the concept of perception, resumed in [6], perception, as the inner sensation that results from a material impression made on the senses, has the function to make abstractions through the qualities that define the essentials of external reality. Following these concepts, studies on the attitudes of teachers towards the new technologies have tended to distinguish different groups based on attitudes [6]:

- ICT is essential in the teaching-learning process.
- ICT is important for certain activities of the teaching-learning process.
- ICT is not a useful tool within the teaching-learning process.

Different attitudes and perceptions of language teachers towards ICT depend on variables of a teacher such as: gender, age, academic level, ICT skills, linguistic and pedagogical competences, etc. Other variables which are relevant refer to the environment, and they can include: resources, attitude of management, contents, syllabus, working environment, technological infrastructure, time management, etc. Finally, a teacher's perception of ICT is shown with the level or grade of its usage, in accordance with the teacher's opinion, as well as in compliance with the influence that ICT can have in the language classroom at a higher education institution. Although some studies show that private university teachers have more favorable perception of the use of ICT in teaching practice than teachers of the public universities [5], the difference in perception can be caused by various aspects in all institutions, such as lack of training programmes in ICT, or limitations in investment in technological infrastructure for teaching and research, as well as factors such as computers, Internet connections, whiteboards in classrooms, intranets, good ICT coordination, and fundamental didactical training in technology [5]. In order to achieve effective learning, the potential of ICT is a significant tool that can improve students' learning strategies [7]. When it comes to effective teaching, necessary skills of the professionals of the digital society and professional teachers'



competences include the use of new technologies and effective communication with students, along with team work, evaluation and educational research, in order to achieve competency to select relevant, updated teaching material and implementation of main ICT elements in teaching practice: devices, programs/applications, and web content [8]. This paper, which is focused on the attitudes of foreign language teachers, was conducted as an additional research to the previous study based on students' perception of the impact and benefits of implementation of new technologies and ICT tools in a foreign language classroom, teaching activities, practice and assessment. According to students' answers³, ICT tools do not have an essential impact on their learning, but they represent an optional and additional aspect that can help language learning, whereas traditional materials such as textbooks and workbooks in paper format are still considered to be a basic useful tool that helps them improve learning a foreign language, regardless of which language that is [3]. According to another research about students' perception of ICT, the students with higher academic results recognise a greater potential of ICT to support their learning strategies, although all students show positive valuation of ICT to improve and facilitate the preparation of work, organise their academic activity, review tasks, work with classmates, find resources and fulfill their academic tasks [7]. In the same way, the research we referred to previously [3] shows that almost 50 % of the students who participated in the research claim that they prefer to practice foreign language with a textbook, which is a form of a traditional teaching method. When asked if students can imagine their language class without the use of ICT, 51.6% of answers were positive, which implied the conclusion that, although students perceive ICT as a significant tool for their learning (91.6%), they highly value the teacher's role with presentations, lectures and explanations in the language classroom. The language teachers at the same institution have confirmed that they receive the same opinion from their students in classrooms, when they discuss these issues in language classes. Students do not have expectations about the teaching strategy and tools or media their language teachers might use. However, what they claim and point out to be important is the learning objective which needs to be clear and the usage of class material with online tools in order to help students to develop their language skills.

³ The research conducted in 2019 implied a quantitative analysis among 119 male and female students who study at Singidunum University in Belgrade, Serbia (Faculty of Business, Faculty of Tourism and Hospitality Management, and Faculty of Technical Sciences).

Accordingly, the role of the language teacher is indispensable for effective learning, as 64.7% of students answered that they agree, and 27% of students strongly agree that a language teacher's lectures, presentations and explanations are more effective for learning than the use of ICT tools.

2. RESEARCH METHODOLOGY AND RESULTS

As stated previously, the research conducted for the purpose of this paper is similar to the previous research by the same authors, presented in 2019 [3], whose aim was to analyse students' perspective. As this time the focus is on foreign language teachers and their opinion and experience, this quantitative analysis aimed to discover and analyse whether teachers found teaching in ICT-oriented classroom easier or more difficult, and more or less useful than teaching in the traditional classroom.

The instrument used for this study was an online, anonymous questionnaire which foreign language teachers (English, Spanish, German, Italian, Russian, French) were asked to fill in. As the sample for the previous study included only the students from Singidunum University, this study also included only teachers from Singidunum University (18 foreign language teachers). The 14 questions given to teachers were mostly multiple choice questions and they could choose only one answer per question, whereas some of the questions were open-ended. Even though this sample might be considered small, the point of the study was to discover the perspective of teachers at a higher education institution who certainly use ICT in the classroom, which is why teachers at Singidunum University have been chosen as the only examinees. The biggest percentage of the examinees, 44.4% (8 teachers) teach the English language, whereas 16.7% of them (3 teachers) teach the Spanish language, also 16.7% of them (3 teachers) teach the German language; 11.1% (2 teachers) teach the Russian language, 5.6% (1 teacher) of them teach the Italian language, and 5.6% (1 teacher) teach the French language. More than 50% of our examinees have been teaching for more than ten years, whereas the rest of them have at least five years' experience. All of them have Internet connection and a computer in their classroom and 61.1% of them often use it (once a week), whereas 38.9% of them always use it (in all classes).

When asked which online or digital tools they prefer (e.g. platforms, online activities, websites, devices), the biggest percentage of teachers (22.2%) chose online



interactive activities such as educational websites and educational application Quizlet⁴, whereas YouTube, as a significant online resource for language learning and teaching with authentic language content, and Kahoot⁵, a recognized learning tool for gamified language teaching and learning [9], were only chosen by 5.6% each. Other mentioned applications were *Madtakes*⁶ and *Quizizz*⁷.

When asked whether they feel comfortable when using digital tools in the classroom, 83.3% of the examinees (15 teachers) said yes, and 55.6% of them confirmed that they are skilled enough for using ICT tools. However, when asked whether they thought that the usage of ICT should be mandatory in a language classroom, more than half of the examinees (55.6%) said no. Also, 50% of teachers claimed that their language class is often traditional (e.g. the usage of a textbook, workbook, or a whiteboard), even though 88.9% of them find it easier to teach a language with ICT tools. Moreover, only one teacher thinks that their lectures and explanations are more effective than the use of ICT tools, and 66.7% of them think that their students prefer learning a foreign language with a textbook and a workbook to learning with a computer and Internet. The same percentage of teachers claim that they can imagine their language classroom without the usage of ICT tools. In the conclusion, the same percentage of teachers (66.7%) do not think that the usage of ICT in teaching has an influence on the students' attendance in the classroom. In the following tables, some of the answers which illustrate the perception of foreign language teachers at Singidunum University regarding the application of new technology tools in their teaching practice are presented.

Question	Do you think that the usage of ICT tools should be mandatory in a language classroom?	
Answer	38.9%	55.6%
	Yes	No

Table I. Teachers' opinion on the usage of ICT in the language classroom.

Question	Do you feel comfortable when using digital tools in the classroom?	
Answer	83.3%	16.7%
	Yes	No

Table II. Teachers' answer to the question whether they feel comfortable when using ICT tools in classroom.

Question	Are your lectures and explanations more effective than the use of ICT tools?	
Answer	94.4%	5,6%
	Yes	No

Table III. Teachers' opinion on the effectiveness of their teaching supported with ICT tools.

Question	Do you think that using ICT in the classroom contributes to better language acquisition of students?		
Answer	77, 8%	5.6%	5.6%
	Yes	No	Sometimes, like additional tool

Table IV. Teachers' opinion on whether the ICT affects the learning of students.

Question	How often is your language class traditional?		
Answer	33.3%	50%	16.7%
	Always	Often	Rarely

Table V. Teachers' answer to the question about traditional methodology in their classroom.

Question	Do you think that your students expect you to use ICT tools in the classroom?		
Answer	44,4%	44,4%	5.6%
	Yes	No	Not sure

Table VI. Teachers' opinion on students' expectations regarding their usage of ICT tools in the classroom.

Question	Which online/ digital tools do you prefer to use?			
Answer	11,1%	22.2%	5,6 %	5.6%
	Online interactive activities	Educational platforms and applications	You-Tube	Kahoot

Table VII. Online tools that teachers mostly use in their language classroom.

Question	Can you imagine your language class without the use of ICT?		
Answer	66,7%	33,3%	0%
	Yes	No	Not sure

Table VIII. Teachers' opinion on the ICT-free classroom.



3. CONCLUSION

Students and language teachers in the university context where the research was conducted share the general opinion regarding the positive impact of the new technology in language classroom as a tool that can help to acquire language contents and improve effective teaching. The teachers who were examined believe that the implementation of ICT is an expected approach in language teaching in academic classroom. However, according to the study referring to students' opinion which has been published in the previous paper by the same authors, new technology is not an essential, but an additional aspect in the classroom. When it comes to the traditional materials in paper form such as textbooks and workbooks, students and teachers and they share the same opinion. Although some teachers believe that students expect the usage of technological devices, online platforms, applications and other ICT tools during lectures in the class that will replace the traditional role of the textbook or intervention of the human factor, such as teacher and student verbal interaction, students support any methodology (which is either supported by ICT or not) that may help the improvement of their language and communication skills and which includes language effective practice in every class. On the other hand, teachers' pedagogical competences regarding foreign language teaching with appropriate ICT skills may enhance a more functional and effective language learning in university classroom. The needs and interests of students do not necessarily have to comply with teachers' perceptions. For this reason, teachers may use research instruments such as questionnaires to know both students' and teachers' expectations better, to be aware of their needs and learning/teaching styles, and perception regarding the teaching and learning process, in order to improve their language skills and make foreign language learning more effective. As far as teachers are concerned, the usage of ICT tools is becoming an essential part of a language classroom, though traditional teaching methods are still not obsolete. According to the opinion of teachers who participated in the questionnaire for this research, although they state that they feel comfortable using ICT tools in their classroom (83,3%) and perceive new technology as a tool that contributes to better language acquisition of students (77,8%), teachers also often (50%) or always (33,3%) apply traditional methodology in the teaching practice, which shows that they consider benefits of innovative methodologies assisted with new technology, but do not discard the

proven traditional formulas for effective teaching and learning.

It is also important to mention that this study was conducted before the outbreak of COVID-19 pandemic, and that the authors believe that teachers might give different answers to some questions from the questionnaire (e.g. 'How often do you use Internet and ICT in your classroom', 'Do you think you are skilled enough for using ICT tools', etc.) now that they have been required to implement ICT tools as the only language teaching tool, due to virtual classes all over the world. Furthermore, the authors believe that several other studies should be introduced in order to fully understand the attitude of both teachers and students towards the usage of ICT tools in the classroom, especially when it comes to comparing the attitudes of teachers and students and comparing these attitudes before COVID-19 and during COVID-19 pandemic. With that in mind, the authors of this paper are currently working on the comparative analysis of the attitudes of students and teachers towards the usage of ICT tools in the language classroom, and the results of that study are to be published soon.

REFERENCES

- [1] Gilakjani, Abbas Pourhosein. "A review of the literature on the integration of technology into the learning and teaching of English language skills." *International Journal of English Linguistics* 7.5, 2017, pp. 95-106.
- [2] Velea, S. "ICT in education: responsible use or a fashionable practice. The impact of eTwinning action on the education process". In ICVL. *Proceedings of the 6th International Conference on Virtual Learning*. Bucharest: University of Bucharest Publishing House, 2011.
- [3]. Veljković Michos, M.; Nasradin, K.; Bošković Marković, V.; "Traditional Language Teaching Versus ICT Oriented Classroom". In *Sinteza 2019 - International Scientific Conference on Information Technology and Data Related Research*, Apr, 2019, pp. 627-632.
- [4] Sigalés, C. *Formación universitaria y TIC: nuevos usos y nuevos roles*. *Revista de Universidad y Sociedad del Conocimiento (RUSC)*, 2004, vol. 1, N° 1.
- [5] Marqués Graells, P. *Impacto De Las Tic En La Educación: Funciones Y Limitaciones*. 3C TIC. Cuadernos De Desarrollo Aplicados a Las TIC, Vol. 2, n.º 1, Jan. 2013.
- [6] Riascos-Erazo, S. C., Ávila-Fajardo, G. P., & Quintero-Calvache, D. M. *Information Technology in the Classroom: The views of university professors*. *Educación y Educadores*, 12(3), 2009, pp. 133-157.



- [7] Muñoz-Repiso, Ana García-Valcárcel, and Francisco Javier Tejedor Tejedor. "Percepción de los estudiantes sobre el valor de las TIC en sus estrategias de aprendizaje y su relación con el rendimiento." *Educación xx1* 20.2, 2017, pp. 137-159.
- [8] M. A. Zabalza, *Competencias docentes del profesorado universitario. Calidad y desarrollo profesional*, Madrid, Narcea, 2003, pp. 71-168.
- [9] Veljković Michos, M. "Gamification in Foreign Language Teaching: Do You Kahoot?". In *Sinteza 2017-International Scientific Conference on Information Technology and Data Related Research*. Singidunum University, 2017, pp. 511-516.



USING POPULAR CULTURE TO DEVELOP STUDENTS' MEDIA LITERACY AND CRITICAL THINKING SKILLS

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Abstract:

This paper addresses the ever-growing complexities pertaining to information consumption, which are particularly enhanced by the advancement of technology. It focuses on the essential skill which is needed nowadays for an effective navigation in digital age – media literacy. This paper investigates how the core concepts of media literacy can be applied in the analysis and evaluation of media products, with the aim to promote and develop students' media literacy and critical thinking skills, as well as their digital competence. The purpose of this work is to present the process and the results of a project conducted among secondary school students which focused on the use of popular culture as a resource for the application of the key media literacy concepts and principles.

Keywords:

media literacy, five key concepts, popular culture, technology-mediated, critical thinking.

INTRODUCTION

Technology has become an integral part of almost every segment of human activity, and the ever-changing processes affecting social and cultural relations also influence many aspects of education, resulting in various new or redefined theoretical concepts. One of them is, undoubtedly, the redefinition of media literacy, which casts a new light on the scope of traditionally perceived notion of literacy and what it means to be literate in the 21st century.

For the last couple of decades not only has media literacy gained in importance in the sphere of social sciences, but also it was introduced in educational context, and was defined as one of the key skills to be developed in the classes, or even introduced as a separate subject in many school systems around the world. According to the Law on the Education System Foundations of the Republic of Serbia, in 2018 media literacy was incorporated within an optional subject called 'Jezik, mediji i kultura' (*Language, Media and Culture*), taught in grammar schools, and legal documents regulating all aspects of education also state that media literacy is one of the key skills to develop in the classroom through all subjects [1].

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Closely related to medial literacy is the notion of critical thinking skills, and these two are often studied together because being media literate implies having well developed critical thinking skills. In terms of legal documents which regulate education and its aspects, critical thinking skills are defined as the key skills teachers need to aim at developing while planning their lessons [1].

This paper focuses on a project initiated by the Fulbright Teaching Excellence and Achievement Programme the author of this paper was a part of during the academic year 2019/ 2020. This project, drawing on the knowledge and experience the author gained at the training programme called Media Literacy, held at the Kent State University, the USA, was conducted among secondary medical school students in Belgrade. The aim of this study is to reflect on the theoretical framework related to media literacy and its core concepts, and to suggest how they can be incorporated in the syllabus, through a description of the conducted projects and its results. The empirical part of this study reveals the results related to students' awareness of media literacy and its main principles, and how they apply them in their studies and everyday life. Another part of the research provides pedagogical principles arising from the results obtained from the project organised in English language classes, incorporating media literacy core concepts, and focusing on the use of popular culture as a resource for the application of these principles.

1. BEING LITERATE IN THE 21ST CENTURY

The context wherein we teach today is much more complex and diverse than ever before, and the aims of teaching have also been modified; in order to support 21st century learners and their needs, 'a multiplicity of discourses' must be negotiated in pedagogy [2].

In traditional terms, literacy is defined as the ability to read and write. However, as the complexities of the nature of reading texts and the channels we get them are growing, the scope of literacy is being expanded as well. Over time, the perception of literacy was modified and started to include a variety of skills needed for a proper and functional use of reading and writing. Nowadays, being literate in the 21st century involves many aspects, and media literacy indisputably takes an important role in creating a more literate nation [3].

The Council of Europe passed a resolution on media literacy back in 1989, and the last revision was made in 2019, and in its fifth paragraph, it says "Media education should address all members of the public.

It should start at school and continue as part of a life-long learning process, aiming to enable all individuals to exploit the potential of media for access to culture, entertainment, learning and intercultural dialogue; to help them acquire a critical approach to media as regards both quality and accuracy of content, to develop their digital skills and knowledge of existing protection tools; and to improve their online behaviour." [4].

The explanation given in the revised version clearly illustrates the variety of aspects media literacy includes, and how complex it is. It also implies that the task of schools and educational institutions surpasses a traditional perception of literacy, and that the issue of media literacy should be approached in a systematic way within the institutional framework.

As a part of the reformed system of education, media literacy was introduced as an optional subject in grammar schools in 2018, and the legal documents regulating education in the Republic of Serbia define media literacy, along with information literacy, as an obligatory competence to develop among primary and secondary school students through all subjects [1]. However, according to the research done by the Faculty of Philosophy of the University of Niš, in cooperation with the Media and Reform Centre, the level of media literacy among Serbian students is poor, and teachers usually lack knowledge and training in the field [5]. The amount of information students are exposed to on a daily basis is enormous, and the use of the Internet and social media allow them not only to consume, but also to upload and share information, which makes the issue of media literacy even more relevant.

2. MEDIA LITERACY AND ITS CORE CONCEPTS

Today, the notion of literacy is much wider, and it encompasses different perspectives – it is cultural, critical, transformative and creative [6], and all these make the key elements of media literacy.

Media literacy can be explained as a complex ability comprising a set of various skills. Being media literate means being able to access information, read and analyse it critically, evaluate its content, and, finally, create one's own information based on the received set of data. It is complementary to information literacy, and both literacies came into the focus of worldwide attention with the introduction of the global curriculum devised by the UNESCO [7]. The skills we use while processing media input are not restricted to media literacy, but are



developed within various contexts and daily situations, and, therefore, they can be enhanced through strategies employed in different situations.

In formal terms, media literacy is defined as "a set of perspectives that we actively use to expose ourselves to the mass media to interpret the meaning of the message we encounter" [8]. One of the main features of media literacy is that it is multidimensional, i.e., it is characterised by a variety of different perspectives, which makes the task of teaching media literacy a complex pedagogical issue demanding a careful and well-planned approach.

One of the starting points in studying and tackling the issue of media literacy is a proper understanding of its key concepts, and what they involve. These concepts can serve as guiding principles to rely on while developing media literacy skills, and due to their straightforward and clear definitions, they can compose a helpful framework within which we can teach media literacy in school. It has also been emphasised that knowing and understanding media literacy key concepts can help young people "make sense of life in a media-saturated age" [9].

The first media literacy concept states that all media are constructs, meaning that the message we receive was carefully planned and created by someone, who had some reason and intention for creating it at a certain time and place. Being media literate means being able to deconstruct this message and get its real meaning. The second concept refers to linguistic content and visual aspect of a message, i.e., what language and visual devices are used in order to convey the message. The third principle which needs to be taken into consideration is the way how different people perceive the same message, which means that being aware of different perceptions opens different perspectives on the same piece of information. The fourth concept is also crucial because it casts light on values and points of views represented in a certain message. Being able to decipher what types of messages are communicated, and what the lifestyles and values involved are, implies having a higher-order critical thinking skills. All media messages are created with a certain intent, and the fifth core concept states the importance of recognising the purpose of the constructed message [10].

All the above mentioned concepts imply the following key aspects we need to consider while endeavouring to develop media literacy and critical thinking skills: the authorship of the media message, its format (linguistic and visual/ auditory), what the aimed audience is, the content of the message, and its purpose.

3. PROMOTING MEDIA LITERACY IN THE CLASSROOM

Resulting from inevitable effects of media on all aspects of human endeavour, school systems and educational institutions around the world have started to consider teaching media literacy as an inseparable part of the official school curriculum. Finland was the first country in Europe to introduce media literacy systematically into education in the early seventies, and more than a decade took other European countries to follow the example [11].

The importance of specifying the objectives of media-literacy-based classes is emphasised when it comes to incorporating media literacy content into the syllabus of specific subjects [11]. The starting point for implementation of the key principles in the syllabus and promoting media literacy in the classes involves the learners' needs and learning rationale lying behind a specific subject. A careful planning and lessons designed in alignment with both the curriculum and its objectives and the main principles of media literacy can contribute to a better organisation of lessons whose aim is to promote media literacy and critical skills development.

4. PROJECT-BASED MEDIA LITERACY TEACHING

Due to the fact that media literacy is complex by its nature and characterised by a variety of aspects, the model of project-oriented organisation of classes provides an excellent framework for the full potential of the development of students' media literacy and critical thinking skills.

Regardless the framework and the subject being taught at school, the method relying on the project-based teaching and learning has always aimed at engaging students in a meaningful and real-life manner [12].

Project-based teaching represents one of the innovative teaching models which has existed for centuries in educational contexts, but gained in its relevance a few decades ago, when the necessity of incorporating the principles of project-based teaching into the school system became observable in various regulations and education-related laws. Project-based teaching is defined as an active teaching method whose purpose is to connect the content studied within various school subjects, with the aim to enhance various competences, skills and literacies [1].



The reformed programmes also introduce project-based teaching as a model wherein students have the opportunity to conduct some research and investigate a given issue through an interdisciplinary approach.

In an educational context, like the one above described and officially prescribed by regulations and laws, media literacy can be developed through project-oriented classes in all subjects. This work reports on one project conducted among secondary school students, in English classes, which relies on the core media literacy principles.

5. THE DESCRIPTION OF THE PROJECT AND ITS RATIONALE

The project was devised for secondary school students, and approximately 270 seventeen and eighteen year old students took part in it. The project was incorporated in the syllabus and comprised seven 45-minute classes. The main aim of the project was to help students understand the main principles of media literacy, and learn how to analyse and evaluate media products using the five core concepts of media literacy. Through the analysis of popular culture, the students were introduced into its scope and nature, and were scaffolded to develop their analytical and critical thinking skills. Another important aim underlying the project was to make students aware of the scope and impact of popular culture, and to support them to be smart consumers of popular culture on a daily basis.

The reason why popular culture was chosen as a resource for promoting media literacy skills lies in the fact that students are exposed to various aspects of popular culture and consume it on a daily basis, using different channels of reception, without being fully aware of its impact on their lives. Furthermore, they already have some knowledge and a big interest in it, so the very source of investigation was motivating for the students, and, it made them more comfortable to work on and analyse material which had some relevance and value for them. The topic was chosen according to the students' needs, with the main aim to help students develop media literacy and critical thinking skills. The main rationale lying behind this choice was to empower students with adaptable set of skills they can apply in analysing any type of information or media input.

The project consisted of seven 45 minute periods: one preparatory and introductory lesson, one lesson providing theoretical background on media literacy, two lessons with students working on their projects in

groups of 4, and three lessons with students presenting and evaluating their projects.

The students went through a training session about media literacy and popular culture, and were presented with theoretical background to the issue and were given instructions how to use the five core question framework to analyse some media products. After the preparatory stage, and equipped with necessary input for their independent work in groups, the students were involved in the process of accessing, analysing and evaluating a media product on popular culture chosen by the students themselves. They created their own product which reflected the whole learning process, providing reasons to justify their choice of popular culture in terms of type, values and impact on young people.

When the students' works on the projects were over, the phase of presentation followed, and the students presented their works in front of the whole class, and the most successful ones were exhibited for the whole school. The project products were in different forms – PPT presentations, posters, or oral presentations with no visual support – and were chosen by the students themselves.

6. THE EVALUATION OF THE PROJECT AND ITS RESULTS

The important aspect of the whole project was the phase of a three-sided evaluation – students self-assessed their own contribution to the success of their group, peer assessment took a significant role in the evaluation process, and, finally, the teacher made her own evaluation sheet composed of rubrics referring to the application of media literacy principles in students' works.

The evaluation provided by the students has affective value and reveals how they felt during the whole process of preparation and participation in this project, and what their own contribution to the final product was. The answers they provided contained positive attitudes to the whole experience, and the students found project-based teaching and learning motivating and engaging, describing it with the words/ phrases such as "fun", "creative", "different", "motivating", "interesting", "working together", "relying on each other".

The rubrics that the teacher devised for the evaluation of students' works contained questions referring to the main objectives of the project and to what degree they were reached. Since the project was realised through a series of 45 minute lessons delivered in 9 classes/ groups (each group comprising approximately



30 students), there were 63 different groups working on different projects. The evaluation sheet the teacher used contained 6 rubrics which assessed to what degree the students applied the core media literacy principles, and one question assessed how successful they were in defending the reasons for choosing a certain pop culture media product.

All questions from the teacher's evaluation sheet were structured in the same way, starting with "To what extent did the students apply the principle of ...", and the 4-point scale was used to assess the achievement of the students' projects, 1 being the least favourable, and 4 the most successful outcome.

The analysis of the evaluation sheets shows that the majority of the students (over 80%) were able to identify the author of the media product they analysed, namely, who created the message, where and when it was produced. Another very successful outcome relates to the format of the message and the students could formulate the techniques used to draw the audience's attention rather successfully. What strikes as an encouraging result of the students' work on the task of analysing a piece of popular culture product is the way they tackled other core principles which demand a more thorough reading and analysis, with the application of critical thinking approach and a subtle interpretation of the messages. More than 70% of the students showed a high degree of awareness related to the intention of the creator of the message, different interpretations by different audiences, and the very content of the media product. Even the most demanding task related to the identification of lifestyles, values and points of view was tackled by over 40% of the students, who provided some answers related to these issues.

All these results show that the students were aware of the core medial literacy principles and the majority of them incorporated them in their analysis of the pop media products they had chosen.

The last rubric from the evaluation sheet referred to the reasons why the students opted for a certain pop culture product, and all groups provided some answer to this question. However, the quality of their explanations vary from a very detailed, supported by sound arguments, and well illustrated by examples, to those that were just mentioned with rather vague and superficial explanations, such as "because I like it", or "because many young people watch it", without any critical insight why it is relevant for discussion and analysis.

The analysis of the students' self and peer evaluation, as well as the teachers' evaluation sheets and rubrics shows

that the main objectives of the project were achieved: the students could identify the scope and nature of popular culture; they learned how to analyse and evaluate a media product using five core concepts of media literacy; the active students' involvement enhanced their analytical and critical thinking skills; working as members of teams helped the students improve their communication and collaboration skills.

However, the results have been analysed and discussed through group work, not individual achievements of each student, and they should be approached accordingly. It implies that the percentage of the achieved objectives per student could be smaller, but since the aim of the project was to realise the whole project on media literacy through work group, individual achievement was not prioritised in the process of evaluation.

7. PEDAGOGICAL IMPLICATIONS

The results of the project conducted among secondary school students, who are susceptible to consuming a variety of media products to a large extent, on a daily basis, show that a carefully planned organisation of the teaching process, wherein the students' needs as well as complex aspects of the modern teaching paradigm are taken into consideration, can enhance students' skills and literacies, among which media literacy and critical thinking skills take a significant place.

Incorporating relevant topics on media literacy into the syllabus, and applying those teaching methods which are successful for their realisation, help students be not only wise consumers of media products but also responsible producers of various messages delivered and shared on numerous media platforms. When students get a hands-on experience, the knowledge they gain is more functional and applicable in a variety of contexts, and, therefore, more stable and longer-lasting, equipping students with skills for lifelong learning and managing in the world saturated with media production and consumption.

The inquiry process makes students active participants in the process of learning, wherein they take responsibility over their own learning, and, thus, learn how to be more responsible and independent, while the teachers take the guiding and supporting role in the teaching and learning process.

Teaching media literacy through project-oriented lessons creates the environment wherein integrated approach can reach its full potential and allow students to learn a certain content through different scientific areas.



The use of five core media literacy principles can serve as a replicable model, or a framework for the analysis of any information, media product or input in any format, which can be reinforced and repeated in many subjects and at all educational levels, thus helping students internalise all these principles and apply them in any real life situation connected with any kind of media consumption and production.

CONCLUSION

The notion of media literacy goes beyond the media studies and media education [6], making the importance of incorporating media literacy into a curriculum even more compelling – by doing so we help learners gain lifelong skills which can be effectively employed outside the classroom, in a real world.

This paper focused on a project which was organised and delivered as a part of the curriculum, incorporating the topics of “media” and “popular culture”, and delivered through project-oriented classes. This organisation of lessons encompasses various aspects of the curriculum – the topics, innovative teaching methods, skills and competences, with the focus on media literacy and its main tenets.

The aim of the described project was to motivate students to reflect upon popular culture critically, and to be aware of their own media diet. Pertaining to the exploration of the topic of popular culture, students were encouraged to think in the direction of being smart and responsible users and creators instead of being passive consumers of everything they see, hear and read about.

The main goal of the described project was to help students approach media inputs critically, with the application of five core concepts whilst selecting, analysing and evaluating a certain media product. The analysis of the whole project, based on the evaluation done by the students and the teacher shows that a project-based lesson organisation, relying on students’ needs and interests, creates a supportive and engaging environment for qualitative and functional learning. Research method, as an integral part of project-based method is characterised by the development of cognitive abilities and skills, and the process brings about results which can be applied [13]. The analysis of the teacher’s evaluation sheet rubrics shows that a carefully planned and organised lessons can develop students’ media literacy and critical thinking skills.

Although the importance of media literacy is emphasised in official documents which regulate modern Serbian educational framework, media literacy is still in its infancy, and the real relevance is still to be discovered within all subjects and curricula.

REFERENCES

- [1] S. Glasnik, *Zakon o osnovama sistema obrazovanja i vaspitanja*. Službeni glasnik Republike Srbije, br. 88/2017, 27/2018 –dr. Zakon, 10/2019, 27/2018, 2017.
- [2] V, Schmidt and P. L. Thomas, *21st Century Literacy: If We Are Scripted, Are We Literate?* Furman University: Springer, 2009.
- [3] V, Wolf, and S. Gottwald. *Tales of Literacy for the 21st Century Literacy*. Oxford: Oxford University Press, 2016.
- [4] *Media Education on New Media Environment*. Parliamentary Assembly. Committee on Culture, Science, Education and Media, 2019.
- [5] *Istraživanje o medijskoj pismenosti*. Univerzitet u Nišu. Filozofski fakultet. Media & Reforms. Centar Niš, 2016. Available: <http://mirc.rs/wp-content/uploads/2016/12/Istrazivanje-MEDIJSKA-PISMENOST-MRCN.pdf>.
- [6] A, Burn and J. Durran. *Media Literacy in Schools: Practice, Production and Progression*. London: Paul Chapman Publishing, 2007.
- [7] B. S. Abreu, *Teaching Media Literacy*. Chicago: ALA Neal-Schuman, 2019.
- [8] W. J. Potter, *Media Literacy*. Thousand Oaks: Sage Publications, Inc, 2008.
- [9] M. Hoechsmann and S. R. Poynt. *Media Literacies: A Critical Introduction..* Malden, MA: Wiley-Blackwell, 2012.
- [10] *Center for Media Literacy*. Available: <https://www.medialit.org/reading-room/10-benefits-media-literacy-education>
- [11] R. Kubey, *Media Literacy in the Information Age*. Current Perspectives. London: Transaction Publishers, 1997.
- [12] P.C. Blumenfeld, E. Soloway, et all, "Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning," in *Educational Psychologist*, 26 (3&4) , p.p. 369-398, 1991.
- [13] S. J, Krajcik and N. Shin, "Project-Based Learning," in *The Cambridge Handbook of the Learning Sciences*, R. K. Sawyer, R. K, Ed. New York: Cambridge University Press, 2014, pp. 275-298.



WORDUP MOBILE APPLICATION – AN ENTERTAINING FORM OF PERFECTING YOUR ENGLISH VOCABULARY

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Abstract:

Combining innovative ideas with the latest digital technology has enabled learners worldwide to perfect their English in a revolutionary way. This paper presents WordUp mobile application for learning new English words and improving vocabulary. This app has succeeded in ranking all the words in the English language in order of how useful they are. WordUp first detects knowledge gaps and then creates a personalized learning plan that focuses on one word at a time, always ensuring that most useful word is being learnt first. The aim of this paper is to examine students' views on the usefulness of this app. In accordance with the set goals and hypotheses, the qualitative research, in the form of a focus group, has been conducted on a representative sample of the student population of Singidunum University in Belgrade. The study results confirmed that students want to learn English vocabulary in an innovative and fun way. Their enthusiasm leads the authors to believe that mobile applications for learning foreign languages should be introduced into curricula. An important finding of this study is that WordUp is quite often used instead of a dictionary. This app is suitable for all people willing to improve their English vocabulary in a flexible and dynamic way.

Keywords:

WordUp, mobile applications, foreign language learning, vocabulary acquisition.

1. INTRODUCTION

Vocabulary did not have a special status in teaching foreign languages until the Communicative Language Teaching or Communicative Approach has become extremely popular and used worldwide. Leading linguists and language teachers often disagree on formal instructions, strategies or methods that would be most effective for vocabulary acquisition. In recent years, the most significant progress in the study of vocabulary within applied linguistics has been the use of Computer-Assisted Corpus Analysis (CACA) [1]. In that way, an empirical basis for determining word characteristics was obtained, instead of simply relying on intuition [2]. Computer-Assisted Corpus Analysis is considered to be

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a revolutionary approach to teaching vocabulary. It has contributed to the development of modern dictionaries based on corpus data. CACA also enables us to determine lexical units frequency in both spoken and written language, as well as to obtain important information on phrases and collocations. Phrases and collocations are believed to be lexical patterns that native speakers adopt quite easily, while foreign language students still focus on learning individual words [2], although learning collocations is essential for making a foreign language sound fluent and natural [3]. The main source of language data is the corpus. A corpus is a collection of thousands of different 'texts' stored on a computer or in the cloud [4]. The point of using a corpus is that we can't observe all the English that is being used by millions of people all over the world, so instead we look at a representative sample of English texts by using intelligent digital tools. Corpus enables discovering the contexts in which words appear as well as identifying patterns and functions that are not obvious or are contrary to the intuition of a teacher or a textbook writer [5]. The data obtained from the corpus are the best indicators of the words frequency, as an important aspect of lexical processing [2]. In language, the more frequent something is, the more useful it is to learn. Based on the frequency, vocabulary lists are created in order to meet the teaching and certification requirements at certain levels in accordance with the Common European Framework of Reference for Languages [6].

Due to the tremendous development of IT sector, Computer-Assisted Language Learning (CALL) has become E-learning, Distance Learning and Mobile Learning [7]. CALL requires students' digital competence. It is necessary to pay special attention to the concept of mobile learning due to the fact that children get their mobile phone quite early and young population increasingly use the available content [8]. The Millennial generation has grown up with digital devices, so mobile learning is tailored to the way they work and think. Easy accessibility is one of the most important aspects of m-learning. Additionally, m-learning enables learners to take their learning materials with them. Mobile applications for learning foreign languages play an important part within it.

2. WORDUP MOBILE APPLICATION

Word Up is a revolutionary mobile application for learning new English words and improving vocabulary. It is completely different from all other mobile appli-

cations aimed at foreign language learning. The main goal is to combine innovative ideas with the latest digital technology, in order to facilitate the language challenges people all around the world regularly face. The philanthropic vision of the application creators is to help everyone who wants to improve their English vocabulary, both productive and receptive, without financial compensation, in an innovative and modern way [9].

It is important to emphasise the fact that WordUp app has ranked all the words in the English language in order of how useful they are by using Computer-Assisted Corpus Analysis. Therefore, every user makes the most of their learning time because they focus on what matters the most.

This mobile application analyses millions of movies, TV shows, songs, stories, newspaper articles, famous people's quotes and similar captivating material in order to bring the most helpful, exciting and enjoyable examples for each word to its users. One of the main objectives is to learn in context; in other words, to learn how to use each word in real life, while truly enjoying the process of learning.

One of the main principles of this mobile app is "*remember forever*". When a user learns a new word, the next day the app will check if the user remembers it. If not, the user sees the explanation, examples or translation in order to practice again. The users can also practice pronunciation (it is possible to choose between British and American English). This repeats until one day the user says "*I remember*". Then it comes back in 3 days. If the user still remembers the word or phrase, it comes up in 7 days, then a month, then 3 months and finally after a year. According to WordUp, if the user remembers the word or phrase after a year, they have learnt it for life.

One of the features that make this application so special is personalisation. WordUp first detects where the gaps in users' knowledge are and then creates a personalised learning plan that focuses on one word at a time, always ensuring that the users learn the most useful word first.

WordUp is designed to become a part of users' lives, supporting them every day. Once the map of their knowledge gaps is created, the users will start to fill the gaps. They begin to follow a plan while learning new words and phrases.

WordUp can be one of the best pastime activities. Rather than wasting time on social media, learners can consume entertaining news and other content that WordUp will gather for them, all while improving their knowledge in a relaxed fashion [9].



3. STUDY AIMS AND HYPOTHESES

The aim of this paper is to determine students' views on WordUp mobile application and its usefulness. Before conducting the research, the following hypotheses were set:

- ◆ Students who use WordUp mobile application prefer/enjoy personalized learning plan and the fact that WordUp has ranked all the words in the English language in order of how useful they are.
- ◆ Students find learning in context the most helpful option (users are offered movies, TV shows, songs, stories, newspaper articles, famous people's quotes etc.).
- ◆ Students, due to their faculty obligations, are not ready to spend much time using this mobile application on a daily basis, but they would strongly support this app to be introduced into their curriculum.

4. RESPONDENTS

The respondents are Singidunum University students who voluntarily agreed to participate in this research. They are fourth-year students of the Faculty of Informatics and Computing and the Faculty of Tourism and Hospitality Management, as well as second-year students of the Faculty of Business in Belgrade. Qualitative research, in the form of a focus group, was conducted in order to determine the clearest possible picture of students' views concerning WordUp mobile application and possible ways to improve the English language vocabulary. Six students who have used and/or still use this mobile application participated in qualitative research; therefore, their opinion can be considered relevant. It should be noted that this is a deliberate, not a simple random sample, since selected students are communicative, open-minded, extroverted and quite motivated to learn foreign languages according to data from practice (active participation in the learning process and extracurricular activities at the university). Students, participants in the focus group, previously filled out an online survey and thus participated in the quantitative part of the study on modern trends in learning English and improving its vocabulary by using WordUp mobile app, which was part of our previous research [10]. We opted for qualitative research considering it more suitable for expressing attitudes and describing experiences.

5. RESEARCH QUESTIONS

Our study was guided by the following questions:

- ◆ Have you ever used/Do you use WordUp mobile app?
- ◆ Has this app helped you improve your English language skills? When did you find it most useful?
- ◆ When introducing a new word, which option helps you the most?
- ◆ What do you like most about WordUp and what distinguishes it from all other language applications?
- ◆ List the benefits/advantages of WordUp.
- ◆ List the disadvantages/shortcomings of WordUp.
- ◆ How much time a day do you spend using this app?
- ◆ At what times of the day do you use this app?
- ◆ Would you recommend this app to others? Why?
- ◆ Would you like this application to be used as part of regular classes or as homework?

6. RESEARCH RESULTS

When asked whether they used/use WordUp mobile application, five out of six respondents answered in the affirmative. Most of them continued to use it on a regular basis, stating that this app is more reliable than all the others, and above all, it is useful, efficient and easy to use.

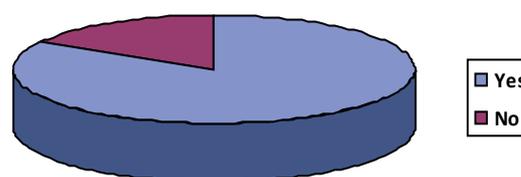


Fig. 1. Have you used/Do you use WordUp?

One respondent finds this application to be particularly useful during English classes; she points out the importance of „learning in context“ concept – by using „Search“ option she manages not only to check the meaning of a word or phrase but also real life situation examples such as short movie inserts, newspaper articles, popular songs etc. The rest of the group completely agreed with her.



Respondents stated various advantages of WordUp app such as easy word/phrase memorization strategies, word families and parts of speech explanations. Also, it is confirmed that this application is great for filling knowledge gaps. Moreover, it proves to be great additional tool to stay in daily contact with the English language. Words and phrases are presented visually as well, through photos and pictures, which is particularly suitable for visual types of people. Visual representations of words through photographs and pictures is particularly emphasized in relation to easier memorization of new words and phrases. One of the students stated that this app is aimed only at learning the English language which is one of its biggest disadvantages. She adds that, due to the fact that English is a global language and „everyone speaks English“, it would be more useful to learn other languages, such as French, German or Spanish in the same way.

The question „Has this app helped you improve your English language skills? When did you find it most useful?“ proved to be really interesting one. One student said that the language progress was evident and the app especially helped her in improving her speaking skills. While listening to series and movies inserts and popular songs lyrics, she repeated the words, remembered them far easier than before and found it much more entertaining. Another student claimed that this application helped her improve her listening skills. There is also an important observation regarding all the functions of the app which was particularly emphasized by our students. WordUp ranked all the words in the English language in order of how useful and complex they are, always ensuring users learn the most useful (and the simplest) word first. Additionally, WordUp helps the users assess their vocabulary and helps them learn new and useful words in each lesson, starting from simple to really complex ones. Users can choose between English for Specific Purposes and English for Academic Purposes. One of the students believes to be proficient English speaker but he does not prefer learning ESP and EAP because he does not think he will ever be in a position to use those words/phrases. He adds that „those phrases are just for experts to use“. Talking generally about language mobile applications, one of the students claimed he saw no significant progress regarding all language skills. Although he considered mobile apps an excellent additional educational tool, he still preferred traditional teaching methods, class interaction and foreign language teachers to be irreplaceable.

When asked which option helped them the most when introducing a new word, vast majority of respondents said that it was the definition of words from the dictionary, as well

as „learning in context“ concept; students learn how to use words/phrases in real life situations by watching/listening to popular songs, movies and series inserts, newspaper articles, celebrities quotes etc. They particularly liked Test me! option because they could immediately check if they had memorized the word. Additionally, they liked visual presentation of the word. On the other hand, translation of the word into their mother tongue is of the least importance.

Students listed almost all the options that WordUp offers as their favorite ones when asked about the advantages of this app. In their opinion, the most important pros are as follows: personalized dictionary, knowledge map, personalized words ranking in order of how useful they are, regular reminders – users can choose the best time of the day for learning English (just woke up, around breakfast, way to work/school, around lunchtime, way back home, in bed), as well as the amount of time they dedicate to it, depending on the goals set (casual, regular, serious, champion). Category option is also emphasized as most useful one, according to the respondents. This option is usually used when preparing for the exam, as well as expanding vocabulary related to one's profession or specific category such as sport, family, furniture, fruit, cooking, arts, business etc. Respondents said they especially liked the Exam Preparation option, which helps the users familiarize with the format of the tests, questions and task types for each section (listening, reading, writing and speaking) So far, IELTS, TOEFL, PTE, GRE and SAT have been offered. The users can independently prepare for each of the tests mentioned by using WordUp mobile application. Furthermore, participants stated that this app offers extremely fun English learning. There are certain gamification elements and especially designed Word Games option. Subcategories Smart Eyes!, Said What?, Confuse me! and Spell It! in an entertaining way help users improve all their language skills. The respondents see games as a challenge, they hold their attention the most and they consider them meaningful in context of learning new words." Respondents also compared WordUp app and Google Translate favoring the first option due to possibilities of using a given word in various contexts instead of offering basic translation. In addition, when using WordUp as a dictionary, users can hear the pronunciation of the word either in American or British English; also, word definition, synonyms and sentence examples are immediately provided. All of the interviewed students agreed that the previously mentioned option was the most useful to them.

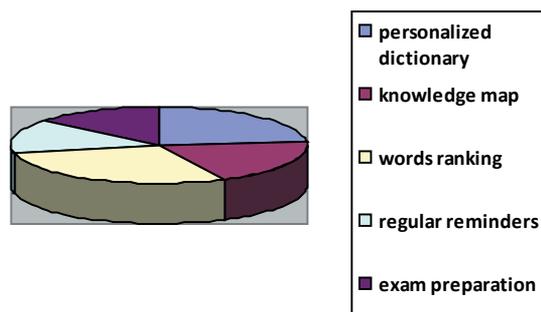


Fig. 2. Advantages of WordUp

After the detail analysis of all the answers, the main benefits of WordUp mobile application are believed to be:

- it is free and accessible
- it can serve as a pocket dictionary
- it can meet different demands.

The app is designed for various needs – all sorts of users can learn English vocabulary they personally need the most. One respondent even found this app more relevant and reliable than the most popular translation platform, Google Translate, and believed it should be included as one of the English dictionaries on Google Play Store. Respondents believe the advantage of the application is its wide range of topics, as well as "all possible categories of words". Furthermore, learning in context concept, knowledge gap detection and personalized learning plan are also strengths that make this application unique.

According to the respondents, technical problems are the main shortcomings of this application. It happens that the application "locks up and slows down" or fails to load or display images. They also believe that this is a young application and that lots of effort has been constantly put in order to improve it. One respondent states that the option of voice recording is missing – she would prefer searching the words by voice instead of writing them. Another participant states that the application sometimes offers a strange choice of words. Lack of communication with other people, the fact that the app is not as interesting and caring as a teacher and taking the app only as a game are also some of the most mentioned disadvantages; sometimes students feel they just improve vocabulary, not all language skills. A participant believes this application is not either aimed at beginners or at those who are fluent English speakers, but at those who are intermediate learners with the main goal of expanding their vocabulary.

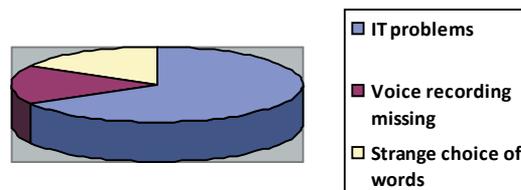


Fig. 3. Disadvantages of WordUp

Regarding the questions "How much time a day do you spend using this app?" and „What times of the day do you use this app at?“ the respondents answered 15 to 20 minutes a day, mostly while commuting or in their leisure time. One respondent says that she uses the app always when she encounters unknown words/phrases – while listening to the music, preparing for exams, even in class. Respondents state that the application sends daily regular notifications at the desired time. It reminds the users that they need to do their daily task (when creating their profile, users choose the amount of time they want to dedicate to this app depending on their objectives).

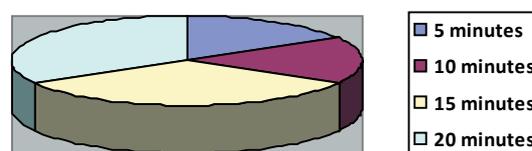


Fig. 4. How much time a day do you spend using this app?

All participants unanimously said that they would recommend WordUp application as a dictionary and as a useful and modern digital tool for English language learning. They think it can be great pastime activity. Also, all respondents would like to see this app as part of their curriculum, either as icebreaker activity or homework.



7. CONCLUSION

It is necessary to emphasize that the study presented in this paper is a small one. More precisely, the sample size is relatively small. On the other hand, bearing in mind that this is a qualitative analysis, sample size is large enough to obtain enough data to sufficiently describe the ways of improving English vocabulary and WordUp app usefulness. Hopefully, this study can be a solid starting point for more complex, practice-oriented educational research.

The research explicitly confirmed that the innovative ways of perfecting the English language, such as mobile applications designed to improve foreign language skills are captivating for students. Students consider mobile apps of this kind to be likeable and helpful so they would like to use them on a regular weekly basis as part of their curriculum. Also, they would enjoy using mobile apps independently in their leisure time. Respondents believe WordUp mobile app to be an effective educational tool that leads to certain learning progress of its users. One of the most important findings of this study is that WordUp is quite often used instead of a dictionary. Students find it reliable, interesting and accessible and prefer using it over standard online dictionaries or platforms.

In conclusion, WordUp mobile application is a great digital tool for improving English vocabulary in a modern, pleasant and fun way. Although students think this app is a great one, they are still in favor of traditional methods and approaches to learning foreign languages.

Students can easily perfect all their language skills by using this app on a regular basis. They can also significantly expand their vocabulary, study according to their personalized learning plan, achieve their academic goals and face specific language challenges.

We would recommend using WordUp on a daily basis to all people motivated to improve their language skills and expand their English vocabulary in an efficient, dynamic and flexible way. Users of this mobile application monitor their learning process and take responsibility for their own progress and ability to communicate effectively in English.

REFERENCES

- [1] M. Stanojević Gocić, „Strategije učenja i usvajanja vokabulara u funkciji razvijanja veštine čitanja u nastavi engleskog jezika struke“, doktorska disertacija, Kragujevac: Filološko-umetnički fakultet, 2017.
- [2] N. Schmitt, *Researching Vocabulary: A vocabulary research manual vocabulary in language teaching*. New York: Palgrave Macmillan, 2010.
- [3] B. Radić Bojanić, *Vokabular u nastavi stranih jezika: budućnost ponikla u prošlosti, Savremena proučavanja jezika i književnosti, Zbornik radova sa I naučnog skupa mladih filologa Srbije*, 439-451. Kragujevac: FILUM, 2009.
- [4] Macmillan Dictionary. [Online]. Available: <https://www.macmillandictionary.com/corpus.html>
- [5] D. Nunan, *Second language teaching and learning*. Boston: Heinle & Heinle, 1999.
- [6] Common European Framework of Reference for Languages. [Online]. Available: <https://www.coe.int/en/web/common-european-framework-reference-languages/level-descriptions>
- [7] C. Chaka, “Portable Handheld Language Learning from CALL, MALL to PALL”, *Handbook of Research on E-Learning Methodologies for Language Acquisition*, Walter Sisulu University, South Africa, pp. 539-554. 2009.
- [8] T. Gajić & N. Maenza, „Korišćenje mobilnih aplikacija u nastavnom procesu učenja stranih jezika na tercijarnom obrazovnom nivou”, *Inovacije u nastavi*, 32 (4), 133-142, 2019.
- [9] WordUp: Discover & Learn the most useful English word. [Online]. Available: <https://www.wordupapp.co/>
- [10] N. Maenza & T. Gajić, “Mobilna aplikacija WordUp – inovativno i zabavno usvajanje vokabulara engleskog jezika”, *Sinergija 2019 – zbornik radova*, Bijeljina: Univerzitet Sinergija, 2019.



**SOFTWARE AND INFORMATION ENGINEERING
SESSION**





COMPETENCE AND MEDIA COMPETENCE IN THE AGE OF THE INTERNET

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Abstract:

The concepts of media competence have different meanings, and the media competence itself most often refers to: *understanding* media messages and content; *ruling the media*, ie the skill of handling media devices; *effective use of the media* in solving school and business tasks (the ability to plan and enjoy free time with the help of the media); *creating the media*, composing media messages and offers; *evaluating of the media*, ie the functions of the media system. Media competence in this sense implies the ability to encompass social relations and (re)evaluate one's own actions according to normative and ethical aspects.

Keywords:

competence, media, media competence, internet

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1. INTRODUCTION

The term media competence runs in different ways through a bunch of analyzes and debates in different fields: not only in science (biology, linguistics, sociology, psychology, pedagogy), but also in politics, law or economics, and therefore the term becomes vague and ambiguous. In a certain context, it is necessary to specify what is meant by it, and also it is very helpful first to analyze the very concept of competence in general. Unlike the term *media* competence, the broader notion of *competence* has a longer history. This history of the development of competence theories can be divided into three phases: 1. linguistic definition of the term competence during the 70s, 2. introduction of the concept of competence in various theories of development and socialization and 3. its use in sociological analyzes of socialization and society during the 80s. Research focused on competency theories has had to face many problems. There have already been many ambiguities [1] about the exact meaning of the term competence, which is divided into the mentioned three phases.



In the social sciences, the term competence is associated with the research in linguistics by N. Chomsky. According to Chomsky, *Linguistic competence* presents intuitive knowledge of the rules available to subjects and is described by the grammar of one language. When children learn a language, they must have generative grammar, i.e. the method how to create a customized grammar from the given primary linguistic data. Thereby, they are innate, individual predispositions, which are on a synchronous level.

Focusing on intrasubjective constructions of competencies led to a *sociological study of socialization*. In addition to the „linguistic turn“ in the social sciences, structuralgenetic theories of competence encouraged J. Habermas to take up the term competence in the theory of connecting socialization and socio-theoretical perspectives. At the socialization-theoretical level, it is about connecting the sociological theory of personal identity creation with psychological theories of cognitive, social and moral development (among others, with the theories of Piaget, Selman, Kohlberg). The „guide“ was the opinion that subjects develop their competencies in social interactions. In this context, Habermas talks about role competence, interaction competence, but also about communicative competence. Subjective competencies are always adopted within the development of communicative competence, and this again as a prerequisite has constant participation in the communication processes. This reverses the developmentalpsychological relationship between subjective and social structures: the processes of social interactions are the ones that accelerate and organize the process of creating subjective competencies.

The concepts of media competence can have very different meanings:

- *Understand the media*: media competence may refer to understanding media messages and content.
- *Rule the media*: media competence may refer to the skill of handling media devices.
- *Use the media*: media competence may refer to the effective use of the media in solving school and business tasks. It may also be expressed in the ability to plan free time with the help of the media and enjoy it.
- *Create the media*: media competence may refer to composing media messages and offers.
- *Evaluate the media*: media competence may finally relate to the functions of the media system. The media competence in this sense implies the ability to include social relations and (re)evaluate its own actions according to normative and ethical aspects [2] [3].

The concept of competence is not only a long-standing topic in the media-pedagogical discussion. In recent years, it has been intensively considered through its practical pedagogical contributions. The discourse of pedagogical competence has developed in two directions:

1. Within the discussions about educational standards, the relationship with the models of competence has become a central aspect of the discourse on education planning and school development. Competence models concretize the contents and levels of general education and thus gain central importance for the problems of construction and legitimacy of current debates on education and curriculum.

2. Lately, the concept of competence has been intensively dealt with in the context of adult education. The discourse on competence here excludes the theory of „key qualifications“ and emphasizes the importance of lifelong learning and the related necessity of self-regulatory life management. Replacing the term qualification with the term competence indicates a social change of the 20th century, which is characterized by the individualization of life circumstances. Qualifications as objective measurement units that describe what one can, so to speak, for a lifetime, are becoming increasingly dysfunctional in a society characterized by rapid technological change. When professional requirements change rapidly, adjustment efforts are constantly needed, which require self-organized action, as well as dispositions of self-organization, and non-formal and lifelong learning.

Erpenbeck and von Rosenstiel understand competencies as dispositions of self-organization in a model of class competencies, which starts from the fact that self-organized action relates to the person who acts (P) and is more closely determined through the activity and will components of the one who acts (A). In addition, it refers to the material environment and its professional-methodological understanding and change (F) and to the social environment - that is, to other people or a group of people (S). Thus, the classes of competencies differ as follows:

- (P) Personal competencies: dispositions of a person to act reflexively and self-organized, i.e. to assess oneself, to develop productive attitudes, systems of values, motives and auto-stereotypes, to develop one's own talents, motivation, intentions and to develop creatively and learn within and outside work.



- (A) Competencies of activities and realization: dispositions of a person to work actively and self-organized and to direct this action to the realization of intentions and plans - either for themselves or for others or with others, in a team, in a company, in an organization. These dispositions imply the ability to integrate one's own emotions, motivation, abilities and experiences and all other competencies - personal, professional-methodical and social-communicative - into one's own will and successfully realize deeds.

- (F) Professional-methodical competencies: disposition of a person to act spiritually and physically self-organized when solving problems, ie. to solve problems creatively using professional and instrumental knowledge, abilities and skills, to rank rationally and evaluate knowledge; this includes the disposition that activities, tasks and solutions are shaped methodically self-organized and that methods are developed creatively.

- (S) Social-communicative competencies: dispositions to act communicatively and cooperatively self-organized, ie. to discuss creatively with others, to act as a team and to develop new plans, tasks and objectives.

As we have already indicated, the debate on competence in media pedagogy had its own tradition even before the current discourse in pedagogy. This comes from Dieter Baacke [4], who referred to Habermas' „communicative competencies“, in the 1970s [5]. The classical formulation proposed by Baacke distinguishes the following areas of media competence:

- *Media criticism*, the ability to analyze media content analytically, ethically and reflexively;
- *Media science as knowledge about the media* in terms of information about the media system, as well as the ability to use media technologies within the instrumental qualification capacity;
- *Use of media*, both through the reception and as a sender;
- *Innovative and creative media action* (media creation, innovative media systems).

If we compare this view with the classes of competencies cited by Erpenbeck and von Rosenstiel, we can conclude the following: Baacke's concept of media competence, which is not proved cognitively-theoretically, but activity-theoretically - related to communicative action - comes to very similar dimensions of competence: media criticism, in which individuals are reflexive towards the media, is closely linked to the personal competencies of Erpenbeck and von Rosenstiel. Here,

too, it is about attitudes, views of the world, motives and autostereotypes within the encounter with the media. The science of media refers to professional-methodical competencies - that is, to the dispositions of a person to act self-organizedly in solving specific problems. The use of media is closely linked to Erpenbeck's and von Rosenstiel's competencies oriented to the activity and implementation, which are based on the ability to achieve motivation, skills and experiences through action. Finally, the creation of the media is close to social-communicative competencies, which is about how to collaborate creatively with others in order to implement joint plans.

Moser's understandings of media competence [6] are largely compatible with the model of Erpenbeck and von Rosenstiel, because he also bases the competence model on four groups of competencies, the details of which are modeled somewhat differently (Figure 1):

Technical competence

- ◆ Ability to perform simple maintenance and installation tasks on media devices (battery replacement, software installation, removal of light failures, etc.).
- ◆ Handling the basic functions of media devices (hardware and software) in terms of user competencies.
- ◆ Thinking in simple programming and navigation schemes (programming remote control, adapting text to personal needs, controlling internet addresses, using browsers, etc.).
- ◆ Understanding professional terms.

Cultural competence

- ◆ Openness and curiosity towards the offers of new media as a part of modern everyday culture, but without uncritical and euphoric adoption.
- ◆ Competence to use not only literary and auditory, but also visual information.
- ◆ Development of orientation competence in the world of redundant information (eg in terms of knowledge management).
- ◆ Multicultural competence of movement in different spheres of the globalized world.
- ◆ Ability to deal with new forms of media communication creatively.

Social competence

- ◆ Possibility of competent behavior within mediated types of connections and communication schemes.
 - ◆ Ability to deal with a mixture of real and virtual connections.
 - ◆ Ability to adapt to new forms of organization and content of work within the information society (eg telework, forms of action and work based on the Internet, etc.).
-



Reflexive competence
<ul style="list-style-type: none"> ◆ Critical thinking on certain media and media develop-ment. ◆ Ability to assess independently your own behavior when using media. ◆ Having the criteria in order to be able to judge the media information, its validity and relevance.

Figure 1. Model of media competence [6]

2. MEDIA-PEDAGOGICAL MODELS OF COMPETENCE IN THE SCHOOL CURRICULUM

Previous thoughts have followed the concept of media competence, which is not primarily related to the field of education and media-didactic issues, so we will try to establish a media-pedagogical connection between the issue of educational standards and the concept of competence. Here we point out that media pedagogy is not a school subject, but we look at it as extra-subject and integrative. This refers to topics in which, in proportion to the orientation of media pedagogy, an integrative concept is required in which the hitherto separate concepts of reading, watching television or basic information education are combined [7]. Basic knowledge related to the media is designed interdisciplinary, primarily because it is useful in a variety of school subjects. Thus, „media education“ and „informatics“ in the curriculum of the Swiss canton of Zurich is one of interdisciplinary subjects. The double meaning of media-pedagogical topics is clearly described: For the school, information technology and communication technology are a tool and a teaching subject at the same time [8]. Media pedagogy is therefore something like an „interdisciplinary subject“ at school - or a transversal topic.

Based on that, it is clear that - in terms of discussion about the standard of education - media-pedagogical content refers to knowledge specific to a certain domain, but in terms of average competence, it cannot be limited only to that. Media pedagogy proves that there is a peculiarity that does not appear in the traditional canon of subjects - and which is still relevant to school education. The growing importance of digital media for learning and school means that it is important to formulate standards for these domains, which all students could reach.

The double relation of media pedagogy with disciplinary and interdisciplinary contents does not make the discussion of the standard of education in this field any easier. Some authors such as Hartung point out that there is a consensus that media education should be indirectly transferred through all subjects, in order to build and expand media competence in specific teaching contents. But at the same time, he remarks: „As to the question, whether there should be an additional, independent subject on media education, there are divergent opinions“ [9, p.13].

The author Tulodziecki, in an attempt to formulate the standards of education in the field of media, faces the same di-lemma, but finds an interesting way out: on the one hand, he sees the possibility of formulating educational standards according to the fields and areas of media competence, ie. according to dimensions and partial competencies [10]. He sees as a danger that content specific to the media could lose its seriousness and form and be seen as second-rate. Therefore, as an alternative, he formulates the possibility of structuring according to the type of media - with the advantage of taking into account the specifics of the types of media. For him, two models of competence arise from this - one based on the types of media as domains of media use and the other which defines the fields or areas of media competence as superior. The di-vision according to the types of media means that the areas of competence are „print media“, „audio-visual media“ and „computer and internet“. This seems problematic for several reasons:

- It is obvious that the print media are closely linked to the teaching of the mother tongue, because that is exactly the subject, which has been connected with the media from the very beginning. While there are obvious connections of interdisciplinary areas of media with the traditional school subject, this is not the case with the other two types of media. Thus there is a danger that the associated standards will move in a vacuum.

- „Types of media“ are generally non-permanent subjects, which are interconnected in various ways and change very quickly from the point of view of digital media. Today, watching television is also done via computers, as well as reading newspapers; and it is likely that the previously divided media will merge so much with each other in the near future that the traditional boundaries between them will disappear. In this sense, it would be a conservative prejudice if these traditional categories were taken as a principle of structuring a progressively oriented curriculum.



- Thirdly, the question is to what extent the competencies are specific to the current types of media. Precisely because separate media are increasingly digitally interconnected, interdisciplinary competencies have become important in many types of media. Visual competencies, which are used to interpret images, are used in a similar way in the types of media newspapers / magazines, television and the Internet.

For this reason, approaches based on interdisciplinary competence should be favoured. At the Faculty of Teacher Education in Zurich, a model has been developed that links the media competence as a broad medial field of action with personal competence of action (Figure 2) [11].

Personal competence				
	Professional competence	Methodological competence	Social competence	
Medial fields of action	Application and creation of media products (A)	A1.1 stadard	A1.2 standard	A1.3 stadard
	Exchange and mediation of media messages (B)	B1.1 stadard	B1.2 standard	B1.3 stadard
	Reflection and criticism of the media (C)	C1.1 stadard	C1.2 standard	C1.3 stadard
Level of competence 1		End of basic level (end of 2 nd grade)		
Level of competence 2		End of intermediate level (end of 6 th grade)		
Level of competence 3		End of 8 th school year Secondary level I		
Level of competence 4		End of 11 th school year Secondary level II		

Figure 2: Zurich competence model [11]

Similar to the concept of Erpenbeck and von Rosenstiel, this model starts from the key competencies of media action, which are important in most domains, ie. school subjects. Knowledge specific to the media is not excluded, because it is explicitly stated under the title „professional competence“. It needs to be further discussed whether it is adopted in a single subject or integrated into different subjects of the curriculum.

In the model briefly described here (Figure 2) we start from following understandings:

- The field of action is, concerning content, structure by media-pedagogical domains; from the point of view of the actor (teachers and students), they define the field of learning and teaching the media. In the presented model, three spheres are specified:

a) Application and creation of media products (and thus the use of „production media“).

b) Exchange and mediation of media messages (ie the area of handling „communication media“).

c) Reflection and the criticism of the media (as a domain-specific field of action, which has always stood out as an important subject of media pedagogy since the 1970s).

- The real model of competence is based on these three areas of action and is followed by three areas of competence, namely

1. Professional competence in which declarative knowledge is collected, ie. professional and conceptual knowledge, which must be acquired for the purpose of competent action in certain fields.

2. Methodological competence, ie procedural knowledge or. techniques and knowledge of the rules, which serve to work competently with the media.

3. Social competences, ie medially reformed social rules, the mastering of which is necessary for the purpose of competent exchange and cooperation with the media.

Competencies are upgraded in one level model, whereby four levels of competencies are defined. The graded structure allows media competence to be defined as a developmental task for students.

3. MEDIA COMPETENCES IN THE AGE OF THE INTERNET

It would be problematic to view media competences and related educational standards primarily under the aspect of learning to test. Thus, those dangers that Tulodziecki connects with the definition of educational standards could arise:

- Dominance of set goals to the detriment of student participation and process orientation;

- Orientation towards taking exams instead of connection with interdisciplinary ideas of upbringing and education;



- Orientation towards current requirements instead of orientation towards the future, which would be important given the rapid development in the field of information and communication technology;

- Dominance of uniform requirements towards the view of individual development of competencies within the biographical process.

The essence of this is that there is a danger that media competences are defined through qualification standards as products of school teaching that can be achieved, no longer in the sense that Erpenbeck and Sauter [12] define as the ability to think and act self-organized, as dispositions of selforganization. In such a context, teaching with digital media is less directed towards narrowly formulated learning objectives, but towards „didactics of guidance“, which, generally speaking, starts from the open action of the teaching-learning process [13]. For professional knowledge, which is mainly disproportionately represented in the tests, this means: that the facts are not simply learned by heart and activated mechanically, but that the acquisition of knowledge is seen in close connection with the building of the ability to act [14].

This orientation of media competences towards the dispositions of self-organization is not important only because the learning styles through which young people face digital media are starting to change. Primarily in the Anglo-Saxon area under the terms „Netgeneration“, „Google generation“, „Homo Zappiens“, „Digital Natives“, „Producer“, etc. there are a multitude of approaches that describe this development. According to Cross, the decisive feature is that learning is increasingly moving from the *push* principle to the *pull* principle. Learning is less and less program-oriented, and tries to respond to changes that occur within the uncertain perspective of the future. Those who deal with digital media learn more by trying, experimenting or using a social network. Targeted drafting of instructions or conducting a formal course on the introduction to a new program rarely happens today - which has the consequence that digital media providers (either hardware or software) today, as a rule, hardly attach instructions to their products. At the same time, the locus of control, which has been determined by teachers in traditional teaching, is increasingly shifting to the complex arrangements of students, coaches, lecturers, technology and resources [15].

CONCLUSION

For today's generation of students and lecturers, the importance of the school for the transfer of media competencies must not be overestimated. Children and youth intensively use the media, primarily in extracurricular everyday life, and „Netgeneration“ also adopts many media competencies that it currently has at its disposal. But then what is left of the school's educational efforts in this regard? If students in extracurricular activities adopt media competence that enable them to conquer the world of computers on their own within the framework of self-organized learning, one might wonder whether the efforts of the school are still needed at all. Nevertheless, we conclude that there are numerous arguments advocating the sustainable use of computers at school.

More frequent use of computers at school is required, because everyday use of them at home puts the need for entertainment in the foreground: playing computer games, sharing and downloading music, watching videos, chatting via MSN, etc. On the contrary, working on a computer in professional everyday life sets other focuses: texts are processed, data-bases are worked on, creative software is used, photos are processed, etc. The task of school could be to fill in the gaps and work systematically with the software, which are not in use during free time - such as Office programs, image and movie editing programs, etc. Professional knowledge and reflective knowledge of the information society and the risks of working with technology could be a program for digital media education in schools. These are areas that no one in society cares about and that are not learned automatically by everyday computer use (for example, in working with Web 2.0, there are constant warnings that children and young people carelessly handle personal data on their profiles) [16].

Also, we must go beyond the issue of protection and gaps in knowledge and skills and start from the fact that the computer and the Internet belong to the everyday life of children and young people to such an extent that related media competences represent a resource that the school should use much more. If the media competence is viewed from the angle of self-organization competencies, then in the school context of learning, tasks should be set that enable the simultaneous application of media competences, differentiation of abilities and development of own competencies during the practice of self-organized learning. Therefore, it is less about transferring clearly defined and prescribed skills of working with digital



media in terms of mediation didactics, and more about encouraging independent learning processes within the didactics of enabling that allow both informal and self-didactic learning with / and / about media, which are included as a source in school learning.

This particularly suits the requirements associated with Web 2.0. Such learning spaces „translate“ the interactive Web into the context of the student experience and provide encouragement and motivation not to consume this Web passively. For this reason, Erpenbeck and Sauter focus on the development of online competence and emphasize „new blended Learning“ within Web 2.0. because the use of social software provides an opportunity to interconnect the methods of creative problem solving (professional and methodological competence), self-reflection (personal competence), social perspectives / views and worldviews (social competence) and individual actions (activity competences) [17].

If a school fails to accept the media competence of its students, which they bring from everyday life, and to create learning environments in which they can be used, then in the work with digital media there is a gap between school and non-school everyday life: Google generation implicitly conveys that their (extracurricular) media competences have nothing to do with that area, which is traditionally called education. And that means that significant opportunities for learning are gambled away - and that the development of media competences in the domains that increasingly determine the chances for a job and career in the information society is neglected. Montgomery presents alternatives to the education system: either the teaching will remain as it is - and we are still wondering why the school can no longer reach the world of young people, who belong to the „Digital Natives“. Or we will follow them and offer students a digital learning environment that suits them, because it belongs to the life that determines the everyday life of new generations in today's society. Networked media at school will then soon become as central in teaching as information and communication technologies in the world of work.

Schelhowe points out that children and young people should be given the opportunity to use digital media spontaneously and in a fun way that characterizes their imagination, „by experiencing new ways of learning, experiencing the processes of emergence and thus taking responsibility“ [18, p.180]. This does not only apply to the technical and IT side of working with the media - in this way we should also work with the Internet; and students in school should be given the opportunity to

try out the application of Web 2.0 by actively participating in a blog, collaboratively creating text using a wiki, including photos and movies in school projects, and so on. Thus, it is not the basic IT education that is understood by media competence in terms of learning for testing, but the application of digital media in various school settings - such as decision-making, creation and reasoning, all in the context of the perspective for E-Learning at school.

REFERENCES

- [1] M. Andevski, D. Ristić, *Obrazovanje za menadžment*, Novi Sad, CEKOM-books, 2010.
- [2] H. Moser, *Die Medienkompetenz und die 'neue' erziehungswissenschaftliche Kompetenzdiskussion*, U: Herzig,B.,Meister,M.D.,Moser, H., Niesyto, H.,(Hrsg.) *Jahrbuch Medienpädagogik 8. Medienkompetenz und Web 2.0*. Wiesbaden, S. 59 – 81. 2010.
- [3] H. Moser, *Einführung in die Netzdidaktik. Lehren und Lernen in der Wissensgesellschaft*. Hohengehren: Schneider, 2008.
- [4] J. Habermas, *Vorbereitende Bemerkungen zu einer Theorie der Kommunikativen Kompetenz*. U: Habermas, J. Luhmann, N (Hrsg.) *Theorie der Gesellschaft oder Sozialtechnologie- Was leistet die Systemforschung?* Frankfurt/M: Suhrkamp, S. 101-141, 1971.
- [5] D. Baacke, *Kommunikation und Kompetenz. Grundlegung einer Didaktik der Kommunikation und ihrer Medien*. München: Juventa, 1973.
- [6] H. Moser, *Die Medienkompetenz und die 'neue' erziehungswissenschaftliche Kompetenzdiskussion*, U: Herzig,B.,Meister,M.D.,Moser, H., Niesyto, H.,(Hrsg.) *Jahrbuch Medienpädagogik 8. Medienkompetenz und Web 2.0*. Wiesbaden, S. 59 – 81. 2010.
- [7] W. Wagner, R. Peschke, *Auf dem Weg zu Bildungsstandards? Rückblick auf 20. Jahre, „Neue Technologie und Schule“*. U: *Computer + Unterricht*, 63/2006, S. 6-11. 2006.
- [8] *Lehrplan für die Volksschule des Kantons Zürich*, Zürich, 2000.
- [9] R. Hartung, *Standards für die Medienbildung? Anmerkungen zu Medien und Bildungsstandards*, U: *Computer + Unterricht*, 63, S. 12-13, 2006.
- [10] G. Tulodziecki, *Medienbildung-welche Kompetenzen Schülerinnen und Schüler im Medienbereich erwerben und welche Standards sie erreichen sollen*. U: Winkel, J. (Hrsg.) *Standards in der Medienbildung*. PLAZ-Forum, Heft 16. Paderborn, S. 9-34, 2007.
- [11] H. Moser, *Einführung in die Netzdidaktik. Lehren und Lernen in der Wissensgesellschaft*. Hohengehren: Schneider, 2008.



- [12] J. Erpenbeck, W. Sauter, Kompetenzentwicklung im Netz. New Blended Learning mit Web 2.0. Köln: Lucherhand, 2007.
- [13] M. Andevski, J. Arsenijević, M. Maljković, Computer in media-didactic discourse, Proceedings of 6th International Tehnology, Education and Development Conference, INTED,5-7. March, Valencia, Spain, 2012.
- [14] U. Montgomery, Interneträume für „Digital Natives“ in der Schule. U: Landesmedienzentrum Baden-Württemberg (Hrsg.) E-Learning in der Praxis. Eine Publikation der Medienoffensive II (Baden-Württemberg). Karlsruhe: Landesmedienzentrum BW, S. 29-31, 2008.
- [15] R. Arnold, Ich lerne, also bin ich. Eine systemisch-konstruktivistische Didaktik. Heidelberg: Carl-Auer, 2007.
- [16] H. Schelhowe, Technologie, Imagination und Lernen. Münster: Waxmann, 2007.
- [17] R. Schulz-Zander, G. Tulodziecki, d. Bender, Dietmar, Veränderung von Unterricht mit digitalen Medien. U: Landesmedienzentrum Baden-Württemberg (Hrsg.) E-Learning in der Praxis. Eine Publikation der Medienoffensive II (Baden-Württemberg). Karlsruhe: Landesmedienzentrum BW, S. 9-14. 2008.
- [18] J. Erpenbeck, W. Sauter, Kompetenzentwicklung im Netz. New Blended Learning mit Web 2.0. Köln: Lucherhand, 2007.



DISTRIBUTED LASER THERAPY SYSTEM

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Abstract:

A distributed laser therapy system has been designed to allow laser practitioners to carry out low-level laser therapy (LLLT) and provide simple means to easily collect different laser therapy protocols along with the estimation of the therapy outcome. This article aims to present both the hardware and software design of the system and to discuss three different neural networks used to predict the outcome of the laser therapy, to recommend the laser parameters and to recognize the biological effects. It is concluded that the proposed system could successfully be applied for the collection of a large number of therapy protocols that could later be used for neural network training. Also, the trained neural networks could be easily employed to support the everyday work of laser therapy practitioners by providing different types of laser therapy recommendations.

Keywords:

laser therapy, biomedical equipment, internet of things, neural network, artificial intelligence.

1. INTRODUCTION

Laser therapy is a medical procedure which utilizes the healing characteristics of the laser light to treat different types of ailments in physical medicine, rheumatology, dermatology, or neurology, having the following primary biological effects: [1-8]:

- Anti-inflammatory and anti-edematous effect
- Cicatrization, collagen production, wound healing
- Stimulation or inhibition of the cell proliferation
- Normalization of the membrane and action potentials

All the mentioned effects are primarily based on the specific laser light characteristics which include: monochromaticity, coherence, polarization as well as focusability of the laser beam to the very high intensities. Besides the inherent laser characteristics, laser therapy may be characterized by adjustable laser therapy parameters which, in turn, may be used to give rise to different biological effects.

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These parameters include energy, power, intensity, and modulation frequency. Example of the laser parameter values, excerpted from the meta-analysis of the published articles [1-8] may be seen in TABLE I.

Since laser therapy is a method daily applied by different laser practitioners, many of whom try to improve therapy results by adjusting laser parameter values, it was thought out to design the laser therapy system capable to collect all therapy protocols applied by many different laser therapy practitioners. Data collected likewise could be used to train different types of artificial neural networks (ANN) to help practitioners determine the proper combination of laser parameters, or to differentiate the successful from the unsuccessful therapy protocol.

Table 1. Values of the laser therapy parameters for different indications

Therapy parameter	Unit	Alveolitis	Cervicalgia	Acupuncture
Energy	J	1.5	2	0.5
Power	mW	30	50	3
Intensity	mW/cm ²	120	120	12
Frequency	Hz	250	2000	20
Outcome		0.1	0.6	0.8

Even though ANN are widely used in the biomedical applications, it is only a small number of articles in the literature that deal with ANN related to the biomedical lasers of different types. Majority of those, try to predict the outcome of a single therapy procedure [9, 10] based on the patients' characteristics, while some of the articles use ANN as a controller [11], or as a therapy assistance tool for the recognition of the therapy significant events or objects. By reviewing the literature, no articles could be found to deal with the ANN in the field of low-level laser therapy (LLL) that, based on a large number of collected protocols, try to predict either the therapy outcome or the biological effect on the bases of the chosen therapy parameters, or to propose laser parameters on the bases of the selected indication.

The aim

The aim of the article is to present the design of the distributed laser therapy system which allows the collection of a large amount of applied laser therapy protocols along with the therapy outcomes. Besides, the aim of the article is to analyze and present the architecture of the neural networks suitable for prediction of the laser therapy outcome, recommendation of the laser parameter values, and recognition of the biological effects.

2. DESIGN OF THE DISTRIBUTED LASER THERAPY SYSTEM

Distributed laser therapy system is aimed to allow the practitioner to:

- ◆ Use the laser therapy unit reliably and safely on the basis of all applicable biomedical standards.
- ◆ Allow connection of all laser therapy units with the central server and let each of the units transfer the values for the applied therapy protocols along with the outcome of the therapy, but also, to allow the laser units to receive therapy recommendations and predictions from the trained neural networks located in the central server.
- ◆ Make possible the proper training of neural networks with a large number of therapy protocols obtained from different laser therapy practitioners, as well as to provide the storage of the trained neural network models in the database, and to allow the usage of the trained models in order to get therapy recommendations, predictions of the therapy outcomes, and recognition of the biological effects.

The design of the system includes the system topology, the laser probe, as well as all the software components that take part in the system:

- ◆ Laser probe software installed within the micro-controller circuit of the probe.
- ◆ Desktop application used by practitioners to control the laser probe and to communicate with the central server in order to send the applied therapy protocols, and to get therapy recommendations from the neural networks operating within the server.
- ◆ Server application, the role of which is to communicate with all laser units as well as to host the neural networks used to provide therapy recommendations.
- ◆ Database used to store all data related to different users, patients, therapy protocols and trained models of neural networks.

Topology

The topology of the distributed laser therapy system is presented in Fig. 1. Any laser treatment facility could be equipped with at least one of these laser therapy units and, over the internet, could be connected with the application server. This way, each of the therapy units can send applied therapy protocols to the server.

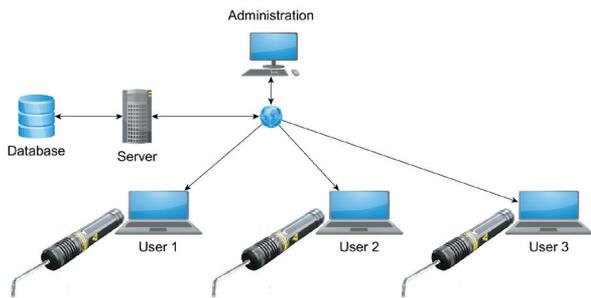


Fig. 1. The topology of the distributed laser therapy system

The application server is directly connected to the database server both of which could physically be located in the same or separate machines.

Applicable standards

During the system design, all applicable biomedical standards were taken care of. These include general medical devices standard IEC60601-1 [12], as well as standards for medical laser equipment IEC 60601-2-22 [13]. Also, during the laser operation, all proposed safety precautions for 3B class lasers were taken into account. As defined by the standards, these included the safety glasses with appropriate spectral characteristics, as well as safety switches.

Laser probe

The hardware part of the system is composed of the laser probe (Fig. 2, Fig. 3), connected to the computer (Fig. 4) over the USB port. Inside the probe, there is the printed circuit board (PCB) with microcontroller and electronic components necessary for the laser irradiation control. PCB is connected with the laser diode which directly adheres to the light guide (Fig. 2).

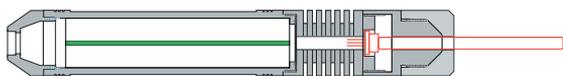


Fig. 2. Laser probe cross-section

Light guides are used to deliver laser light to both accessible and inaccessible parts of the body without energy loss, maintaining constant intensity at the contact surface. Given the fact that they get in contact with the patient's tissue, they need to be replaced and sterilized after each application.

The probe is equipped with the light guide mounting system [14] which allows easy attachment and detachment of the light guides.



Fig. 3. Laser probe with light guides

Central component of the laser unit is the laser probe which, for the laser therapy purposes, usually uses laser diodes that generate laser light with wavelengths between 780-904nm. The laser diode is a very sensitive and expensive component which requires an electric connection over the driving circuits to guarantee its reliable operation.



Fig. 4. Laser therapy unit

The laser probe is connected to the personal computer which requires the desktop application designed to communicate with the probe microcontroller and transfer all the therapy parameters. At the beginning of therapy, microcontroller receives the laser parameters from the desktop application over the USB port (Fig. 5), and the driver module, over DA (digital to analog) converters, control lines, and internal signal generator, drives the analog laser lines, while simultaneously, over control lines and AD (analog to digital) converter, it reads the state of the laser diode in order to allow driver module to maintain irradiation at the level defined by the laser parameters [15].

On one side, the purpose of the analog laser control is to maintain irradiation parameters at the specified



level, while on the other side, its purpose is to filter all electrical disturbances that could potentially reach the diode and damage it. Laser diode is an expensive element very sensitive to transient electrical surges.

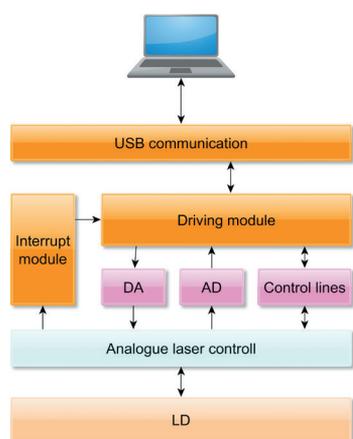


Fig. 5. The architecture of the microcontroller application and connection with the analog laser control

Having in mind the limitations of the laser therapy defined in the literature and the limitations of the safety class 3B lasers, the laser probe was constructed to fulfill these requirements and has the characteristics presented in TABLE II.

Table 2. Values of the laser therapy parameters for different indications

Therapy parameter	Unit	Value range
Energy	J	0-10
Power	mW	0-100
Intensity	mW/cm ²	0-400
Frequency	Hz	0-10000

Desktop application

Besides the hardware components, the most important part of the system for carrying out the therapy surely is the desktop application. Its main purpose is to control the work of the laser probe and communicate with the server in order to transfer all the applied therapy protocols, and also to receive the therapy recommendations from the trained neural networks. Desktop application is realized using the C# in Visual Studio 2013. It allows the practitioner to select the therapy protocol and, on its initiation, transfer the laser parameters to the microcontroller application.

After starting the application, the available therapy protocols are first synchronized with the server and

then presented to the practitioner. The synchronization is started in the presentation layer (Fig. 6), which calls the service layer in charge for the communication. On the server side, the web layer receives the request and engages the subsequent layers to retrieve all the available therapy protocols from the database, and then returns them back to the desktop application.

The sequence of events engaged to start the laser therapy is initiated in the presentation layer of the desktop application (Fig. 6) which further calls the communication layer, over the service layer, to transfer the therapy parameters to the laser probe and start the therapy. In the further course of the therapy, the microcontroller application monitors and controls the process of irradiation. In case of the laser malfunctioning, or in-compliances between the defined and measured laser parameters, the microcontroller application informs the desktop application which, in turn, forwards the information to the practitioner.

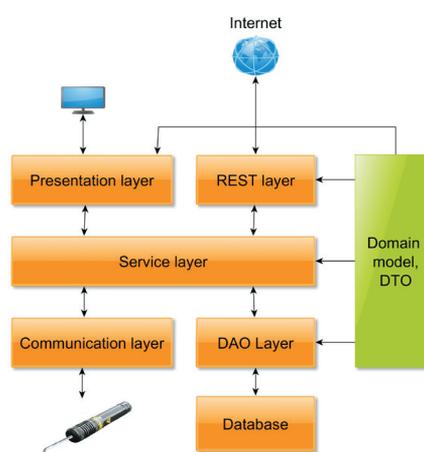


Fig. 6. The desktop application architecture

During the course of the therapy, the practitioner can follow the recommended irradiation points (Fig. 4). Desktop application guides the practitioner to follow the order of the treatment points, while the laser probe automatically receives the laser parameters in the way that practitioner does not have to readjust settings of frequency, energy or power for different points.

Server application

Server application is created using Java v1.8 language and Spring v4.2.4. framework [16]. Besides Spring, Hibernate v5.1 was used as object-relational mapper and database access tool.



The architecture of the application (Fig. 7) is based on a multilayer model including the web, service, and DAO (Data Access Object) layers [17].

Web layer was designed to provide REST API, using which, all the desktop applications can communicate with the application server. All requests received in the web layer are realized over the service and DAO layers. The service layer is used to control the training and the operation of the neural networks, while DAO layer is used to provide a connection with the database.

Therefore, in case that the neural network should be trained to recognize the resulting biological effect on the basis of defined laser parameters, the service layer is chosen to host the algorithms for the neural network training, while the trained model is, over DAO layer, stored in the database.

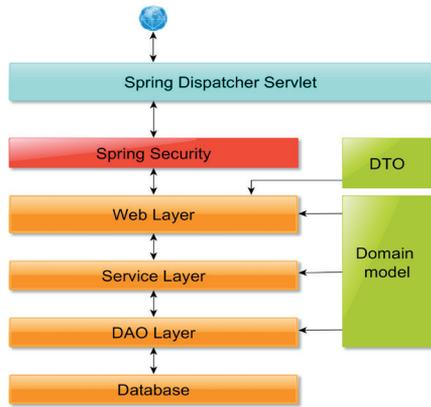


Fig. 7. The server application architecture

Entity and DTO classes are used for the interlayer communication, but also for serialization/deserialization during the communication between the desktop and server applications.

Database

The database is implemented using the Oracle v11g. As shown in Fig. 8, the database tables are organized in the way that one therapy is connected to many protocols, each of which is in relation to many treatment points. On the other side, practitioners (Users) can access only their own patients, each of which could have multiple therapies. The models of the trained neural networks are stored in the ANN_weights table. Each therapy protocol can be connected with many different types of ANN, each of which contains its own weights defined in the table ANN_weights.

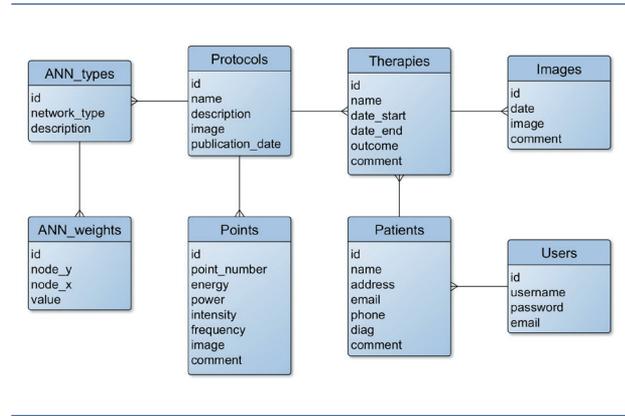


Fig. 8. E/R database model

3. DATA ANALYSIS

As can be seen in the table (TABLE I.), each therapy protocol consists of the diagnose and laser parameters such as energy, power, intensity, and frequency. Besides the parameters, each protocol contains the therapy outcome expressed as a number between 0 and 1, where 0 means completely unsuccessful, while 1 means completely successful therapy.

Protocols stored in the database can be used for different purposes, with the final goal in mind, to make the work of the laser practitioner easier and more successful. Using the community knowledge stored in the database, neural networks could be trained to understand various aspects of this knowledge. Therefore, different modalities of their application will be discussed subsequently:

- 1. Application of ANN (Artificial Neural Network) for the recognition of the therapy outcome.
2. Application of ANN for the therapy parameter recommendation on the basis of the selected biological effect.
3. Application of ANN for the recognition of the biological effect on the basis of defined laser parameters.

All mentioned ANN are realized in Java v1.8 programming language, regardless of any existing machine-learning library, so that the number of input, hidden and output nodes, as well as the number of hidden layers can be changed dynamically depending on the requirements [18-20].

Therapy outcome estimation

The evaluation of the therapy outcome is realized using the multilayer perceptron with the architecture shown in Fig. 9.

The network has four input nodes into which the values of laser parameters (energy, power, intensity, and frequency) are fed forward.



The perceptron has one node in the output layer which gives the prediction for the therapy outcome. Having in mind that the network architecture could be defined dynamically, the network would be able to self-adjust by adding new nodes in the input layer if other laser parameters had to be taken into consideration.

To prepare the network, it is necessary to train it using both the values of the therapy parameters, along with the treatment outcome which, in this case, would be used as a supervised value. The training process is initiated by the system administrator over the server application.

After receiving the training request, the server application retrieves all available protocols from the database and feeds them forward to the neural network. At the same time, therapy outcome related to the current protocol is used as supervised value and the network is trained using the backpropagation technique [21].

This network may be used whenever the practitioner wishes to check for the prediction of the therapy outcome on the basis of the selected therapy parameters. In order to check for the prediction of the therapy outcome, the practitioner first defines the values for each of the therapy parameters (energy, power, intensity, frequency) and asks for the prediction. The desktop application contacts the server application by sending the defined therapy parameters.

The server application loads the trained network model and feeds forward the received values for the therapy parameters. The ANN responds with the prediction in the output layer and the server application returns the prediction to the practitioner. The result is obtained in a range between 0 and 1, where a number closer to 0 means minimal chance, while a number closer to 1 means maximum chance of having a successful therapy outcome.

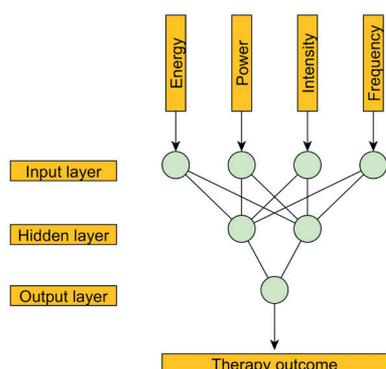


Fig. 9. The architecture of the multilayer perceptron for the therapy outcome prediction

This means that the practitioner can get the prediction of the therapy outcome and decide in advance whether to proceed with it or not. The effectiveness of this ANN is still to be tested on the bases of the real therapy parameters and real therapy outcomes. Once these tests are performed, it would be possible to bring conclusions about the effectiveness of this neural network.

Laser parameter recommendation on the bases of the chosen biological effect

The neural network used for the recommendation of the therapy parameters has the potentiality to be used most frequently simply because this represents the most common request among practitioners. The architecture of the multilayer perceptron is shown in Fig. 10. The ANN has three input nodes that correspond to the number of biological effects, while in the output layer it has the number of nodes that corresponds to the number of laser parameters. In this case, the network has three input nodes and four output nodes. Given the fact that the architecture of the network can be adjusted dynamically, it is not a problem to change it during the run time and retrain the network accordingly. The number of hidden layers and their nodes would be dependent on the experimental results obtained during the perceptron testing. The desired biological effect could simply be selected by feeding forward the value 1 to the input node that corresponds to the chosen effect, while all the other input nodes would be fed forward the value 0. At its output layer, the values of the corresponding laser parameters (energy, power, intensity, and frequency) are obtained.

This network can be trained the same way as the previous ANN, but this time, only the therapy protocols whose therapy outcome is greater than the defined threshold should be loaded from the database. The higher value the threshold has, the more reliable therapy protocols would be loaded from the database. The protocols selected this way are used for the ANN training in the way that the selected biological effects are fed forward to the input nodes of the network, while the laser parameters are used in the process of backpropagation to adjust the weights. After completing the training, the trained model of the perceptron is stored in the ANN_weights table of the database (Fig. 8).

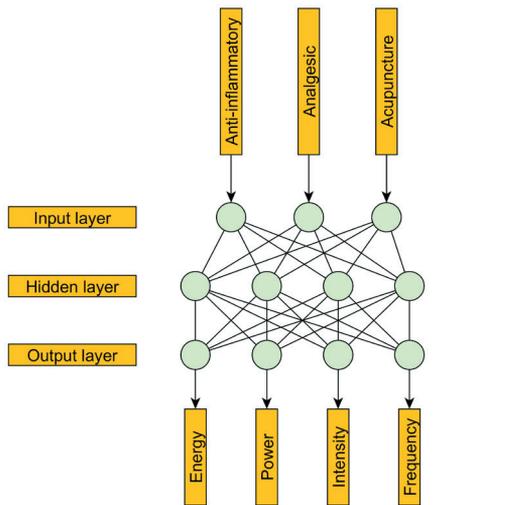


Fig. 10. The architecture of the multilayer perceptron for the laser parameter recommendation on the bases of the chosen biological effect

In daily work, the practitioner can select the desired diagnose or a biological effect in the desktop application and ask for the therapy recommendation. The desktop application would immediately contact the server sending the chosen biological effect, and the server application can load the trained network model from the database and ask for a recommendation. At the output layer, the network would deliver the recommendation for the laser parameters and server would return these values to the desktop application. After reviewing the recommendation, the practitioner may accept the recommended values or not.

In order to check the practical value of the presented ANN, its effectiveness should be investigated with the real laser parameter values and realistic therapy outcomes.

Therapy protocol recognition

In many occasions, laser therapy practitioners need to understand which therapeutic effect could be achieved by employing certain therapy parameters. To recognize the biological effect on the basis of laser parameters, the multilayer perceptron with the following architecture (Fig. 11) has been created.

The architecture of the ANN is designed in the way that the input layer has as many nodes as there are laser parameters, while the output layer has as many nodes as there are biological effects to be recognized.

To train the network, it is necessary to use only protocols from the database with therapy outcome above a certain threshold. Ideally, only the protocols with maximal therapy outcome should be retrieved. The laser parameters of the protocols are fed forward to the input nodes of the perceptron, while the biological effect is used during the backpropagation in the output layer of ANN by specifying number 1 as the supervised value of the output node of the resulting biological effect and specifying 0 for all the other supervised values.

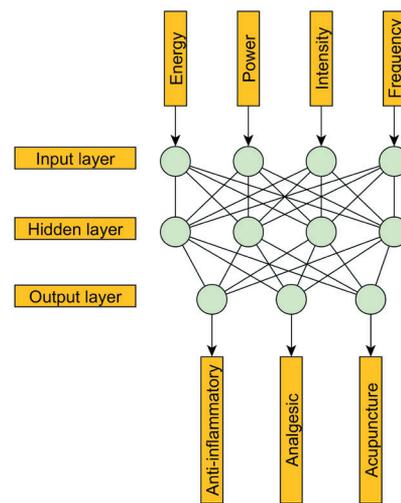


Fig. 11. Architecture of the multilayer perceptron for the biological effect prediction on the bases of the therapy parameters

By testing this type of neural network [8], it was concluded that in the case of application of therapy protocols employing all four laser parameters used in this article, the network was successful in classifying 100% of the protocols. That is, the network did not make any mistakes in the recognition of any therapy protocol when all 4 laser parameters (energy, power, intensity, frequency) were specified. In cases of therapy protocols specifying only 3 laser parameters, the success rate ranged from 67-100%.

4. CONCLUSION

In reference to the aim of the article, it can be concluded that the distributed laser therapy system is designed in accordance with the following targets:

- ◆ The system was designed in accordance to all applicable biomedical standards and is equipped with all the electronic and software means to generate the laser radiation in accordance with



the laser parameter specification which includes energy, power, intensity, and frequency.

- ◆ The system is designed to collect therapy protocols along with the therapy outcomes from all the users of the system.
- ◆ The system allows the training, storage, and usage of multilayer perceptrons with the proper architecture for: the estimation of the therapy outcome, the recommendation of the laser parameters on the basis of the chosen biological effect, as well as for the biological effect recognition on the basis of the chosen laser parameters.

It may be concluded that the presented design allows the users to obtain therapy recommendations based on the neural networks trained with the community knowledge of all the users of the distributed laser therapy system.

REFERENCES

- [1] V. Randjelovic., D.Tatic. J.Randjelovic, Computer Controlled Laser, Nis, Ei Bull HN, 1994.
- [2] F. Watban, X. Zhang, "The comparison of effects between pulsed and CW lasers on wound healing", *J Clin Laser Med Surg.*, vol. 22, no. 1, pp. 15-18, Feb. 2004.
- [3] D. Hawkins, H Abrahamse, "Laboratory Methods for Evaluating the Effect of Low Level Laser Therapy (LLLT) In Wound Healing", *African Journal of Biomedical Research*, vol. 8, pp.1-14, 2005,
- [4] JH. Lee, MH. Chiang, PH. Chen, ML. Ho, HE. Lee, YH. Wang, "Anti-inflammatory effects of low-level laser therapy on human periodontal ligament cells: in vitro study", *Lasers Med Sci.*, vol. 33, no. 3, pp. 469-477, 2018.
- [5] A.Alves, R.Vieira, E. Leal-Junior, S. Santos, A.Ligeiro, R. Albertini, J. Silva Junior, P. de Carvalho, "Effect of low-level laser therapy on the expression of inflammatory mediators and on neutrophils and macrophages in acute joint inflammation", *Arthritis Res Ther.*, vol. 15, no. 5, 2013.
- [6] M. Artés-Ribas, J. Arnabat, A. Puigdollers, "Analgesic effect of a low-level laser therapy (830 nm) in early orthodontic treatment", *Lasers in Medical Science*, vol. 28, no. 1, 2012.
- [7] S. Moskvina, "Low-Level Laser Therapy in Russia: History, Science and Practice", *J Lasers Med Sci.*, vol. 8, no. 2, pp. 56-65, 2017.
- [8] V. Randjelovic, "IoT Based Laser Therapy System and Multilayer Perceptron for the Recognition of the Therapy Protocols", Telsiks conference proceedings, 2019, in press.
- [9] A. Nagy, Z. Mowafy, R. Alkhoribi, "Prediction of abdominal contouring response to low level laser using Artificial Neural Network", *Bioscience Research*, 2018; 15(2): 950-955.
- [10] S. Cazzaniga, F. Sassi, S. Mercuri, L. Naldi, "Prediction of clinical response to excimer laser treatment in vitiligo by using neural network models", *Dermatology*. 2009;219(2):133-137.
- [11] S. Razavi, "A neural controller for online laser power adjustment during the heat therapy process in the presence of nanoparticles", *Australas Phys Eng Sci Med*. 2017;40(2):401-411.
- [12] IEC standard: Medical Electrical Equipment, IEC60601-1, 2000.
- [13] IEC standard: Particular requirements for basic safety and essential performance of surgical, cosmetic, therapeutic and diagnostic laser equipment, IEC 60601-2-22, 2007.
- [14] V. Randjelovic., Patent: Light guide holder for laser probe, Intellectual property Office of Serbia: MP836/2006.
- [15] V. Randjelovic., Patent: USB therapy laser, Intellectual property Office of Serbia: MP837/2006.
- [16] W. Wheeler, J. White, "Spring in Practice", Shelter Island: Manning, 2013.
- [17] C. Binildas, B. Malhar, C. Vincenzo, "Service Oriented Architecture with Java", Birmingham: Packt Publishing, 2008.
- [18] M. Kubat, "An Introduction to Machine Learning", New York, Springer, 2015.
- [19] J. Bell, "Machine Learning", John Wiley and Sons: Indianapolis, 2015.
- [20] F.M.Souares, A.M. Souza, "Neural Network Programming with Java", Packt Publishing: Birmingham, 2016.
- [21] M. Buscema, "Back Propagation Neural Networks", *Subst Use Misuse*, vol. 33, no. 2, pp. 233-70, 1998.



E-SERVICES: EFFICIENCY AND USE IN MODERN BUSINESS

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Abstract:

The accelerated development of the Internet and information technologies has conditioned the emergence of new forms of business. One of the most important types of the application of new technologies is electronic business (eBusiness). The term eBusiness is a general term for the electronic way of doing business. This paper will provide an overview of the development and advantages of using electronic business in today. The importance of the service sector in the Republic of Serbia is also evidenced by data showing the share of various sectors in domestic GDP. The service sector generates over 50% of GDP in Republic of Serbia. The importance of the global service economy, the strengthening of the service sector and the support of information technologies have conditioned the emergence and development of eServices. Therefore, special attention in this paper will be paid to examples from the field of eServices of the public and private sector of the Republic of Serbia. Even though some efforts have been made to develop eBusiness and eServices, additional efforts need to be made to educate and inform natural and legal persons about the use and advantages of these services.

Keywords:

electronic business, eServices, Internet, eBanking, mBanking.

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INTRODUCTION

The increase in the use of the Internet in the daily performance of activities and communication between the company and users has brought a new, modern form of business. Changes in the needs and habits of consumers and the development of technologies on the other hand have conditioned the development of electronic business as a modern type of business. Availability of information, wide range of products and services, time saving and disappearance of spatial barriers are just some of the advantages recognized by users. In order to use all advantages of electronic business, it is necessary to harmonize information and communication technologies and strategically adjust to the goals and technological achievements [1]. The intensive transition from traditional to modern ways of doing business, from the aspect of finance, requires



certain capital expenditures. It is necessary to provide funds for financing the implementation of the software solution, its testing and maintenance, as well as training of employees so that the entire process runs smoothly.

The development of new technologies and the application of the Internet in everyday business enables more efficient performance of activities. Electronic business (eBusiness) refers to the performance of various transactions in electronic form, via the Internet, which enables more efficient performance of daily business activities [2]. At the same time, it represents a general concept that includes all forms of business transactions or exchange of information in the free market that are performed by using the information and communication technology [3].

The legislative framework of eBusiness in the territory of the Republic of Serbia is the Law on Electronic Document, Electronic Identification and Trust Services in Electronic Business [2]. According to the abovementioned Law, electronic business is defined as the use of data in electronic form, means of electronic communication and electronic data processing in the performance of activities of natural and legal persons.

If adequately organised, eBusiness can bring a series of benefits to companies. Some of the advantages of eBusiness are reflected in simpler and faster access to information, efficient and effective use of available resources, easier and safer data exchange, faster processing of collected data, greater security of data storage and generally greater time savings of all stakeholders in the eBusiness process.

According to the Strategy for Development of the Information Society in the Republic of Serbia till 2020, the plan is that citizens will be able to make all contacts with administrative bodies, holders of public authority, courts and the health care system, without leaving their apartment, i.e. workplace, except for those contacts that require physical presence [4].

The increasing participation of the service sector in advanced economies causes special attention and provides many opportunities to modern users. According to [5], the share of services/service sector in the total GDP of the Republic of Serbia in 2018 was 51.02%. This data indicates the importance of the service sector in our country. In order for the service process to be successfully realized, it is necessary to monitor and understand the needs and behaviour of users during the service process. An important component in the provision of e-services is real-time response [6]. The success of e-service delivery depends on the set strategies, the choice

of an adequate method for measuring performance, as well as raising awareness and better understanding of the concept of electronic service [6]. Different forms of using eBusiness and their advantages have been recognized in both the private and public sectors. Further in this paper, an overview of the current examples of eServices in the Republic of Serbia will be presented.

1. ESERVICES IN THE REPUBLIC OF SERBIA

According to [7], eService is defined as a service that is available via the Internet, and which enables the execution of tasks, solving problems or doing transactions. Both legal and natural persons can be eService users. Some of the important areas of successful application of the Internet and new technologies in the service sector that are applied in the territory of the Republic of Serbia will be presented further in the text:

1. eBanking

Modern business conditions in the field of banking have transformed the traditional system of delivering services to the population. Therefore, today financial institutions provide their services through various channels, such as branch banking, ATMs, internet banking (eBanking) and mobile banking (mBanking).

Electronic banking (eBanking) is a fast, secure, simple and efficient electronic service that allows an access to a bank account, but also the provision of Internet services, 24 hours a day and 7 days a week [8]. The main goal of electronic banking is faster and safer connection of clients and information. This form of banking can be realized by using the Internet, but with other specialized computer networks. Business efficiency is achieved by lower costs, as well as by a better competitive position in the business market, which in eBusiness is achieved through the use of wireless communication devices, namely: mobile phones, Palm OS devices and Pocket & Handheld PCs.

The main advantages of using the eBanking system are reflected in the following:

- time saving;
- lower commissions for all online payments;
- two-way communication with clients;
- reduction of operating costs;
- smaller volume of paper documentation;
- payment on the go;
- faster and simpler cash flow;



- the possibility to perform transactions from different geographical distances;
- current account balance overview;
- current review of all payment transactions.

Disadvantages of using the eBanking system relate to:

- business security;
- lack of legislation;
- lack of privacy;
- alienation;
- aversion to innovations;
- danger of data misuse;
- identity theft.

2. mBanking

The development of information technology has enabled financial institutions to revolutionize the patterns of providing their services. Mobile banking (m-banking) is the fastest growing and most profitable channel for providing banking services [9]. Mobile banking is any transaction with a monetary amount, which is performed by the use of mobile networks. The basic characteristics of mobile banking are reflected in time availability, device mobility, savings of time and resources, simplicity of operations and security.

The reasons that led to the development of different types of mobile services, including mobile banking, are the following:

- developed mobile telephony market;
- rapid development of the Internet and e-commerce;
- possibilities of authentication and authorization in different types of transactions;
- new principles of charging for different services.

3. eGovernment

The eGovernment portal was created with the idea of enabling the citizens of the Republic of Serbia to quickly and efficiently solve their administrative tasks without physically going to the government counter. The Law on Electronic Administration defines the tasks performed by the administration of state bodies and organizations, bodies and organizations of the provincial autonomy, bodies and organizations of local self-government units, institutions, public enterprises, special bodies through which the regulatory function is exercised and legal and

natural persons entrusted with public authorities by using information and communication technologies [10]. The manner of work of the eGovernment portal is regulated by the Government of the Republic of Serbia.

eGovernment is defined as a central place for providing electronic services to three categories of users, namely: citizens, economy and state. For each of the above stated categories, there is a defined range of electronic services whose idea is to enable simpler and faster execution of various administrative tasks.

eGovernment portal started working in June 2010 in the territory of the Republic of Serbia. It is the result of the work of a large number of different state institutions and some local self-governments that have made available their electronic services and the necessary information related to the services they provide to citizens and the economy. [11] Based on the report of the Statistical Office of the Republic of Serbia, an overview of the movement of the number of Internet service users in the Republic of Serbia in the period from 2010 to 2019 was made. Within the users of Internet services, the tendency of the movement of the number of users of eGovernment in the Republic of Serbia is separately shown. Having in mind that the eGovernment portal started operating in 2010, a graphic presentation of the movement of users of this service for that period will be presented below.

Table 1. NUMBER OF USER OF PUBLIC ADMINISTRATION ELECTRONIC SERVICES



Source: Statistical Office of the Republic of Serbia, <https://www.stat.gov.rs/>

Based on the previous chart, there is a noticeable increase in the number of users of electronic service of eGovernment in the observed period in the Republic of Serbia. The number of users today, compared to 2010, when the implementation of eGovernment started in Serbia, is almost five times higher, which indicates the

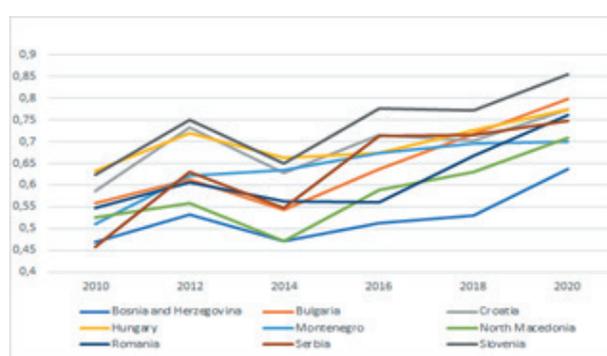


recognition of the importance and significance of the implementation of the eGovernment portal by the users of this service.

Further development is defined by the eGovernment Development Programme as a public policy document by which the Government of the Republic of Serbia plans the development of eGovernment in the Republic of Serbia, and which is defined for the period from 2019 to 2022. The programme plans public policy measures along with the harmonization of this document with the goals of public administration development goals set by the Public Administration Reform Strategy in the Republic of Serbia and continuity in the implementation of measures for eGovernment development in the Republic of Serbia for the period 2015-2018. [12]

The e-Government Development Index (EGDI) is used as a parameter for measuring the success of eGovernment development and ranking of countries. This index is used to rank countries that are members of the United Nations. The EGDI consists of three important dimensions of e-government - provision of online services, telecommunication connectivity and human capacity. [13] Below is an overview of EGDI trends in the Republic of Serbia and countries in the region (Bosnia and Herzegovina, Bulgaria, Montenegro, Croatia, Hungary, Romania, Northern Macedonia, Slovenia) for the period 2010-2020. The value of the EGDI index ranges from 0 to 1 so that better ranked countries have values closer to 1 and it is calculated every two years.

Table 2. E-GOVERNMENT DEVELOPMENT INDEX



Source: UN E-Government Knowledgebase, <https://publicadministration.un.org/egovkb/en-us/data-center>

When it comes to the Republic of Serbia, in 2010, when the implementation of eGovernment began in our country, we had the worst rank, i.e. the lowest value of the EGDI index taking into account the observed countries from the region. By observing all UN member

states, in 2010, Serbia was 81st on the ranking list of 193 UN member states using this index. The latest data from 2020 show that Serbia is currently ranked 58th with the EGDI index of 0.7474, which is the largest index that the Republic of Serbia had in the observed period.

The eGovernment Development Programme in the Republic of Serbia is designed to be implemented in compliance with certain principles. One of the basic principles of this programme is the principle of environmental protection, which implies the gradual complete abolition of the use of paper.

4. eTourist

A new eTourist platform has been created within the eGovernment portal. The Ministry of Trade, Tourism and Telecommunications has created the eTourist platform with the idea of a central information system in the tourism and hospitality industry.

The Law on Hospitality regulates the conditions and manner of performing hospitality activities, in nautical tourism facilities and hunting tourism facilities, residence fee and penalties, as well as other issues important for their development and improvement. [14] According to the [14], central information system in the field of hospitality industry and tourism of public administration electronic services (eTourist) is defined as the unique and centralized electronic information system, which contains all relevant data on accommodation providers and accommodation facilities, through which their records is kept and other data derived from the hospitality, nautical and hunting tourism, i.e. tourism activities or services in tourism industry.

A great advantage of such a centralized system is reflected in the unification of all data from hospitality employee and accommodation facilities in the Republic of Serbia. The benefits of the eTourist can be viewed from different angles, such as: hospitality employee, consumers i.e. tourists and the state institution and the tourist organization point of view.

The characteristics of the centralized information system are reflected in the following: it is free, with an easy and fast access to the system, it facilitates business, and it is important in the segment of hotel systems integration.

After the full implementation of the eTourist system, numerous benefits for the users of this system are expected. From the point of view of hospitality employee, some of the advantages mentioned are simplification of procedures for registration of domestic and foreign



tourists, simplification of administrative procedures, online submission of requests for categorization. From perspective of tourists, some of the benefits are related to the security, accommodation in legal accommodation facilities and higher quality of service. Benefits of the eTourist implementation from the perspective of the state are reflected in monitoring data such as: total number of tourists who visited the country, their geographical and demographic characteristics in real time, daily insight into the database containing information about accommodation facilities and accommodation service providers and promotion of Serbia as a tourist destination [15].

The full implementation and launching of the eTourist were planned for April 2020. Due to the spread of the COVID-19 pandemic, the launch of the e-Tourist central information system has been fully postponed [16].

CONCLUSION

An integral part of the business of today's companies are the constant changes that are occurring in the market. The turbulent environment influences companies to be innovative and proactively oriented in everyday business. In order to successfully perform their activities and place their products and services companies need to adequately adapt to the new changes.

The importance of electronic business has gained special significance in the past period. Global business and the spread of the COVID-19 pandemic have influenced the creation of new and improvement of the existing products and services. Although they bring benefits, there are certain disadvantages of online services that can affect the dissatisfaction of users of various services.

If users are not enough familiar with computers and new technologies, have no previous experience and they may be dissatisfied. In that case, companies face challenges such as setting simpler procedures and providing additional guidelines for using and implementing online services in order to influence ultimate satisfaction of their users.

This paper presents some of the services that were of great importance in the period behind us and refer to services in both the private and public sectors.

As a country in the process of negotiations for accession to the European Union, the Republic of Serbia is harmonizing its eGovernment development strategies with European Union regulations. Since the eGovernment was launched until today, there has been a notice-

able increase in the number of users, as well as the expansion of the range of services of state authorities that are available to users. Also, a positive trend of ranking Serbia by the quality of eGovernment is noticeable. In order to maintain and improve its current position, it is necessary to continuously develop and improve its services, but also to inform the population about all benefits and educate them about the self-use of various services within the eGovernment. eBusiness enables several times faster way of doing business than usual, greater adaptability to market changes, more precise and easier access to information on the state of the company, lower costs for material and postal services and thus lower costs of manual labour.

Changes are inevitable, and it is up to companies to adapt to the changes and see them as a chance to further improve their business. Recommendations for further research would be to examine the satisfaction of users of electronic services and to monitor the trend of further development of electronic services in both the public and private sectors. Also, attention can be paid to the analysis of new electronic services that emerged during the global crisis caused by the spread of COVID-19.

REFERENCES

- [1] S. Stanišić, "Razvoj i uticaj elektronskog poslovanja na poboljšanje usluga u bankarskom sektoru," in *Sinergija*, Bijeljina, 2017.
- [2] "Sl. glasnik RS", br.94/2017, *Zakon o elektronskom dokumentu, elektronskoj identifikaciji i uslugama od poverenja u elektronskom poslovanju*, 2019.
- [3] I. Stojanović, *Elektronska trgovina i kupovina putem Interneta u Srbiji*, 2011.
- [4] "Sl. glasnik RS" br.51/2010, *Strategija razvoja informacionog društva u Republici Srbiji do 2020. godine*, 2020.
- [5] Statista, "Serbia: Share of economic sectors in the gross domestic product (GDP) from 2008 to 2018," [Online]. Available: <https://www.statista.com/statistics/440654/share-of-economic-sectors-in-the-gdp-in-serbia/>. [Accessed 28 april 2020].
- [6] K. N. L. Roland T. Rust, "E-Service and the Consumer," *International Journal of Electronic Commerce*, pp. 85-101, 2014.
- [7] J. E. Bateson and K. D. Hoffman, *Marketing usluga*, Beograd: Data Status, 2013.
- [8] S. Chandrasekaran and M. Narayanan, "Recent and future trends in e-banking services for Indian banking sector," *Journal of The Gujarat Research Society*, vol. 21, no. 16, pp. 245-251, 2019.



- [9] S. A., J. C. and A. M., "How do electronic word of mouth practices contribute to mobile banking adoption?," *Journal of Retailing and Consumer Services*, vol. 52, 2020.
- [10] Službeni glasnik Republike Srbije, "Zakon o elektronskoj upravi," Narodna skupština, [Online]. Available: www.parlament.gov.rs/upload/archive/files/cir/pdf/zakoni/2018/164-18.pdf. [Accessed 22 July 2020].
- [11] "Kancelarija za informacione tehnologije i elektronsku upravu," [Online]. Available: <https://www.ite.gov.rs/tekst/sr/77/portal-euprava.php>. [Accessed 22 July 2020].
- [12] "Program razvoja elektronske uprave u Republici Srbiji za period od 2019. do 2022. godine i Akcioni plan za njegovo sprovođenje," 24 July 2020. [Online]. Available: <http://mduls.gov.rs/wp-content/uploads/Program-razvoja-e-uprave-za-period-od-2019-do-2022.pdf>.
- [13] UN E-Government Knowledgebase, "E-Government Development Index (EDGI)," [Online]. Available: <https://publicadministration.un.org/egovkb/en-us/About/Overview/-E-Government-Development-Index>. [Accessed 24 July 2020].
- [14] Službeni glasnik Republike Srbije, "Zakon o ugostiteljstvu," [Online]. Available: <http://www.parlament.gov.rs/upload/archive/files/cir/pdf/zakoni/2019/3154-18.pdf>. [Accessed 22 July 2020].
- [15] Ministarstvo trgovine, turizma i telekomunikacija, "Centralni informacioni sistem u oblasti ugostiteljstva i turizma," [Online]. Available: <https://www.eturista.gov.rs/extfile/sr/331534/eTurista%20ppt1.pdf>. [Accessed 22 July 2020].
- [16] Ministarstvo trgovine, turizma i telekomunikacija, "eTurista," [Online]. Available: <https://www.eturista.gov.rs/vest/331570/odlozeno-pokretanje-eturiste-centralnog-informacionog-sistema-u-oblasti-ugostiteljstva-i-turizma.php>. [Accessed 25 July 2020].



EVALUATION OF HOTEL EMPLOYEES' SATISFACTION USING UGC (USER GENERATED CONTENT)

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Abstract:

Job satisfaction is correlated with employees on job performance, guest satisfaction and implicitly with financial performance of a hotel. Previous studies showed that employees' satisfaction when published online can influence guests booking intentions. We argue that it can influence and that it should be used to facilitate the human resource management process and prevent high turnover rates which are characteristic for hospitality. User generated content created a space for hotel employees to share their satisfaction/dissatisfaction online with thousands of other jobseekers. This giant database could be used to improve working conditions, increase job satisfaction, and consequentially increase performance and guest satisfaction. This paper presents initial results from data collected from one of the most visited websites in the world glassdoor.com. In total, primary findings from more than 10.000 workers reviews were presented. Results show that *culture and values* and *career opportunities* are ranked as top variables that contribute to the overall job satisfaction. In addition, these two variables showed strong correlation with rating of *senior management*. This could be understood that employees their career opportunities and culture and values that prevail in organisation significantly associate with senior management.

Keywords:

job satisfaction, hotel employees, user generated content.

1. INTRODUCTION

Satisfied employees in a hotel, tend to provide a better service quality to a customer as they feel more enthusiastic and inspired with their job [1]. Apart from the fact that satisfied employees provide better service, they also show a higher intention to stay in the company [2] This is extremely important in hospitality as it records a high employee turnover rate across the industry. There are estimates that an average turnover of frontline employees in a year in hospitality moves around 65% [3]. This should not be that surprising if we know that tourism is distinguished by poor working conditions for employees, which logically lead to high turnover rates [4]. However, high turnover rates are certainly not desirable to top management. It is not only a time-consuming process,

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but a very costly one as well. There were several attempts from academics to estimate the cost of employee turnover in a hotel. A study from Wasmuth and Davis from 1983 estimated that each incident of an employee turnover costs around 2,500 \$ [5]. A more recent study from Simons and Hinkin estimated even greater costs of employee turnover per incident (around 5,000\$) in their research [6]. Even though there are limitations in both studies, it is clear that hospitality faces a serious problem regarding employee turnover, which, as previously stated, is directly linked with employee satisfaction i.e. dissatisfaction at work.

Yet, employee satisfaction doesn't reflect only on retention rates. Many academics demonstrated that a satisfied employee performs better in the workplace as well i.e. that employee satisfaction is positively correlated with employee performance [7]–[9]. As Guest points out, employees' linkage with performance is the most common thing researched by many academics in the domain of HR [10].

Finally, employee satisfaction is set to be indirectly correlated with financial performance having customer satisfaction as mediator [11], [12]. Therefore, employee satisfaction sets to be one of the crucial factors in terms of successful hotel managing nowadays as it affects customer satisfaction, employee performance and finally financial results.

2. LITERATURE REVIEW

Many academics worldwide explored the topics covering employees' satisfaction. The pioneer work in this field may be traced back to almost a century ago, i.e. to prof. Fritz Roethlisberger. He developed a series of experiments in Western Electric Company in which more than 20,000 employees took part. A broad correlation between working conditions, motivation, incentives, organizational structure and performance was discovered [13]. Despite the fact that the conclusions sparked off many debates, its significance was so immense that Rust et al. highlighted that there had been over 5,000 studies on employee satisfaction prior to 1995 [14]. However, despite the tremendous effort, academics have not reached an agreement about what the most important factors that influence employee satisfaction are. One of the reasons for it is, as Lester points out, the number of variables that needs to be taken into consideration when one discusses employee satisfaction [15]. Simply put, employees are human beings, and they differ very much

at many different levels, thus the idea about finding one perfect recipe for employee satisfaction which may be applicable on every organization is perhaps too optimistic.

Yet, some considerable efforts have been made, as in the study done by Cotton and Tuttle. They performed a meta-analysis in order to determine the most significant variables that lead to employee satisfaction or dissatisfaction which ultimately led to employee turnover [16]. Loveman analysed employee satisfaction and service profit chain in the retail banking sector [17]. Yee et al. explored employee satisfaction in high contact service industries [12]. However, most of the research conducted until recently hasn't involved hotel employees exclusively.

In the meantime, tourism and hospitality emerged as independent scientific disciplines and academics started to dig into the differences between hospitality and other industries. Finding the differences in hospitality is significant as it is fast and a vibrant, growing industry, globally speaking [18]. Moreover, repeating the experiments and research similar to prof. Roethlisberger would cause enormous costs and require significant resources. In addition, the working environment in hospitality is changing rapidly, therefore managers need a quick and efficient tool to access the job satisfaction of their employees. With the development of new technology and mass use of user generated content, this process could be facilitated much more efficiently.

3. USER GENERATED CONTENT AND WORKER WORD OF MOUTH

Since 2006, there was a major shift looking at the way media content has been produced [19]. Regular people became the online content creators, and most importantly they created the content everyone was interested to look at. There are several major reasons why UGC (User Generated Content) had such a strong impact in the world. Firstly, it is inexpensive and, in most cases, even free, since people usually create content at no charge [20]. Secondly, for content consumers information they consume is perceived as more relevant, and they tend to show higher rates of trust [21]–[23].

UGC is a big resource of data which travellers and employees in hospitality leave on the Internet. In hospitality, there is a growing interest in using UGC in order to determine and gain insights into research problems which were not clearly understood by conventional methods [12, p. 200], [24]



While most of the previous studies analysed UGC from the demands side (large guest reviews on the Internet distribution systems such as booking.com, Expedia or even social media) little has been analysed using UGC from hotel employees. This should not be surprising as UGC posted by hotel employees almost didn't exist in the way it could be analysed. However, its significance was recently demonstrated in a study undertaken by Gonzalez and Gidumal, using the experiment as a method. It showed that customers' booking intentions can be seriously affected if they find any kind of injustice towards employees on the Internet [25]. For that reason, employers nowadays, apart from all the other factors, need to pay attention to what their employees share and post online as it can affect their reputation and even sales. Not only do employees make posts about their job satisfaction on their private platforms, but also do so on specialized platforms for integrated exchange of opinions which were created with a view to having a centralized database containing employees' reviews of their employers. This data is quite relevant and important for job seekers, but it also serves as a unique database for research as well. Considering that this has been a rising phenomenon, Gonzalez and Gidumal even invented the term weWOM which stands for "Worker eWOM". Before internet and platforms containing UGC, the process of finding information about prospective employer was quite demanding. Job seekers often found out most of the information about prospective employers, only after they started working [25].

At the moment, one of the best online sources for weWOM internationally is the website www.glassdoor.com. To add to the relevance of the source, Glassdoor contains the information from over 600,000 companies worldwide, while studies from web traffic ranked it among the first 800 websites searched online in the world [25], [26]. Even though Glassdoor offers significant amount of information that primary of interest to jobseekers, it may offer valuable information for hotel managers as well. Managers can gain insight in what drives the overall satisfaction of their employees. In addition, hotel managers could use UGC platforms to gain knowledge and differentiate their job offerings towards potential candidates as well as towards their current employees in accordance with their attitudes presented online.

In order to gain insight in what drives employee satisfaction in corporate hotel chains, in this paper we decided to look into the data publicly available from Glassdoor.com. The dataset downloaded from Glassdoor included 10.207 valid reviews from hotel employees. Research findings are presented below.

4. RESEARCH FINDINGS

Research sample included ratings and reviews from the employees of 8 international corporate hotel chains that were ranked in the top 20 biggest hotel companies in 2018 according to the [27]. The selected hotel companies operate with over 4,000,000 hotel rooms worldwide and hire over 500,000 employees globally [27], [28]. In total employee ratings from 2719 hotels worldwide were evaluated. Hotels data were collected during the period of May 2008 up to June 2018. The sample included employees from six continents, and properties ranging from the small ones, with 10 rooms, to the big ones with a 1,000-room capacity. The positions held by the employees who left their reviews ranged from that of a *Housekeeper* to *General Manager* i.e. from the top management to an entry level. Every respondent left answers about 5 specific variables in total followed with additional information and open comments and recommendations for management. Our research focused only on quantitative marks related with 5 variables. These 5 variables were: work life balance, culture and values, career opportunities, compensations and benefits and senior management. The respondents rated their satisfaction on a 5-point scale.

The results from descriptive statistics and correlation matrix are presented in tables 1 and 2. Before running the Pearson correlation, normality distribution of each variable was checked. Two variables were slightly skewed towards higher rating points, yet not significantly to be excluded from performing the analysis.

The reviews analysed in this paper rated their satisfaction on a 5-point scale (1- lowest satisfaction, 5 – highest satisfaction). In table 1 results show that employees were the most satisfied with culture and values in their respective organisations followed with career opportunities and compensations and benefits. Contrary they rated the lowest on average the senior management and work-life balance.

Table 1. - Descriptive statistics

	N	Min	Max	Mean	std	var
	Sta	Sta	Sta	Sta.	Std. er.	Sta
WLB	11837	1	5	3,31	,012	1,29
CV	10419	1	5	3,72	,013	1,31
CO	11868	1	5	3,46	,012	1,29
CB	11840	1	5	3,35	,011	1,23
SM	11643	1	5	3,21	,013	1,37
Valid	10207					

Legend: WLB- Work life balance; CV – Culture & Values; CO- Career opportunities; CB – Compensation & Benefits; SM – Senior Management, Sta – Statistic, Std. er. – standard error, var- variance, N - number



Results from table 1 are in accordance with previous findings which demonstrated that financial benefits are not still the top priority for hotel employees, as well as that career opportunities are among the highly appreciated job satisfaction factors within generations Y and Z [29], [30]. Furthermore, correlation matrix (table 2) shows that there is a moderate, positive correlation among all variables except culture and values and career opportunities with senior management. Each correlation was proved statistically significant at the level of 0.95.

Table 2. - Correlation matrix

		WB	CV	CO	CB	SM
WB	r		.57	.46	.49	.58
	p		.00	.00	.00	.00
CV	r			.65	.55	.72
	p			.00	.00	.00
CO	r				.59	.64
	p				.00	.00
CB	r					.52
	p					.00

Legend: WLB- Work life balance; CV – Culture & Values; CO- Career opportunities; CB – Compensation & Benefits; SM – Senior Management; r – Pearson correlation; p – significance (2-tailed)

This could be understood that the highest rated variables on average (Culture and values and Career opportunities) are in strong correlation with the actions taken from senior management. Further analysis could demonstrate if these findings were under the influence of younger workers. Finally, results from table 2 also prove that overall job satisfaction is influenced by multiple factors which are all positively correlated.

5. CONCLUSION

This paper analysed job satisfaction of corporate hotel employees using workers reviews left on UGC website. Over 10.000 worker reviews from 8 hotel chains were analysed. The results showed that non-financial factors such as culture and values and career opportunities remain the top factors that contribute to the overall job satisfaction, which is in accordance with previous recent findings. In addition, the results from correlation matrix showed that these two variables had strong correlation with senior management. This could be understood that employees consider that the culture and values in an organisation as well as their career opportunities are dominantly influenced by senior management.

The importance of hotel employees' satisfaction and the impact it has on hotel performance has already been demonstrated multiple times. Yet hotel industry remains distinguished by poor working conditions and high turnover rates. We argue that UGC could be used by hotel managers to facilitate the process of job satisfaction analysis. WeWOM was already proven to influence booking intentions of potential guests, and we argue it could be used to offer better working conditions and to prevent a very costly process of turnover in hospitality.

Further analysis should look into differences among hotel scales, market where hotels operate as well as the difference in rating according to the job title of worker i.e. if it is service line, middle management or top management level of employee.

REFERENCES

- [1] H. Kong, C. Cheung, and H. Song, "From hotel career management to employees' career satisfaction: The mediating effect of career competency," *Int. J. Hosp. Manag.*, vol. 31, no. 1, pp. 76–85, Mar. 2012, doi: 10.1016/j.ijhm.2011.03.002.
- [2] C.-F. Chiang, K.-J. Back, and D. D. Canter, "The Impact of Employee Training on Job Satisfaction and Intention to Stay in the Hotel Industry," *J. Hum. Resour. Hosp. Tour.*, vol. 4, no. 2, pp. 99–118, Dec. 2005, doi: 10.1300/J171v04n02_06.
- [3] L. Myers, "News from Cornell's Center for Hospitality Research: Free Web-based management tool helps hotels and restaurants weigh employee turnover cost," *Cornell Chronicle*, Jul. 19, 2005. <http://news.cornell.edu/stories/2005/07/new-tool-helps-hotels-weigh-cost-employee-turnover> (accessed Jul. 18, 2019).
- [4] T. Baum, "Human resources in tourism: Still waiting for change," *Tour. Manag.*, vol. 28, no. 6, pp. 1383–1399, Dec. 2007, doi: 10.1016/j.tourman.2007.04.005.
- [5] W. Wasmuth and S. Davis, "Why Employees Leave -," *Cornell Hosp. Q.*, vol. 24, no. 1, pp. 11–18, 1983, doi: 10.1177/001088048302400103.
- [6] T. Simons and T. Hinkin, "The Effect of Employee Turnover on Hotel Profits: A Test Across Multiple Hotels," *Artic. Chapters*, Aug. 2001, [Online]. Available: <https://scholarship.sha.cornell.edu/articles/446>.
- [7] J. K. Harter, F. L. Schmidt, and T. L. Hayes, "Business-unit-level relationship between employee satisfaction, employee engagement, and business outcomes: A meta-analysis," *J. Appl. Psychol.*, vol. 87, no. 2, pp. 268–279, 2002, doi: 10.1037//0021-9010.87.2.268.



- [8] M. M. Petty, G. W. McGee, and J. W. Cavender, "A Meta-Analysis of the Relationships between Individual Job Satisfaction and Individual Performance," *Acad. Manage. Rev.*, vol. 9, no. 4, p. 712, Oct. 1984, doi: 10.2307/258493.
- [9] Y. Li and S. (Sam) Huang, "Hospitality service climate, employee service orientation, career aspiration and performance: A moderated mediation model," *Int. J. Hosp. Manag.*, vol. 67, pp. 24–32, Oct. 2017, doi: 10.1016/j.ijhm.2017.07.012.
- [10] D. E. Guest, "Perspectives on the Study of Work-life Balance," *Soc. Sci. Inf.*, vol. 41, no. 2, pp. 255–279, Jun. 2002, doi: 10.1177/0539018402041002005.
- [11] C. G. Chi and D. Gursoy, "Employee satisfaction, customer satisfaction, and financial performance: An empirical examination," *Int. J. Hosp. Manag.*, vol. 28, no. 2, pp. 245–253, Jun. 2009, doi: 10.1016/j.ijhm.2008.08.003.
- [12] R. W. Y. Yee, A. C. L. Yeung, and T. C. E. Cheng, "The impact of employee satisfaction on quality and profitability in high-contact service industries," *J. Oper. Manag.*, vol. 26, no. 5, pp. 651–668, Sep. 2008, doi: 10.1016/j.jom.2008.01.001.
- [13] F. J. Roethlisberger, W. J. Dickson, H. A. Wright, C. H. Pforzheimer, and Western Electric Company, *Management and the worker: an account of a research program conducted by the Western Electric Company, Hawthorne Works, Chicago*. Cambridge, Mass.: Harvard University Press, 1939.
- [14] R. T. Rust, G. L. Stewart, H. Miller, and D. Pielack, "The satisfaction and retention of frontline employees: A customer satisfaction measurement approach," *Int. J. Serv. Ind. Manag.*, vol. 7, no. 5, pp. 62–80, Dec. 1996, doi: 10.1108/09564239610149966.
- [15] P. E. Lester, "Development and Factor Analysis of the Teacher Job Satisfaction Questionnaire (TJSQ)," *Educ. Psychol. Meas.*, vol. 47, no. 1, pp. 223–233, Mar. 1987, doi: 10.1177/0013164487471031.
- [16] J. L. Cotton and J. M. Tuttle, "Employee Turnover: A Meta-Analysis and Review with Implications for Research," *Acad. Manage. Rev.*, vol. 11, no. 1, pp. 55–70, Jan. 1986, doi: 10.5465/amr.1986.4282625.
- [17] G. W. Loveman, "Employee Satisfaction, Customer Loyalty, and Financial Performance: An Empirical Examination of the Service Profit Chain in Retail Banking," *J. Serv. Res.*, vol. 1, no. 1, pp. 18–31, Aug. 1998, doi: 10.1177/109467059800100103.
- [18] R. Howard and M. Fishbin, "Global hospitality insights," Ernst & Young, 2016.
- [19] M. Lavoie and G. Rodríguez, "The Economic Impact of Professional Teams on Monthly Hotel Occupancy Rates of Canadian Cities: A Box-Jenkins Approach," *J. Sports Econ.*, vol. 6, no. 3, pp. 314–324, Aug. 2005, doi: 10.1177/1527002504268614.
- [20] T. Daugherty, M. S. Eastin, and L. Bright, "Exploring Consumer Motivations for Creating User-Generated Content," *J. Interact. Advert.*, vol. 8, no. 2, pp. 16–25, Mar. 2008, doi: 10.1080/15252019.2008.10722139.
- [21] Stephen Burgess, Carmine Sellitto, Carmen Cox, and Jeremy Buultjens, "USER-GENERATED CONTENT (UGC) IN TOURISM: BENEFITS AND CONCERNS OF ONLINE CONSUMERS," in *17th European Conference on Information Systems*, Verona, pp. 1–14.
- [22] J. Rupert Hills and G. Cairncross, "Small accommodation providers and UGC web sites: perceptions and practices," *Int. J. Contemp. Hosp. Manag.*, vol. 23, no. 1, pp. 26–43, Jan. 2011, doi: 10.1108/095961111111101652.
- [23] R. Williams, T. van der Wiele, J. van Iwaarden, and S. Eldridge, "The importance of user-generated content: the case of hotels," *TQM J.*, vol. 22, no. 2, pp. 117–128, Jan. 2010, doi: 10.1108/17542731011024246.
- [24] Y. Yang, H. Zhang, and X. Chen, "Coronavirus pandemic and tourism: Dynamic stochastic general equilibrium modeling of infectious disease outbreak," *Ann. Tour. Res.*, p. 102913, Apr. 2020, doi: 10.1016/j.annals.2020.102913.
- [25] S. Melián-González and J. Bulchand-Gidumal, "Extending the scope of hotel client reactions to employee injustice: Hotel employer reviews on the Internet," *Int. J. Hosp. Manag.*, vol. 63, pp. 93–100, May 2017, doi: 10.1016/j.ijhm.2017.03.003.
- [26] Glassdoor, "Glassdoor Job Search | Find the job that fits your life," *Glassdoor*, 2020. <https://www.glassdoor.com/index.htm> (accessed Sep. 10, 2020).
- [27] J. Weinstein, "Special report 325," *HOTELS' magazine*, Special report, 2019.
- [28] Forbes, "America's Best Large Employers," *Forbes*, 2019. <https://www.forbes.com/best-large-employers/> (accessed Oct. 19, 2019).
- [29] D. Gursoy, C. G.-Q. Chi, and E. Karadag, "Generational differences in work values and attitudes among frontline and service contact employees," *Int. J. Hosp. Manag.*, vol. 32, pp. 40–48, Mar. 2013, doi: 10.1016/j.ijhm.2012.04.002.
- [30] M. Alvesson and S. Sveningsson, *Changing organizational culture: cultural change work in progress*. New York: Routledge, 2008.



FUSION OF MULTIMEDIA SMART GAMIFICATION AND GAMES WITH APPLICATION IN MENTAL HEALTH

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Abstract:

Serious games and smart gamification potentially represent an efficient combination of smart systems and technologies on the one hand, while on the other hand they represent a combination of mechanics used for computer games in serious fields of application and gamification. The capabilities and advantages of both fields are combined and as a result they get help from users who need it. This paper describes their application in mental health, as an important issue for all of us.

Keywords:

gamification, serious games, smart objects, smart systems, mental health.

INTRODUCTION

During the last decade, we are witnesses to an enormous growth in the field of computer training systems, which allow an integration of multimedia, serious gaming, and smart technologies in different areas such as education or health [1]. Such techniques utilize recent advances in virtual reality (VR) and augmented reality (AR) to form three-dimensional (3D) virtual models with avatars, which increase the usability of these platforms. Serious gaming includes methods and conception of game technology (multimedia, VR, AR, computer graphics, etc.) with various areas, such as information and communication technologies (ICT), psychology, design, etc. We must point out “serious areas of applications” such as learning, military situations, or health applications, among others [2].

The rapid growth of smart connected systems and smart technologies enables users to implement new approaches to solve different requirements, and reduce time required to provide better Quality of Service (QoS) [2]. On the other hand, the development of serious games and game-related technologies stimulated research in serious areas such as e-health, education, military and other fields. One definition of gamification includes the usage of various objects to design games in contexts unrelated to games [3, 4].

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While serious games are not used for entertainment purposes, gaming applications use game elements but never reach the level of being called a game. Along with serious games, gamification utilizes games for purposes other than entertainment. Having that in mind, gamification represents the active implementation of concepts for serious games, game analytics, computer game technology, and so on, to enhance customer skills and experience [2].

Recent advances on smart systems, smart technologies, gamification, gaming applications and serious games show that these areas will be very important in the following years and are expected to be broadly accepted by users. The aim of this paper is to understand the upcoming smart gaming technologies and serious games, to make classification of main components and technologies on which they are based, and to formulate the requirements for design and development of smart applications.

We can say that researches on this topic should:

- Describe the present position smart systems and smart technologies, as well as gaming applications and serious games;
- Analyze and classify smart objects and their properties, as well as their levels of intelligence;
- Analyze and classify smart gaming and serious games, their technologies, features and characteristics;
- Show the differences between serious games and smart gaming applications;
- Provide opportunities for merging gaming and smart systems/technologies into smart gaming, as well as serious games with smart systems/technologies into smart serious games [2].

This paper is organized as follows: the first section after introduction describes with smart objects, technologies and systems, as well as their classification. Gamification and Smart Serious Games (SSG) are presented in the next part, followed by describing their application in very important field mental health. Finally, the last section concludes the paper.

1. SMART SYSTEMS, FACILITIES AND TECHNOLOGIES

Smart systems/technologies with different types of intelligence are already used today. An example of a smart object is smart material. It can detect sensitivity changes depending of environmental parameters, individual

signals, or even restore degraded sensitivity [2]. An example of a smart textile material is a smart T-shirt. One application of a smart T-shirt is related to soldiers. If a soldier is hit by a bullet, the smart T-shirt detects a number of signals from the soldier's body based on how urgent the response is (whether the wound is dangerous and must be urgently intervened or not).

An example of smart technology is smart home technology. Smart home technologies enable users to use energy efficiently in their homes, and to use home resources to make their life easier, as well. They allow temperature control by monitoring its changes e.g. devices such as if air conditioning are switched on/off on the command of smart home technology. The other example of smart home technology is room lighting that can also be controlled. This control regulates energy consumption and reduces costs, which is important for green technologies. Also, an integral part of the smart home is the anti-theft system. One example of a smart activity is the smart shopping list application supported by mobile phones.

Smart entity classification

Smart entities can be divided into:

- *Smart systems* (smart phones, smart cities, smart classrooms...);
- *Smart objects* (smart sensors, smart materials, smart medical devices...);
- *Smart activities* (smart learning, smart gaming, smart shopping...)
- *Smart technologies* (smart sensors, smart RFID (Radio Frequency Identification), smart grid technologies...)

Smart entity features include:

- *Collecting* raw data from the real world (environment) using sensors, which facilitate environmental monitoring. The obtained data is converted and thus saved for further processing;
- *Transmission* of the collected data by sensors to the control unit by means of transmitters;
- *Big data* to manage the system appropriately as determined by the processing of the previously obtained data by the sensor;
- *Transmission* of instructions from the processing unit to other devices in the network, via internet;
- *Activation* of real and/or virtual actuators in response to the obtained data.



Taking it into account, we can classify the main features of a smart system:

- *Objective* - Use of sensors, infrastructure components, processes, technologies, to obtain quality information, can help users to make effective crucial decisions at the right time;
- *Components* - Smart objects, smart technologies, smart services, and corresponding subsystems;
- *Connections*- Radio/electrical, physical, thermal, infrared and internet based connections;
- *Input size* - Large amount of raw data and significant environmental information such as sensor data;
- *Output size* - Recommendations based on information, immediate execution of certain actions using software systems and information technologies, web services, actuators, and so on;
- *Interfaces* - Internet Protocols (IP), RFID Protocols;
- *Limitations* - weight, type, size, processing time of raw data, and so on;
- *Environment*.

Smart System Intelligence Levels

In order to highlight the differences among smart systems by which one is smarter, we can use classification by intelligence levels and smart technology skills:

- *Adaptation* - The ability to change physical characteristics or behavior to adapt to the environment;
- *Sensitivity* - The ability to detect, understand, recognize and/or perceive a phenomenon, event, or object;
- *Inference ability* - The ability to make logical inferences based on raw data, or information based on specific rules;
- *Learning ability* - The ability to acquire new skills or to change existing to improve performance;
- *Expectation* - The ability to predict what will happen or what to do next;
- *Self-organization capability* - This is the ability of a system to modify its components, or to refresh in certain circumstances without an external agent or entity.

Definition of smart games: software that combines a "gaming" dimension (concept, design and model of games), game structure, game technique and graphical user interface) [5]. Classification of smart gaming is important for better understanding of the purpose, domain, type of game, and as a result, effective fusion of smart technology with smart games.

The purpose of smart games can be different, such as broadcasting messages (educational, so-called edugames, persuasive advergames, informative news-games, military games and art games), physical and mental training and data exchange [6, 7].

Scope of smart games may consist of market/domain codes (such as state and government, military, public health, education, corporation, art, scientific research and entertainment) and general public, experts and students [2]. Smart games can be game-based (with a defined aim to play), and play-based (aimless to play).

2. GAMIFICATION

Gaming can be defined as the process of incorporating gaming dimension - game design, structures, game-like graphical user interface into an existing non-game dimension (such as a software system, corporation or learning community, customer community, web-site, etc.) to motivate professional development and personal productivity growth and efficiency, quality of learning and training, active participation and engagement, and/or long-term loyalty [2].

It is generally accepted that gamification can increase user participation and encourages distinctive unique experiences, as it increases access to other services and opportunities, enabling the participants to gain information for active interaction with other users. Because of the benefits of providing information and knowledge using game design and development, gamification has a lot of advantages in practice. Since gamification is a relatively new concept, it is largely uncertain how an effective design can be accepted, and there is limited knowledge on how to a variety of systems will take advantage of gamification [8].

Gaming mechanics included into a gaming application or software can have an important influence on the user or player type, who may or may not use those techniques in an efficient way. Significant vendors including Microsoft, Google, Adobe, Oracle, Cisco, Siemens, Ford... have already implemented gamified techniques and applications in supporting core functions, processes and/or activities [2].

Moreover, advantages of using smart games in business processes increase positive psychology of workers, strengthens and include the following [2, 9].

- *Positive emotions* (joy, pleasure, fun, safety, etc.);
- *Engagement* (continuous involvement in activities);



- *Relationships* (mutual supportive interactions);
- *Meaning* (creating a meaningful narrative);
- *Achievement* (achievement of goals, monitoring of basic value).

In addition, smart games on the web-sites promote: good retention and effective memory factors, high information adaptability, more interactivity, attractive and unobtrusive promotion, and higher 'virality'. Table 1 presents one possible classification of the smart serious games (SSG) [2].

Table 1. Proposed classification of the smart serious games

SSG feature	SSG characteristics	SSG details (types, classes)
Purpose	Decision making	Instruments for faster and better decision making
	Simulation	Face-to-face or simulation of real situations
		Subjective (military games, art games)
	Knowledge sharing	Edugames
		Informative games (news games)
	Influence to do	Persuasive games
	Data capture/exchange/exploration	Games based on data capture and exchange
Focus on research&innovation		
Adventure games		
Motivation	Badges and rewards points, included in work	
Training	Focus on analytical skills	
	Focus on technical skills	
	Focus on management skills	
	Focus on communication skills	
	Focus on team working skills	
Scope	Domain	Corporation
		Education
		State and government
		Health care
		Marketing
		Military
		Culture and arts
		Ecology and environment
		Politics
		Advertising
		Humanitarian
		Research

		General public
		Professionals
		Students
Game play	Type	Game-based
		Play-based
	Goal	Choice: Avoid, Match, Destroy
	Means	Choice: Create, Manage, Analyze, Solve, Move, Select, Write, Random
Smartness	Acquisition of real-world data of signals	Attach real-world input data to the smart games
	Processing of real-world data in real time, smart predictive analytics	Attach real-world business models and analytics to the smart games
	Adaptation and/or activation of real or virtual actuators	Attach adaptation and/or activation functions to the smart games

3. SMART GAMIFICATION

Smart gamification (SGM) is aimed at connecting smart systems, smart technologies, smart sensors, etc. Gamification features include: game mechanics, game design/methodology, game analytics, and graphical user interfaces.

Set of intellectual features that can be implemented consists of:

- *Collecting* (reading) of raw data or signals, or possibly locally processing the raw information [2];
- *Transfer* of raw and/or pre-processed sensor information;
- *Data processing* and detailed analysis of obtained information (smart analytics);
- *Transfer* of instructions;
- *Activation* of real and/or virtual actuators (software systems and tools).

The research, development, and wide acceptance of SGM and SG in society would show the way to the convergence of physical and virtual society. The results of the research community allowed to show the expected tendency of development in the field of SGM and SG.

Effective coupling of smart systems and smart technology with gaming techniques and serious games will be established on the addition of smart games characteristics, gaming and gamified applications.



Smart characteristics of SG and SGM - customization, feeling, learning, anticipation, self-organization will connect users with the environmental issues, different activities, and better solutions [2].

SGM and SG will be developed into "smart" instruments to help users in solving "serious" problems. This is because SGM and SG will actively use sophisticated virtualization techniques, computer technologies, advanced video games, as well as smart systems and technologies [10]. SGM and SG can help users to focus on real-world scenarios and situations, applying various methods to potential solutions, as well as changing/enhancing their behavior and skills [2].

SGM and SG analytics can help to interpret and process big data produced by computer information systems, to improve production, security monitoring and other systems. In addition, they will help them to make decisions based on data that minimize potential risks. It will also allow the presentation of relevant findings and outcomes in a simplified way. Users who are not experts in this field can optimize gaming techniques to increase their productivity, efficiency, motivation, behavior, etc.

SGM and SG will influence the development of smart tools that significantly increase customer engagement. Key components of smarter user engagement are: (a) research (curiosity, search, gathering, analyzing ...), (b) competition (challenges, winning, coaching, learning), (c) collaboration (teamwork, assistance), (d) expression (creativity, design), and (e) being smart (inference, foresight, self-organization..)

The active implementation and use of SGMs and SGs will enable significant benefits. Some of the benefits are: (a) improving the performance, productivity, (b) comfortable quality training and acquiring new skills and knowledge, (c) moving staff through smarter health initiatives, (d) insight into customers and business partners, (e) customer engagement as part of a long-term relationship to develop a strategy, and (f) innovation through the mutual insight of the Internet of Things (IoT) [2, 11].

SGM and SG will reinforce positive organizational psychology. They will strengthen and expand PERMA concepts including: (a) Positive emotions, (b) Engagement, (c) Relationships (pleasant interactions with other users), (d) Meaning (producing meaningful narration), and (e) Achievement of goals. SGM and SG will be firmly incorporated into new kinds of mobile, social and virtual systems and technical platforms.

4. SERIOUS GAMES AND MENTAL HEALTH

In this section, the prospective of gamification and serious games for mental health advancement will be presented. Serious games show a positive impact of internet technologies in mental health improving by employing three different processes. First process offering the online applications to users who otherwise would not have a chance to use them [12]. Second process is improvement of users' engagement during game based and "serious" motivation. Third, by using various mechanisms for changing behavior and various kinds of learning including therapeutic processes [12].

Having that in mind we can distinguish five different types of serious games in mental health improvement. There are, as following: *virtual and augmented reality, exergames, Cognitive behavior therapy, Cognitive training games, and Serious Motion-Based Exercise Games for Older Adults* [13]. It was shown that traditional approaches can be replaced with computer approach, and to avail characteristics of serious games for remedial purposes [12]. We can conclude that serious games show significant potential to improve mental health with advanced internet technologies [12].

Dimensions of serious games-goals, interaction, and involved technologies show tremendous variations. They encompasses many different types from fast-paced mini-games (e.g., simple as stacking dots in a row), through Applied Games for Mental Health to augmented reality (AR), and complex shared worlds. Quality serious games have been shown to improve concentration (3), improve information retention (4), facilitate deep learning (5), and lead to behavior change (6) [12].

Although the application of serious games in areas such as psychological and behavioral changes or symptom relief is still in its infancy stage there are indices that they can be useful. While barriers still exist, there has been a significant increase in adoption of smartphone applications for mental health.

It is first necessary to point out that applied gaming offers potential in mental health, as given the popularity of serious games suggests. Applied approaches might be able to help improve many of the mental health interventions for people who might not otherwise be able to access help. Games play an important role for person that suffer from mental health problems and still are not treated (gap in treatment of mental health).



Furthermore, applied gaming has attractive possibility. People experience serious games as funny, want to “win” the game, or see how the story unfolds. Such dynamics can influence to the reduction of high exhaustion rates in naturally conducted internet interventions.

Next, applied gaming has a capability for efficiency, because it has the opportunity for both traditional and non-traditional behavioral and learning that can be applied. For example, applied gaming can provide real experiences in which the “flow” state can be achieved, support sensory environments that could offer assistance for learning, provides behavioral models and social learning, enable users to try new abilities in a safe but reactive environment, and rehearsing to teach a new behavior.

Further escape motivation has also been reported (where a user needs to play to avoid real-world problems). A user may have high motivations for game playing, and the main motivations to play game may vary depending on demographic characteristics, contexts, and types of games [2].

We will explain now five main types of applied games, which can be found in the open literature [2]. It should be pointed out that they can provide opportunities by reaching large amount of people.

Virtual Reality (VR) and Augmented Reality (AR) are an interactive and immersive experiences in the virtual or augmented world, with visual, audio, and with sensory modalities to increase engagement of users and possibly therapeutic influence [2].

Exergames are sport games or games based on movements. There is a significant larger effect of playfulness in exergames for depressive symptoms GAMES FOR HEALTH, with it being more attractive among other playful games, over those that involving less game elements [14, 15].

Cognitive behavior therapy (cBt) is an efficacious treatment which uses serious games and gamification that often use an adorable environment, and designed at a rate of one level weekly on average on a computer. Each of these therapeutic programs was created for children or young people [14]. One example of those games is *SPARX SuperBetter* narrative, computer based serious game. Another example is *SuperBetter*, which offers another approach to gamification, with rewards & scoring joy serious games have impact on mood. Users playing a violent serious game reported reduced depressive symptoms immediately after the interference of the serious game *Bejeweled II* [12]. It is suggested to be employed in this visually spatial cognitive-behavioral activity when traumatic memories are activated to help preventing flashbacks [2].

Cognitive training games - It would be helpful to examine popular types of games for target audience and compare their important characteristics with those features used in mental health games. For example, high-access games presently involve mobile gaming on smart phones, numerous multiplayer serious games in which many players interact, games that allow user-generated media content, and games related to main social media platforms [2].

Popular among marketing and learning environments, gamification also pays attention to health care. Evidence suggests that gamification raises enjoyment, engagement and compliance of health related activities [16], while positively impacting both the cost of service provision and health outcomes. Its implementation has been enhanced by the development of smart platforms based on digital health, created around the ecosystem of wearable devices for fitness purpose (such as *Fibit*) or other sensing devices such as smartphones [17].

Gamification has great potential to add additional positive experiences to their primary health goals. Mentioned digital services can be called as Health Behaviour Change Support Systems (HBCSS), while their goal is to change the belief and behaviour of individuals towards well-being and a healthier lifestyle. Therefore, the main assumption of HBCSS gamification is that behaviour and attitudes of humans can have a positive influence through communication interventions [17]. These attitudes and behaviours need to have time to be maintained in order to offer concrete and positive health and well-being results. In this sense, the temporal dimension inside gamification is of utmost importance [17].

They aim, through artifacts, to induce behavioral change. The main areas of application of gamified HBCSS are the health promotion, physical activity, dietary guidance, as well as supporting the health practitioners within their education and daily activities [17].

Serious Motion-Based Exercise Games for Older Adults - Ambient Assisted Living (AAL) is a field to involve communication technology, sensors, actuators, into the real environment to improve safety and security, the everyday life, and independence in older adults in order to facilitate aging in homes. Examples of AAL technologies include sensors invisibly integrated into the system to detect falls, supportive prescribed medication, communication channels to members of family or medical nurses, and home service robots to support elderly care. However, their aim is to ensure that aging technology is aligned with the needs of older adults and, most importantly, in the motivation for use to adopt it [13].



The natural development of computer applications is moving towards mobile applications that can be used on a smartphone. Smartphone mental health applications can include many of the benefits, such as cost-effectiveness, plus they are always online, almost always with a person, and can collect data through their integrated sensors.

Last, but not least, serious games designed for their psychotherapeutic properties have been used for, among others, to treat depression, impulse-control disorders, schizophrenia, and anxiety disorders [18].

5. CONCLUSION

We presented in this paper the possibilities of gamification and multimedia serious games as relatively new fields with an emphasis in mental health which can help numerous users. This application could be potentially very applicable in the recent pandemic, such as COVID-19. This area is accessible for future improvement, taking into account various approaches. Future survey should compare options that are game based and non-based for different groups of users.

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REFERENCES

- [1] M. Favorskaya (et al.): "Advances in Smart, Multimedia and Computer Gaming Technologies", in "Fusion of smart, multimedia and computer gaming technologies", Springer, pp 1-6, 2015.
- [2] Sharma, M. Favorskaya, L. Jain, R. Howlett (eds.): "Fusion of smart, multimedia and computer gaming technologies", Springer, 2015.
- [3] S. Deterding, R. Khaled, L. Nacke, D. Dixon: "Gamification: toward a definition", in ACM Workshop CHI'11, Vancouver, Canada, 2011.
- [4] [mafiadoc.com]
- [5] Uskov, B. Sekar: "Serious games, gamification and game engines to support framework activities in engineering: case studies, analysis, classification and outcomes", in Conference on electronics/information technology EIT-2014, Milwaukee, WI, USA, pp. 618-623, 2014.
- [6] A. Jaume-i-Capo, A. Samčović: „Interactive multimedia system using serious game for users with motor disabilities”, Telfor Journal, Vol. 7, No. 2, pp 97-102, 2015.
- [7] A. Samčović: „Serious games in military applications”, Vojnotehnički glasnik, Volumen 66, broj 3, str. 597-613, Beograd, jul-septembar 2018.
- [8] D. Djaouti, J. Alvarez, JP Jessel: "Clasifying serious games: the G/P/S model", in P. Felicia (ed.), Handbook of research on improving learning and motivation through educational games: multidisciplinary approach, IGI Global, Hershey, 2011.
- [9] B.C. Lee: "The effect of gamification on psychological and behavioral outcomes: implications for cruise tourism destinations", Sustainability, Vol. 11(11), paper 3002, May 2019.
- [10] P. Boinalis, P. Fingar: "Serious games for business using gamification to fully engage customers, employees and partners", Meghan-Kiffer Pres, Florida, 2014.
- [11] D. Drajić: "Uvod u IoT (Internet of Things), Akademska misao, Univerzitet u Beogradu – Elektrotehnički fakultet, Beograd, 2017.
- [12] A. Uskov: "Gamification in computer science", IIMSS, 2013.
- [13] [games.jmir.org]
- [14] T.M. Fleming, et.al.: "Serious games and gamification for mental health: current status and promising directions", Frontiers in Psychiatry, Vol. 7(215), January 2017.
- [15] J. Li, Y.L. Theng, S. Foo: "Exergames for older adults with subthreshold depression: Does higher playfulness lead to better improvement in depression?", Games for Health Journal, Vol. 5, No. 3, pp 175-182, June 2016.
- [16] E. Duarte, P. Pereira, F. Rebelo: "A review of gamification for health-related contexts", International Conference of Design, User Experience, and Usability, June 2014.
- [17] S. Stepanović, T. Mettler: "Gamification applied for health promotion: does it really foster long-term engagement? A scoping review", 26th European Conference on Information Systems ECIS 2018, pp. 1-16, Portsmouth, UK, 2018.
- [18] P. Brauner, M. Ziefle: "Serious motion-based exercise games for older adults: evaluation of usability, performance, and pain mitigation", JMIR Serious Games, Volume 8, No. 2: e14182, 2020.



MOBILE APPLICATIONS IN EDUCATION

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Abstract:

The problem we tried to solve is based on an assessment of the current state of mobile applications, services and platforms applicable to the education process. The current state of these services is viewed from the domain of their technical solution (availability, support from multiple platforms, ...) and the domain of legal norms application governing distance learning. The problem of using mobile applications is reflected in the adaptability of these services to the educational process, as well as in the equipping of students with mobile devices where the teaching process can be monitored. The research has shown great availability of such services. In contrast to the availability of e-services, their implementation is far less than expected, which is especially underlined in primary and secondary education institutions, as well as in universities that are not in the field of technical sciences. Furthermore, institutions that have an eLearning system do not have adequate rules and legal norms that precisely regulate the learning and grading processes.

Keywords:

e-learning, e-testing, mobile devices, web platforms.

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INTRODUCTION

Modern information and communication technologies as well as their increasingly frequent application have become an integral part of everyday life and work of people. With the help of digital technologies, people communicate and connect with each other. Some examples of the most commonly used communication and social interaction services are email services and social networks [1]. Taking advantage of digitalization, the educational system around the world is increasingly relying on the use of new hardware and software solutions in the daily performance of teaching activities. Elementary and high school students, as well as college students, can now transfer their classrooms to computers and mobile devices. In this way, the availability of education is not conditioned by the proximity of educational institutions or the presence within the auditoriums. Course participants can attend classes even if they are in remote and inaccessible areas.



The development of the use of computer and mobile applications intended for education differs depending on the institutions and the region. Mobile technologies stand out as one of the most important technologies. Viewed from the angle of productivity and practicality in the use, mobile technologies represent one of the revolutionary tools. Applied to the educational system, mobile technologies allow students to use smart devices and mobile phones during classes to acquire new skills and learn new things. Different types of smartphones and other digital devices can be used as very useful scholastic resource both in the process of distance learning and in classroom university studies [2]. In the digital market, both in the form of free applications and in the form of applications for whose use users need to paid, a wide range of applications intended for use in education can be found. Viewed from the perspective of mobile learning, mobile devices must meet different forms of commercial use, language support, and support for different types of learning processes. Nowadays, a clear parallel between real and digital life is visible. Transferred to the learning process, the parallel is advertised in making contacts and communication with colleagues, online work on domestic and international projects, exchange of teaching materials, taking exams, etc. [3]. Using online and mobile platforms today, students anywhere in the world, no matter how far they are away from the professor, can follow classes in almost all fields, such as mathematics, physics, programming, foreign languages, etc. The use of distance learning systems must be accompanied by adequate information and communication equipment of course participants. Also, the successful implementation of distance learning is conditioned by the equipment of the institution, as well as a set of legal norms that regulate the distance learning process and especially assessment process. In most countries, primary and secondary education is insufficiently organized and not prepared for the distance learning process using mobile applications. This type of education is closer to higher education institutions. The aim of this paper is to consider the readiness of educational institutions of the Republic of Serbia in terms of the application of distance learning through the use of mobile platforms. The implemented platforms for distance learning of educational institutions of the Republic of Serbia have been compared with similar platforms of educational institutions in the world. The assessment process as one of the indispensable parts of education is especially demanding when it comes to the implementation of distance tests. This type of assessment must first be provided for by the legal acts of the education system. For this reason, the

paper considers the legal regulations of higher education institutions that have implemented systems for distance learning.

Paper is organized as follows. The first section presents similar research related to the topic. Second section presents some of the most popular distance learning and mobile learning platforms and applications that are in use worldwide. Third section presents platforms and applications that are in use in the Republic of Serbia. The main conclusions are given in the fourth section. The last section represents used references.

1. RELATED WORK

In one of the research the authors investigated the effects of mobile devices on the learning process. Their research is based on design approach [4]. This approach was chosen in order to support two main objectives. First objective was to support designing tools created for usage in learning process. The second objective is chosen to support conducting of pedagogical interventions. By meeting the set two basic objectives, the authors achieved a connection between researchers, professors and students. In order to prove their theory, authors implemented different mobile applications that were used as test applications. The created applications were adapted to both individual users and working groups. One of applications that were used for individual users was named ReFlex. From the other side, for the collaborative use TeamUp application was used. Design for the both applications is optimized for the use on the mobile devices (tablets, smartphones, etc.). In the same time, design provides use on some other devices such as laptop computers and smart whiteboards. Created and described applications were intended for use in teaching that is performed within the classrooms of the faculty. Besides teaching using these applications, students could work on projects individually or in groups.

Research conducted at the Spanish National University of Distance Education encompassed the current activities that include the use of mobile phones and applications created for the specific needs of subjects. The results of this research are given in [2]. The main goal of the conducted research was to assess didactic use of the applications. In the same time, authors tracked the potential of applications in order to improve the subject learning process at the university. The main goal was to develop the generic competencies based on European Higher Education Area. Evaluation process was conducted based on the predetermined scale.



In the conducted study 388 students participated. Students who participated in the research attended a course called “Curriculum design and innovation” within the “University Degree in Pedagogy” program. At the beginning of the research, the authors set out two basic directions of research. The first is through a descriptive methodology. This meant that the researcher had to describe in detail the creation process of the used application. The main actors of the second perspective were students. In this phase students’ perception and improvement in learning process were assessed. It was especially important to assess the progress in students’ knowledge conditioned by the use of mobile devices and applications. The results of the assessment showed that the impact of mobile devices and applications on student learning is highly valued. One of the main conclusions is that universities need to continue to develop new didactic strategies that will be used in order to provide better learning process.

The research described in [5] presents the results of a project in which students from two countries participated. The aim of the authors was to discover the perception of the use of smartphones in the process of education both by students and teachers. The student’s task was to create YouTube tutorials in which they described possibilities of using mobile devices in the learning process. The learning process was based on the use of applications available for mobile platforms. Based on all available information, authors explored the use of smart mobile devices in the classroom.

In the research presented in [6] authors explore different parameters that have an impact on the learning process. Based on explored group of parameters, authors proposed specific strategies which include the use of mobile technologies and applications in the everyday students activities. The main ideas from which the defined strategies emerged were based on literature research, comparisons with similar researches, as well as specific individual needs. The first of two main questions defined at the beginning of the research were whether technology can assist in the learning process. The second question that authors analyzed is focused more on the teaching process that is performed in classrooms as well as on the pedagogical aspect that is manifested in direct communication between teachers and students. As a result of the research, the authors singled out eight potential technical solutions and applications. Based on these applications the authors identified and defined four possible strategies: problem based learning, situated learning, collaborative learning, and cooperative learning.

Each of the defined strategies practically represents one type of learning style. Defined applications as well as examples of their use in the educational process were created in correlation with information and communication technology. Details of the use of each of the applications are described in detail and discussed within the ISO9241 part11 standard.

The research conducted and described in [7] aimed at a different approach. The main goal of the author was to explore the opinion of teachers about how much mobile technologies and applications have an impact on the learning process, especially if they are used as a teaching tool within the teaching process that is performed in classrooms. The teachers’ attitude is especially important precisely due to the fact that the attitude of teachers regarding the use of a teaching aid has a great influence on the teaching process. The research included 12 primary schools in Spain. From 12 selected schools, 102 teachers were selected. The selected teachers had the task to fill in the questionnaire with various questions starting from personal information, through expressing personal views on the use of mobile applications in the learning process. Based on the results obtained by processing the questionnaire, two main factors of the impact of mobile technologies on the learning process that is performed in the classroom were identified. The first factor is facilitating access to information, while the second is increasing engagement to learning. In addition to the mentioned results, the research showed that selection of application that will be used in the learning process also largely depends on the opinion of the professor on how and to what extent a specific application can affect learning.

In the research presented in [8] authors described the results of research related to implementation possibilities of technological applications in medical education. More precisely the goal of research was related to implementation and application of Technology Acceptance Model (TAM). In the same time, the research was supposed to show that this model can be applied in order to measure the degree of acceptance of the use of mobile technologies and applications within medical education. The research methodology was based on a created questionnaire, which was filled out by students and employees from University of Salamanca. The results of the research explained that 46.7% of users decide to use mobile allocations based on acquired habits. The authors concluded that this data can help them in adapting the curriculum of the medical faculty in order to introduce the use of mobile applications in the educational



process [8]. Another conclusion of the author is that the research showed that there are many unknowns about the use of mobile applications in medical subjects, both from the point of view of students and from the point of view of professors.

2. MOBILE APPS IN WORLD EDUCATION

The rapid development of human society, everyday human activities as well as applied technologies has conditioned the need for continuous learning. Because of that, a person today could not imagine the time when it was enough to know one skill in order to work for their whole life. In order to get a better job and thus achieve a better quality of life, people must constantly improve their knowledge. The use of digital technologies to provide support for distance and mobile learning creates the opportunity for students and professors to acquire and improve their knowledge and skills. These technologies make learning independent of location and time. Learning applications base their work on modern mobile technologies. Also, different approaches such as psychology and gamification make the learning process easier and more tempting. Precisely because of the different possibilities of application many schools and universities already use distance learning mobile applications to make learning more interesting. These applications can be used on various mobile devices like mobile phones, tablets, lap tops, etc. In some cases, such devices can be used as learning tool within the classroom during the classes, or for distance learning.

In order to reduce the pressure that the teaching process leaves both on students and professors and to make learning more appealing, a lots of different approaches and applications are developed. Beside the fact that learning process can be organized online through the use of online portals, students can use different mobile applications for mutual communication, as well as for communication with professors, taking notes, sharing files, etc. Whether it is applications used during in-class teaching or applications used for distance learning, applications facilitate the learning process. Practically, the benefit that mobile applications bring both to students and educational institutions is constantly increasing [9].

The popularity of educational applications is largely reflected in their mobility. Application mobility is important quite because people do not have much free time for additional training and learning. Because of that, in order to get additional knowledge, they turn to

using mobile applications instead of attending classes and sitting in front of a book [10]. With the use of mobile devices and educational applications, students can learn anytime and anywhere. Some of the main benefits for students that use mobile applications are numbered in continuation:

- Learning process is not dependent of place and time
- High levels of commitment
- Constant assessment process
- Learning strategies proven in practice
- Modern learning methodology
- Great learning experience gained thanks to the Internet and modern ICT technologies
- Monitoring student progress
- Social characteristics
- Everyday motivation

The use of information and communication technologies in educational institutions has led to the introduction of new frameworks, models of work, as well as ways of working, all in accordance with the modern needs of students and professors around the world. Applications whose purpose is to be used in the educational process, in addition to basic functionalities, also have the task of making the learning process more interactive, more committed, and more successful.

A large number of feasibility studies, as well as research have shown that the use of smart devices and mobile phones in the learning process is far closer to today's students compared to the traditional use of books. The results of such research are confirmed by the fact that today's students have encountered mobile phones and use them since the beginning of their childhood, which justifies the slogan of "education in your hands. Different mobile applications that can be found and downloaded from application stores can be classified into the following categories:

- Online tutorials and online schools
- Application for paying tuition fees electronically
- Attendance records applications
- Worksheet and workbook management applications
- Applications for telling stories to children
- ERP software for universities
- Online quizzes and tests



Learning applications and different learning platforms created to run on mobile devices have provided a way to expand educational courses. The education process is currently available to all age groups of people, starting from children to retirees. Different groups of people access different online courses. In doing so, they all have the same goal, and that is to learn new technologies like robotics, artificial intelligence, computer vision, etc. In most of the cases these courses are free of charge, and are organized by some of the best universities in the world. With the use of mobile learning applications as well as distance learning platforms, the availability of top courses has increased not only in the education system but also within the industry. For example, many companies allow their employees to follow the courses of different universities in order to improve their knowledge and thus acquire the necessary knowledge in the field [11]. The basis of the use of mobile technologies in education is reflected in the collaboration of students and professors with each other, both within the classroom and outside it. It is possible to find a large number of applications on the market that store student activities and monitor the performance of their learning. Such applications can be accessed from multiple devices and from anywhere. Some of the applications that can be used for this purpose are TeacherKit and Attendance application. Some of the tracked performances are attendance, grade records, performance assessment, etc. At the same time, the applications have functionalities such as informing parents about their children's progress, achieved test results, possible problems as well as grades [11].

One of the applications that allow students to watch video lessons from their home is Flipped Classroom. This application is widely accepted by students and professors around the world. Practically, students from home follow the lectures in the form of video lessons that the professors were previously recorded. In this way the time spent in classroom can be used for discussion, questions and possible additional research [11]. This way of working enables students to study in a pleasant environment of their home, which causes the improvement of the achieved results. Viewed from the angle of students who have problems with learning disabilities, the use of such applications can help them overcome disabilities and gain better knowledge. Finding the right educational application is a very easy task, given that in 2020 there are over 500,000 applications. The large number of available applications indicates their popularity. On the other hand, from the users' point of view, it is necessary to find a suitable application from a wide range of ones.

In the field of education technology, the main goal of most of the applications created to work on mobile devices is to improve educational experience of both the student and the professors. If we search for services like the App Store and Google Play Store, we can see that tens of thousands of applications intended for education can be found on them. Available applications cover a wide variety of areas from learning different skills, languages, math, programming, etc. [12]. Some of the most innovative and used applications for students, teachers and parents are described in continuation.

If the quality of the application is assessed based on the number of users who downloaded and used the application, the reminder application in the United States holds the leading position with the highest number of downloads during 2018. The Remind application is practically an online communication platform that enables students to successfully complete the set tasks through the exchange of messages during and after the class. By using this application, students can send individual or group messages in more than 85 languages, can exchange files, images, documents, etc. The popularity of this application is evidenced by the fact that it is used in more than 95% of public schools in the United States, which represents a total of 27 million users, both students and teachers and parents. The second most downloaded application in the United States from the group of educational applications is known as Photomath. This app has approximately 10 million downloads. The main purpose of this application is to help students master the material in mathematics. Practically this application represents some kind of camera calculator. The main purpose of Photomath application is to identify mathematical problems based on camera created photo. When the problem is identified, the application shows all steps in solving the problem on the mobile device screen. Scientific calculator is an integral part of the application. By using this application, students master the material of mathematics much easier, and simply come to the solution of mathematical problems practically through the game. Photomath application is available in over 30 languages.

When we talk about learning a language using an application, one application stands out. It is an application called Duolingo. Duolingo is an application that enables learning of over 30 most popular languages. Its download is completely free. The users of this application are offered a quality work environment, as well as the ability to monitor learning progress.



Another application that offers distance learning capabilities using video streaming is Zoom. This is practically an application that can be used for any type of video conferencing. The number of simultaneous users is not limited, so that a large number of students can follow the lectures of professors at a given time. In addition to video streaming, teachers can use this application to share files, lesson plans, and additional materials and exchange text messages with individual users or with a group of users.

Edmodo represents learning applications that is which is intended to students, professors, and different educational organizations. Through the use of Edmodo application user can exchange messages, course materials, create and solve quizzes and tests. One of the benefits of the Edmodo application is the creation and use of accounts for parents. Such accounts allow parents to monitor their children's activities, homework assignments, grades, as well as exchanged messages with teachers.

A large number of educational institutions around the world provide their students with the opportunity to follow classes using online platforms. The created online platforms are adapted for use on different types of devices, as well as on different operating systems. The courses available on the raised platforms contain both learning materials and interactive quizzes and tests to test knowledge. Depending on the level of the educational institution, the platforms may be owned by them or the courses are offered within a portal that combines different courses from different educational institutions. One of such portals is Coursera. Coursera portal as a portal whose main purpose is to enable distance learning has cooperation with more than 200 leading universities and companies. Content from almost all scientific fields can be found on this portal. The courses available on this portal are created by eminent experts and professors for the given field. The materials available within these courses are also used by their creators in the daily teaching process within the classrooms of the faculties where they work. The quality of the material is evidenced by the fact that each course is signed both by the professor and by the university where it is initially conducted. Coursera offers about 3900 courses and specializations intended for different levels of study. For a large number of courses, participants are given the opportunity to check their knowledge through a series of tests and quizzes after completing the course, and for the same they receive a certificate of successful completion of the course.

The symbiosis of universities and online learning platforms shows how much the availability of knowledge via mobile devices has developed around the world. There are practically no restrictions on the availability of knowledge in this way. Another example is Udacity. This university is one of a group of universities that have their own online learning platform. On their platform you can find a large number of courses that belong to different areas.

3. DISTANCE EDUCATION IN REPUBLIC OF SERBIA

Various courses available within the online platforms offer the opportunity to the Serbian citizens to improve their knowledge and skills. By searching the courses, it can be seen that there are a small number of available courses in the Serbian language. Available courses are offered for a certain fee, and last for a certain period of time. The fee includes access to the course materials as well as the final exam based on the outcome of which it is possible to obtain a certificate of completion of the course. Of course, the fact that foreign language courses are available on world-famous portals such as Coursera cannot be ignored. In this way, the citizens of the Republic of Serbia can follow the same courses as the participants abroad, and receive certificates of successful completion.

Distance learning within the school education system using online platforms and mobile applications in the Republic of Serbia is regulated through two basic legal documents. The first document is the Strategy for the Development of Education in the Republic of Serbia until 2020¹. This strategy deals with determining the purpose, goals, directions, instruments and mechanisms of development of the education system in the Republic of Serbia over a period of ten years, in other words, it deals with the attempt to shape the development of this system in the best known way. The strategy defines the development trends of both primary and secondary education and higher education. It is possible to analyze the visible effects of this strategy on the expiration of the mentioned period. The strategy defines basic norms of distance learning as well as its implementation both at the level of primary and secondary education and at the level of higher education.

1 Strategy for the Development of Education in the Republic of Serbia until 2020, Retrieved 15.05.2020. from: <http://www.mpn.gov.rs/wp-content/uploads/2015/08/STRATEGIJA-OBRAZOVANJA.pdf>



However, the number of educational institutions that conduct distance learning using mobile technologies is far less than the total number of institutions that conduct traditional forms of education. Observed from the angle of equipping institutions with information and communication hardware and software equipment, it can be noticed that still institutions, especially primary and secondary schools, are not equipped with sufficient quality for this type of teaching.

Another legal document on which the development of education is based is the Law on Higher Education². According to the Law on Higher Education, distance learning is allowed in Serbia. Article 43 defines that any higher education institution may conduct a distance learning program, in accordance with the work permit. This practically means that every higher education institution that has a license to conduct distance learning had to previously met all the conditions for quality teaching in this way. The conditions that need to be met are defined within the accreditation standards. Article 96 of the Law on Higher Education defines that closer conditions and ways of realizing a distance learning program are regulated by a general act of a higher education institution.

Serbian legislation does not recognize any other way of taking pre-examination and examination obligations, except for the physical presence of the student in the institution itself and in no other way. The vast majority of higher education institutions that educate students at a distance still do not allow online taking of colloquia and exams. With this, schools distanced themselves from possible cheating on exams, and students from the ridicule of the environment that "Google" passed all their exams.

The preparation of colloquium and final exams is held exclusively in the premises of the School and there is no difference in their organization for distance students and students of classical studies. The student of distance studies is then obliged to be physically present at the School and to take the exam in person.

The manner of conducting the exam is defined in Article 105 of the Law on Higher Education. Paragraph two of this article defines that the exam is taken at the seat of the higher education institution, i.e. in the facilities specified in the work permit. The provision of paragraph 2 of Article 105 also refers to conducting a distance learning program, with the proviso that for a foreign student, a higher education institution may enable exams via electronic communications, provided that the application of appropriate technical solutions ensures control of student identification and work.

² Law on Higher Education, "Official Gazette of RS no. 88/2017, 73/2018, 27/2018 - other. law, 67/2019 and 6/2020 - other. laws"

Paragraph 10 of Article 105 defines that the detailed conditions and manner of taking the exam via electronic communications referred to in paragraph 3 of this Article shall be regulated by the standard for accreditation of distance learning programs.

The secondary education system does not offer the possibility of distance learning, so there are no applications available with learning materials. Distance learning failed the exam during the Covid 19 pandemic. It was especially noticeable in the area south of the Sava and the Danube. Practically, teachers in primary and secondary schools are left without any preparation to just figure out how to organize classes. The most common form of teaching was via Viber groups, in which the influence of the school was almost non-existent. Practically, the teachers themselves found a way to work with students, which may not have been ideal, but it was almost the only viable solution. The observed problems were reflected in the unavailability of a quality internet connection, although the education development strategy defined the introduction of broadband internet in all households by 2020. As far as hardware resources are concerned, the largest percentage of students followed the classes on mobile phones through the Viber application. Students and teachers of equipped schools most often decided to use zoom applications in order to perform better.

Of the total number of accredited both state and private universities and vocational colleges, very few have accredited distance learning study programs. The Faculty of Organizational Sciences in Belgrade is in the lead in terms of distance learning. In addition to it, in the Republic of Serbia there is another number of state faculties that offer their students the availability of materials through various e-platforms. Precisely such platforms were used for material exchanges during the pandemic. Faculties such as the Faculty of Electronics in Nis (more precisely, the study program Computer Science and Informatics at this faculty) have decided to use Microsoft Teams tools. Regarding higher vocational schools, officially four higher vocational schools in the Republic of Serbia have accredited distance learning. High vocational schools that have moodle platforms can also be singled out as a supplement to the traditional way of learning. The organization of studies in higher vocational schools that are not equipped with the necessary equipment for distance learning during the covid 19 pandemic was reduced to communication between teachers and students via email, viber groups, zoom applications, etc. A number of private universities have accredited distance learning study programs. It can be said that private universities saw distance learning as a



chance to attract students. Some of them, in addition to the learning process itself, also perform knowledge test using online platforms. One of the universities where the process of teaching and testing students has reached a notable level is Singidunum University. Working with students and their testing process is accompanied by strictly introduced criteria that allow precise information on whether the student has independently created the tests. The parameters that are monitored during the tests refer to the duration of the test, the number of exits from the window in which the test platform is started, the student's focus on the window in which the test is performed (monitoring via camera). Similar parameters are monitored with Microsoft teams tools. The testing process refers to the preparation of tests that belong to the pre-examination obligations, while the exam in accordance with the Law on Higher Education is performed on the premises of the institution.

4. CONCLUSION

The use of information and communication technologies in the field of education has enabled and facilitated the availability of knowledge to a much larger number of people than is the case with traditional forms of education. The principles of distance learning, as well as the advantages of mobile applications intended for the education process, were especially evident during the pandemic of covid 19. In the Republic of Serbia, in the countries of the region and the world, distance learning was on a test during the previous months. Research has shown that the degree of success of this type of teaching as well as individual training through online materials available on different platforms depends on the technical equipment of teachers (schools and universities) and the technical equipment of course participants. Equipping primary and secondary schools with the information and communication equipment necessary for conducting this type of teaching, as well as the training of teaching staff in the Republic of Serbia, is still not at a satisfactory level. As far as universities are concerned, their equipment and approach to this problem are far better. Monitoring the development and progress in the use of mobile platforms in the educational process as well as opportunities for their improvement is one of the main goals of future research.

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REFERENCES

- [1] K. Beck, and C. Andres, "Extreme programming explained: embrace change," Addison-Wesley, Boston, 2012.
- [2] V. C. Esteban, "Mobile distance learning with smartphones and apps in higher education," *Educational Sciences: Theory & Practice*, vol. 14, no.4, pp. 1505-1520, 2014.
- [3] C. Norris, A. Hossain, and E. Soloway, "Using smartphones as essential tools for learning: A call to place schools on the right side of the 21st century". *Educational Technology*, vol. 51, no. 3, pp. 18-25, 2011.
- [4] L. Teemu, K. Anna, V. Marjaana and T. Tarmo, "Mobile apps for reflection in learning: A design research in K-12 education," *British Journal of Educational Technology*, vol. 47, no. 1, pp. 184-202, 2016.
- [5] C. Kara and M. Amanda, "Smartphone apps in education: Students create videos to teach smartphone use as tool for learning," *Journal of Media Literacy Education*, vol. 8, no. 2, pp. 99-109, 2016.
- [6] D. Athanasios and A. Pantelis, "Mobile applications within education: an overview of application paradigms in specific categories," *International Journal of Interactive Mobile Technologies*, vol. 11, no. 4, pp. 17-29, 2017.
- [7] G. D. Marta and B. G. Antoni, "Exploring the use of educational technology in primary education: Teachers' perception of mobile technology learning impacts and applications' use in the classroom," *Computers in Human Behavior*, vol. 56, pp. 21-28, 2016.
- [8] B. P. Laura and J.G.P Francisco, "An empirical assessment of a technology acceptance model for apps in medical education," *Journal of Medical Systems*, vol. 39, no. 176, 2015.
- [9] S. Pares, "Mobile apps in the education industry: A productive approach," *Educational Technology*, 2019.
- [10] C. Sveta, "M-Learning: Types of Educational Apps and Development Tips," *Mobindustry*, Retrieved 25.05.2020. from: <https://www.mobindustry.net/m-learning-types-of-educational-apps-and-development-tips/>
- [11] Anurag, "Make Learning FUN: 5 Impacts of Mobile Apps on Education," *Mobile Applications, mobile apps, technology in education*, Retrieved 15.04.2020. from: <https://www.newgenapps.com/blog/mobile-applications-are-revolutionizing-the-education-landscape/>
- [12] Best Apps for Schools 2020: For Teachers and Students, Retrieved 10.06.2020. from: <https://www.educationalappstore.com/app-lists/best-apps-for-schools>



MODERN APPROACH TO PROJECT MANAGEMENT, USAGE, AND SUCCESS RATE OF AGILE METHODOLOGIES: AN EVIDENCE FROM SERBIA

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Abstract:

The global trend of using “Agile” tools and techniques within organizations and implementing them on everyday projects is evident in the past decade, especially in the information technology and software engineering industries, where constant change of requirements and directions are quite common and mostly appreciated. Prior research showcased that the success rates of projects implementing “Agile” are generally higher and that the damage done from canceled or failed engagements are far less than on traditionally run projects. Many of the authors suggested that more value has been provided to the customers by using iterative approach and by utilizing “scrum” multi-disciplinary teams, which also include team members from the client side. The main purpose of this paper is to showcase the adoption level of modern project management methodologies and their perceived importance in Serbia, by conducting research among its users, managers, and IT experts from the country. This paper contributes to the topic by providing real industry insights and opinions by professionals using modern project management tools and techniques in their workplace.

Keywords:

Agile Adoption; Project Management, Agile transformations.

1. INTRODUCTION

In the last two decades, the practice of project management has evolved to the new heights, changing the way companies and organizations plan and execute projects. Ever since the creation of Agile manifesto in 2001. [1], the benefits of more flexible and incremental approach to project management and project delivery were obvious. Today, almost twenty years after the formal inception of “Agile Manifesto” document, many organizations have already implemented a big subset of agile methodologies and tools on their projects and programs, empowering their employees and customers to achieve greater value and satisfaction on both ends. As previous research has shown, this trend is also helping many organizations in becoming more productive and efficient, especially when working on high demanding endeavors or overly complex programs [2].

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Project management is mostly defined as the application of knowledge, skills, tools and techniques to project activities to meet the project requirements [3], but it has evolved in recent years and now includes other activities or shares similarities with other fields, creating a wider bound by sharing and using methodologies with recurring nature of the process management [4]. Recent research shows that number of projects included in bigger corporate strategies is constantly increasing, composing multi-project efforts divided only by deliverables and grouped in big “programs” or in some cases “portfolios”, which makes them extremely complex and hard to manage, even with the usage of “Big Data” tools and techniques [5]. Given this fact, it should be clear that the main goal of modern project management is development and delivery of value to the clients in a proactive way that improves guidelines of the PMBOK and the “Cruise-control” paradigm [6].

The “Agile Manifesto” adheres to previously mentioned goals of modern project management by providing simple values drawn by the leading industry experts of that time and adjusting them for the current industry needs and requirements.

Because of this premise, the starting point of this research was to find previously published scientific papers on the topic of adoption levels and success rates of Agile project management methodologies and then compare their results and findings with our research in the case of Serbia. The main hypothesis from authors of this paper was that the adoption level of modern project management methodologies and techniques in Serbia are on par with other countries, with similar usage and success rates.

2. LITERATURE REVIEW

Many surveys have been conducted in previous years on the topic of project success and usage of modern methodologies and techniques on projects in multiple industries. One of the most quoted research was performed by Standish Group, an internationally acclaimed IT research and consulting company, which created the infamous “Chaos Report” in 1994 and showcased the troubling state that the IT project management industry was in. Stating that only 16% of the projects involved in the study was successful, they created a staggering amount of 189% software cost overruns [7]. The report also presented a new methodology for establishing the standard for measuring project success by defining terms such as on time, on budget and on target as

the primary attributes. In the years that followed, The Standish group continued to monitor and report on the state of the project management in the IT industry, publishing several new “Chaos Reports”, and one of the latest reports of this kind has been adopted as a standard for the future research on this topic. The 2015 “Chaos Report” included a new set of attributes for measuring project success including on time, on budget, on target, on goal, value, and satisfaction as the primary attributes [8]. Their report included results for FY2011-FY2015, based on the data from more than 10.000 software projects and showed that only 36% of the projects were successful in the year 2015, 45% of them were challenged and 19% failed. On average for those years, only 44% of the project were on budget, 40% on time and 56% on target. Also, using the new methodology attributes and adding the 59% of the projects were valuable, 62% on goal and 56% satisfactory.

	2011	2012	2013	2014	2015
SUCCESSFUL	29%	27%	31%	28%	29%
CHALLENGED	49%	56%	50%	55%	52%
FAILED	22%	17%	19%	17%	19%

Table 1. Modern resolution for all project (On time, on budget and satisfactory result) Source: (Standish Group International, 2015)

The Standing Group “Chaos Report” also noted that project size is a single most important factor for the outcome of the project, reporting that only 6% of the “Grand” projects are being successful and, on the opposite, the 61% of “Small” ones are being successful [8]. In addition, many recent studies identified similar attributes contributing to project failure, including bad requirement engineering as one of the primary causes [9].

In the similar manner, one important research suggested that the Agile methodologies are widely used in the project management and that the project success is related to the extent this modern approach is being used [10]. Furthermore, one of the most interesting finding of this research is the fact that there was no correlation between “seasoned” staff and project success, showing that Agile is a powerful tool even for inexperienced teams [10]. Also, the most recurring theme in the surveys conducted on this topic was that the Agile methodologies contribute to innovation, flexibility and value orientation of the traditional business more than ever before, giving them comparable advantage over the organizations that are not yet implementing this methodology on



their projects [11]. Combining these approaches, by using modern software applications and project management tools, it has never been easier to plan and execute projects and then measure the success rate and progress within organizations [12].

Furthermore, many studies in this field tried to define the critical success factors for agile projects but with different results and conclusions. For example, one study showed that “correct delivery strategy”, “proper practice of agile software engineering techniques” and “high-caliber team” could only be called critical [13], and the other showed no relation between them and success, only to confirm that “strong executive support” and “project type” had no influence either, as described in previous research [14]. The second study performed by D. Stankovic (2013) was conducted in the similar region as the research presented in this document and represents the early attempts to quantify usage of modern project management tools and techniques and their success rate in the SEE region [14].

In addition, there are studies showcasing the implementations of “Agile” paradigm in digital transformation projects done in Finland, highlighting productivity, quality, and responsiveness as main motivators for their endeavors [2]. This concludes that for most of the research conducted on this topic, the Standish Group findings and reports are the baseline for comparisons and metrics with other data gathered from different sources.

3. PROJECT MANAGEMENT METHODOLOGIES

Modern project management methodologies compound of many different ideas, techniques and tools bound together for the same purpose of tackling obstacles that emerged in the last three decades. Many renowned institutions presented their solutions and frameworks, including the Project Management Institute with the PMBOK guide and the United Kingdom Government with the PRINCE 2 method. At the same time, many experts from the IT industry became heavily involved in complex software development projects which failed in large numbers [8], creating the large gap between the traditional pre-planned project management paradigm and the IT industry specific problem of constant scope change and technology debt. Because of this, many embraced the more simplified model of project management, based on feature request from the users, quality requirements and technology advancement.

That ensured the emergence of popular methods such as SCRUM and Extreme Programming in the mid 90’s, even before the “Agile” manifesto was created. Therefore, for the purpose of this document, some of the most popular frameworks and methods were used in our questionnaire, including PMBOK, PRINCE 2, SCRUM, XP, KANBAN and AGILE for the group category.

4. METHODOLOGY AND RESEARCH SAMPLE

Using the survey methodology [25], author conducted a research on the application of project management methodologies and their success rate in the year 2019. The online survey was conducted in Serbia within the IT professional’s community and engaged 53 participants who were selected based on subjective sampling, students, freelancers and full-time employees that had contact with or worked on projects in last five years (98.1%) were included. Among the survey participants, 96.23% confirmed that they permanently live in Serbia, and only 3.77% answered that they live elsewhere. Most of the respondents are employed full time (64.15%), but the rising trend in freelance and part time employment among younger working population is evident, declaring their status in our survey by 15.09% and 11.32% respectively. The rest of our participants replied either that they are students (5.66%) or unemployed (3.77%).

Majority of the respondents are professional workers in areas of software engineering (30.19%), project management (22.64%) and consultancy (18.87%), while others (20.75%) choose different occupations not mentioned in the survey. Only the small number of the respondents selected “product owner” (7.55%) as their occupation, showing that most of the project work is done for other clients, organizations, or governments.

5. FINDINGS AND DISCUSSION

Within the conducted survey 8 questions were presented to the participants, of which some were the control questions with the scope to determine the demographics of the participants. The results presented in this document are directly correlated to the research topic of usage of the modern project management methodologies in Serbia and their success rate. In the survey, the following questions were asked:

- ◆ Do you reside in the Republic of Serbia?
- ◆ Are you employed?
- ◆ Are you working in any of the following positions?
- ◆ Have you been part of a project in the last 5 years?



- ◆ Do your projects use any of the following methodologies?
- ◆ What is the success rate of the projects you worked on?
- ◆ Do you think that agile techniques and methodologies have helped you to increase success, raise product quality and customer satisfaction?
- ◆ On what kind of projects did you mostly work?

As indicated by the participants, modern project management methods and techniques are immensely popular in Serbia, choosing Agile and Scrum (47.2%), Kanban (28.3%) and XP (15.1%) respectfully. Furthermore, one third of our respondents choose Waterfall (32.1%) traditional approach and only small number of participants responded that they use complex methodologies on their projects, PMBOK (9.4%) and PRINCE2(5.7%) (Fig 1.).

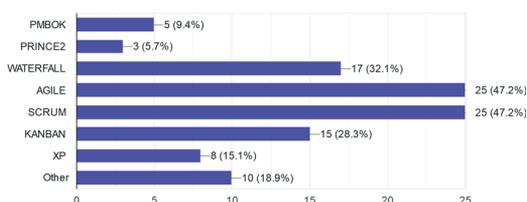


Fig 1. Survey responses on using methodologies and techniques on their projects (Source: Author)

The responders of this survey mostly selected IT related fields by answering that they work on the Web Application development (32.08%), Business software development (26.42%), Information Systems implementations (20.75%), Game Development (9.43%) and on other projects (11.32%) (Fig 2).

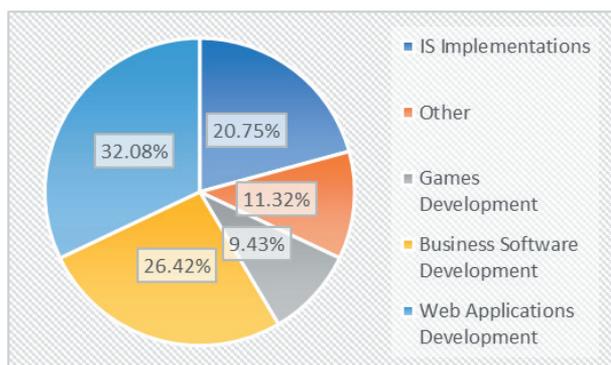


Fig 2. The project types where the survey responders were involved in (Source: Author)

The survey participants were asked about the success rate of the projects that they participated on. Majority of them (58.10%) and (35.20%) responded with 100% and 75% success rate respectively, with only small portion of them (6.70%) responded that their projects have 50% success rate (Fig 3.).



Fig 3. The project success rates (Source: Author)

This is aligned with the worldwide trends in project management [9], and also very similar with the results of the latest revised version of the “Chaos Report”, showing improvement and higher success rates from the previous report presented in the 90s, and with new attributes taken into account, defining success by “on budget”, “on time” and “on target” [8]. As mentioned before, this paper uses “Chaos” reports from Standish group as a baseline for comparisons and analysis.

Most of the participants in this survey (80.39%) agree that agile techniques and methodologies helped them reach higher success rates, better quality, and client satisfaction and only a small number of the participants (19.61%) disagree with that statement (Fig 4.). This result continues to show improvement in usage of modern project management tools and techniques, and it is a clear indicator of the value it brings into the industry. Other studies show successful implementation on larger scale and on enterprise levels, including using Agile methodologies in digital transformation of large organizations [2].

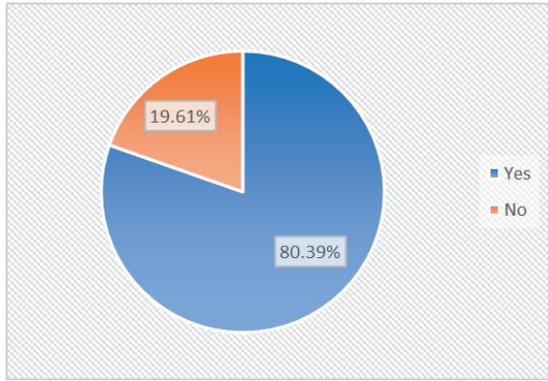


Fig 4. Do Agile tools and techniques help achieve higher success rates, quality, and customer satisfaction?
(Source: Author)

Furthermore, the “Annual State of Agile Report” 14th edition, with over 40,000 survey participants responding during the previous years and conducted among many executives, practitioner and consultants, showcased similar trends mentioned in this paper, finding that the most used agile framework is Scrum (75%) in general, and SAFE for SCRUM at scale (35%) [26]. Also, the report highlighted organization culture as the biggest challenge with resistance to change, inadequate management support and sponsorship ranked at odds with Agile values. [26]

6. CONCLUSION

From the more traditional approach to project management by sequentially creating, planning, and executing tasks, to more iterative and agile way of doing things, the practice has greatly evolved in the past thirty years, changing the way people organize their work, create requirements, plan budgets and prioritize tasks. Many companies have started employing proven “Agile” methods and tools within their organizations, transforming company cultures, business processes, and operational models. Previous studies have shown that the primary goals for most business organizations are to be more resilient, lower production costs, and reduce project failure rates to a minimum. Furthermore, by comparing previously published reports from Standish Group and VersionOne / Digital.ai, it is evident that there is big progress in all previously mentioned areas, especially in the software development and information technology industries. The main hypothesis of this paper was based on those results, and with the premise from the authors that the adoption level, usage, and success rate of modern project management methodologies in

Serbia are on the same or similar levels to those showcased in the previous reports. The authors have shown that there is a solid basis for such hypothesis by showcasing the survey research data and by comparing the results with similar studies done on the same topic. With over half of the respondents selecting some type of “modern” project management methodology, authors concluded that the global trend of “Agile” is also well established in Serbia, especially among professionals in IT and other tech industries. Methods such as “Scrum”, “Kanban” and “XP” are well represented in the sampling data with “Agile” as a main group selected by the survey respondents. Furthermore, the second biggest group of the survey respondents selected more traditional and standardized approaches to project management by employing “Waterfall”, “PMBOK” and “PRINCE2” on their projects, showcasing that there is still space for robust and highly detailed frameworks. The authors also concluded that most of the survey respondents are using some form of standardized or well-known project management methodology or technique, with only a small percent of them not using any special method, tool, or technique on their projects. Most of the survey participants acknowledged that “Agile” helped them become more successful, with over two-thirds of them reporting remarkably high project success rates.

This research presents new insights into project management trends in Serbia, based on the responses and opinions of the survey participants included in the study. Furthermore, this paper contributes to the topic by uncovering the value and impact of using Agile methodologies on digital transformation and software development projects, thus explaining its high popularity among engineering and project management professionals. As shown in this paper, there is still significant work to be done in regard to successful project delivery with a still relatively high percentage of failed or partially delivered projects.

In this paper and with the conducted research, the authors agree that the survey data is a preliminary one and that future research is needed to better understand the correlation between adoption levels, usage of modern project management methodologies, digital maturity, and highly specialized teams on project success rates. Furthermore, there is space and need for deeper insights and scientifically proven evidence for the hypothesis proposed by this research.

Finally, further research will continue to provide insights on project management evolution as a whole and the popularity of modern approaches to 21st-century challenges.



REFERENCES

- [1] K. Beck, M. Beedle, A. Van Bennekum, A. Cockburn, W. Cunningham, M. Fowler, J. Grenning, J. Highsmith, A. Hunt and R. Jeffries, "Manifesto for agile software development.," 2001.
- [2] P. Kettunen, M. Laanti, F. Fagerholm, T. Mikkonen and T. Mannisto, "Finnish enterprise agile transformations: a survey study," International Conference on Agile Software Development, pp. 97--104, 2019.
- [3] Project Management Institute, A guide to the project management body of knowledge (PMBOK guide), 2013.
- [4] W. Chmielarz and M. Zborowski, "Determinants of using project management in the implementation of information systems," Procedia Computer Science, vol. 126, no. 1, pp. 1224-1236., 2018.
- [5] J. Whyte, A. Stasis and C. Lindkvist, "Managing change in the delivery of complex projects: Configuration management, asset information and 'big data'," International Journal of Project Management, 34(2), vol. 34, no. 2, pp. 339-351, 2016.
- [6] P. Morris, "Reconstructing project management re-visited: A knowledge perspective," Project Management Journal, vol. 44, no. 5, pp. 6-23, 2013.
- [7] M. Jorgensen and K. Molokken-Ostfold,, "How large are software cost overruns? A review of the 1994 CHAOS report," Information and Software Technology, vol. 48, no. 4, pp. 297-301, 2006.
- [8] Standish Group International, "The chaos report," United States of America, 2015.
- [9] A. Hussain and E. O. Mkpojiogu, "Requirements: Towards an understanding on why software projects fail," in AIP Conference Proceedings, 2016.
- [10] S. Pedro and K. Jeffrey, "Does Agile work?—A quantitative analysis of agile project success," International Journal of Project Management, vol. 33, no. 5, pp. 1040-1051, 2015.
- [11] VersionOne, CollabNet, "13th annual state of agile report," 2018.
- [12] R. E. Levitt, "Towards project management 2.0," Engineering project organization journal, vol. 1, no. 3, pp. 197-210, 2011.
- [13] T. Chow and D.-B. Cao, "A survey study of critical success factors in agile software projects," The Journal of Systems and Software, vol. 81, no. 6, p. 961–971, 2008.
- [14] D. Stankovic, V. Nikolic, M. Djordjevic and D.-B. Cao, "A survey study of critical success factors in agile software projects in former Yugoslavia IT companies," The Journal of Systems and Software, vol. 86, no. 6, pp. 1663-1678, 2013.
- [15] D. Hinde, "PRINCE2 Study Guide: 2017 Update," John Wiley & Sons, 2018.
- [16] Great Britain. Office of Government Commerce, Managing successful projects with PRINCE2, London: The Stationery Office, 2002.
- [17] C. Bentley, Prince2: a practical handbook, Routledge, 2010.
- [18] Agile Alliance, "Extreme Programing Glossary," 10 July 2020. [Online]. Available: <https://www.agilealliance.org/glossary>. [Accessed 10 July 2020].
- [19] Don Wells, "When should Extreme Programming be Used," 1999. [Online]. Available: <http://www.extremeprogramming.org/when.html>. [Accessed 10 July 2020].
- [20] W. W. Royce, "Managing the development of large software systems: concepts and techniques," in Proceedings of the 9th international conference on Software Engineering, 1987.
- [21] "SDLC Waterfall Model" Tutorials Point," Tutorials Point, 2020. [Online]. [Accessed July 2020].
- [22] K. Schwaber and J. Sutherland, "The scrum guide—the definitive guide to scrum: The rules of the game," SCRUM. org, Jul-2013, 2013.
- [23] Scrum.org, "What is Scrum?," 2020. [Online]. Available: <https://www.scrum.org/resources/what-is-scrum>. [Accessed July 2020].
- [24] D. J. Anderson, Kanban: successful evolutionary change for your technology business, Blue Hole Press, 2010.
- [25] M. Radovic-Markovic and B. Alecchi, Qualitative methods in economics, Taylor & Francis, 2016.
- [26] Digital.ai, "14th annual state of agile report," 2019.



MODERN DATABASE ON HUMAN AND MATERIAL AND TECHNICAL RESOURCES IN EMERGENCY MANAGEMENT SYSTEMS

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Abstract:

Emergencies caused by natural or man-made disasters have been occurring more in the last decade. The consequences of earthquakes, floods, fires are more catastrophic than before. People, material and cultural goods are suffering. Efficiency and effectiveness are the primary goals when it comes to responding to emergencies. In order to provide an adequate response as soon as possible, it is necessary that the responsible institutions have the necessary information on human and material-technical resources that can be available in the endangered territory. However, in this part usually, problems arise. Specifically, a lack of information on available resources has proven to be a barrier to providing the required level of response. However, the use of modern software solutions and databases can greatly help to eliminate these barriers. Time restrictions may be a key factor when responding to emergencies. Often, decision-makers are constrained in this regard and must make a response plan for a limited period of time. The ability to use a modern database on human and material-technical resources in emergency management systems provides a large number of possibilities in order to better respond to emergencies.

Keywords:

database, human and material-technical resources, emergency situations and management.

1. INTRODUCTION

Databases are widely used in various fields. In addition, different definitions of the term database can be found in theory. A database is simply a collection of organized information, usually as a set of related lists of similar entries. The data is often organized in order to be easily accessible. Large databases are used all around the world in the police (criminal records – Department of motor vehicles - driving history, driving records), banks (all customers and their transactions) and in the Government (statistics, election information, tax records) [1]. From the previous definition, it is important to point out the part that indicates that large databases are being used in systems such as police, government or banks. There is a link to the use of databases in the field of emergency



management with an emphasis on reviews of real and operationally usable human and material - technical resources. A database is an organized collection of information, usually with one central topic. In a computer database (as opposed to a paper database), the program that you use to enter and manipulate the data is either a database program or a database management system (DBMS) [2]. In this definition, the emphasis is placed on the fact that the database in most cases is focused on a single central parameter. In the case of an emergency management system, this would be an opportunity to review the available human and material resources at any time and depending on the need. Furthermore, the development of databases in this area may have different ways of access. Databases can be developed depending on the scope of the data to be covered, then the level of decision for which purposes will be used and depending on the territorial distribution that the database will cover. When it comes to the amount of data that will be used in emergency management databases, database creators need to clearly prioritize the specific group of data that will constitute the contents of the database. Obviously, such databases should not have too much, and at the same time, too little data. This means that the database must not be overloaded with information that will not be used in any emergency caused by natural or man-made disasters. So, database creators need to find the optimum when it comes to the data that will make up the database. Another criterion that must be considered is the level of decision maker who will use the database. This part is more about the software implementation and implies that research should be conducted on who and what profile of persons will later use the database when making decisions about resource allocation in different emergencies. The database must be tailored to these persons. This means looking at their IT skills and creating a database that would be simple and easy to use. When it comes to territorial coverage, it is possible to create databases for macro or micro-location. For example, many countries around the world take this topic seriously. India is a good example of a developed database in this area. Towards supporting country's efforts the efficient management of natural disasters, The Indian Space Research Organization has evolved a comprehensive space-based Disaster Management Support (DMS) programmed and institutionalized the same in association with concerned ministries/agencies. To support the total cycle of disaster/emergency management for the country, in near real-time, the database creation is addressed through National Database for Emergency Management (NDEM), a GIS based repository of data.

NDEM is envisaged to have core data, hazard-specific data, and dynamic data in the spatial form as well as textual form. The database enables the development of a decision support system in the form of customized user interfaces with necessary security mechanisms [3]. The National Database for Emergency Management (NDEM) Version 3.0 Released is currently being developed. The portal is browser independent and compatible to all computer devices and mobile phones with vector rendering services. One and very important part of the salient features of the NDEM Version 3.0 is a resource management module for the allocation and monitoring of relief resources [4]. The emphasis in one part of this database is precisely on the allocation and monitoring of emergency resources. In this part, it should be pointed out that such databases can also be used in the case of humanitarian aid provided to countries affected by emergencies. Namely, in addition to human and material resources that are primarily focused on an operational response in the case of natural and man-made disasters, humanitarian aid consists of goods such as food, sanitary, cosmetic, medical and similar equipment, which are also needed by the vulnerable population in the case of an emergency. Other countries are also developing their own databases on human and material resources that may be operational immediately before, during, and after an emergency situation. Good examples are United States, Russian Federation, and others.

2. THE ROLE OF DATABASES ON HUMAN AND MATERIAL – TECHNICAL RESOURCES IN THE EMERGENCY MANAGEMENT

Emergency management involves several phases. Disaster Risk Management includes few activities, programmes, and measures which can be taken up before, during and after a disaster with the purpose to avoid a disaster, reduce its impact or recover from its losses. The three key stages of activities that are taken up within disaster risk management are as follows:

- Before a disaster (pre-disaster) – disaster mitigation and disaster preparedness,
- During a disaster (disaster occurrence) – emergency response,
- After a disaster (post-disaster) – recovery [5]

Considering the importance of databases in an emergency management system, it is obvious that each of the above mentioned phases has the need for quality data-



bases containing information on human and material resources that should be available at all times. If we start from the preparation and prevention phase, then the database must contain descriptions of all the subjects participating in the prevention section. What would this practically mean? For example, if floods are taken as a referent natural disaster, the database should provide review into all the requested data pertaining to entities working on the preventive action of flood protection and defense. These would be data on the human and material resources of the water management companies, which build embankments, coastal fortifications and channel network systems. It is also important for decision-makers to understand what action is being taken at all times to prevent floods in order to know whether the eventual flood risk is reduced, reduced to a level of acceptability or eliminated altogether. Before moving on to the next phase of emergency management, human and material resource databases also play a very significant role in the immediate danger phase. This should cover a period of several hours before the danger itself. It is crucial for decision-makers, for example the management of the competent emergency management headquarters or the competent emergency management institutions, to have information on what resources they have for disposal for a particular threat that should threaten people, material and cultural property. The next phase is maybe the most important part of emergency management. It is the response phase, where we can find the most important role of databases on human and material - technical resources. Namely, the absence of such databases put decision makers, operational management or commanders of rescue units in a very uncomfortable position. In situations where even minutes decide on someone's life or property, it is clear that decision-makers must have a complete picture to respond to a natural or man-made disaster. If the database contains everything that decision makers need about human and material resources, they will have a much easier job. The question is what are the key data that one database in this field should contain. We will take an example of a national database. Data, which will be part of the national database, should be:

- number of personnel,
- a specialty of people,
- affiliation with a particular organization and institution,
- the location of the organization/institution involved in the event of a specific emergency (list of all facilities and branches),

- available machinery – quantity and type,
- means of transport available – quantity and type,
- rescue equipment available – quantity and type,
- review of medical facilities with capacity,
- review of accommodation and food preparation facilities.

This data framework is only the basic level of data that these databases must contain. Of course, depending on the risk, the necessary information can be added. For the sake of complete transparency and availability of data, the database can also be combined with advanced software solutions through which data is presented on mapping content. One suggestion is to use the GIS - geographical information system. Through this application, a link to the database can be made on the maps to provide decision makers a more meaningful and accessible overview of available human and material resources. Finally, databases are also needed for the last phase of the emergency management cycle. It is a recovery phase. During this phase, decision makers need to look through the database to find out what resources they have in order to complete the rehabilitation phase and return life conditions to normal.

It is also important to point out that the content of databases on human and material and technical resources depends on several parameters, such as end users and the extent of the territory to which the database relates. Only up-to-date data have to be part of the database. Without up-to-date data, meaning and importance are lost, as is the inability to make the right decisions.

3. SOFTWARE SOLUTIONS FOR DATABASES ON HUMAN AND MATERIAL – TECHNICAL RESOURCES IN THE EMERGENCY MANAGEMENT

We will use the example of the possible software solution for a database on human and material – technical resources in the Sector for emergency management as an organizational unit of Ministry of interior of the Republic of Serbia.

Considering that these resources are distributed on the whole territory of the Republic of Serbia, where the majority of these resources are state-owned as the equipment of the Ministry of the interior, the most optimal solution is to have a database for managing human and material - technical resources as the user application of information system of the Ministry of the interior.



IT system of the Ministry of interior has an adequate IT infrastructure for this task. Data entry into the database would be performed by the persons responsible for updating the situation in each of the 27 territorial organizational units of the Sector for emergency management. Upon entry, the data should immediately become available to decision makers both locally and at the headquarters of the Sector for emergency management. The presentation of the data contained in the reports should be flexible and adjusted to the current situation and the requirements of the management.

It should also be defined access control for the database and different permissions for data entry, then the production of specific reports as well as for user administration, modification of data nomenclature, or for customization of the data set to be entered into the database. The software should be used primarily by employees of the Sector for emergency management of the Ministry of interior, and, if necessary, through certain services, it should be allowed limited access to other institutions of importance that need the above information. Data insight should be vertical, meaning that decision makers at the national level should have complete access to all data, while at the regional level it should be restricted to the regional unit and the neighboring regional units.

It is important to note that it is necessary to replicate the database to another, physically remote location, which in the event of failure and termination of the primary site will assume its role and allow the smooth operation of the service.

If we take into account the existing software solutions for database development it is obvious that there are several options. One of the simplest is to use excel files that would be used with multiple addresses. With this solution, and if we have a local area connection, all users in the network can have access to any file. Not only that, but any changes made to the file can also be tracked. We can also set which users would have access to the file [6]. In this way, local users can create a database with the number and specifications of various resources that can be activated in the event of emergencies of local character. In addition, through shared excel files, decision makers at the highest level can have access to the same database and thus make optimal decisions on how to help local authorities. The disadvantage of this software solution is the fact that it is very slow in case you have to make the quick search as well as to generate reports. The next option is to use MS Access. Microsoft Access is a Database Management System (DBMS)

from Microsoft that combines the relational Microsoft Jet Database Engine with a graphical user interface and software-development tools. It is a part of the Microsoft Office suite of applications, included in the professional and higher editions. It stores data in its own format based on the Access Jet Database Engine. Like relational databases, Microsoft Access also allows you to link related information easily. For example, customer and order data. It can also import or link directly to data stored in other applications and databases. MS Access can also understand and use a wide variety of other data formats, including many other database file structures [7]. These are some of the features that can be useful when creating a database on human and material and technical resources in emergency management by MS Access.

One good example is a software solution for creating a database of health facilities and resources that can be activated in case of natural or man-made disasters. It is called the LiveProcess Emergency Manager. It is a proven system for emergency preparedness planning, mass mobilization, real-time coordination and tracking healthcare emergency management platforms for every type of healthcare organization and agency. Hospitals and health systems, ambulatory centers, home health agencies, nursing homes, and public agencies use Live-Process Emergency Manager to prepare for and respond to disaster events and for everyday coordination [8].

As an example of good practice, we can use the project "Disaster Reduction, Standardized Hazard Analysis and Risk Evaluation (DR SHARE)", which was created as a result of the cooperation of several institutions from Serbia, Croatia and Bosnia and Herzegovina. The main aim of this project is to improve risk management with the reducing the consequences, intensity and frequency of natural and man-made disasters, as well as protecting the population, the environment and property through the exchange of good practices, harmonizing methodologies in the three countries and creating new IT solutions that can help manage risks in the border region between Croatia, Serbia and Bosnia and Herzegovina [9].

The next example is connected with the project "Supporting the Management of Natural Disasters Risk - Comprehensive Early Warning System". The project "Supporting the Management of Natural Disasters Risk - Comprehensive Early Warning System" is implemented by the Public Investment Management Office, as a new body of the Government of the Republic of Serbia, with the support of the World Bank and with donations from Switzerland. One of the results of this project is a new digital platform - The Disaster Risk Information System (DRIS). The Disaster Risk



Information System (DRIS) is an integrated emergency management system that contains all the digitized relevant information that exists in the disaster risk assessments and protection and rescue plans of all emergency management levels in the Republic of Serbia. Data can be accessed from the DRIS platform from many different levels so that the local self-government units will be able to see the current state of affairs, which through this platform also updates the data, but also the state administration bodies, especially the Sector for emergency management. Through the use of accurate and up-to-date information, the efficient exchange of information, and the faster involvement of entities at different levels, the information system will enable a more effective response to risks and disasters. Until now, at the Serbian-Korean Information Access Center (SKIP Center) as a part of the Ministry of Public Administration and Local Self-Government, trainings were organized for representatives of local government units to use the new application (DRIS) [10]. It is expected that this application will greatly contribute to a more efficient and effective response in emergencies. It is important to note that disaster risk assessments identify risks, their level and degree of acceptability. Measures to be taken to mitigate risk are also suggested in the risk assessment. Later, the plans for protection and rescue specify the activities to be carried out in accordance with the identified risks. Plans also provide information on human and logistical resources that should be used in real emergencies. This confirms that the Disaster Risk Information System (DRIS) is a good example of the database on human and material – technical resources in emergency management.

International cooperation is also a significant factor in emergency management. Natural disasters, such as floods, often affect multiple states simultaneously. In addition, in some situations, states can not respond independently to an emergency, so they need assistance from other countries. Assistance can be provided in the form of rescue forces and operations teams or through humanitarian assistance, equipment and relief supplies. One example is the database that is used by European civil protection and humanitarian aid operations as a part of the European Commission. The European Emergency Disaster Response Information System (EDRIS) is a database that lists annual contributions made by the Member States' Ministries of Foreign Affairs and the European Commission's Civil Protection and Humanitarian Aid Operations (ECHO) for the delivery of humanitarian assistance to people affected

by natural or man-made disasters worldwide. It also provides information on how much each EU Member State contributes to a disaster response operation and to which area. EDRIS contains records of humanitarian aid contributions dating back to 1999 and it is free of access for reporting purposes. However, recording national humanitarian aid contributions and data input is restricted to the Member States' Ministries of Foreign Affairs. Member States are responsible for encoding the information. Information on EU funding is transferred from EDRIS to the global humanitarian Financial Tracking System managed by the UN. EDRIS also feeds in data into the EU Aid Explorer – an EU-wide database on humanitarian and development aid funding [11].

4. THE POTENTIAL USE OF NEW SOFTWARE SOLUTION

In the previous parts, the basic characteristics that the new software solution should satisfy are presented. It is necessary to indicate how the practical realization of the software solution should look and what advantages the use should bring.

Firstly, a software solution that should be used is a database created in a way that allows the useful and functional queries to be asked by end-users. It is very important that the database at the start is adequately created and adapted to the end-users, in this case to the decision-makers of different levels in emergency management. This means that the masks that make up the database provide a clear overview of the data needed to make a decision during some emergency situations. For example, if a flood occurs, the decision-maker needs to see through the database the schedule of the nearest teams with boats that can participate in the evacuation of the endangered population. Or, if an earthquake has occurred, decision-makers need to inspect the nearest entities to the endangered area that have machinery that can be used to excavate the rubble. In most cases someone who makes a decision before or during an emergency situation is limited in time. Therefore, it is necessary that the software that would be developed for these needs, or the database, be simple for end users and at the same time to provide the ability to easily and quickly search for data in order to make an efficient and effective decision. Secondly, attention must also be paid to what data is entered into the database. The validity and accuracy of the data is very important. Incorrect data can lead decision makers in the wrong direction.



In the area of emergency management, one wrong decision can cause a series of negative consequences that are reflected in human casualties or material damage. This is just one of the reasons why it is necessary to enter only accurate and current data when creating a database. Moreover, it is important to have trained people who will enter data relevant to this type of database. Further, the importance of developing such software and database is reflected in several facts. It often happens that decision makers do not have enough information and data in situations when minutes decide on someone's life in situations of threat from floods, fires, earthquakes and more. However, if they have a modern database with the ability to make quick queries and obtain accurate data on human and material - technical resources, they will greatly facilitate the decision - making process. In addition, software that should enable compatibility with GIS layers should also provide the ability to make optimal decisions. One of the benefits that is provided is the connection with other databases that contain data of importance for emergency management. Examples are cadastral databases, then demographic and infrastructure databases. Linking databases on the human and material and technical resources with the aforementioned databases, allows users more opportunities to direct them towards the efficient and effective solutions. In this way, the possibility of mapping and displaying data on maps of different formats is obtained. This is another option that complements software or a database intended for decision makers in emergency management. Current practice shows sporadic examples of such databases used in the world. However, countries that do not have adequate databases on human and material and technical resources have visible problems in allocating the forces of the system of protection and rescue. By developing the database they should get a useful tool that can be used in various emergency situations and thus to contribute to the reduction of human casualties and consequences for property and material and cultural goods. In terms of the financial aspect, it is obvious that significant financial resources would not be allocated for the development and further use of such databases. One of the disadvantages is that the database on human and material resources must be constantly updated. It must not happen that inaccurate or outdated data is in the database. This can cause later problems when making a decision during an emergency.

5. CONCLUSION

Practice shows that after every natural and man-made disaster, an adequate analysis is required. The analyzes conducted have shown as one of the main conclusions that a lot depends on timely decisions and optimal allocation of resources. Most decision makers seek accurate data and information to make optimal decisions.

Database on human and material – technical resources can be a very useful tool in emergency management. Properly set parameters, updated data, and search and reporting criteria make databases very useful for emergency responders. Without databases, it is difficult to expect that optimal resource allocation will be made. A complete inventory of the information needed during the emergency response is often lacking, as well as a good structure for storing the information. The data structuring would facilitate fast access to a desired piece of information, as well as the automation of analysis of the information, and its use in the decision-making process. A database system provides for these: an organized way of storing the information, mechanisms that enable fast access, and functionality for the analysis of the information [12].

It is very important to have developed databases at all levels, both nationally and locally. In addition, it is of great importance that the database is up-to-date in order to provide decision makers in emergency management a platform for optimal allocation of human and material and technical resources.

REFERENCES

- [1] C. A, "COMP 1001 - Introduction to Computers for the Arts and Social Sciences," School of Computer Science, Carleton University, 2004.
- [2] D. E, "What is a Database," *The Journal of World Intellectual Property* 5(6), p. 981 – 1011 , 2005.
- [3] I. S. R. O. Application, "isro.gov," 2013. [Online]. Available: <https://www.isro.gov.in/national-database-emergency-management-ndem-services-tackling-disasters>. [Accessed 05 03 2020].
- [4] D. o. s. -. I. S. R. O. N. v. 3.0., "isro.gov," 2015. [Online]. Available: www.isro.gov.in/national-database-emergency-management-ndem-version-30-released. [Accessed 05 03 2020].
- [5] H. Khan, L. Vasilescu and A. Khan, "Disaster management cycle – a theoretical approach," Institute of Information Technology, Abbottabad, Pakistan; University of Craiova, Romania; University of Science and Technology, Bannu, Pakistan., 2008.



- [6] B. J.B., "How to share an excel file for easy collaboration," 2019. [Online]. Available: <https://helpdesk-geek.com/office-tips/how-to-share-an-excel-file-for-easy-collaboration>. [Accessed 30 03 2020].
- [7] T. Point, "MS Access tutorialas point," 2018. [Online]. Available: <https://tutorialspoint>. [Accessed 30 03 2020].
- [8] B. e. m. software, "LiveProcess Emergency Manager," 2020. [Online]. Available: <https://www.g2.com/products/liveprocess-emergency-manager/reviews>. [Accessed 30 03 2020].
- [9] E. A. F. A. Vojvodina, "Project DR Share.," 2016. [Online]. Available: <http://www.vojvodinahouse.eu/src/kancelarija-u-briselu/aktivnosti/286/projekat-dr-share-predstavljen-na-konferentsiji-u-briselu>. [Accessed 10 03 2020].
- [10] T. D. R. I. S. (DRIS), " Project Supporting the Management of Natural Disasters Risk - Comprehensive Early Warning System.," 2020. [Online]. Available: http://skipcentar.rs/en_GB/vesti/nova-dris-aplikacija-omogucice-bolje-reagov. [Accessed 19 03 2020].
- [11] E. c. p. a. h. a. operations, "The European Emergency Disaster Response Information System (EDRIS)," 2020. [Online]. Available: https://ec.europa.eu/echo/resources-campaigns/online-databases_en. [Accessed 25 03 2020].
- [12] S. Dilo and A. Zlatanova, "Data modelling for emergency response," Delft University of Tchnology, 2010.



MY BABY – SYSTEM REQUIREMENTS

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Abstract:

In modern era, new parents rely on technology to guide them through the development of their babies. In order to create software product that will be useful both for parents and for the community, it is necessary to address all the requirements of such a system. In this paper we define a list of requirements related to system infrastructure, privacy protection, user interface and data collection that will enable us to create a platform that will utilize young parent's willingness to log and share data, while being useful for parents in their everyday struggles. In that manner, we will be able to specify a distributed system that can be used to extract non trivial knowledge related to baby development and based on real world data.

Keywords:

baby development tracking, requirements engineering, data science, machine learning.

INTRODUCTION

One of the most significant challenges for young parents nowadays is baby care. In the era of sensors and actuators, era of information, people are relying on technology to keep them and their babies safe. Different infant monitoring systems are available on the market. However, these systems just provide information about current situation in close environment. In order to maximize the use of technology and all the advances it can bring, it is necessary to develop a system that will monitor baby's behavior, but also record it so as to learn from it, or use it for extracting non-trivial knowledge. Such system is beneficial both for parents and for the community. Parents will allow the system to collect the data so as to receive valuable information, generate different plots and graphs and so on. Community can benefit from this data as it can be used to train different models and make informed assumptions based on identified correlations in the data itself. However, it is not a trivial task to draw on any systematic research about the requirements of aforementioned system. The specific objective of this study was to identify different possibilities of a system named My Baby intended for use for baby development tracking, and

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create a list of basic requirements for it. In that manner, it will be possible to identify most of the challenges that might arise during the detailed architectural planning of a baby monitoring system.

The system design is dependent on different data input, so it is necessary to define all groups of data sources in order to properly define requirements related to data management and processing. It is important to take into account different data sources, including automatic ones such as different sensors that provide trivial information without any processing, data sources that require the system to perform some kind of processing so as to extract non-trivial data such as camera input, and manual data inputs that require users to provide data using system user interface. Furthermore, in the early stage of the development, it is important to define high-level functional and technical requirements that will define the general system behavior. In this paper we give an overview of available data sources that can be useful for baby monitoring, and we create a list of functional and high-level technical requirements for My Baby system thus creating a testing grounds for further development of the system.

The remaining part of the paper proceeds as follows: First section gives a brief literature overview. Second section describes different data sources significant for the topic. Third section gives an overview of the identified functional and technical requirements. Fourth section concludes the paper.

1. LITERATURE REVIEW

In one of the research authors proposed system that had many features such as: displaying live video and audio, recording audio and playing it to the baby, measuring the room temperature and humidity, supporting Arabic language, determine if the baby is awake or sleep, and the most important characteristic is the ability to listen the baby noise, which is the cry detection feature [1]. Proposed system is tested and compared with the current system and in this way its effectiveness and functionality is proved. Proposed system was consisted of one of the famous microcontrollers, which is Raspberry Pi connected with some objects and devices. This system in comparison with the earlier ones can support seven different features on one system and all of the required properties. Nevertheless, one of the shortcomings noted by the authors is the fact that proposed system does not support the heartbeat-measuring feature. Moreover, the system can send notifications to the parents in some abnormal cases such as high temperature and baby crying.

In research presented in [2] authors described a real-time infant monitoring system for tough hearing parents by using mobile devices based on Android operating systems, which has sensors such as finger heart-beat, body temperature, humidity and sound detection. In particular, this system is designed to monitor physiological information obtained from children and then produces alarms in case of abnormal situations. The implementation of this system depends on one of the Arduino boards which is the Leonardo board. This device is used to collect and sense information using the connected sensors and then create an appropriate alarm, based on this data. Smartwatches and smartphones based on Android operating system were used to report alarms to the parent. From the implementation results, the data collected were observed and sensed by the appropriate sensors which also contain any abnormal conditions and finally the alarms were notified.

Internet of Things-based Baby Monitoring System (IoT-BBMS) is proposed as an efficient and low-cost IoT-based system for monitoring in real time [3]. Authors in this research also proposed a new algorithm for system that plays a key role in providing better baby care while parents are away. In the designed system, Node Micro-Controller Unit (NodeMCU) controller board is exploited to gather the data read by the sensors and uploaded via wi-fi to the AdaFruit MQTT server. The proposed system exploits sensors to monitor the baby's vital parameters, such as ambient temperature, moisture, and crying. A prototype of the proposed baby cradle has been designed using Nx Siemens software, and a red meranti wood is used as the material for the cradle. The system architecture consists of a baby cradle that will automatically swing using a motor when the baby cries. Parents can also monitor their babies' condition through an external web camera and switch on the lullaby toy located on the baby cradle remotely via the MQTT server to entertain the baby. The proposed system prototype is fabricated and tested to prove its effectiveness in terms of cost and simplicity and to ensure safe operation to enable the baby-parenting anywhere and anytime through the network. Created baby monitoring system is proven to work effectively in monitoring the baby's situation and surrounding conditions according to the prototype.

In [4], Kaur and Jasuja proposed a system that can monitor the pulse rate and body temperature of the person. Dedicated sensors are placed along with Raspberry Pi and IoT to monitor the health condition and store the obtained data to Bluemix cloud. The data stored are sent to a doctor for health analysis and to detect abnormalities.



The KG011 sensor is used to measure the heart rate, and the DS18B20 sensor is used to measure the temperature. Then, the readings are shown in the IBM Watson IoT Platform in graph form. The article proposed a good point, which is about using the sensors to send data to the IoT platform. However, this system is unsuitable for infants, because their bodies' immune system is weaker than that of adults. This wearable system might emit some radiation that could harm the infants and cause some side effects.

This system presented in [5] is helpful for busy parents to ensure care and safety of their babies with use of advanced technology. Implemented work going to detect baby's crying sound, motion as well as live streaming of baby position in cradle. The live streaming of babies position and activities are displayed on display unit which helps parents to have continuous baby monitoring. The implemented work deals with design and development of a baby cradle using Raspberry Pi B+ as control unit. The different sensors like rain drop sensor, condenser MIC and camera are used to assist baby monitoring and are interfaced with the Raspberry Pi B+. The baby sound like crying is detected by condenser MIC. Live streaming is done by the pi camera. Baby's urine is detected by wet sensor and SMS will be sent to parents. The result obtained from the designed work shows the easier and convenient way of baby monitoring for busy parents.

Authors in [6] presented a baby monitoring system based on GSM network. This system monitor's body's health parameters like temperature, moisture, pulse rate and movement and deliver these measured parameters on the parent's mobile using GSM network. System presented in [7] includes reminder system as important feature in baby monitoring activity. It conveys measurements of various parameters to the parents with an alarm triggering to initiate proper actions. Using this feature, parents or caretakers can set reminder about feeding time and vaccination date.

2. DATA SOURCES

As for any other data processing systems, a system for baby tracking and monitoring is relying on the input data to produce output. That output can be as trivial as graphics charts of the given input, but can also include results produced by different machine learning techniques along with raised alarms and actions. Complexity of the system is correlated to the complexity of the methods used for analysis and their requirements

related to the input data. Input data can be data obtained from traditional baby monitoring systems, different environmental sensors and medical sensors that are used to track specific conditions, smart devices for babies such as smart cribs, data provided by parents or caregivers, historical data and common knowledge data [8].

Most commonly used baby monitors are traditional audio and video monitors. Audio monitor allows parents to hear noise even if they are not in the room. Video monitor sends a video from a camera positioned in the baby's room. These monitors can be replaced with two phones or tablets and appropriate mobile app. However, these types of monitors are used when parent is observing baby's behavior, and are generally not used as a data source for a system that is tracking a baby. Automatized and semi-automatized systems for baby monitoring and tracking are relaying on different sensors that not necessarily produce visible or auditable results, but results that can be easily processed. These sensors can be different: wearable and medical sensors, environmental sensors and movement detectors, and smart sensors that can be adapted to detect specific mimics or behaviors.

Medical sensors enable constant health monitoring for infants. They are often embedded to baby's clothes so as to minimize the discomfort they are causing. They can include fully-integrated sensors for measuring electrocardiography (ECG), temperature, respiration and humidity (excess sweat detectors), pulse oximetry, grip strength, etc. Different papers present novel materials to use for manufacturing the sensors and wearables that include them, such as conductive textile wires [9]. However, some of these sensors are invasive, and are not to be used in normal circumstances: if there is not a medical necessity to monitor baby's medical parameters, same is often not recommended. This is due to sensors that must be attached to baby's body and can cause discomfort. Many of them can be manufactured as a part of baby's clothes, but that can complicate washing the clothes. Since the main idea with this system is to make it easier for parents, it makes no sense to introduce unnecessary sensors that can complicate everyday life and actions. However, if the infant requires continuous health status monitoring, system that processes data from sensors can be used as a clinical tool applied in constant monitoring of physiological parameters and transmit the information to clinicians or parents. In this case, wearable sensors for infants can be a life-saving technology.

Environmental sensors on the other hand do not cause any discomfort for an infant or parents, can be placed near the baby and can be used to monitor not



only the infant itself but also the environment. These sensors include but are not limited to temperature, humidity, weather, CO₂ levels, noise detectors, and light sensors. This type of sensors can be used to control the air-condition devices, to inform parents if something might be causing a discomfort for their baby, etc. However, similar sensors can be used to detect different problems with infant's health. For example, through detecting the variation in the exhaled CO₂ concentration using CO₂ sensors placed in the crib around an infant, system can be able to detect if there is anything unusual with the infant's respiration. Sensors that monitor the baby can be extremely useful in preventing sudden infant death syndrome (SIDS). Although the main cause for this syndrome is not known, there are many studies that link this syndrome with problems in the ability of the baby to arouse from sleep, so if the sensors are able to detect low levels of oxygen or a possible buildup of carbon dioxide in the blood, the system can alarm the parents. When babies sleep face down, they may re-breathe exhaled carbon dioxide, which can also be a use case for a baby monitoring system [10]. Another benefit from environmental sensors is retrieved knowledge: the historical data from environmental sensors can be used to track some problems down to the root and to link different states with the environmental changes. For example, trivial noise detectors can show the cause of baby's insomnia. Non-trivial analysis can extract useful knowledge that can relate some problems to the environmental factors. Given the fact that the system will have access to dataset for different infants and their environment, as well as the context provided by parents, the same can be used to extract different correlations and patterns which are impossible to infer without constant and thorough monitoring of different parameters. This will be beneficial not only for parents, but also for the community and medical sciences in general.

Another type of sensors that can be beneficial for infant monitoring system are different motion sensors that can detect movements of a baby. This can be used for trivial use cases as detecting if a baby is awake, but also for a very complicated analysis related to infant's posture and movements. Different types of sensors can be used for this purpose: camera can take a video of an infant that can be processed to detect the movements, cradle can be equipped with various movement sensors, or they can also be developed as wearables. Video input can be valuable source of information, but in order to extract it, it is necessary to conduct processing of a video input. For example, using eulerian magnification, the system can amplify small infant movements by compar-

ing pixel color differences between subsequent frames and therefore detect basic actions such as breathing [11]. Using pose estimators, system can learn baby's behavior depending on different environmental factors, or even correlate infant mood with detected events. At last, there are smart sensors that can act as actuators, and adapt themselves and the environment based on the readings. These sensors are not of utmost importance when used as a part of an intelligent system for baby monitoring.

Along with the sensors, very important parts of the input data are the data provided by parents via different logging techniques and historical and common knowledge data. Logged data can contain information related to baby's mood, weaning habits, accoutered problems, etc. Also they can include environmental information, pediatrician advices, parents' observations. These logs might seem worthless in the moment of the input, but can be used in different machine learning analysis as a missing data, because they often provide a context for different events. Additionally, logs are the most suitable way of providing information about solids given to a baby. System for monitoring must be designed so to encourage users to log as much information as possible, to ensure a good training set for future knowledge extraction. Furthermore, historical data for monitored infant or other infants that might be of importance along with the data that represents common knowledge should be taken into account when developing machine learning models and knowledge bases.

3. SYSTEM REQUIREMENTS

System requirements related to My Baby platform can be tackled from different points of view. In early stage of a development, it is from utmost importance to firstly define functional requirements that should be implemented. Secondly, technical requirements should be listed. Functional requirements should list all the general functionalities the system should have, while technical ones define the properties of the platforms that can be used for implementation of such a system.

First of all, the system must be scalable and adaptive: it should work with all the provided sensors, and it must be able to support multiple users, providing each one of them with the privacy protection on the level that is requested. Different users will share different amount of data with others, and the system must be designed so to fulfill privacy requests for each user. List of the available functionalities per users is dependent on the available data sources.



One important subset of functional requirements for baby tracker systems are requirements related to infant's nutrition. From day one, system can provide information about breastfeeding or amount of fluids for formula-fed babies based on common knowledge bases and health-care provider recommendations. Furthermore, as parents start weaning, the system should be able to suggest new solids for baby to try, and different recipes for healthy meals. The key role in this functionality is up to parents, as they must provide all information about already introduced solids, possible allergies, intolerances, etc. Based on similar groups of groceries, system should be able to suggest new solids, or provide parents with groceries lists and recipes. Another subset of this type of requirements includes the ones related to environment adjustments. System should be able to track the environmental parameters from available sensors and, given the thresholds, alarm the parents or automatically use actuators so as to regulate the problematic features. For example, if the temperature sensor is available, and it is detected that it is too hot, system should either activate air condition or alarm the parents, depending on the available components. Another useful feature of our baby monitoring and tracking system is discomfort detection. It should alarm the parents if the baby is experiencing any discomfort. If there is a video input of a baby sleeping in a cradle, using different techniques for image recognition, it is possible to detect for example if an infant is covered with a blanket. Parents should be able to select different events that can trigger an alarm or actions. If an infant requires special medical care, and the system has all the required data sources, the healthcare providers should define different alarms and statuses in the system that are tailored to current condition. Caregivers often need to leave the room where the infant is located, and many of them prefer audio or video streaming features. Although this is something that basic traditional monitoring systems provide, a complex one should have it too. Another important part of the systems are visualizations for parents: different graphs that track measurements such as weight and height or amount of food taken, status of different alarms and parameters, readings from different sensors, and possible recommendations. These graphs can be also useful for pediatrician that is monitoring baby development – parents can show them the information in the system during the monthly check-ups, for identification of possible problems. Furthermore, the system should inform the users if some of the input data sources are not working properly. It is not uncommon for sensors to fail, but the parents must be informed if the system is missing the needed data sources. This is very important if the system is used to track critical medical conditions.

Baby monitoring system should be flexible regarding the input data sources. Different infants and parents have different needs and require different measurements and logging activities. System should be able to work with different sets of input data sources, although it is possible to define minimal requirements regarding input data for each of available functionalities. For example, if there is a cry detection capability, users must provide the input from which the system can be able to detect and recognize noise. Furthermore, if parents choose to rely on the system related to baby's weaning, they should log every introduced grocery as well as baby's reactions to it. For each introduced functionality, data input requirements must be defined and checked in a runtime.

Technical requirements are dependent on the design solution. They include both internal interface constraints between the elements of the system and implementation details for each of the components. In [12] we presented architecture for baby tracking and monitoring system named My Baby. An overview of this architecture is given in Fig. 1. This architecture implies most of the technical requirements, as well as the communications between different modules.

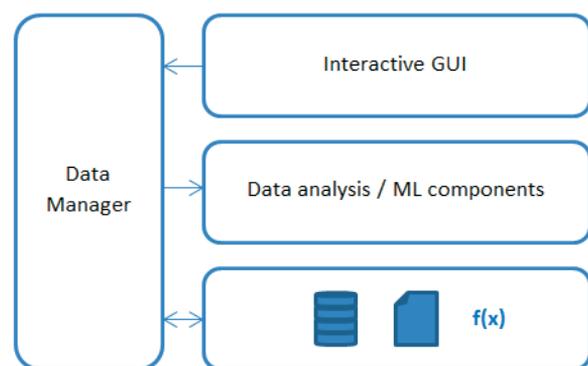


Fig. 1. My baby – system architecture.

Defined modules include interactive GUI, data manager, data analysis and machine learning module, database and a set of rules and models representing a common knowledge. Data manager should support different data sources listed in section II. Data from these sources should be stored and processed locally, but also, after applying various anonymization techniques, can be shared with other users of the system. This will create a perfect ground for a development of a common knowledge basis because the parents will log data for their own needs, while contributing to the community. In order to ensure data protection, module must include components for safe data storage and sharing.



This module should be implemented in a distributed manner: one part operates on the edge managing user data, while another part is responsible for updating and retrieving global resources. Graphical interface of the system must be adapted to different users, therefore it must be configurable. A mobile app that provides an interface to the system should be developed to make the system more accessible to parents. It is important to allow users to input data easily, and to interact with the system: define different alerts, rules or share data. Another important module of the system is module that encapsulates knowledge bases, historical data and extracted models. Depending on the number of users, this data can be managed using either traditional databases or Big Data solutions. There should be a way to provide the system with different rules and to represent knowledge obtained from pediatricians and literature, so this module is connected to the graphic user interface via data manager module. Module for data analysis and machine learning is distributed: it must be able to run locally to provide personal assistance for infants, but also it must be able to extract knowledge from the data acquired from different users.

Furthermore, entire system should follow cloud-edge paradigm: data that is important for individual users should be stored locally, while processed data and knowledge representations and models should be stored in a cloud and be easily accessible. In that manner, it would be possible to optimize data driven capabilities of the system by bringing data collection, processing and alerting as close to the end user as possible. This can eliminate latency, leading to faster response times, which makes the collected data more relevant, useful and actionable.

4. CONCLUSION

The aim of the presented research was to examine the possibilities and basic requirements for a system aimed for monitoring and tracking the development of infants. We created an overview of different groups of available data sources that can be used as an input for the system, and create a list of basic requirements that must be met so as to create a system that will be useful both for parents and for community. The proposed system, called My Baby, complies with the standards of cloud-edge architectural paradigm. The most important benefits of this paradigm for baby tracking and monitoring system are ability to increase network performance by reducing latency, reduced amount of data at risk regarding privacy issues, scalability and flexibility regarding number of users and connected devices, powerful analytics and machine learning programs. The present study lays the

groundwork for further planning and implementation of My Baby system. Our future work will include detailed architectural requirements and plans for system development, as well as the actual implementation.

REFERENCES

- [1] I. Dina, H. Mohammed, A. Sadaf, and M. Sajid, "Raspberry Pi-based smart infant monitoring system," *International Journal of Engineering Research and Technology*, vol. 12, no. 10, pp. 1723-1729, 2019.
- [2] F. Aktas, E. Kavus, and Y. Kavus, "A real-time infant health monitoring system for hard of hearing parents by using android-based mobil devices," *Journal of Electrical and Electronics Engineering*, vol. 17, no. 1, pp. 3107-3112, 2017.
- [3] W. A. Jabbar, H. K. Shang, S. N. Hamid, A. A. Al-mohammed, R. M. Ramli, and M. A. Ali, "IoT-BBMS: Internet of things-based baby monitoring system for smart cradle," *IEEE Access*, vol. 7, pp. 93791-93805, 2019.
- [4] A. Kaur and A. Jasuja, "Health monitoring based on IoT using Raspberry PI," in *Proc. Int. Conf. Comput., Commun. Autom. (ICCCA)*, pp. 1335-1340, 2017.
- [5] A.R.Telepatil, P.P.Patil, S.S.Yajare, and S.R.Jadhav, "Intelligent baby monitoring system," *International Journal of Research in Advent Technology*, vol. 7, no. 6, pp. 191-194, 2019.
- [6] S. P. Patil and M. R. Mhetre, "Intelligent baby monitoring system", *ITSI Transactions on Electrical and Electronics Engineering*, vol. 2, Issue 1, pp.11-16, 2014.
- [7] S. Shreya Pai, S. Cynthia Pereira, T. Nicole, A. Ushadevi "Advanced baby monitor," *International Journal of Internet of Things*, pp 51-55, 2017.
- [8] Z. Zhu, T. Liu, G. Li, T. Li, and Y. Inoue, "Wearable sensor systems for Infants," *Sensors*, vol.15, no. 2, pp. 3721-3749, 2015.
- [9] W. Chen, S. Dols, S.B. Oetomo, and L. Feijs, "Monitoring body temperature of newborn infants at neonatal intensive care units using wearable Sensors". In *Proceedings of the Fifth International Conference on Body Area Networks*, Corfu Island, Greece, pp. 188-194, 10-12 September 2010;
- [10] S. Bouwstra, W. Chen, L. Feijs, and S.B. Oetomo, "Smart jacket design for neonatal monitoring with wearable sensors". *IEEE Body Sens. Netw.* vol. 40, pp. 162-167, 2009.
- [11] D. Yogita, and G. D. Sachin, "Baby monitoring system using image processing and IoT," *International Journal of Engineering and Advanced Technology (IJEAT)*, vol. 8, Issue 6, pp. 4961-4964, 2019.
- [12] S.I. Aleksandra, I. Milos, S. Petar., A.H. Shanta A.E.S, "My baby - system proposal", In: Zdravković, M., Konjović, Z., Trajanović, M. (Eds.) *ICIST 2020 Proceedings* vol.2, pp.244-249, 2020.



OVERVIEW OF THE PROJECT V-NAST2019

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Abstract:

The Project V-NAST2019, funded by the Ministry of Education, Science and Technological Development, was achieved through five workshops each presenting the necessary steps towards a successful transition from traditional learning to hybrid or/and online learning. By attending the workshops, lecturers/associates at the Belgrade Polytechnic had the opportunity to gain knowledge about the possibilities of innovative forms of teaching supported by modern digital technologies as well as the "how-to" and "know-how." Also, acquaintance with new technology imposed new pedagogical approaches that differ from those found in traditional teaching. The intention of these new pedagogies is to promote a humane and ethical approach for the common good, which is an essence of educational goals for everyone. Therefore, educational technology should ensure student engagement as well as the institution's responsibility to participate in the global knowledge network. The new pedagogy seeks to encourage such engagement by ensuring the presence of interactive social dynamics in educational media spaces. The hybrid interaction between humans and virtual agents provides a real learning experience in the shared lifelong learning domain. By realizing the V-NAST2019 project, insight was given toward strategic goals and key issues that should be addressed at an early stage in the development of online teaching. The five workshops involved: strategic planning, content creation, preparation of lectures, selection of technologies, and methods of analyzing the success of teaching and student progress. The following platforms were considered for technology selection: Canvas LMS, Google Classroom, and Moodle. As a result of the project, a model of hybrid teaching was created and applied to the class CAD2 - teaching PTC Creo Parametric. From this implementation, evidence emerges that supports the benefits of hybrid teaching and the positive effects on student engagement and achievement.

Keywords:

hybrid learning, e-learning, virtual learning, LMS, flipped classroom

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1. INTRODUCTION

The ubiquity of digital technologies has profoundly changed almost all aspects of human life. The way we communicate, the way we work, the way we enjoy our free time, the way we organize our lives and the way we transfer knowledge and information.



The way we think and behave has also changed. Children and young people grow up in a world where digital technologies are part of everyday life. They do not know, nor can they know otherwise. However, this does not mean that they are naturally endowed with the appropriate skills for the efficient and conscientious use of digital technologies.

The educational staff is a role model, someone to look up to, for every next generation of students. Therefore, it is crucial for teachers to possess certain digital competencies to be able to actively participate in the digital society.[1] The European Digital Competence Framework for Citizens (DigComp) specifies these competences. DigComp has become a widely accepted tool for the evaluation and recognition of digital competences and has been used as a basis for teacher training and professional development across Europe and beyond. As citizens, educators must possess these competencies to participate in society, both personally and professionally. As role models, they must be able to clearly show students their digital competence and convey their creative and critical use of digital technologies.

However, teachers are not just role models. As professionals committed to teaching, in addition to general digital competencies for living and working, they also need digital competencies specific to teachers in order to be able to use digital teaching technologies effectively.

When it comes to online programs, they differ in many key elements. Fig. 1 shows a set of dimensions that define online programs. These dimensions describe whether the online program will be complementary or fulltime; geographically how far it reaches; what is the organizational type and operational control; location of classes and type of classes. Some of these attributes can be combined or applied continuously (e.g. location and type of teaching).

2. THE PROJECT V-NAST2019

Currently in Serbia, there are no clearly defined, complete trainings or courses that would serve the professional development of teaching staff in preparation for some form of innovative teaching (virtual teaching, flipped classroom, blended learning). The project V-NAST2019 was realized through a workshop of courses and trainings that enabled each teacher to improve teaching by adopting new competencies and pedagogies, as well as by using modern technologies and trends in education. Within the project, workshops and trainings were held for professors/lecturers and associates of the Belgrade Polytechnic. In further work, similar activities are planned for teachers/educators from other interested institutions (educational or business), aiming to improve teaching /training in a much larger population, and as a consequence to raise and improve digital competencies and professional development of all attendants and their institutions (schools, colleges or companies).

The implementation of the project defines guidelines for the practical application of hybrid forms of teaching in the sector of higher education. The V-NAST2019 project has set out the following goals:

- ◆ to inspire lecturers, researchers and management staff to design and implement actions that would exploit the potential of digital technologies to expand participation in education,
- ◆ encourage innovation in education and training,
- ◆ improve the conditions of lifelong learning,
- ◆ transfer new (digital) skills and competencies needed for employment, personal development and social engagement.

The project V-NAST2019 was realized through five work-shops during which lecturers/associates at the University of Belgrade Polytechnic had the opportunity to gain knowledge about the possibilities of innovative forms of teaching supported by modern digital technologies (TEL - Technology Enhanced Learning).[2]



Fig. 1. Defining dimensions of online programs



Also, new pedagogical approaches that differ from those in traditional teaching are described. New pedagogical approaches should promote a humane and ethical approach to the common good, which is essential for every educational goal for everyone. Therefore, educational technology should ensure the engagement of students as well as the responsibility of the institution to participate in the global knowledge network. New pedagogy seeks to encourage such engagement by ensuring that interactive social dynamics are systematically present in educational media spaces. Hybrid interaction between humans and virtual agents provides a real learning experience in a common lifelong learning domain. [3]

Workshops and courses held within the project V-NAST2019 provide insight into strategic goals and key issues that need to be addressed at an early stage in the development of online teaching. They are divided into five parts: strategic planning, content creation, lecture preparation, choice of technologies, methods of teaching and student progress analysis.

Organized Strategic Planning

At this stage, the essence is to consider certain issues that determine how online teaching will be further realized and developed. It is important that all participants are engaged and that a decision is made on the issue of defined educational goals for the selected group of students. The first question that arises is which subjects should innovation be introduced. This is important because the specifics of the case determine how the realization of its online adaptation will be approached. It is also important to determine whether a mixed form of teaching, supplementary online teaching, full online teaching or a mixture of all these forms will be developed. Other issues that arise and need to be addressed at this stage relate to:

- ◆ how to manage the process of change in the organization;
- ◆ how to influence on the role of lecturers and students, as well as on the use of time;
- ◆ what goals to set in terms of teaching individualization for students;
- ◆ whether adapt online teaching to the traditional teaching calendar;
- ◆ will the online classes be open or closed?

Regardless of any case, student-centered learning dominates at this stage is.

Preparing Teaching Content and Materials

Before preparation of any specific teaching materials and content, it is necessary to make certain strategic decisions. When it comes to generating content, the questions that may arise are whether to build your own content, whether to buy it or a bit of both? The answer to this question depends on many variables, which include: expertise of the teaching and/or administrative staff, time and resources needed to create content, time to launch the course, funding to run and/or maintain existing online courses, the need for adapting the courses, compatibility with the goals, mission, and vision of the school, and it certainly depends on the unique needs of the students. When purchasing certain content, it is necessary to consider whether it is the entire curriculum (comprehensive content), individual course or individual teaching units, lessons and other objects. Open educational resources (OER) can also be used, but should be considered in advance. How will the quality of online content be assessed is a also frequently asked question. Local or national quality standards for online content (if defined) can be used for this. In addition, the educational institution should develop or harmonize its own standards with those recommended regarding the quality of online teaching. In general, these standards should include:

- ◆ *Content* - The course should provide online students with more ways to engage and connect with learning experiences that promote content mastery and are in line with national standards.
- ◆ *Teaching design* - courses are defined to use activities that encourage student engagement and active learning, while providing more learning pathways based on students' needs. Also, there should be options for student-student, teacher-student, and student-teacher interaction.
- ◆ *Student evaluation* - courses should have several strategies and activities by which the student's readiness and progress during the course can be evaluated.
- ◆ *Technology* - The course should take full advantage of a variety of technological tools, have a user-oriented interface and meet interoperability and accessibility standards for students with special needs.
- ◆ *Course evaluation and support* - courses should be evaluated regularly for effectiveness. For this purpose, various strategies can be used, as well as those in traditional teaching. It is necessary to constantly improve, both the content and how the technology is used.



The quality of each teaching must be related to the learning outcomes. This can be linked to the online course curriculum. During the final course of the project V-NAST2019, we have clearly presented mechanisms that can be used within the Canvas LMS platform.

Educator Role

Student success comes from the quality experience in the classroom, regardless of whether the classroom is physical or virtual. However, online teaching requires additional skills that need to be defined and developed (it is also valid in a hybrid form of teaching). Compared to a conventional teacher, the role of the virtual (online) teacher is more oriented towards directing and individualizing learning; on engagement in efficient digital communication with students; to evaluate and grade students using unique online tools; and in some cases, is oriented towards the development of content and structure of the online course. When the development of these skills is combined with the desire to give students more flexibility over time, place, path and pace of learning, then it becomes clear what the teacher needs to become more effective in an online course.

As the field of online learning expands, it is becoming increasingly clear that online learning requires a new and different set of skills compared to the traditional form of teaching. In developed countries, in addition to the usual teaching requirements, there is already a need for professional development or certification of online lecturers.

During implementation, the project V-NAST2019 was mostly focused on this phase. However, other phases were not excluded in the realization itself. The courses defined during the project were aimed at developing new knowledge and pedagogical skills in combination with practical application. These courses cover a wider range of information, as well as a deeper understanding of the roles of online teachers, online students, as well as the application of online learning tools. Through hands-on exercises and assignments, teachers have acquired new methods how to transfer knowledge and contents of their teaching, how to communicate and evaluate in a specific way. Support to the teaching staff during the first year of conducting a hybrid form of teaching was reflected in providing structures for communication, "brainstorming" solutions, and exchange of experiences. This is a general strategy for building an online teaching staff.

Teacher classification	Role	Sub-role	
Traditional	Teachers who believe that technology has none or very little impact on their teaching, except to serve for converting text and images into visuals.		
	<i>Instructional Roles</i>	Advisor	Support and advise students on how to realize their projects. Encouraging student engagement, interaction between students, and further clarification of lectures
		Instructional Designer	Use available resources to enrich lesson/individual activity in lesson design/team design
		Collaborator	Collaborate with colleagues to create activities or exchange of ideas
	Teaching Team	A group of teachers - a team, acting to set goals for a teaching unit so that teaching is performed with technology; also, plans individual lessons, teaches students, evaluates results	
<i>Technology Role</i>	Instructor	Support to participants in the use of technology / Modeling the use of technology for project implementation / Student support	
	<i>Social Role</i>	Communicator	Support for social interaction and collaboration / Creating a friendly and pleasant social environment
<i>Organizational Role</i>	Team Coordinator	Negotiating a learning program; time-tabling of learning activities and tasks; clarification of procedural rules and decision-making norms.	

Table 1. Potential roles of teachers in online teaching
(source: doctoral thesis – in preparation)



During the realization of the project V-NAST2019, there were teachers who believed that technology had no influence on their teaching and that it only served to convert written material into visual material. For other teachers, depending on the subject matter, new roles have emerged and are presented in Table 1.[4,5]

The final course of this project was a one-on-one mentoring program that enabled teachers to learn from each other, but also a constant connection with the mentor. The impression of most teachers who have realized the online version of their teaching is that the first year of online teaching is very similar to the first year of teaching, in general.

Technology Support to Hybrid Learning

Although online teachers often point out that the focus of online learning is the teacher rather than the computer, technology systems are clearly an important component for online teaching. Computer hardware, software, and connectivity are basically the benefits of online or hybrid learning, just as are classrooms and school buildings. These tools not only provide information and data for program management, but also help teachers become more innovative and efficient in their work.[6] In any case, the goals of education should determine the choice of technology.

To date, many studies have been made regarding the flipped classroom approach. There are many success stories in which the flipped classroom has successfully encouraged student motivation in learning activities. In this case, students have a greater obligation to learn independently as well as the opportunity to manage a video lecture outside the classroom.[7] In addition, through flipped classroom activities, students can establish interaction with the lecturer by providing instant feedback and corrections within given tasks. Today's internet speeds, even with minimal hardware, are sufficient for timely and smooth communication. Students also have the opportunity to follow online classes through developed mobile applications on their mobile devices. Also, through the same applications, they could post comments and questions on discussion panels. Answers were usually posted by the teacher, but it happened that the students themselves posted answers to each other's questions.

From the point of implementation, many LMS platforms were considered for the project. Among the most commonly used are: Blackboard Learn, Brightspace, Edmodo, Google Classroom, Moodle, Docebo LMS, Articulate Storyline, Sakai, Talent LMS. For the implementation of this project, three platforms were considered: Moodle, Google Classroom and Canvas LMS. The selection was determined on the rating basis displayed on the "TrustRadius" website (presented in Fig. 2). The strongest selection criterion was the availability of a free version.

Figure 3 shows a comparative view of the three selected platforms. The criteria by which they are compared relate to content creation, content management, creation and evaluation of tests, evaluation and assessment of student papers, teaching management, collaboration tools, student and teacher portals, as well as opportunities to monitor student progress and course analysis.



Fig. 2. LMS rating according to TrustRadius.com (source: <https://www.trustradius.com/learning-management-lms>)



Fig. 3. Comparative rating review of selected LMS platforms (source: <https://www.trustradius.com/compare-products/canvas-vs-google-classroom-vs-moodle>)



3. THE CANVAS LMS PLATFORM

The Canvas LMS platform is on the rise and one of the most popular at all levels of education. World research shows that a large percentage of high schools and universities (mostly based on American soil) are increasingly switching to this platform. [8,9,10] The possibilities this platform offers are really impressive. The following figures show the basic processes of creating an online course with Canvas. For lecturers new to teaching in Canvas LMS, we have provided essential resources so they can create an account, create a new course, add content to the course, etc. The flowchart in Fig. 4 visually explains the process how teachers create and log into a Canvas account.

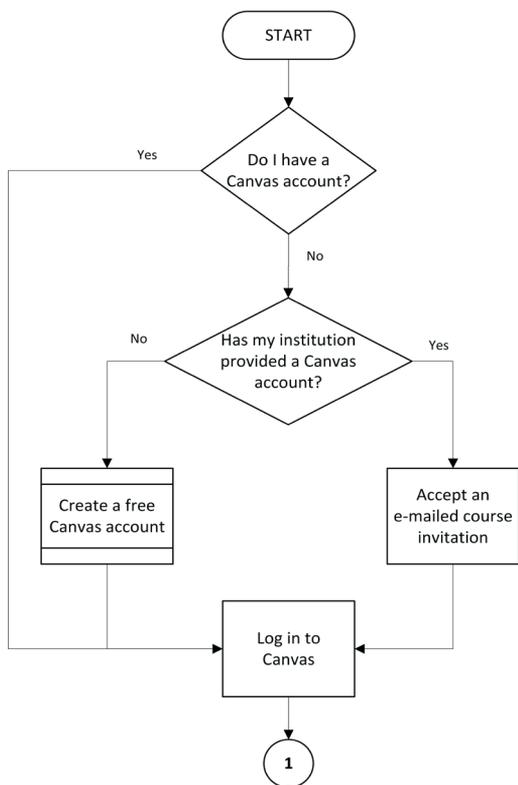


Fig. 4. Creating an account and logging in to Canvas

When logged into a Canvas account, teachers access exist-ing courses, create new courses and content. Creating content assumes creating text, audio/video material, presentations and other type that relate to lectures, tutorials, procedures, etc. The process of creating a new course is presented in Fig. 5. If a course has been setup earlier and taken over by a new teacher it should undergo a checkup in order to determine whether it should modified/updated with new material.

The process is illustrated in Fig. 6.

For the project V-NAST2019, we have developed a 10-step setup for developing and publishing a course using CANVAS LMS:

1. *Settings* – with Canvas there are options for customizing course settings by adding display names, profile images, and/or changing time zones.
2. *Notifications* – allows teachers to tell the system what information they want to be sent outside of Canvas, how often, and where.
3. *Accessing a Course* – when teachers log into Canvas, they can access their courses under the Course Menu. Also, they could find other courses they have been scheduled to teach.
4. *Syllabus* – this is where teachers post a course description, a brief introduction, class guidelines, weekly reminders, as well as other important information. Usually, we have recommended using the syllabus as the home page of the course.

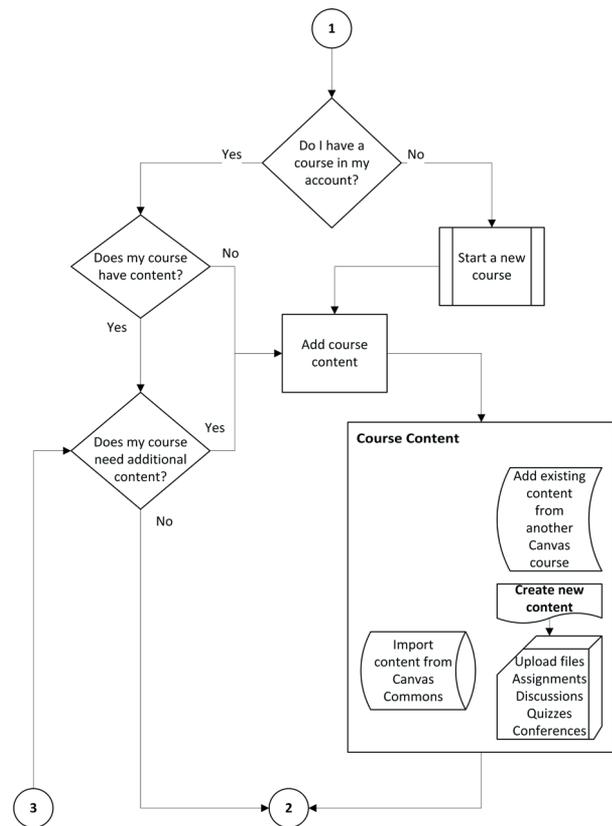


Fig. 5. Starting/Editing a course

5. *Assignments* – should be named, provide task content, a due date and total points if possible. Extra credit assignments can also be defined so they can be calculated as extra points.



6. *Modules* – modules represent a learning unit, but teachers can also break their course into Chapters, Weeks, Sections, etc.). The module usually consists of items and content. Items can be quizzes, assignments, discussions and the content itself (the lecture – one or more), such as PowerPoints, Word documents, webpage links, or texts and videos and content links (web pages within Canvas).

10. *Publishing* – to see the course online and make it accessible, it's status has to be set to Publish. Drafts and unpublished items will not be published by publishing the course. These must be published individually.

4. CONCLUSION

The realization of a hybrid learning environment for the subject CAD2, results in evidence that supports the advantages of blended learning in higher education, as well as positive effects on student engagement and achievement. This type of learning provides students with the opportunity to learn in a variety of ways. From the analytics provided by the Canvas platform, it is clear that students approach learning material when it suits them best. Although most students fulfilled their obligations regularly and on time, there were a minority that did not. Moreover, it would be naive to expect 100% of students to complete their online course assignments on time.

Students had the most positive comments regarding engagement, especially about the quality of classroom utilization. It has been noticed that classroom activities activate thinking at a higher level. As basic elements of modeling have been mastered at home, students had enough time to engage in some research in product modeling. In addition, the online environment has allowed students to stay at higher levels of Bloom's taxonomy for extended periods of time.

The first generation of 40 students attended a hybrid learning class of CAD2. Compared to another similar subject (CAD 1, in the traditional class), students ranked the hybrid CAD2 slightly higher than traditional. The comparison is shown in Table 2 and evaluated according to the Likert scale.

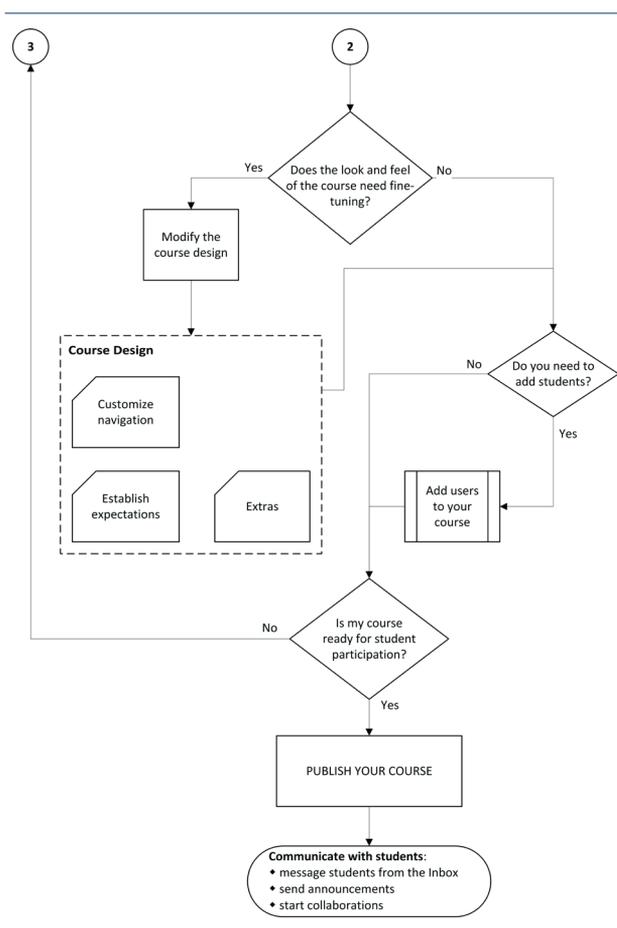


Fig. 6. Modifying the look and feel, adding students and publishing the course.

7. *Course Navigation* – navigation should be simplified for students by hiding unneeded navigation links.

8. *Homepage Layout* – the homepage of the course can be customized, by creating a unique page, or using the Syllabus, Modules, or Assignments as the homepage.

9. *Testing the course* – prior to publishing the course, teachers are advised to test their course as a student. The Student View option enables a full test.

	Online	F2F
Does the course meet the set goals	3,90	3,74
Feedback from instructor	4,00	3,73
Community building with classmates	3,62	3,50

Table 2. Students' evaluation of online and traditional course

Compared to previous generations (generations that attended CAD2 in a traditional manner (F2F class), the generation that attended the hybrid class CAD2 mastered the material faster and at a much higher level.



For example, the generation attending the hybrid learning course has acquired certain skills and knowledge for modelling complex virtual 3D models already by the fifth week of the course, whereas previous generations could do the same but end of the course.

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REFERENCES

- [1] S. Carretero, R. Vuorikari, Y. Punie, "DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use," DigComp 2.1, no. EUR 28558 EN, 2017.
- [2] N. Balacheff and S. Ludvigsen, "Kaleidoscope Impact and lessons learned," 2007.
- [3] Editor and L. Daniela, *Didactics of Smart Pedagogy*, Springer Nature Switzerland AG, 2019.
- [4] Z. N. Khlaif and S. Farid, "Transforming learning for the smart learning paradigm: lessons learned from the Palestinian initiative," *Smart Learn. Environ.*, vol. 5, no. 1, 2018.
- [5] D. Radakovic, "Teacher Competencies in Technology Enhance Higher Education", PhD Thesis, working material, unpublished
- [6] J. Watson and B. Gemin, "Management and Operations of Online Programs," *Promosing Pract. online Learn.*, no. April, p. 27, 2009.
- [7] R. S. Davies, D. L. Dean, and N. Ball, "Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course," *Educ. Technol. Res. Dev.*, vol. 61, no. 4, pp. 563–580, 2013.
- [8] J. F. Gomez, "Higher Education Faculty Use of a LMS in F2F Classes," *Disertation Thesis*, California State University, 2015.
- [9] G. Pillsbury, "2018-19 LMS Evaluation - Phase II , Part 1 : Canvas," 2019.
- [10] E. Werth, "Studying Student Experience Online," 2018. [Online]. Available: <https://community.canvaslms.com/groups/higher-ed/blog/2018/02/16/studying-student-experience-online>.



POSSIBILITIES OF THE APPLICATION OF THE SOFTWARE FOR WELDING IN VIRTUAL REALITY ON THE WELDERS TRAINING

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Abstract:

Welding in virtual reality is an artificial, computer generated, environment where the welder is located with a goal of the successful realization of the welding process. This process should be ended with a best derived welded joint for the given conditions. The main idea of the following type of software is to focus on the training of future welders. During the training, a great amount of energy is consumed, and hazardous radiation, fumes and gasses have an effect on the health of the welder. Therefore, the application of the software for welding in virtual reality allows a great saving in material and energy, moreover, it reduces or eliminates all harmful effects of the welding process. This paper elucidates all the possibilities of the application of one software for welding in virtual reality called "Hyperwelder". The focus is the analysis of the two parts of this software that refers to the welding training, and the simulation in workshop conditions. It is indicated on the possibilities of the software, its advantages and disadvantages, and further development in the way of welding in more real working conditions. Summarizing all the benefits that welding in virtual reality brings, this way of training will most certainly become obligatory in every training process.

Keywords:

virtual reality, welding, simulation, welders training.

1. INTRODUCTION

Welding is a procedure of joining two or more materials using the mechanical energy, heat, or using both the mechanical energy and heat. The result of this process is to obtain one solid piece with a minimum of imperfections [1]. Finally, in the last century, the welding process has spread throughout many branches of industry, and therefore, it became unavoidable.

With this acknowledgement, whole engineering world must be aware of the paramount value of the safety, risks and health of welders. A workplace of the welder can be the hull of the ship, over the tall bridge foundation, and, for instance, inside the long, dark, pipeline. Having said this, intrinsic job of the engineers is to make their job as easier as possible, and to try to reduce an impact on their life. With the development of the information technologies came the opportunity.

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The large welding companies embraced the chance of the development of VR (virtual reality) software focused on welding procedure. The goal of the virtual reality is the accomplishment of the total immersion of the user [2]. Therefore, the experience that user is exposed to, has to be tantamount convincing that the user forgets that he is in an artificial environment. Not only that he has to forget, but also, he has to start acting naturally, as in the real world. The environment where user is located is an artificially made environment [3]. If the goal is the complete virtual experience, the user will use additional equipment such as: headsets, gloves, tracking system, etc. Last but not least, their connection and synchronized work is the final step in this experience.

2. VIRTUAL REALITY WELDING

Welding in virtual reality is an artificial, computer generated, environment where the welder is located with a goal of the successful realization of the welding process. This technology is the ideal solution for the welders training, as he or she develops a feeling of affiliation to the artificial environment. Moreover, this environment can be diverse, from the workshop and the welding of the simple sheets, to the welding simulations of the real, field jobs. The separation and the connection of the real and virtual world is presented on the Fig.1.

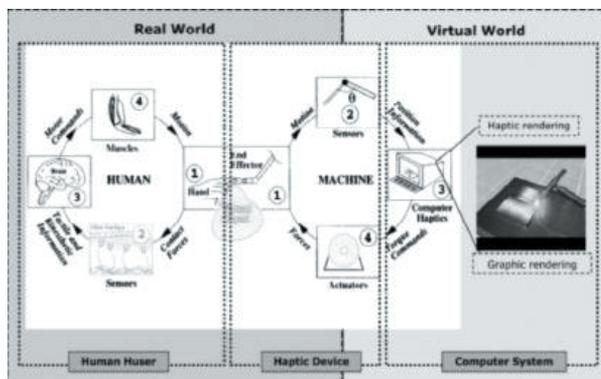


Fig. 1. Functional scheme of one VR software [4]

The terminology of the real world defines the human user with its receptors and actuators [5]. On the other hand, the virtual world includes the whole computer system. The essential part of this complex system is the one that connects both of these two worlds, and this part is named a "Heptic device". Accordingly, it can also be called a kinesthetic communication part of the system [4].

The welder, while he works in a simulator, holds a real, physical welding gun, and next to him is situated a real welding machine. The welder can use this machine for the adjustment of the welding parameters.

The application of this system of education and evaluation of the welders is significantly present in the great, international, manufacturing companies. These companies have their training centers, with the adequate training spots, and competent personnel.

Furthermore, the paramount part is the storage warehouses for the base and filler materials. For the identical training spots, the welding in virtual reality provides astonishingly more welding spots. This kind of the training procedure presents a simple and safe type of the welding procedure, where welders are not exposed to toxic vapors and gases [4].

Fig. 2 presents comparison of the real welding training workshop, and one classroom for training in virtual reality.



Fig. 2. Comparison of the real-life welding workshop and the VR welding classroom

The advantages of the use of this virtual reality softer are numerous. The great monetary savings, savings in the material and energy, the absence of the fumes, gases and vapors, the absence of the possible injuries, ergonomic workspace, simple storage of the welder's data that refers to working hours and results.

3. APPLICATION OF THE HYPERWELDER SOFTWARE

The experimental part of this text will present the application of the "Hyperwelder" software for welding in virtual reality.



The idea of this software is one simple, user friendly, software model, and the presentation of the welding process to the people that have a dearth of information on this topic [6].

The application of this software is potentially wide. It can be used by any novice, but also it can be used for the certification of the welders, and last but not least, for the presentation in the schools and universities.

As a working place, any room equipped with the computer, software, and hardware (headset, controllers, tracking system) can be used. The working place must be defined with the dimensions that are integrated in the software. The tracking system is the simple arrangement of two or more infrared cameras that are easily tracking the position of the user in space [6].

4. EXPERIMENTAL PART

Software structure

Generating of the software allows the user to access the home screen, which is presented on the Fig. 3.



Fig. 3. Home screen [6]

The home screen sets three options that user can choose. Following entities are the main components that software is composed of. They are:

a) Welding training – This part is designed for the users that are, for the first time, connected with the welding process. By selecting this part of the software, the user is introduced to the main welding positions, gun movement, and the whole idea is based on the gamification of the welding process. At the end of the process, welders are focused on the final accomplishment that can be upgraded later on.

b) Setup scene – This part of the “Hyperwelder” software positions the user in one virtual workshop.

The scene requires from the welder to complete one fillet welded joint, on one part made of constructional steel. The welder is situated in the workshop environment, and he holds in his hand one GMAW (Gas Metal Arc Welding) gun. At the end of every completed joint, user can examine his work, moreover, the user can understand the quality of the job.

c) Welding simulation – This is the third, and the most complex part of this software. The user is situated in one realistic welding environment like pipeline welding, reservoir welding, etc. This part of the software is not fully functional; however, it presents the final phase of the welding process in virtual reality. The user can approach to this part of the software after the successful realization of the first two parts.

Welding training

After the decision to participate in this part of the software, the user finds himself in one abstract environment. In front of him appears the structure that has to be “welded”. On the structure, users can locate the weld that is presented with a red coloured line. If the user intends to complete this job, it is obligatory to follow that line, as it is presented on the Fig. 4.

The quintessence of the whole software structure is one gaming platform, moreover, accomplishment of the levels with successful production of one welded joint [6].

Depending from the welding position, the user collects points, and passes several levels. At the end of the process, the user can have a full insight of the achieved result.

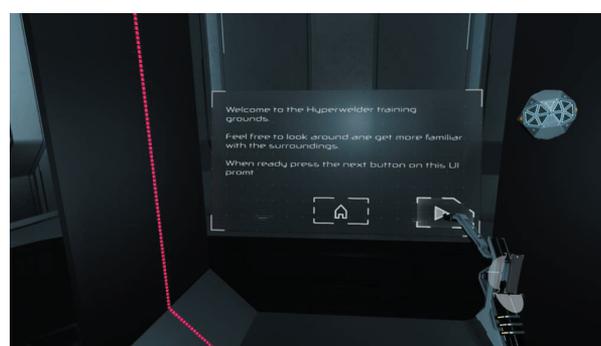


Fig. 4. Slide selection with the control of welding pistole [6]

After the introduction with the software, in front of the user reveals the ghost. The user has to approach to the ghost for the kick off of the welding process. After the suitable positioning of the gun, the user presses the button on the controller, and the welding process starts.



The user follows a blue circle that leads the welding process. This circle follows the improvised joint, with the adequate speed, during the welding process.

Material selected for the selected job is the structural steel. Accordingly, thickness of the material is 5mm, and the welding speed is 28 cm/min [6]. If the colour of the welded joint turns to be green, welding process is regular. On the other hand, various shades of yellow and red are suggesting that the welder is making some mistakes and imperfections are occurring, which is presented on the Fig. 5. This is caused by the inadequate gun position, or the exceptions in the welding speed. The user can stop the welding process at any moment he desires. The user can analyze his score, and the only requirement for the advance of this process is to approach the spot where the welding process is stopped. The preview of the welding process after the break is presented on the Fig. 6.

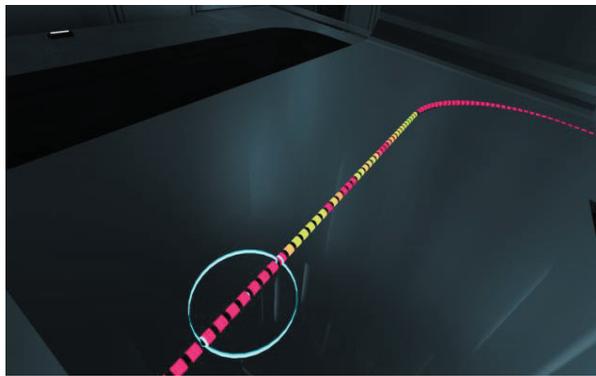


Fig. 5. Close look at one joint with the mistakes (imperfection)



Fig. 6. Stopped welding process with a look on the overall score and welded joint [6]

After the successful accomplishment of the first level, the horizontal welding position, software's marks the beginning of the second level. The complete result is presented in front of the user, and the new ghost is generated, Fig. 7.

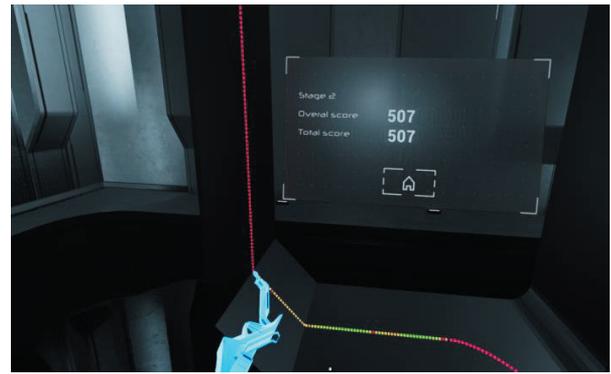


Fig. 7. The end of the first stage with the overall and total score [6]

The second level leads the user through the vertical welding position, which is inherently more complicated. After this level, the user has an insight on the welded joint made in the both levels. The screen in front of the user provides him the information that refers to the achieved result, and the cumulative result made on both levels.

Superseeded level is the most demanding part of the training. That is the overhead welding position. This level leads the user through the overhead contour of this joint. The welding directions are also imported as variables, so the user can be introduced to all the difficulties that this position dictates. The Fig. 8 presents the part of the overhead welding process.

At the accomplishment of this part, in front of the user is presented his complete work. Along with that, the user is introduced with the result he achieved, and the best result ever made in the training, Fig. 9. At the end, the user can decide his future steps between the homescreen and one more training simulation.

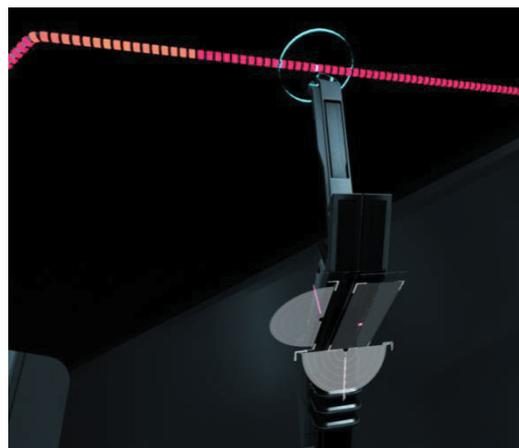


Fig. 8. Example of an overhead welding process [6]

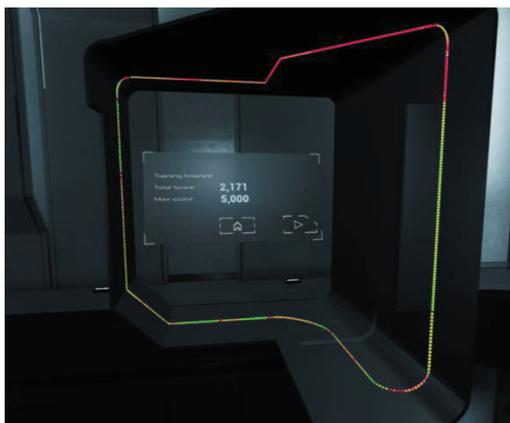


Fig. 9. One completed welding training with the information about total and best score [6]

Welding simulation in a workshop environment

After the selection of this part of the software, on the main screen the user finds himself in one workshop environment. In front of the user is one work desk, on which one two metal sheets are located. These sheets are forming one fillet joint. Depending on the real room, in the real world, the movement is correspondingly limited [6]. The essential factor is the movement of the user around the work desk; therefore, the other components are there just for the cosmetic purpose. The greater immersion is possible with the combination of the different sensory entities, such as lathe, radial drill, etc. This environment is presented on the Fig. 10.

In this simulation, the user holds the GMAW gun, and the spot where welding needs to start is marked with a pointer. This pointer is a green arrow; moreover, the user can see a message that says “Please start here”, as the Fig. 11 prominently present.



Fig. 10. Workshop environment [6]



Fig. 11. Welding gun with the marked beginning point [6]

As the user approaches the starting point, he can notice the main disadvantage of this part of the software. The welding process starts with the pressing on the button of the controller/gun. However, in the realistic world, in front of the welder there is no table, nor work-piece. Therefore, the sense of touch is excluded, and one human sensor response is excluded. The user is relying on the eyesight and his personal feeling where the work-piece actually is. This can lead to the loss of the most intrinsic part - immersion, because the users feeling of the welding position is lost. While leading the gun, it can move far away from the joint, further more, the user can penetrate, physically, through the joint.

Designers can overcome this problem, with the positioning of the realistic table in front of the user. Furthermore, a sample of the real fillet joint is an interesting solution for this problem. If this can sort the problem with the loss of the immersion, it will be the perfect solution. One more disadvantage about this part of the software is the visual aspect of the virtual experience. When the welding process initiates, there is no blackout, which presents the effect of the welding mask. The user is exposed to the welding arc, which is in the real world strictly forbidden [7]. This problem is presented on the Fig. 12., and the most reasonable solution for this problem is the initiation of the blackout as soon as the welding process starts.



Fig. 12. Initiation of welding process with no blackout

After the realization of the one joint, the user can see how one welded joint looks like. The finish of the process orders to the software to comprehend all the data collected. The data is considering the position of the gun, and the welding speed, the factors that the user learnt in the training part. The results are presented on the diagram, which is constituted from the two variables – joint length and the penetration. An example of the diagram can be seen on the Fig. 13. For the previous example, the red line presents maximum values of variables, and the green one the minimum values. At the end of the welding process, the goal of the user is to be in the middle between these two lines [6]. If the yellow line, the process line, is under the minimum line, the welding speed was too fast, and it is more than participated. On the other hand, if the line is over the red, maximum line, the speed is under participated. So, the yellow line between these two lines presents the job well done.

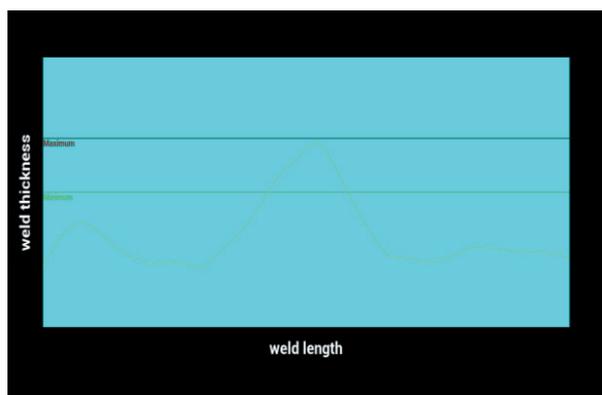


Fig. 13. Welding simulation - graphical feedback [6]

5. CONCLUSIONS

All the softwares for welding in virtual reality have only one goal, and that is the improvement of the working conditions during the training for the future welders. This training requires a significant number of training hours, within which the welder must be provided with the: qualified instructor, safe welding equipment, and material supplies. During the training process, a great amount of energy is consumed. Indubitably, not only this will occur during the real training, what follows the welding process is: the hazardous radiation, vapors, and gases which have a huge effect on the health of the welder. The training facilities, that are conducting the training process exclusively with the conventional welding technique have a worryingly big amount of waste material. The usage of the welding simulators reduces this waste, and with that comes the eco-friendly effect on the human environment and resources. The presented prototype lacks many features, but the constructed platform is more than well starting point for the further development. The initial improvements will be focused on the first two parts of the software – training and the workshop environment simulation. The goal will be the improvement in the field of the immersion of the user. Understanding all the needs and fastidious work will most certainly lead to the construction of the software with the solved problems. The sense of touch must be involved, and the blackout of the mask is an imperative. The full immersion of the user is the aspect that must not be lost. With the perfect realization of these two parts comes the opportunity to start the development of the last part, and that is the welding simulation. Summarizing all the benefits that welding in virtual reality brings, this way of training will, surely, become obligatory in every training process.

ACKNOWLEDGMENT

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REFERENCES

- [1] O. Popović, R. Prokić Cvetković, *Postupci zavari-
vanja*, Faculty of Mechanical Engineering, Belgrade,
2016.
- [2] [https://www.vrs.org.uk/virtual-reality/immersion.
html](https://www.vrs.org.uk/virtual-reality/immersion.html)
- [3] [https://www.vrs.org.uk/virtual-reality/what-is-vir-
tual-reality.html](https://www.vrs.org.uk/virtual-reality/what-is-virtual-reality.html)
- [4] R. Ajith Benson, V. L. Krishnan, [https://www.re-
searchgate.net/ publication/305174345_ Virtual_
reality-based welding training_simulator](https://www.researchgate.net/publication/305174345_Virtual_reality-based_welding_training_simulator)
- [5] [https://www.vrs.org.uk/virtual-reality/what-is-vir-
tual-reality.html](https://www.vrs.org.uk/virtual-reality/what-is-virtual-reality.html)
- [6] M. Dujović, Master thesis – *The development of the
software for welding in virtual reality* – “Hyperwelder”,
Faculty of Mechanical Engineering, Belgrade, 2019.
- [7] V. Lazić, M. Jovanović, *Tehnologija livenja I zavari-
vanja*, Faculty of Engineering, Kragujevac, 2015.



PROTOTYPE OF A MICRO MONITORING STATION WITH REMOTE TORRENTIAL FLOOD ALERTS

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Abstract:

The Internet of Things (IoT) enables the gathering and exchange of data between a multitude of electronic devices. Collected data then can be centrally stored and analyzed, and furthermore, the obtained results can be used for processes automation and timely decision making. These basic principles of IoT can also be applied upon an early warning system for torrential floods, with the aim of protecting people, livestock and property. The basic building block of this system is an automated micro monitoring station (AMMS) based on an Arduino microcontroller with sensors for reading of targeted physical quantities and with a power block allowing autonomous functioning. The AMMS prototype presented in this paper possesses compact dimensions, simple enough and modular architecture, reasonable production price, and thus may prove to be an effective tool for monitoring of torrential streams, which usually occur in remote and inaccessible mountainous areas where standard monitoring stations of the official Hydro-meteorological Institute cannot be set up due to technical or economic reasons.

Keywords:

Internet of Things, Automatic Monitoring Stations, Torrential Floods, Early Warning System, Arduino Flood Detection

1. INTRODUCTION

At the territory of the Western Balkans (WB), representing states formed by the disintegration of the former Yugoslavia and Albania, floods occur on regular basis as a result of seasonal snow melting and heavy rains, most damage causing to agriculture, roads and infrastructure. Due to the characteristic relief of the WB, torrential floods as short-lived but turbulent events originating in the upper parts of the river basins are becoming increasingly frequent, causing significant material damage and loss of lives [1, 2, 3].

The hydrological situation is monitored by the Hydro-meteorological Institutes on all major watercourses, Figure 1. However, due to technical and economic limitations, the floods monitoring network does not cover remote mountainous areas prone to sudden torrential waters, as may be evident in Figure 2.

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Over the last 20 years, the consequences of floods in the region have been intensively monitored and analyzed, with a special focus on the catastrophic events of 2014, Figures 3 and 4, on the basis of which each country developed appropriate flood risk maps.



Fig. 1. River basins network in Serbia [4]

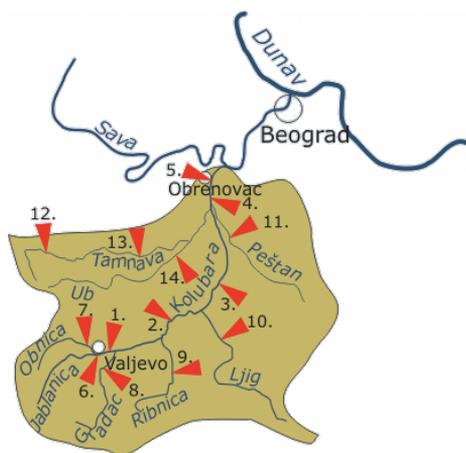


Fig. 2. Surface water station network - The Kolubara river basin [5]

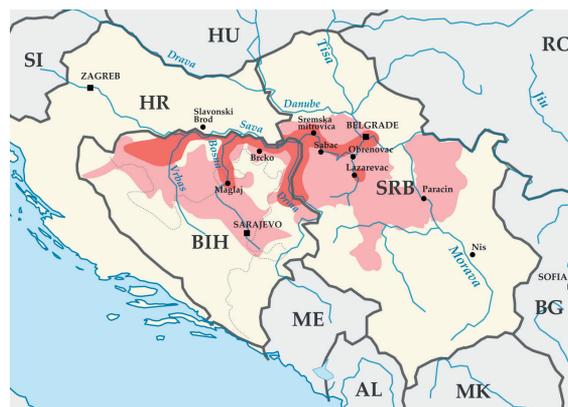


Fig. 3. Floods in the West Balkans, affected territories in 2014 [6]

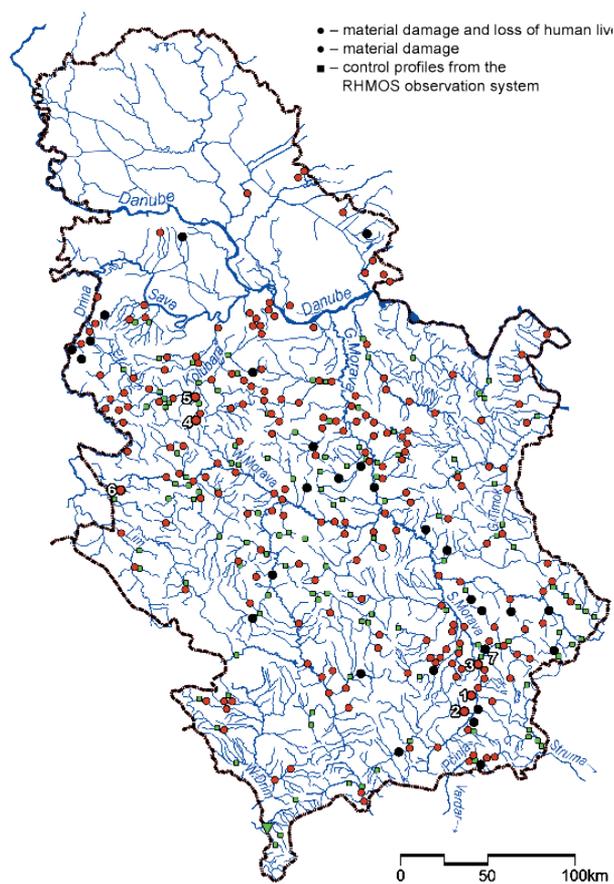


Fig. 4. Catastrophic torrential flood events in Serbia (1950-2010) [7]

2. USE OF IOT IN THE COURSE OF FLOODS

The Internet of Things (IoT) enables the gathering of data and their exchange between a multitude of sensors, electronic devices and applications. A large amount of data collected this way, can subsequently be analyzed



and used to automate day-to-day activities, including decision-making processes [8]. Eventually, integrated systems consisting of computers, microcontrollers, sensors and specialized software can make life easier for an ordinary person, empowering remote control of household appliances (e.g. heating and air conditioning, security systems and alarms, home automation), automation of agricultural production and the like. The application of such technology requires well-developed communication infrastructure and good coverage of the GSM signal, which is a prerequisite already met by all the countries in the Western Balkans.

The same technology can be applied in terms of protection of the population, facilities and infrastructure from natural disasters by observing the critical locations and remotely reading relevant parameters. The collected data is then analyzed, and in case of exceeding the pre-set limits, alarm activation and other actions can be taken.

Although this problem is in the focus of many researchers, primarily the possibility of use of microcontrollers, such as the Arduino, to monitor water levels [9] or to perform video surveillance of flooded areas [10], commercial systems available on the market are mostly intended for use in individual households as basement flood detectors.

3. ARDUINO BASED MICRO MONITORING STATION

Generally, the basic tasks of a flood protection system are:

- ♦ monitoring of water level and other critical parameters on the given perimeter
- ♦ data processing and comparison with the preset boundary values
- ♦ activation of alarm signal, if necessary

The main advantages of the Arduino microcontroller as a base platform for projects of this type are its affordability, modularity and a number of sensors making possible reading of the appropriate parameters and their transmission via wireless network (WiFi, XBee) or via the mobile Internet.



Fig. 5. Automated Micro Monitoring Station

This paper presents a prototype of Automated Micro Monitoring Station (AMMS), based on an Arduino microcontroller, Figure 5, capable of reading the local meteorological parameters, water level and sensing ground oscillations. A limited analysis of collected data can be performed and compared with the predefined values, and in case of exceeding the preset limits, the warning can be sent in the form of a Short Message Service (SMS) message to the predefined cell phone number(s). The station is autonomous in operation thanks to built-in solar cells and batteries. All components are placed into small waterproof housing, which makes the measuring station suitable for use in remote mountainous areas, in locations that are not covered by the network of measuring stations belonging to the Hydro-meteorological Institute.

Proposed AMMS can work as a standalone unit for early warning, for example protecting a village or smaller settlement with a single torrential stream. In such scenario, custom software embedded into Arduino microcontroller evaluates readings, and in case of meeting the critical parameters, sends SMS warning to predefined phone number.

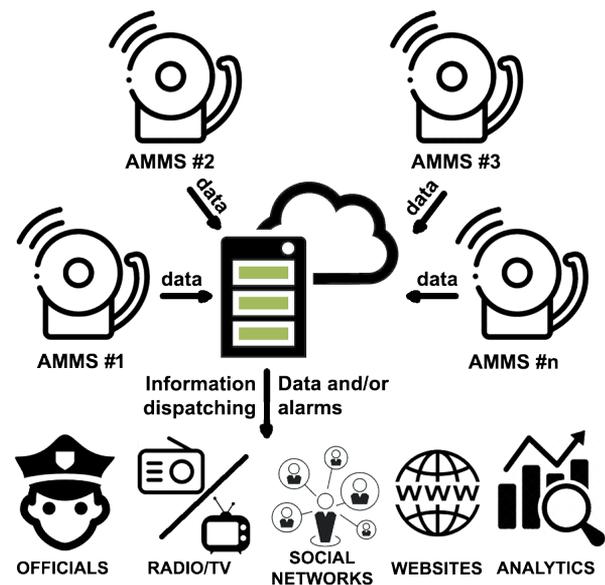


Fig. 6. Multi-AMMS early warning system, schematic representation

Two or more AMMSs may form an early warning system covering one or more torrents, or larger critical area, Figure 6. How many AMMSs the system will contain depends on the size of the observed area, the configuration of the terrain and the complexity of the river basin. In that case, the data is transferred to the central server where it gets stored and processed by custom developed web application which is tasked to perform the analytics and, if necessary, to trigger an alarm signal.



Hardware components of the AMMS

Figure 7 shows an open AMMS housing with system components. The basic component of AMMS is an Arduino microcontroller with the task of reading data from sensors. An ultrasonic sensor is used to read water levels, while a combined temperature sensor, in addition to temperature, reads air pressure and relative humidity as well. Vibration sensor module can be included into package too, in order to provide data indicating landslides. Finally, the AMMS also contains a GSM module used for messages and data dispatching.

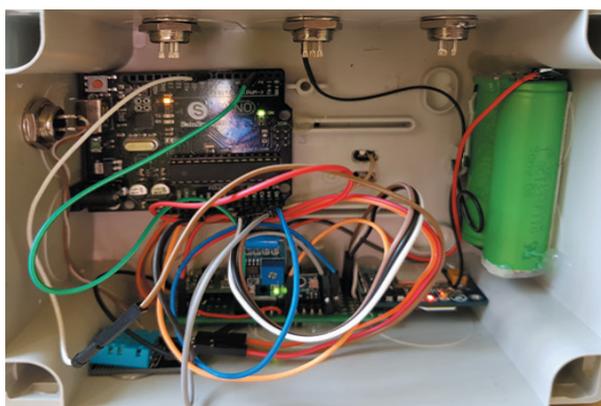


Fig. 7. AMMS, electronic components [11]

Electric power is provided by two Li-Ion battery cells charged by a pair of solar cells, making possible autonomous operation of the AMMS. Due to its light weight and modest dimensions, the AMMS can be easily transported and placed in inaccessible terrain.

In order to conserve power, AMMS is by default in the state of hibernation. The Arduino board wakes up from hibernation every 15 minutes, reads sensors, performs pre-programmed data analysis, sends message or data, and then returns to hibernation.

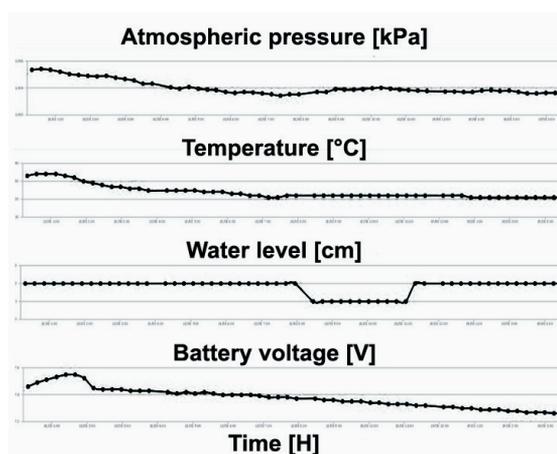


Fig. 8. AMMS, test sensor readings over 12-hour time span [11]

4. DATA MONITORING, DISPATCHING AND ANALYTICS

The AMMS via sensors takes the readings of physical quantities in the immediate environment, Figure 8, and in case of exceeding the preset boundary values, it can take preventive measures. When operating as a standalone unit, the AMMS may send alert messages to predefined cell phone numbers, Figure 9.

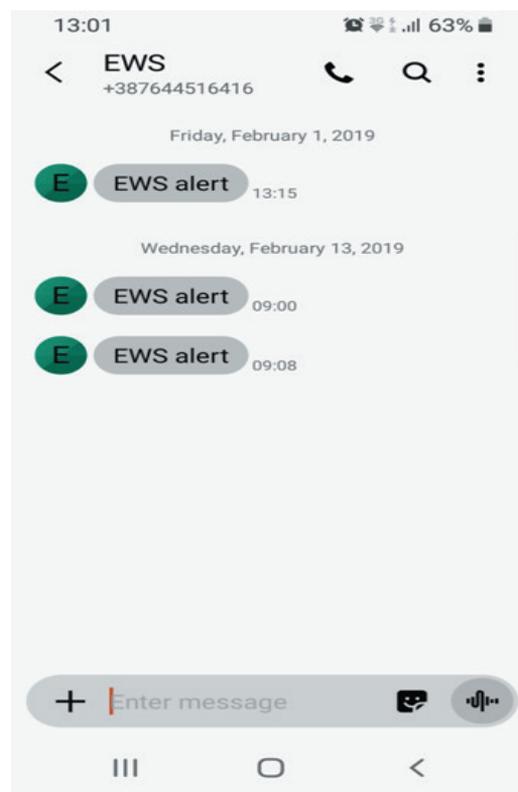


Fig. 9. Text message alert [11]

In scenario when a territory or an entire region is covered by a network of AMMSs, each AMMS converts the collected data into JSON format and sends file via mobile internet to the central web server, where data gets stored in the SQL database for further analysis.

Data control and analytical tasks are performed by a web application written in the PHP programming language, available on the public Internet domain. Processed data afterwards can be distributed publicly or through protected channels, in accordance with the level of access to information that a particular person carries within the flood defense system.

Users can access the application with various electronic devices, such as desktops, laptops, tablets or smart phones.



In case of imminent danger, the web application can trigger alarm signal or broadcast alerts to a wider public through the social networks, radio or TV stations.

5. CONCLUSION

This paper presents a prototype of an automated micro monitoring station that can be used as a standalone unit, or as a component of a larger system, with the aim of early detection of torrential flood hazards.

Due to its modest overall dimensions, simplified modular architecture, low power consumption and affordable price, the AMMS is easy to produce, transport and deploy on inaccessible terrains, where it becomes immediately operational.

Each unit contains Li-Ion batteries and solar cells allowing autonomous operation. Additional power conservation and uninterrupted operation throughout the day, in all weather conditions and seasons was achieved by setting the AMMS into hibernation by default, with periodic short term activation at regular time intervals.

In the current phase of prototype optimization, the built-in software is capable of recognizing the state of emergency in a given time span, upon which it sends warning to a predefined cell phone number.

In scenarios with multiple AMMSs operating within the system, the information is dispatched to web server for storage, further analytics, and if necessary, alert triggering.

In case of severe weather, GSM networks occasionally may become inoperative, which may affect the operation of the proposed early warning system. Data transmission in such conditions may render incomplete and / or delayed, which in turn requires additional research in terms of evaluation of electronic components and applying alternative methods of information transmission in order to improve system stability.

REFERENCES

- [1] S. Pantelić-Miralem, "Odbrana od poplava", Inženjerska komora Srbije, 2015.
- [2] V. Kolarov, M. Babić-Mladenović, "Podaci za izradu preliminarne procene rizika od poplava na teritoriji Republike Srbije", *Vodoprivreda*, vol. 42(1-3), 2010, pp. 79-86.
- [3] "Joint management of flood risks", Romania-Republic of Serbia IPA Cross-border Cooperation Programme, 2016. Available: [http://www.floodrisks.](http://www.floodrisks.rs/uploads/dokumenta/5875e2f479432Vol_4_SR_tekst_def.pdf)

- [4] "Distribution of stations on regional stations and on the basins of major rivers", Republic Hydrometeorological Service of Serbia. Available: <http://www.hidmet.gov.rs/eng/hidrologija/povrsinske/index.php>
- [5] "Surface water station network - The Kolubara basin", Republic Hydrometeorological Service of Serbia. Available: <http://www.hidmet.gov.rs/eng/hidrologija/povrsinske/index.php>
- [6] K. Glock et al., "Report on natural disasters in the Western Balkans", Development of master curricula for natural disasters risk management in Western Balkan countries, Project number 573806-EPP-1-2016-1-RS-EPPKA2-CBHE-JP, 2017.
- [7] R. Ristić, S. Kostadinov, B. Abolmasov et al., "Torrential floods and town and country planning in Serbia", *Natural Hazards and Earth System Sciences*, vol. 12, 2012, pp. 23-35
- [8] K. Schwab, "The Fourth Industrial Revolution", World Economic Forum, 2016, ISBN-10: 1944835016
- [9] V. Vunabandi, R. Matsunaga, S. Markon and N. Willy, "Flood sensing framework by Arduino and Wireless Sensor Network in Rural-Rwanda," 2015 IEEE/ACIS 16th International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD), Takamatsu, 2015, pp. 1-6, doi: 10.1109/SNPD.2015.7176210.
- [10] R.A. Santos, R.R. Guadana, "Flood detector system using Arduino", *International Journal of Management and Applied Science*, vol. 2(7), 2016, pp. 286-290
- [11] E. Šakrak, M. Dobrojević, S.A. Sedmak, "IoT based Early Warning System for Torrential Floods", *FME Transactions*, vol. 48(3), 2020, pp. 511-515, doi: 10.5937/fme2003511S.



SIMULATION OF FSO SYSTEM OPERATION IN DIFFERENT ATMOSPHERIC CONDITIONS

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Abstract:

In this paper, using simulation in the software OptiSystem 7.4, the FSO (Free Space Optical) system operating at wavelengths of 850 nm, 1315 nm and 1550 nm was observed. The influence of different levels of atmospheric turbulence and link distance on the signal transmission quality was investigated. The Q factor and BER (Bit Error Rate) were used as a measure of quality. The changes of the Q factor depending on the observed system parameters are graphically shown. Eye diagrams and signal spectrum are also given. The analysis of the results shows how the quality of the received signal changes due to different atmospheric phenomena at certain distances from the transmitter.

Keywords:

Free Space Optical - FSO, attenuation, atmospheric turbulence, Bit Error Rate - BER, Q factor.

INTRODUCTION

Wired optical networks are sometimes difficult to implement due to their complexity in installation and relatively expensive fiber technology. Therefore, they are not always a good solution, although they provide a wide range and high transmission speeds. FSO technology is a good alternative for short or medium distance transmission, especially for environments where wired optical network infrastructure is difficult to apply [1]. Compared to wired optical networks, the application of the FSO system is simpler, easier, faster and therefore cheaper. It also provides excellent data transmission security, high transmission speeds, as well as high bandwidth capability [2-5].

Beside to the various advantages provided by the FSO communication system, there are also various problems that lead to the degradation of the optical link and hinder its use. FSO systems are very vulnerable to atmospheric conditions. Since the signal propagates in free space, it is affected by atmospheric turbulence and pointing errors, which degrades system performance. Snow and rain have a significantly smaller impact on the transmission quality compared to atmospheric turbulence and fog [1,6-9].

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Atmospheric turbulence has a strong impact on the signal being transmitted and on the wavelengths of the system. Atmospheric turbulence is caused by both spatial and temporal random fluctuations of the refractive index due to changes in temperature, pressure and wind along the path of optical propagation through the channel [1,2]. Due to unfavorable atmospheric conditions, beam spreading, image dancing, beam wander, scintillation and intensity fluctuation and signal phase can occur [10,11]. This affects the FSO system performance and leads to high values of the Bit Error Rate (BER), i.e. to small values of the quality factor (Q factor) [3,12,13].

The deterioration in the FSO system performance is also greatly affected by small changes in the position of the transmitter and receiver. Many factors, such as building sway, wind loads or thermal expansion, can cause a misalignment, leading to pointing errors and signal fading at the receiver. All these factors are essential when planning a FSO system and therefore must be considered [6,14,15].

In this paper, the impact of weather conditions, i.e. atmospheric turbulence and link distance on the transmission quality in the FSO system is investigated. The Section 1 presents a system model that is analyzed in an OptiSystem environment. In the Section 2, the obtained simulation results for different wavelengths and distances between transmitter and receiver, as well as

for attenuations caused by the impact of different atmospheric phenomena, are graphically presented and discussed. The Section 3 is the Conclusion.

1. SYSTEM MODEL

The system model used for the simulation in the software OptiSystem 7.4 [16] is given in Fig. 1. At the input of the observed system are Pseudo-Random Bit Sequence (PRBS) and NRZ (Non-Return to Zero) Pulse Generator that are fed together to the Mach-Zehnder Modulator. The binary sequence of pseudo-random bits generated in the PRBS Generator passes through the NRZ Pulse Generator where that bit sequence is converted into electrical pulses. The pulse thus obtained and the signal from the source modeled by the CW (Continuous-wave) Laser are modulated in a Mach-Zehnder Modulator. The output thus obtained is an optical signal of variable intensity in accordance with the input electrical signal. A modulated optical signal is fed to the input of the component representing the FSO channel, where attenuation values due to atmospheric influences can be entered. The Optical Receiver with Cutoff Frequency = $0.75 * \text{BitRate Hz}$ is located on the receiving side, and a BER analyzer is connected to it, which is used to read the measured parameters.

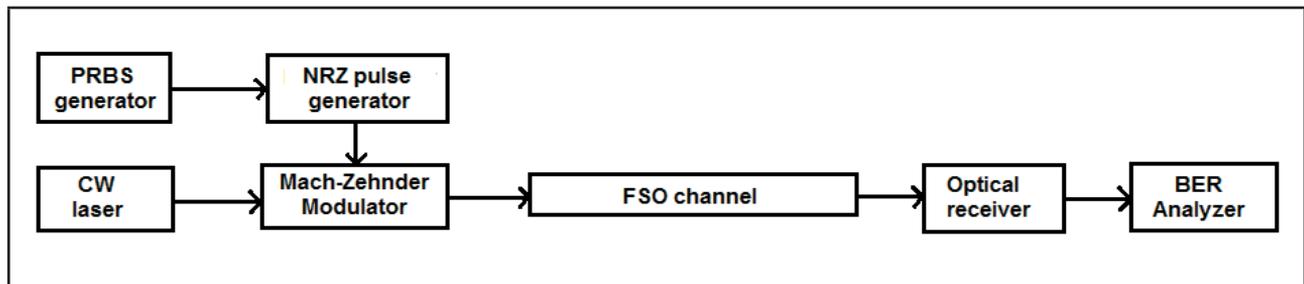


Fig. 1. Block diagram of the system model.

The system was simulated with a transmitter power of 10 mW and at wavelengths of 850 nm, 1315 nm and 1550 nm. The transmitter and receivers aperture diameter are 5 cm and 7.5 cm, respectively, while their losses are 1.8 dB each. The beam divergence is 2 mrad, while the other additional losses are 1 dB.

The analysis was performed for different FSO link distances of 500 m, 1000 m, 1500 m and 2000 m, as well as for attenuations from 0 dB/km to 40 dB/km. Attenuation in this range is caused by the impact of various atmospheric phenomena such as clear weather, haze, rain, fog whose attenuations are given in Table 1 [7,8].

Attenuations in case of clear weather or light haze can be classified as weak turbulence, fog, light rain and very light fog in the category of moderate turbulence, while moderate to heavy rain and fog belong to the category of strong turbulence.



Table 1. ATTENUATION AT DIFFERENT ATMOSPHERIC PHENOMENA

Atmospheric phenomena	Attenuation [dB/km]
Very clear	0.19-0.47
Clear	0.54-0.6
Light haze	1.1-2
Haze	3.1-4.6
Light rain	6.27
Moderate rain	9.64
Heavy rain	19.28
Light fog	6.6-18.3
Moderate fog	28.9
Heavy fog	75

2. SIMULATION RESULTS

Fig. 2, Fig. 3 and Fig. 4 show the behavior of the Q factor versus attenuations caused by different atmospheric phenomena and for different distance lengths between transmitter and receiver, at wavelengths of 850 nm, 1315 nm and 1550 nm, respectively.

From the given figures it can be seen that the transmission is of high quality in clear weather, as well as when the haze is weaker or somewhat stronger, since the value of $Q > 5.5$ is necessary for quality transmission. In light and moderate rain, as well as light fog, quality transmission can be achieved at a maximum distance of 1000 m at a wavelength of 850 nm. Under the same conditions at a wavelength of 1315 nm, the transmission will be correct even at slightly longer distances than 1000 m, while in the case when the wavelength is 1550 nm, the transmission quality will be good up to 2000 m.

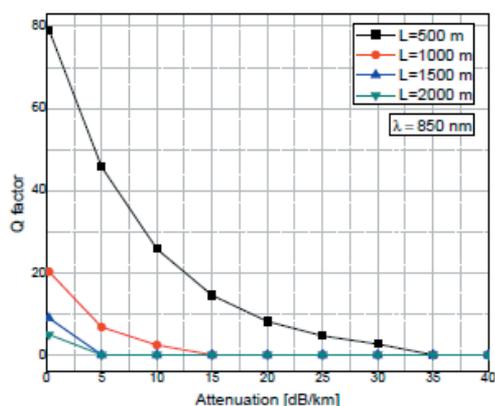


Fig. 2. Q factor for different FSO link distances at a wavelength of $\lambda = 850$ nm.

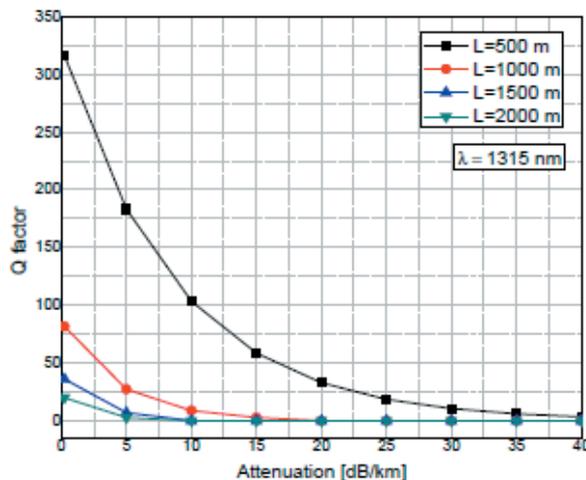


Fig. 3. Q factor for different FSO link distances at a wavelength of $\lambda = 1315$ nm.

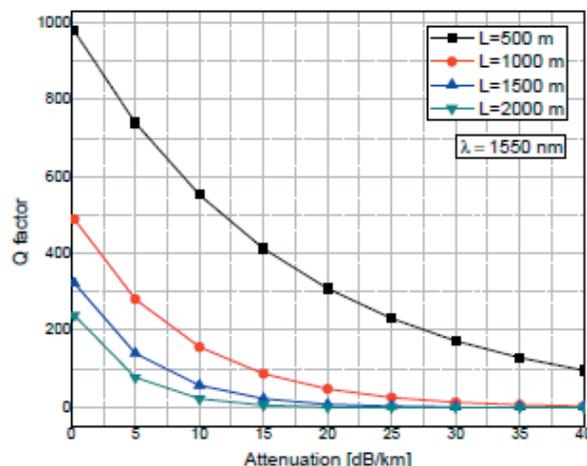


Fig. 4. Q factor for different FSO link distances at a wavelength of $\lambda = 1550$ nm.

From Fig. 2 and Fig. 3 it can be seen that in worse atmospheric phenomena, quality signal transmission is impossible to achieve at distances greater than 500 m. In order for this to be achieved, certain parameters of the system must be changed on the transmitting side, such as e.g. increasing the source power.

Based on the results shown in Fig. 4, it can be concluded that the FSO system has the best performance at a wavelength of 1550 nm, where it is possible to achieve quality transmission over longer distances, at 1000 m in almost all weather conditions, while at longer distances it is achievable for attenuations up to 20 dB/km. Also, the decrease in Q factor is more pronounced at shorter distances. As the link distance increases, the decrease in the Q factor is less pronounced.



Table 2 shows the BER values of the observed FSO system at wavelengths of 850 nm, 1315 nm and 1550 nm for different values of attenuation and link distances.

BER eye diagrams for link distances L = 1000 m and L = 2000 m and attenuation caused by moderate rain

and moderate fog are given in Fig. 5 and Fig. 6, respectively. Closed lines represent sectors with BER values of 10⁻⁸ to 10⁻¹². The eye opening corresponds to the change of the Q factor in Fig. 4.

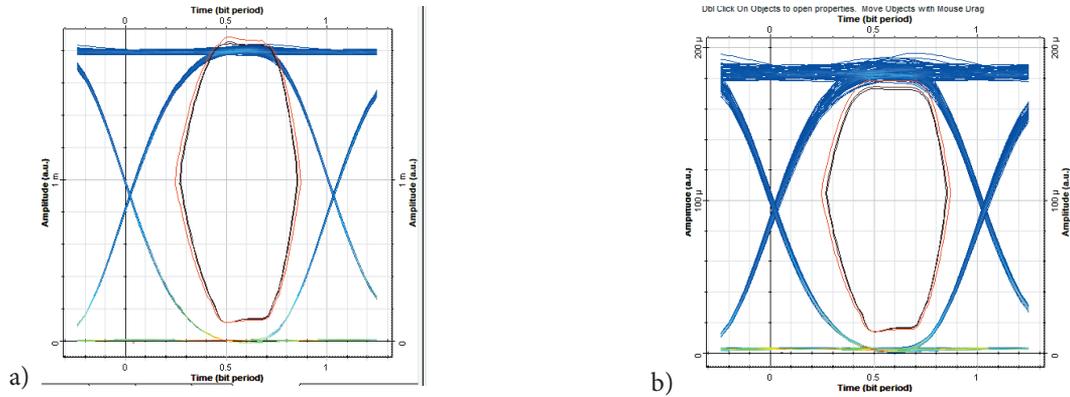


Fig. 5. Eye diagram of the received signal for the FSO link distance L = 1000 m and attenuation caused by: a) moderate rain, b) moderate fog.

Table 2. BER PARAMETER VALUES FOR DIFFERENT FSO SYSTEM CONDITIONS.

Attenuation	L = 1000 m			L = 1500 m			L = 2000 m		
	850 nm	1315 nm	1550 nm	850 nm	1315 nm	1550 nm	850 nm	1315 nm	1550 nm
0.23	1.659e-091	0	0	2.449e-019	5.905e-285	0	4.019e-007	1.344e-088	0
5	6.879e-012	7.712e-165	0	1	1.814e-012	0	1	0.00246	0
10	0.00840034	2.622e-018	0	1	1	0	1	1	3.030e-107
15	1	0.002908	0	1	1	3.289e-106	1	1	2.474e-007
20	1	1	0	1	1	4.156e-014	1	1	1
25	1	1	3.273e-136	1	1	0.007398	1	1	1
30	1	1	6.708e-036	1	1	1	1	1	1
35	1	1	2.582e-009	1	1	1	1	1	1
40	1	1	0.006945	1	1	1	1	1	1

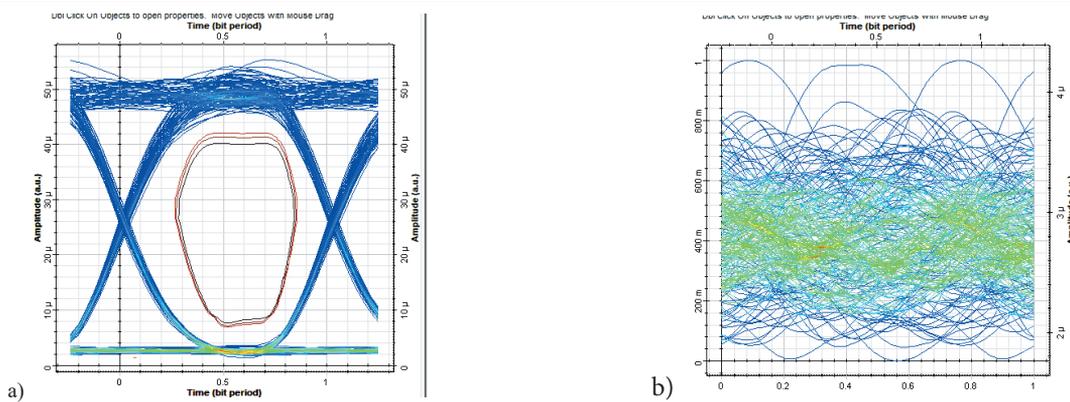


Fig. 6. Eye diagram of the received signal for the FSO link distance L = 2000 m and attenuation caused by: a) moderate rain, b) moderate fog.



Fig. 7 and Fig. 8 show a comparison of the signal spectrum before transmission and after transmission through the FSO channel at attenuation caused by light

haze and light fog for link distances of 1000 m and 2000 m, respectively.

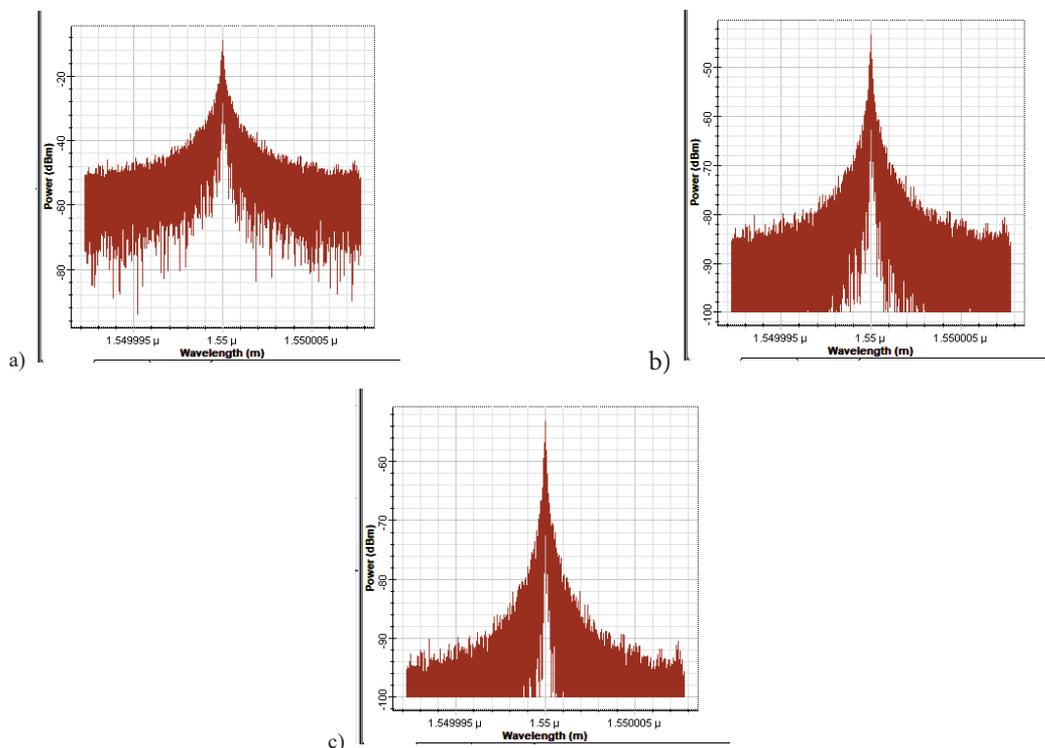


Fig. 7. Signal spectrum: a) before transmission, b) after transmission through FSO channel at 1000 m in light haze, c) after transmission through FSO channel at 1000 m in light fog.

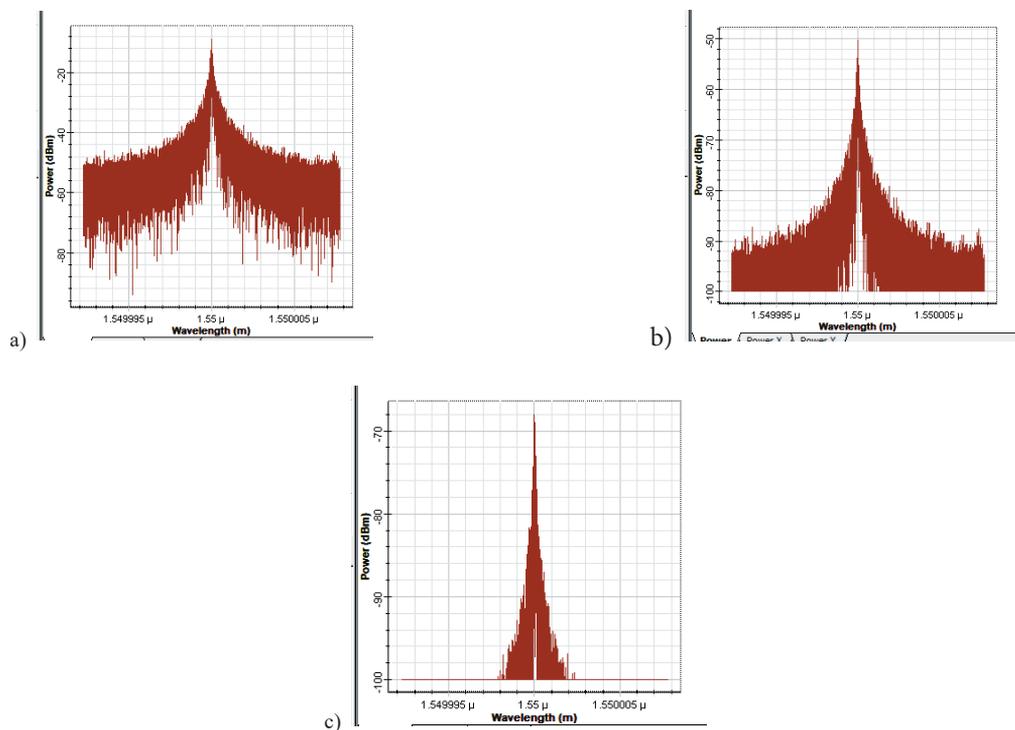


Fig. 8. Signal spectrum: a) before transmission, b) after transmission through FSO channel at 2000 m in light haze, c) after transmission through FSO channel at 2000 m in light fog.



3. CONCLUSION

By simulating the FSO system operating at wavelengths of 850 nm, 1315 nm and 1550 nm, the impact of different levels of atmospheric turbulence and link distance on the transmission quality using the BER parameter and Q factor is shown. The simulation results confirm the analytical results presented in the literature in terms of achieving transmission quality at different lengths of the transmission FSO link operating in different atmospheric phenomena. The FSO system has the best performance in the 3rd optical window (1550 nm), where it is possible to achieve quality transmission over long distances in almost all weather conditions. The decrease in the Q factor is significantly more pronounced at shorter FSO link lengths.

REFERENCES

- [1] O. Hasan and M. Taha, "Optimized FSO System Performance over Atmospheric Turbulence Channels with Pointing Error and Weather Conditions," *Radioengineering*, vol. 25, no. 4, pp. 658-665, 2016. DOI: 10.13164/re.2016.0658.
- [2] A. K. Majumdar, *Advanced Free Space Optics (FSO)*. New York: Springer-Verlag, 2015.
- [3] I. K. Son and S. Mao, "A Survey of Free Space Optical Networks," in *Digital Communications and Networks*, vol. 3, no. 2, pp. 67-77, 2016. DOI: 10.1016/j.dcan.2016.11.002.
- [4] S. Arnon, J. Barry, G. K. Karagiannidis, R. Schober, and M. Uysal, *Advanced Optical Wireless Communication Systems*. Cambridge: Cambridge University Press, 2012.
- [5] M. A. Khalighi and M. Uysal, "Survey on Free Space Optical Communication: A Communication Theory Perspective," *IEEE Communications Surveys & Tutorials*, vol. 16, no. 4, pp. 2231-2258, 2014. DOI: 10.1109/comst.2014.2329501.
- [6] G. K. Varotsos, H. E. Nistazakis, Ch. K. Volos, and G.S. Tombras, "FSO Links with Diversity Pointing Errors and Temporal Broadening of the Pulses over Weak to Strong Atmospheric Turbulence Channels," *Optik - International Journal for Light and Electron Optics*, vol. 127, no. 6, pp. 3402-3409, 2016.
- [7] H. A. Fadhil, A. Amphawan, H. A. B. Shamsuddin, T. H. Abd, H. M.R. Al-Khafaji, S. A. Aljunid, and N. Ahmed, "Optimization of Free Space Optics Parameters: An Optimum Solution for Bad Weather Conditions," in *Optik - International Journal for Light and Electron Optics*, vol. 124, no. 19, pp. 3969-3973, 2013. DOI: 10.1016/j.jlleo.2012.11.059.
- [8] S. N. Zainurin, I. Ismail, U. S. Saulaiman, W. Z. W. Ismail, F. H. Mustafa, M. Sahrim, J. Jamaluddin, and S. R. Balakrishnan, "A Study on Malaysia Atmospheric Effect on Radio over Free Space Optic through Radio Frequency Signal and Light Propagation in Fiber for Future Communication Development," *Proceeding of The 2nd International Conference on Applied Photonics and Electronics 2019 (InCAPE 2019)*, 2020. DOI:10.1063/1.5142110.
- [9] L. C. Andrews and R. L. Phillips, *Laser Beam Propagation through Random Media*. 2nd ed. Bellingham: SPIE Press, 2005.
- [10] H. E. Nistazakis, T. A. Tsiftsis, and G. S. Tombras, "Performance Analysis of Free-Space Optical Communication Systems over Atmospheric Turbulence Channels," *IET Communications*, vol. 3, no. 8, pp. 1402-1409, 2009. DOI: 10.1049/iet-com.2008.0212.
- [11] G. Ritu and S. Preeti, "Performance Analysis of FSO System for Different Fog Conditions," *Proceeding of International Conference on Intelligent Communication, Control and Devices, Advances in Intelligent Systems and Computing*, pp. 181-187, 2017. DOI: 10.1007/978-981-10-1708-7_20.
- [12] M. B. El Mashade and A. H. Toeima, "Performance Characterization of Spatial Diversity based Optical Wireless Communication over Atmospheric Turbulence Channels," *Radioelectronics and Communications Systems*, vol. 61, no. 4, pp. 135-152, 2018. DOI: 10.3103/S0735272718040015.
- [13] S. Malik and P. K. Sahu, "Performance Analysis of Free Space Optical Communication System Using Different Modulation Schemes over Weak to Strong Atmospheric Turbulence Channels," *Optical and Wireless Technologies*, pp. 387-399, 2019. DOI: 10.1007/978-981-13-6159-3_41.
- [14] A. A. Farid and S. Hranilovic, "Outage Capacity Optimization for Free-Space Optical Links with Pointing Errors," *Journal of Lightwave Technology*, vol. 25, no. 7, pp. 1702-1710, 2007. DOI: 10.1109/JLT.2007.899174.
- [15] R. de S. C. Bessoni, L. F. S. e Silva, V. G. A. Carneiro, and M. T. M. R. Giraldo, "A Comparison of Different Modeling Approximations for a FSO Channel with Radial Displacement," *Proceeding of 2015 SBMO/IEEE MTT-S International Microwave and Optoelectronics Conference (IMOC)*, 2015. DOI: 10.1109/imoc.2015.7369167.
- [16] OptiSystem web-site: <https://optiwave.com/optisystem-overview>



STUDENT MOTIVATION TO LEARN ABOUT BLOCKCHAIN TECHNOLOGY

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Abstract:

In this paper, we explore factors contributing to student intrinsic and extrinsic motivation to learn about blockchain technology and cryptocurrencies. We surveyed N=84 university students on the abovementioned topics. First, we examine their familiarity with these new technologies, together with their habits concerning cybersecurity risks involved with owning cryptocurrencies. Then we further investigate their interest and motivation to learn about blockchain and cryptocurrency..

Keywords:

blockchain, cryptocurrency, student motivation.

INTRODUCTION

Blockchain technology is relatively young. Bitcoin, which is the world's first blockchain, is only eleven years old. However, this technology is advancing very fast, and billions and billions are invested every year in its further development. Recent happenings with Bitcoin price reaching as much as 20000 dollars in December of 2017 and then dropping back to 3100 have made this technology world known. Possibly for all the wrong reasons but still that whole publicity contributed to the further development of blockchain technology. In this paper, we surveyed N=84 university students to explore further three topics related to cryptocurrencies and blockchain technologies. Student acceptance of blockchain technology is the first topic we discuss. Every new technology goes through a cycle of acceptance. Blockchain technology is currently in the very early stages of the acceptance cycle; therefore, it is interesting to explore the extent of blockchain technology acceptance within the student population. The awareness of security risks of holding cryptocurrencies is the second topic. Knowledge of security risks that come with owning and using cryptocurrencies is also a relatively new topic, not fully explored yet. Students' motivation to learn about blockchain technologies is the third topic we explore in this research paper.

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1. LITERATURE REVIEW

Blockchain technology

As mentioned before, blockchain is very new technology. That said, the first paper published about blockchain is the bitcoin whitepaper [1] by Satoshi Nakamoto. In this now-famous paper, Nakamoto describes a novel system for cash transactions over the Internet. Based on a peer-to-peer network, this system allows transactions to be made without going through a financial institution. Instead of a bank, there is a decentralized network that creates tokens and processes transactions. This means that every node in the network can make transactions without asking for permission. For the first time in human history, there is an asset that cannot be confiscated by authorities. Only a person that is in possession of the private key associated with an unspent transaction can move the funds. This also means that a transaction can't be rolled back once it is included into blockchain which significantly raises the level of IT security awareness and education needed to securely use and store it. Bitcoin, the first cryptocurrency, is also open-source software that allows anyone with adequate programming knowledge to easily copy or modify its source code and make new Bitcoin-based cryptocurrencies. Besides derivatives of Bitcoin, there are also cryptocurrencies that were programmed from the ground up, but the vast majority of cryptocurrencies are Bitcoin derivatives.

These cryptocurrencies are collectively called altcoins. As their name implies, they offer an alternative to Bitcoin. At the time of writing, over 6000 different altcoins are listed on coinmarketcap.com [2], the website that maintains the list of all significant public blockchain projects. The first group of altcoins that we will mention in this paper are coins that have Bitcoin in their name Bitcoin Cash, Bitcoin SV, Bitcoin Gold and similar coins that are not only software forks of Bitcoin but also forks of Bitcoin blockchain.

The second group of altcoins is the platform altcoins group. These altcoins allow for very easy creation of tokens. For a small fee, the user can create their own tokens on top of platform altcoins blockchain. Such platforms include Ethereum, Neo, Tron, Waves and similar altcoins.

The third group of altcoins is "masternode" [3] coins group. These coins add another layer onto the Bitcoin foundation. Together with normal nodes, these blockchains include collateralized nodes called masternodes or systemnodes that do special tasks like making transactions private or even further securing the network. Most prominent coins in this category are Dash, Pivx and Zcoin.

The fourth group is stablecoins altcoins group. These coins aim to improve on Bitcoins volatility by being tied to an asset or a group of assets that are much more stable than Bitcoin. For example, Tether (USDT) is a stablecoin that is tied to US Dollar so that one USDT is equal to one United States dollar. Prominent coins are Tether, USD Coin (USDC), Paxos standard (PAX).

The fifth group of altcoins is the exchange altcoins group. As we mentioned earlier, centralized exchanges are a large part of the cryptosphere. Some of these exchanges have their own coins that can be used for trading on the exchange. These exchanges include Binance, Kucoin, Huobi.

The sixth group is the privacy altcoins group. The last group of coins that we will mention in this short review are privacy or enhanced privacy coins. We already mentioned Dash when we talked about masternode coins, but there are privacy coins like Monero [4] that are built to provide their users with total privacy. Unlike Dash where user can choose between private and public transactions Monero supports only private transactions.

Besides public blockchains, there are also private or enterprise blockchains. These blockchains are run by corporations or government institutions with closed groups of participants. Blockchain technologies that are the most prominent examples of technologies used to create private blockchains include Hyperledger [5], Corda and Quorum. These technologies [6] [7] are increasingly being used to create business solutions in many industries. Different types of blockchain applications on both public and private blockchains [6] [7] include business, education, healthcare, internet of things, government, identity verification, financial, data management and other applications.

Security risks of using cryptocurrencies

Cryptocurrencies make it very easy to do financial transactions over the Internet. This very quality also makes them very interesting targets for criminals. Criminals can now easily rob their victims from any place in the world that has an Internet connection. This makes the possibility of being hacked and robbed a permanent security threat. Modern computers and mobile devices are constantly connected to the Internet always syncing and installing new updates.

Everyone can download a cryptocurrency wallet from the Internet and receive money [8]. However, not everyone knows how to keep their funds safe. Besides the possibility of getting hacked, there are many other security risks of owning cryptocurrencies.



One such risk is the risk of losing data due to hardware malfunction or theft. Another risk factor is the unskilled handling of the cryptocurrency wallets. Having complete control over one's money is great, but it comes with great responsibility. If the user lacks the required skills and training, it can lead to very expensive errors. Failure to make regular backups of wallets or private keys can lead to losses.

To mitigate these risks, in the age of cloud computing, there are, of course, multiple online services that offer to store cryptocurrencies on the user's behalf on their servers. These Internet services include cryptocurrency exchanges and online wallet providers. Although this method solves issues of backups and proper data handling it also brings many new challenges with it.

The first problem is the safety of the Internet connection between the user and the service. Users must be able to determine if their connection is secure and then when it is; there is a problem of securely logging into Internet service and mitigating the risk of the user's password being compromised. Safety aware online exchanges offer multifactor authentication as a measure to solve the stolen password problem. According to [8], multifactor authentication can include something that the user knows, something that the user has or something that the user is (biometrics). In practice, two factors are considered to be good enough for most applications. In this way, when accessing the system user is prompted to enter the password (first factor) and then a code that proves that he has access to a device (second factor). In practice, the most used two-factor authentication methods include sending SMS messages with one-time passwords to the user's phone or using a software installed on the user's mobile device to generate a one-time password at the time of login. Most popular two-factor service is Google Authenticator [9] that uses TOTP (Time-based One-time Password algorithm) and HOTP (HMAC-Based One-time Password).

The second problem with online services that store user-owned cryptocurrencies is the safety of the online services themselves. In the last couple of years, many of these services have lost user's funds after being attacked by hackers. Also, there is a business risk of exchanges going out of business and dragging users into endless liquidation processes.

Student motivation

Unlike blockchain technology topics that are very new, the research field of student motivation is a very mature research discipline. Numerous studies have identified student motivation as a significant variable for student academic achievement. A common thread in these studies is identifying internal and external sources of motivation [10] where intrinsic and extrinsic motivational factors explain engagement in education. Ryan and Deci [11] in their Self-Determination theory make the distinction between intrinsic and extrinsic motivation.

Intrinsic motivation [11], in general, is when a person does an activity for itself because it is enjoyable and satisfaction and pleasure derived from participating in the activity. [12] Vallerand et al. mention a taxonomy of three different types of intrinsic motivation: intrinsic motivation to know, intrinsic motivation to accomplish things and intrinsic motivation to experience stimulation.

They define [12] intrinsic motivation to know as "The fact of performing an activity for the pleasure and the satisfaction that one experiences while learning, exploring, or trying to understand something new." So it is a motivation that student has because of the pleasure of learning something new.

According to [12], intrinsic motivation to accomplish things is defined to be "The fact of engaging in an activity for the pleasure and satisfaction experienced when one attempts to accomplish or create something." They give an example of a student that does more than is required just to feel the satisfaction of having written a challenging term paper.

The third form of intrinsic motivation – intrinsic motivation to experience stimulation is when an individual, for example, reads a book [12] that creates intense feelings of cognitive pleasure because of exciting content that it contains.

Extrinsic motivation [11] is the motivation that stems from behaviors that are a means to an end and not motivating for their own sake. Students are motivated to do something because they will reach a certain outcome, like earning points or passing exams and not because they enjoy learning a subject. [12] Vallerand et al. mention a taxonomy of three different types of extrinsic motivation: external regulation, introjection, and identification. External regulation is comprised of externally imposed rewards and constraints for a student that motivation is, for example, when student studies because his parents want him to study and will possibly reward him for good grades. Introjected regulation is,



for example, when a student studies something because it is what is expected. Identified external motivation [11] is when a student has identified with the behavior. For example, a student could say that he is learning about a particular subject because it is important to him.

2. METHODS

In this paper, we used an intersectional survey to gather data about research topics. We surveyed N=84 students. The survey included 41 questions about three topics and four demographic questions. Demographics were used to separate students into two groups IT students and other students, so we can see if there are any significant differences.

The first topic was the student familiarity with blockchain technologies and cryptocurrency; it includes seven yes/no questions. Questions like have they ever used blockchain and cryptocurrencies and how.

The second topic included ten questions about student habits concerning cybersecurity risks. Questions about what operating system they have on their desktop and smartphones. Then questions about using antivirus, doing backups and enabling two-factor authentication.

Third set of questions included 24 Likert scale questions on the topics of their interest and motivation to learn about blockchain technologies. First six questions were about interest in various topics on blockchain technology. Next 18 questions were adapted for our needs from [12]

Their scale includes seven constructs but for our purposes we adopted first six constructs that measure two types and total of six subtypes of motivation.

Construct “intrinsic motivation to know about blockchain” is measured with three questions. It measures intrinsic motivation to learn about blockchain that stems from students enjoying learning something new.

Construct “Intrinsic motivation toward accomplishment” is also measured by three questions. It is designed to measure intrinsic motivation to learn about blockchain that comes from the student’s pleasure of accomplishing a task.

Construct “Intrinsic motivation to experience stimulation” is measured by three questions. It measures the component of intrinsic motivation to learn about blockchain produced by intense feelings of reading about something exciting.

Construct “Extrinsic motivation - external regulation” is measured by three questions. It measures external regulation. In this case, external rewards come in the form of a well-paid job.

Construct “Extrinsic motivation - introjected regulation” is also measured by three questions. It measures the introjected regulation component of extrinsic motivation.

Construct “Extrinsic motivation – identified regulation” is again measured by three questions. It measures the identified regulation component of extrinsic motivation. In this case, the student identifies learning about blockchain as important for him and his career.

3. RESULTS

Out of 84 respondents, 53 (63.1%) were IT students, while 31 (36.9%) were non-IT students. By gender, 41(48.8%) were male, and 43 (51.2%) were female.

The first group of questions was about student familiarity with blockchain technologies. Table I shows the results for the first seven questions. 57.1% of the respondents have heard about blockchain. 19% of the respondents have cryptocurrencies. 50% of the respondents know someone who has used cryptocurrencies. Only 8% have invested in cryptocurrencies. 51.2 percent know someone who has invested in cryptocurrencies. The percentage of students who mined/staked cryptocurrencies is 6%. However, 34.5% of the respondents know someone who has mined/staked cryptocurrencies.

Divided into IT and non-IT groups results are the following. 58.5% of IT students have heard about blockchain, and 54.8% of non-IT students have heard about blockchain. 22.6% of IT students have used cryptocurrencies, while only 12.9% of non-IT students have. IT students know more people who have used cryptocurrencies 56.6% compared to 38.7% non-IT students. Also, the number of IT students who have invested in cryptocurrencies is much larger than that of those who have not 13.2% compared to 3.2%. However, when asked if they know someone who has invested in cryptocurrency, results are much more balanced 52.8% compared to 48.4%. On the question about having personally mined or staked cryptocurrencies, 7.5% of the IT students responded affirmatively while only 3.2% of non-IT students indicated that they have mined or staked cryptocurrency. On the question, if they know anyone who has been producing cryptocurrencies, 37.7% IT students responded affirmatively while only 29% of non-IT students responded affirmatively.



Question	Yes(%)	No(%)
Have you heard about blockchain?	57.1	42.9
Have you ever used cryptocurrencies?	19	81
Do you know someone who has used cryptocurrencies?	50	50
Have you invested in cryptocurrencies?	9.5	90.5
Do you know someone who has invested in cryptocurrency?	51.2	48.8
Have you produced (mined/staked) cryptocurrency?	6	94
Do you know someone who has produced (mined/staked) cryptocurrency?	34.5	65.5

Table 1. BLOCKCHAIN AND CRYPTOCURRENCY USE

For second group of questions we got following results. First question was about desktop operating system. 83 out of 84 respondents (98.8%) are using Windows operating system and only one (1.2%) is using Linux desktop operating system. For mobile operating systems 61 respondent (72.6%) is using Android operating system and 23 respondents (27.4%) are using iOS operating system. On the question if they are using antivirus on their desktop computer 85.7% said yes. For mobile phones percentage of respondents that are using antivirus is much less 40.5%. 59.5% of the respondents makes backups of data on their desktop and 79.8% of the respondents makes backups of data on their mobile phones. Two factor authentication is used by 34.5% of the respondents. Last three questions in this group were about lost data. Total 33.3% of the respondents have lost their data due to computer virus, 28.6% of respondents lost data due to hard drive failure and 39.3% of the respondents lost data due to loss of the mobile phone.

Then we compared IT and non-IT students and got following results. Only student that uses Linux operating system is an IT student and all other students use Windows on their desktop computers. IT students use Android in greater percentage 75% compared to 67.7% for non-IT students. More non-IT students use antivirus, both on desktop (93.5% vs. 81.1%) and mobile phone (58.1% vs. 30.2%). Bigger percentage of non-IT students backs up data. On desktop computers 67.7% compared to 54.7%. On mobile phones 83.9% versus 77.4%. Bigger percentage of IT students uses 2FA 37.7% compared to 29% of non-IT students. Non-IT students had more problems with losing data. 45.2% of non-IT respondents lost data due to computer virus while only 26.4% IT students lost data due to computer virus.

Hard drive failure led to the loss of data for 35.5% of the non-IT students compared with 24.5% of the IT students. Loss of mobile phone led to the loss of the data for 51.6% of the non-IT students compared to 32.1% of the IT students.

Next six questions were about different reasons why students are interested in learning about blockchain. Results are presented in the following paragraphs and can be seen in table II. On the Likert scale from 1 to 7 where 1 is "I completely disagree" and 7 is "I completely agree" students scored their interestedness about the different aspects of the blockchain technologies.

Question	Mean	Std. Deviation
I am interested to learn more about blockchain technologies	4.46	2.05
I am interested to learn more about cryptocurrencies	4.79	2.083
I am interested to learn more about business application of blockchain technology	4.52	2.074
I am interested to learn more about using cryptocurrencies safely	4.68	2.043
I am interested to learn more about production (mining) of cryptocurrencies	4.24	2.189
I am interested to learn more about blockchain programming	4.36	2.075

Table 2. INTEREST IN LEARNING ABOUT BLOCKCHAIN



Questions about interestedness in blockchain technology by group			
Question	Group	Mean	Std. Deviation
I am interested to learn more about blockchain technologies	IT	4.74	2.123
	Non-IT	4.00	1.862
I am interested to learn more about cryptocurrencies	IT	4.89	2.118
	Non-IT	4.61	2.044
I am interested to learn more about business application of blockchain technology	IT	4.68	1.998
	Non-IT	4.26	2.206
I am interested to learn more about using cryptocurrencies safely	IT	4.85	2.032
	Non-IT	4.39	2.060
I am interested to learn more about production (mining) of cryptocurrencies	IT	4.58	2.179
	Non-IT	3.65	2.106
I am interested to learn more about blockchain programming	IT	4.66	2.009
	Non-IT	3.84	2.115

Table 3. INTEREST IN LEARNING ABOUT BLOCKCHAIN BY GROUP

We then compared IT and non-IT students. Results can be found in table III.

Last eighteen questions measured six student motivation constructs results can be seen in table IV. Mean value for construct "Intrinsic motivation – to know" is 4.43 with Cronbach alpha 0.906. For construct "Intrinsic motivation – toward accomplishment" mean is 4.44 with Cronbach alpha of 0.889. Mean value of construct "Intrinsic motivation – to experience stimulation" is 4.44 and Cronbach alpha 0.91. Extrinsic motivation constructs mean values are 4.73 for identified, 4.14 for introjected and 4.48 for external regulation. With Cronbach alpha values respectively 0.911, 0.921 and 0.937.

Question	Mean	Std. Deviation	Cronbach alpha
Intrinsic motivation – to know	4.46	2.05	0.906
Intrinsic motivation – toward accomplishment	4.79	2.083	0.889
Intrinsic motivation – to experience stimulation	4.52	2.074	0.91
Extrinsic motivation – identified regulation	4.68	2.043	0.911
Extrinsic motivation - introjected regulation	4.24	2.189	0.921
Extrinsic motivation - external regulation	4.36	2.075	0.937

Table 4. STUDENT MOTIVATION TO LEARN ABOUT BLOCKCHAIN

Afterwards we compared motivational constructs values for both IT and non-IT groups. Results of this comparison can be found in table V.

Question	Group	Mean	Std. Deviation	Cronbach alpha
Intrinsic motivation – to know	IT	4.65	1.81	0.905
	Non-IT	4.05	1.90	0.869
Intrinsic motivation – toward accomplishment	IT	4.71	1.65	0.876
	Non-IT	3.96	1.82	0.898
Intrinsic motivation – to experience stimulation	IT	4.59	1.75	0.889
	Non-IT	4.18	1.90	0.938
Extrinsic motivation – identified regulation	IT	5.01	1.70	0.877
	Non-IT	4.24	1.93	0.949
Extrinsic motivation - introjected regulation	IT	4.32	2.01	0.927
	Non-IT	3.83	1.93	0.907
Extrinsic motivation - external regulation	IT	4.67	1.86	0.933
	Non-IT	4.16	2.08	0.942

Table 5. MOTIVATION TO LEARN ABOUT BLOCKCHAIN BY GROUP

4. DISCUSSION

In the first part of the survey students gave answers about their familiarity with blockchain and cryptocurrency. Students have generally heard about the blockchain and know people who have used it. However, percentage of students that have actually used cryptocurrency is very low. Only 19% of the respondents have actually used cryptocurrencies.

Almost all respondents 83/84 use Microsoft Windows operative system on their desktop computers as we expected. Microsoft Windows is definitely dominant operating system for desktop computers. It is however not the safest operating system. Linux and Apple's operating systems are safer options.

For mobile devices there is not much choice two most popular operating systems are Android and iOS. Mobile operating systems are much more resistant to security threats. Android which is open-source is less safe than Apple's iOS which is completely closed platform. Percentage of respondents that uses Apple device's (27.4%) is very significant considering that their devices are much more expensive and that at the time that survey was conducted Apple didn't officially support Serbia. Although mobile devices are much more resistant to viruses and malware it is still recommended to have



antivirus or some variant of antimalware software just to be sure especially if one has a jailbroken device.

Since 85.7% of respondents have antivirus on their desktop computers and 40.5% have antivirus on their mobile phones we can say that they are very responsible concerning the computer virus threat. However, when we group respondents by IT and non-IT students we discover some very interesting facts. IT students are less responsible than non-IT students. Fact that 93.5% of non-IT students use antivirus on their computers and only 81.1% IT students have antivirus on theirs is very worrying. And this is not the only area where IT students are less responsible, smaller number of IT students backs up data.

Results for the rest of the data security questions are as expected. Bigger percentage of IT students uses 2FA and bigger percentage of non-IT have lost data in incidents related to viruses, hard drive failure and loss of mobile phone. Percentage of respondents that use 2FA is very small (34.5%). Fact that every other non-IT student and every third IT student has lost a mobile phone is also something that is very worrying. Mobile phone cryptocurrency wallets are very popular and loss of mobile device would equal the loss of cryptocurrency if one does not have a backup.

There is a large difference in interestedness in learning about blockchain and cryptocurrency. IT students show interest in all aspects of blockchain technology and non-IT students show interest only in topics about cryptocurrencies and their safe use.

Topic of motivation is the part of this research where differences between IT and non-IT students are most evident. On a seven point Likert scale four marks neutral position and results for non-IT students are very close to four (table V). This shows that non-IT students are not very motivated in learning about blockchain which is expected. Extrinsic motivation factor of identified regulation has the highest mean score of all motivation factors with a mean of 4.24 and that is quite low.

IT students on the other hand are much more motivated to learn about blockchain which is normal considering that they are studying information technology. Intrinsic motivation construct mean values are at very similar levels which could mean that students are intrinsically motivated to learn about blockchain. Of the extrinsic motivation constructs identified regulation is the strongest and introjected regulation is the weakest. It is interesting that the fact that knowledge about blockchain can help their carrier is more of a motivating factor than that fact that blockchain and cryptocurrency jobs are currently one of the best paid in IT industry.

5. CONCLUSIONS AND FURTHER RESEARCH

Respondents are aware of the existence of blockchain technologies, majority of them has heard something about blockchain and cryptocurrency and know someone who have used it in some way. Relatively small percentage has used cryptocurrency personally. These numbers are likely to grow over time and following the rate of their growth could be an interesting direction of further research. Respondents are aware of security risks that come with storing valuable data. Large percentage uses antivirus and makes backups. IT students are less responsible in this regard. Reason for this irresponsibility remains unclear and is a possible topic for further study. Topics in which IT and non-IT students differ the most are topics of interestedness and motivation to learn about blockchain. IT students show interest and are motivated to some extent to learn about blockchain. Non-IT students with exception of couple of topics neither show interest nor are motivated to learn about blockchain. This leads us to the conclusion that any similar further studies of this type should be focused primarily on IT students.

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REFERENCES

- [1] S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System", 2008
- [2] CoinMarketCap, Top 100 Cryptocurrencies by Market Capitalization, Retrieved at September 10th, 2020, <https://coinmarketcap.com/>
- [3] M. Opačić, M. Veinović, D. Adžić, "A Short Introduction Into Innovative World of Masternode Coins", Sinteza 2018, Beograd, 2018, doi:10.15308/Sinteza-2018-147-152
- [4] Q. Feng, D. He, S. Zeadally, M. K. Khan, N. Kumar, "A survey on privacy protection in blockchain system", *Journal of Network and Computer Applications*, vol 126, pp. 45-58, 2019 ISSN 1084-8045, <https://doi.org/10.1016/j.jnca.2018.10.020>.
- [5] T.Kuo, H. Z. Rojas, L. Ohno-Machado, "Comparison of blockchain platforms: a systematic review and healthcare examples", *Journal of the American Medical Informatics Association*, vol. 26, no.5, pp. 462-478, 2019 doi: 10.1093/jamia/ocy185



- [6] P. J. Taylor, T. Dargahi, A. Dehghantanha, R. M. Parizi, K. R. Choo, "A systematic literature review of blockchain cyber security", *Digital Communications and Networks*, vol 6, no. 2, 2020, pp. 147-156, ISSN 2352-8648, <https://doi.org/10.1016/j.dcan.2019.01.005>.
- [7] F. Casino, T. K. Dasaklis, C. Patsakis, "A systematic literature review of blockchain-based applications: Current status, classification and open issues", *Telematics and Informatics*, vol 36, pp. 55-81, 2019 ISSN 0736-5853, <https://doi.org/10.1016/j.tele.2018.11.006>.
- [8] D. Folkinshteyn, M. Lennon, "Braving Bitcoin: A technology acceptance model (TAM) analysis", *Journal of Information Technology Case and Application Research*, vol 18, no. 4, pp. 220-249, 2016.
- [9] Google, Google Authenticator OpenSource Wiki, Retrieved at September 10th, 2020, <https://github.com/google/google-authenticator/wiki>
- [10] A.P. Rovai, M.K. Ponton, M.J. Wighting, J. D. Baker, "A Comparative Analysis of Student Motivation in Traditional Classroom and E-Learning Courses", *International Journal on E-Learning*, vol 6, no. 3, pp. 413-432, 2007.
- [11] R. M. Ryan and E. L. Deci "Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions", *Contemporary Educational Psychology* vol 25, no 1 pp 54-67 2000 doi:10.1006/ceps.1999.1020
- [12] R.J. Vallerand, L.G. Pelletier, M.R. Blais, N.M. Briere, C. Senecal, E.F. Vallieres. "The Academic Motivation Scale: A Measure of Intrinsic, Extrinsic, and Amotivation in Education". *Educational and Psychological Measurement*, vol 52, no 4, pp. 1003-1017. 1992 doi: 10.1177/0013164492052004025



THE INFLUENCE OF THE INTERNET ON PREADOLESCENT STUDENT WORK HABITS FORMATION

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Abstract:

The constant development of new technologies and internet services, and above all their wide availability, have contributed to modernization in all spheres of life and work. As digital competencies became part of everyday life and work, their constant development is necessary. Teachers are expected to know modern concepts, methods and educational tools, and students to be active participants in the teaching process. Having in mind the advantages that modern technology brings with it, we cannot ignore the numerous negative consequences it leaves on all generations. Younger children and children of school age are especially susceptible to this. With the development of technology, the ways of teaching and learning are also changing. Therefore, care should be taken about the measure and manner of using ICT in teaching and. The results of research conducted on a sample of 359 preadolescent student shown what impact new technologies have on this population and the extent to which their work habits have changed..

Keywords:

working habits, preadolescents, internet, learning.

1. INTRODUCTION

Technology development has led to significant structural changes in the life and work of all of us. It has a special impact on children, preadolescents and adolescents, who encounter the Internet and various digital media from early age. This leads to disturbances in the relationship between adults and children, but also children among each other. Uncontrolled or poorly controlled technology access can lead to various negative consequences that can be manifested through irritability, anxiety or attention deficit disorder. This can also lead to conflicts between children and their parents due to the denial using ICT devices for a longer period of time. The younger children are, the more control parents have over the use of digital technologies in order to ensure the safety of children and to prevent possible negative behavior. The older children get, the more parents lose control over the digital content that children absorb every day and activities they undertake.

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Digital technology has already changed our worlds, the way we think and conclude or find solutions. As children and young people are the most active users of digital technologies, the greatest impact on their growth and development there is. All this leads to changes in the way of learning, organization and formation of work habits. It is becoming increasingly difficult for students to resist the influence of video games and other digital interactive content provided online. Due to that, but also a number of other factors, students quickly lose motivation to learn. There is a growing problem of decreased concentration and maintaining continuity in learning. Most of the children do not develop the habits of self-controlled learning or engaging in some physical activity on their own, and it became necessary to initiate these activities by their parents. With a change in the way of thinking, there clearly are changes in the way of behaving.

2. THEORETICAL FRAMEWORK

Digital literacy is one of the eight key competencies for lifelong learning and a necessary prerequisite for the personal development of each individual in today's society [1]. Young people are the backbone of today's information society due to the fact that over 80% of population aged between 15 and 24 use the Internet [2]. As digital technologies have become an integral part of everyday life, today's generations of students spend most of their free time with computers or smartphones. The concept of extracurricular teaching in the digital environment can be one of the possible solutions to alleviate this imbalance and often inadequate use of technology [3]. The concept of this model is to encourage student creativity, development of critical thinking, better communication, research and problem solving. The use of modern technologies in the teaching process should contribute to the support of different learning styles of students, timely feedback and a safe learning environment. The introduction of mobile technologies in teaching activities further enables beforementioned model. Taking into account the fact that about 84% of fourth grade students and as many as 94% of eighth grade primary school students in Serbia have a mobile phone [4], the potential for using mobile applications as modern teaching aids is becoming more than real. This has proven to be very useful during the state of emergencies (e.g. Covid-19 pandemic) as learning facilities are available to students at any time and in any place.

This enables alternate means of communication with teachers and timely feedback. In addition to communicating and sharing content via Viber, Google Classroom, Microsoft Teams, Zoom, Skype, etc., students can follow the lessons through TV broadcasts, access the content online and review it at any time of the day [5]. Nevertheless, parents should monitor and direct activities in order to maintain learning continuity and in order to prevent neglect of work obligations.

The importance of using ICT in modern learning is immeasurable, as it encourages an active approach of students, arouses interest, develops independence and cooperation, but also develops skills of using digital resources in the function of learning. According to Blum's assessment, cognitive characteristics have the largest share in school achievement (50%), followed by affective characteristics (25%) and teaching quality (25%) [6]. Operationalized outcomes of the educational process, and especially teaching, are precondition for improving the teaching process, directing the teaching activities and also enabling students to recognize the goals and purpose of their learning consciously and actively. This facilitates self-regulated learning and encourages the development of cognitive strategies that are the basis of better school achievement [7]. Taking into account the individual differences of students and their ways of learning, we can create an environment in which they have the opportunity to feel important through discussion, searching for answers and solutions and incorporating their own knowledge and experience. In this way, students become active participants in teaching, equal to the teacher, and learning is then perceived as a process in which information circulates among each other [8]. A student who has developed work habits and has a high level of independence can apply various strategies and skills that enable selection, comparison of information and their connection with already acquired knowledge. Students continuously acquire knowledge and develop their personality through cooperation and the activity itself becomes an internal motivation and reward. By introducing innovations in teaching methodology, the formation and development of work habits is also changed.

The 2018 PISA assessment report shown that every third student in Serbia does not reach the basic level of literacy [9]. In relation to previous assessments, the fact is that our educational system and applied strategies have not made significant progress. As learning through experience is the fastest way to acquire functional knowledge, the aim should be introducing new teaching methods and procedures that contribute to this.



By applying collaboration, project teaching, research and problem-based learning, students should handle various procedures to achieve results while strengthening skills in the field of digital technologies.

The role of teachers in encouraging student activities

The development of student digital competencies depends on the levels of competencies of teachers and their readiness to innovate. The application of modern digital tools offers opportunities and potentials for increasing students' interest. However, excessive use of educational technology can lead to a counter-effect - lack of interest, feelings of boredom or inattention. As technology develops over time, so does the ways in which it can be used in teaching, with care being taken about the moderate use and adequate harmonization of learning content with students' age [10]. When we analyzed the educational systems that achieved the best results in the PISA assessment, we concluded that these countries are careful with the introduction of technology into the teaching process. Students who make extensive use of technology performed worse than those who use technology sparingly [10]. Therefore, large investments of certain countries in the introduction of technology in education with the reason that it will contribute to the improvement of students' knowledge are not justified. It is necessary to implement existing educational technology better in order to improve the quality of learning. The teacher must create classes so that the teaching is dynamic and innovative, relying on his/her knowledge, abilities and imagination, and at the same time taking into account the goals, as well as the characteristics of students and the conditions in which he/she works [11].

In addition to formal education, students learn in other places as well in their free time. These activities are supplemented by multimedia technology, so in that sense, the school would have to intensify cooperation with parents and direct students to quality use of free time [12].

The influence of the family on school success

The family is the most important part of children's lives in which they acquire the first knowledge, skills and habits. In addition to encouraging emotional and social development, one of the important goals of family education is to help and encourage the child in intellectual development and the development of personal learning potential. Children who are encouraged by their parents and who are involved in various activi-

ties and forms of learning, both in and out of school, show greater achievements. In the phase of developing creative abilities, parents have a great responsibility to create a learning environment that will also support motivation. Therefore, it is necessary for parents to show self-confidence, positive attitudes towards learning, high expectations of themselves and their children, as well as interest in the child's success. The child must have freedom, but also the rhythm of the day, predictability, established habits.

If there is a strong affective connection between the child and the parents, learning is very intense and spontaneous, takes place through everyday social relationships, and the child's motivation is very strong [13]. The family must provide the child with the most positive examples of behavior in life, constructive solving of real problems, gradually burden it with greater duties and responsibilities in accordance with the degree of physical and mental development.

The influence of modern technologies

Exposure to digital content begins very early in age and reaches its peak in adolescence where it is noted that students spend an average of about 4 hours a day consuming digital media [14]. It is noticeable that each succeeding generation acquires greater digital literacy than its predecessors, and each succeeding one shows a greater capacity for digital expression [15]. It cannot be said that the growing prevalence of the Internet among the younger population is not worrying. As many as 8.2% of the total population of the Western world has some form of digital addiction [16]. The application of multimedia and the Internet in teaching enables individualization and progress of students depending on their prior knowledge and interests, unlimited repetition of given content, organization of cooperative-interactive learning, management of the learning process, easier access to different sources of knowledge, easier insight into different views of a problem and feedback [17]. Researchers are unique in stance that it is not important how long young people use the computers and/or the Internet, but how they use it.

The results of research conducted in Serbia [4] show that the use of digital devices and the Internet is widespread among students, as well as that the availability and frequency of use increase with the age of students. In the same research, almost two thirds of the surveyed students state that their parents have weaker digital skills compared to theirs and therefore do not view them as partners in digital communication.



Also, research shows that parents are more knowledgeable and more likely to mediate in the activities of girls than boys, and that they rarely use technical protection measures, i.e. “parental control” in order to ensure the safety of children online, much less often than in other countries [18]. Experts believe that a total ban is not an effective method against excessive use of Internet services, but that more frequent conversations with children, warning them of the dangers of excessive computer use and motivating them to engage in physical activity is [16].

3. RESEARCH METHODOLOGY

The research problem was estimating the work habits of upper grade primary school students and the impact of technological changes on their motivation and learning. The research covered different social, material and demographic motives that influence the learning and teaching processes, as well as different preferences of preadolescent students.

The research was realized by non-experimental method of surveying students at school. A questionnaire was developed for the purpose of the research. IBM SPSS Statistics v22 was used for data processing. The research was conducted in three primary schools in the area of Čačak and Gornji Milanovac, on a sample of fifth, sixth and seventh grade students.

Hypotheses

Basic hypothesis was that preadolescent students have developed online working habits.

Hypothesis H1: Students actively participate in teaching and are able to connect new material with materials from other subjects and see the connection between related subjects.

Hypothesis H2: Students engage in sports activities in their free time and spend time in nature.

4. RESULTS AND DISCUSSION

A total of $N = 359$ students participated in the research, of which $N = 179$ (49.9%) boys and $N = 180$ girls (50.1%). The structure of the sample according to grades and sex is shown in Table 1.

Grade	Gender				Total	%
	Male	%	Female	%		
5 th	51	14,2	48	13,4	99	27,6
6 th	66	18,4	79	22,0	145	40,4
7 th	62	17,3	53	14,7	115	32
Total	179	49,9	180	50,1	359	100

Table 1. Structure of the sample by gender

Based on the processed data, it can be concluded that the largest number of students live with one sister $N = 120$ (33.5%) or with one brother $N = 97$ (27.1%), while 49 students (13.7%) do not even have brother or sister, and 40 students (11.2%) live in a community with one brother and one sister, as in Table 2.

No. of broth.	No. of sisters								Tot.	%
	1	%	2	%	3	%	Null	%		
1	40	11,2	5	1,4	3	0,8	97	27,1	145	40,5
2	6	1,7	1	0,3	0	0	18	5	25	7
3	3	0,8	0	0	0	0	2	0,6	5	1,4
Null	120	33,5	14	3,9	0	0	49	13,7	183	51,1
Tot.	169	47,2	20	5,6	3	0,8	166	46,4	358	100

Table 2. Family structure of the sample

By processing the obtained results, it can be concluded that the largest number of the surveyed students used the Internet over two hours per day (34.3%), which is an extremely high percentage among the younger population, as shown in Table 3. We concluded that both boys and girls use the Internet equally without major deviations. Further analysis shown that the frequency of Internet use increased with age. There were no statistically significant differences according to the gender of preadolescents in relation to the average daily internet use ($t(352) = 1.397$; $p = 0.163$).

Time	Frequency	Percent (%)
30 minutes	35	9,7
1 hour	102	28,4
2 hours	94	26,2
Over 2 hours	123	34,3
Total	354	98,6

Table 2. Time spent on the internet

By analyzing the results of our research, we came to the conclusion that preadolescents used the Internet mainly for playing games, entertainment and communication.



50.7% of students said that they used the Internet as a source of knowledge. There was a statistically significant difference in the analysis of Internet use for play among preadolescent students in relation to male ($M = 0.77$; $SD = 0.425$) and female ($M = 0.38$; $SD = 0.486$) gender; ($t(357) = 8,040$; $p < 0.001$). Boys used the Internet to a much greater extent for gaming, while girls used it for communication. Similar results were obtained in a study conducted by the Institute of Psychology [4]. Student activities on the Internet were divided into three groups: communication, entertainment and finding information. According to the obtained data, boys more often used the Internet as a form of entertainment and were more skilled in using the Internet.

When asked if they study every day, 58.7% of students said they did not have that habit, while 41.3% of students answered affirmative. An independent sample t-test was conducted to compare students' daily learning habits. There was a significant difference in male ($M = 1.67$; $SD = 0.471$) and female ($M = 1.50$; $SD = 0.501$) gender; ($t(352.1) = 3.248$; $p = 0.001$).

It was concluded that the largest number of students have developed work habits when solving homework - 68.3% stated that they perform their work tasks in an organized manner, during the day, 19.3% do tasks immediately after school, 12.4% at night before bed, and a small number of students stated that they did not do their homework, as shown in Table 4.

Homework...	Gender				Total	%
	Male	%	Female	%		
right after school	28	8,1	39	11,2	67	19,3
in the evening before sleep	22	6,3	21	6,1	43	12,4
during the day	119	34,3	118	34	237	68,3
Total	169	48,7	178	51,3	347	100

Table 4. Homework habits by gender

It is interesting that with age, students change their work habits, so in older grades, the number of students who finished their obligations at the end of the working day before going to bed increases, and the number of those who finished those obligations immediately after school decreases. The t-test confirmed that there was no significant difference in analysis for male ($M = 2.54$; $SD = 0.764$) and female ($M = 2.44$; $SD = 0.830$) sex; ($t(345) = 1.104$; $p = 0.271$).

The largest percentage of the examined sample had a habit of learning immediately before the exams (43.2%) and on weekends (40.1%), while learning is practiced every day by a much smaller number of students (28.7%), as shown in Table 5. However, a fairly large number of students stated that they usually study before the end of the school year. By reviewing the obtained results, we can see that girls show a greater interest in acquiring knowledge regularly every day and on weekends.

Learning...	Gender		Total	%
	Male	Female		
at the beginning of schoolyear	36	39	75	20,9
before trimester	19	21	40	11,1
before testing	72	83	155	43,2
at the end of schoolyear	43	40	83	23,1
weekend	59	85	144	40,1
every day	39	64	103	28,7

Table 5. Learning continuity by gender

The largest number of students (34.8%) stated that they were most motivated to get a good grade, while 10.9% of students stated that their parents motivate them the most to learn. A certain number of students (12.3%) believe that they are best motivated to be educated and acquire new knowledge. As many as 11.4% of students stated that they do not know what motivates them to learn or that there is no motivation.

We asked students how much time they spend learning, and by analyzing their answers we concluded that most students need about two hours to master the new teaching material (40.1%). One hour is enough for a large number of students (27.4%), and a significant number of students need three hours or more (20.5%). There was a statistically significant difference in the analysis of the time required for learning in relation to male ($M = 2.47$; $SD = 0.884$) and female ($M = 2.93$; $SD = 0.923$) gender ($t(315) = -4.557$; $p < 0.001$). Boys need significantly less time to learn, or are still less interested in learning than girls. A large number of girls stated that they need two to three hours to acquire knowledge.

The following data proves that concentration has a great influence on the speed of learning and memory. As many as 65.8% of the surveyed sample stated that they cannot fully concentrate on learning when other people are in the room where they are studying. The presence of others distracts girls and boys alike, without exception.



A smaller but not insignificant number of students (34.2%) confirm that they can learn and that other people in the room do not interfere with their learning. Using the t-test, it was found that there were no statistically significant differences in the analysis in relation to male ($M = 1.61$; $SD = 0.490$) and female ($M = 1.71$; $SD = 0.456$) gender; ($t(352) = -1.987$; $p = 0.048$).

A little over half of students (55.2%) understand the material they are learning and occasionally compare it with similar material from other subjects. Using the t-test, it was found that there was no significant statistical difference in relation to male ($M = 1.43$; $SD = 0.496$) and female ($M = 1.47$; $SD = 0.500$) gender, ($t(355) = -0.802$; $p = 0.423$). However, there is a large number of those who do not notice the connection between the subjects (44.8%) and do not connect the new with the already learned material from other subjects.

By examining the procedures that students used when solving homework, it was found that 61.8% of students used the logic and memory of the material from the class when solving tasks, and then check the procedure and solution. A certain number of students (38.2%) first remember what they did in class, check the procedure, and then solve the planned tasks. Also, most students who rely on logic and memory, solve their obligations and homework during the day, while a small number of students postpone obligations until they go to sleep. The T-test did not show a statistically significant difference between male ($M = 1.64$; $SD = 0.482$) and female ($M = 1.60$; $SD = 0.492$) gender, ($t(344) = 0.768$; $p = 0.443$).

The analysis of the obtained data showed that the repetition of already learned material is the easiest way for students to learn as 57.1% of students chose this way of learning as the most effective method in learning (Table 6). Practical work, homework and research on the Internet are equally represented among students from fifth to seventh grade, with minor deviations. It turned out that practical work and research on the Internet were more suitable for boys, while repetition of materials was most suitable for girls.

Learning...	Gender		Total	%
	Male	Female		
by practice	49	31	80	22,3
by doing homework	43	44	87	24,2
by repetition	80	125	205	57,1
by exploring on the Internet	52	41	93	25,9

Table 6. Most efficient knowledge acquirement

When we talked about the teaching aids that students prefer using while acquiring new knowledge, we concluded that the largest number of students used a textbook as the most dominant tool (78%), while 67.7% used a notebook. Internet content is less present among students - only 19.5%. Observing the gender characteristics of students, it can be concluded that both girls and boys mostly used textbooks and notebooks, and notebooks were more important source of knowledge among girls.

According to their statements, the largest number of students who participated in this research spent their free time playing outside (32.3%). A significant number of students (27.8%) spend their free time with friends, as well as using the phone, computer and the Internet (22.8%).

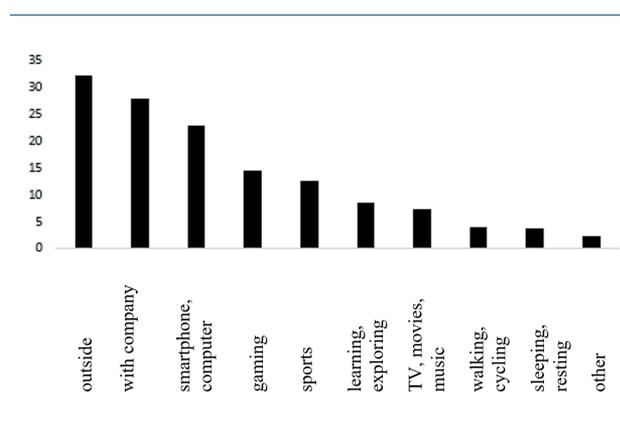


Fig. 1. How students spent their free time.

5. CONCLUSION

The research confirmed the basic hypothesis that preadolescents developed working habits of learning via the Internet. Their use of ICT is not primarily focused on the learning, but often for communication, entertainment and research in order to acquire certain knowledge. However, the results show that 50.7% of students used the Internet to learn. It was concluded that as many as 99.7% of students had access to the Internet, and that only 9.7% of students used it every day for up to half an hour. However, the largest number of students who used modern technologies was over two hours per day (34.3%).

The assumption that students take active part in the teaching process and are able to connect new material with materials from other subjects turned out to be correct, which confirmed hypothesis H1. Students stated that they actively participated in teaching (77.9%) and 55.2% answered that they understood and connected the material they were learning.



The H2 hypotheses that students engaged in sports activities in their free time and spent time in nature has been confirmed. The largest number of students (32.3%) stated that they spent their free time in nature and 12.5% of the examined sample were engaged in sports. However, it is surprising that a large number of students did not engage in any sports activity (34.5%). Sports activities and recreation are especially important for the proper growth and development of students, especially in preadolescent age.

We can conclude that technological progress greatly changed the roles of both teachers and students. Children should be provided with the most stimulating learning environment possible. Parents are expected to encourage, or at least not hinder the development of their child's abilities, interests and creativity. The school must adapt to changing requirements, and it has a great responsibility to support the positive attitude of students towards learning, to help them develop effective learning strategies and strengthen their interests. Guided by the iceberg metaphor, we can conclude that learning that takes place in schools and other educational institutions makes up 20% of the visible part above water, while self-organized learning makes up the remaining 80% below water. Although working habits and learning strategies are changing, educational technology can under no circumstances replace teachers in the learning process. Digital games and other multimedia content have many advantages as they lead to acquiring logical skills, develop problem-solving strategies, set and achieve goals.

REFERENCES

- [1] Carretero, S., Vuorikari, R., Punie, Y. (2017). The Digital Competence Framework for Citizens. Publications Office of the European Union. Posećeno u avgustu 2018., [https://publications.jrc.ec.europa.eu/repository/bitstream/JRC106281/webdigcomp2.1pdf_\(online\).pdf](https://publications.jrc.ec.europa.eu/repository/bitstream/JRC106281/webdigcomp2.1pdf_(online).pdf)
- [2] Kuzmanović D. (2017). Empirijska provera konstrukta digitalne pismenosti i analiza prediktora postignuća. Doktorska disertacija. Beograd: Filozofski fakultet.
- [3] Ristić M., Blagdanić S. (2017). Nove perspektive u obrazovanju – vanučionička nastava u digitalnom okruženju. *Inovacije u nastavi – časopis za savremenu nastavu*, 30(2), str. 1-14. DOI: 10.5937/inovacije1702001R
- [4] Popadić D., Kuzmanović D. (2016.). Mladi u svetu interneta: korišćenje digitalne tehnologije, rizici i zastupljenost digitalnog nasilja među učenicima u Srbiji. Beograd: Ministarstvo prosvete nauke i tehnološkog razvoja Republike Srbije, UNICEF
- [5] Politis, D., Stagiopoulos, P., Aleksić, V. (2020). *Advanced Technologies and Standards for Interactive Educational Television*. Hershey, PA: IGI Global.
- [6] Brković A. (2011). *Razvojna psihologija*. Čačak: Regionalni centar za profesionalni razvoj zaposlenih u obrazovanju.
- [7] Bjekić D., Aleksić, V. i Vučetić, M. (2012). Dvodimenzionalni model Blumove taksonomije u nastavi TIO. *Tehnika i informatika u obrazovanju*, rad štampan u celini, 1–3. juna 2012., Čačak (66 - 75). Čačak: Fakultet tehničkih nauka u Čačku.
- [8] Juranko, G. (2016). *Školski projekti: primjeri aktivnog učenja i poučavanja*. Diplomski rad. Zadar: Sveučilište u Zadru.
- [9] Videnović M., Čaprić, G. (2020). PISA 2018 izveštaj za Republiku Srbiju. Beograd: Institut za psihologiju Filozofskog fakulteta u Beogradu, Zavod za vrednovanje kvaliteta obrazovanja i vaspitanja.
- [10] Činko M. (2016). *Upotreba informaciono komunikacionih tehnologija u nastavi*. Diplomski rad. Sveučilište u Rijeci, Filozofski fakultet u Rijeci.
- [11] Gombar, M. (2011). *Primena projektne nastave u izučavanju društvenih sadržaja u nižim razredima osnovne škole*. *Norma*, 16(1), 103-114.
- [12] Jorgić D. (2013). *Tradicionalno i savremeno u intelektualnom vaspitanju*. Filozofski fakultet, Univerzitet u Banja Luci.
- [13] Todorović K. (2011). *Komunikacija kao sredstvo i efekat vaspitanja*. *Vaspitanje i obrazovanje – časopis za pedagošku teoriju i praksu*, 4, 59-69.
- [14] Aleksić, V. (2020). iTV: Exposure Risks?. In D. Politis, P. Stagiopoulos, & V. Aleksić (Eds.), *Advanced Technologies and Standards for Interactive Educational Television: Emerging Research and Opportunities* (pp. 134-139). Hershey, PA: IGI Global.
- [15] Vidaković M. (2011). *NET generacija i E – učenje: savremena obrazovna revolucija*. Digitalne medijske tehnologije i društveno-obrazovne promene: medijska istraživanja, Zbornik radova V. Novi Sad: Filozofski fakultet, Odsek za medijske studije, str 255-264.
- [16] Branković V. (2018). *Zavisnost od interneta: simptomi, uzroci, lečenje*. Posećeno u junu 2018., <https://samoobrazovanje.rs/internet-zavisnost/>
- [17] Ristić M., Vosika Z. (2011). *Primena internet resursa u nastavi kvantnih računara*. *Tehnologija, informatika i obrazovanje za društvo učenja i znanja*, rad štampan u celini 3–5. juna 2011. Čačak: Tehnički fakultet Čačak.
- [18] Kuzmanović D., Pavlović Z., Popadić D., Milošević T. (2019). *Korišćenje interneta i digitalne tehnologije kod dece i mladih u Srbiji: rezultati istraživanja Deca Evrope na internetu*. Beograd: Institut za psihologiju Filozofskog fakulteta u Beogradu.



THE ROLE OF FLIGHT SIMULATION IN FLIGHT TRAINING OF PILOTS FOR CRISIS MANAGEMENT

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Abstract:

Every day over 102.000 commercial passenger flights take place on a global scale above our heads. Because of that many questions arise in the areas of safety and security in massive air traffic. If airlines use crisis management, any activity concerning the preparation of the crew and the aircraft for a particular task - flight gets more significance and importance. During the flight, the pilot - the captain of the aircraft, is the key person of any company activity that includes transport of people and goods, and that is the reason why a pilot's psycho-physical abilities and flying performance must be constantly checked, evaluated and improved. In a plane crash near North Macedonia's capital city Skopje, the aviation investigators discovered the number of serious failures in pilot training that led to the fall of a private plane Cessna 340. The investigation revealed that although the pilot was certificated to fly in instrument meteorological conditions, his actions in the air indicate that he was not well trained. European and American aviation authorities have clear legal regulations regarding the training and certification for individual flight categories as well as a categorized simulation technique where pilots exercise before they get one of the flying categories. Flight simulators play an essential role in the training of the future pilots for both visual and instrumental flight conditions.

Keywords:

Crisis management in aviation, Airlines, Flight training, Flight Simulators.

1. INTRODUCTION

Because of the specificity of this work and regarding the still poorly known issues about which the work is, in this introduction we will present the cross section of the events which will lead to the situation of crisis of the aircraft “Cessna 340”, on the flight Thessaloniki - Innsbruck. With the absence of the prompt reaction of the pilot to transform the flight from the visual flight to the instrumental one, the procedures for solving the situations of crises will not be applied consequently, because, upon entering clouds it will hit a hill, which will, unfortunately, cause its fall and the death of the pilot and passengers [1].

The Austrian aircraft “Cessna 340”, flown by the Austrian professional pilot with the license for instrument flight took off from Thessaloniki to Innsbruck. The wife of the pilot was in the plane as a passenger.

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The weather conditions over North Macedonia were bad. The clouds were low with precipitation. The flight according to the rules for a visual flight could hardly be feasible. Nevertheless, the pilot made the decision to take off. Somewhere above Skopje he realized that he would fly into the clouds, so he asked for the approval of the flight control in Skopje to lower the height of the flight. Since he fulfilled the plan of the flight by the regulations for a visual flight, he got such the approval. He started to lower the height although he was warned by the flight control of the thickness of the cloud layer. Although the pilot was trained for instrumental flight, he decided to continue the visual flight.

By descending under the clouds, he tried to continue his visual flight, but soon he entered a snowstorm. In the conditions of reduced visibility, he crashed a hill. The propeller of the right engine hooked the top of the rock. The wing was broken together with the engine. The pilot and his wife were killed, and the plane was destroyed.

Namely, during a visual flight, a pilot determines his position according to a visible earth horizon and leads the navigation by visible landmarks on earth. During an instrument flight, a pilot determines his position according to the artificial horizon and leads the navigation by radio navigation instruments on earth, completely excluding physical feelings and their false signals. The transfer from one type of flying to the other is a very complex process, which is proved by a great number of accidents that happen to the pilots who have passed from a visual flight to an instrument flight.

The pilot of the Austrian aircraft was trained for such flights, but during the last year he mostly flew visually, as a pilot of agricultural aviation.

Being conscious of the difficulties of passing from a visual flight to an instrument flight, he made the wrong decision, the situation of crises finished accidentally. The aviation investigation board of the authorities of North Macedonia wrote in their conclusion: Insufficient training of the pilot for instrumental flight is the main reason of the crash of the "Cessna 340", flown by the Austrian pilot on the line Thessaloniki - Innsbruck.

2. WHY FLIGHT SIMULATORS?

Flying a plane is one of the most difficult and most complex jobs a man has ever done. A pilot has to have necessary psychological and physical predispositions and great knowledge because he manages an aircraft in the third dimension of the space.

Those who want to do that profession are demanded to have top qualities that are not the conditions for doing many other professions.

According to an American study from the beginning of the 1960s, it was proved that out of 12.429 young men capable for military service, according to the criteria of medical boards for flying, only a thousand of them, or eight out of a hundred, were admitted to the schools for military pilots. The growth of the prices of planes and the price of the training had crucial influence to the increasingly rigorous selection of the candidates.

In the book "Outliers: The Story of Success", the author Malcolm Gladwell claims that the key to achieving world-class expertise in any skill, is, to a large extent, a matter of practicing the correct way, for a total of around 10,000 hours. According to the study of the State University of Florida, the professor Anders Ericsson interprets this "rule" in the way that the success in a certain activity is based not so much on the talent as on much practice. It would be wonderful if all pilots could have 10.000 hours of real flight, but it probably is not feasible for those ones who fly by recreation. No matter how much we want that, most of the pilots all over the world do not have enough time and finances for such the level of activities[2]. For that reason, flight simulators are key instruments which provide training and learning of pilots in safe conditions on earth. A well documented use of simulation in air transport for training clearly indicates both advantages and values of such approach. Fortunately, for all those who fly, current simulation technologies provide endless opportunities for the development of the knowledge and skills, and also the improvement and learning the procedures necessary for pilots to have a safe and secure flight.

"A flight simulator is a device that artificially creates a flight of an aircraft and the environment in which it flies, for the purpose of training of pilots or other purposes. That includes the elaboration of the equations that regulate how planes fly, how they react to the applications of flight control, effects of other aircraft systems and how an aircraft reacts to external factors such as air density, turbulence, current vibrations, clouds, precipitation etc. Flight simulation is used for various reasons, including trainings for flight (mostly of pilots) trainings and the development of an aircraft itself and the investigation of the characteristics of a plane and the control of management quality" [3].



3. TYPES OF FLIGHT SIMULATORS

The pilots in the air companies are able to use sophisticated simulators with three axes motion, for training, certification and testing the knowledge. Many passengers could be surprised if they knew that many maneuvers are firstly examined on simulators and never in reality until the situation of crisis itself.

Modern devices for training in aviation (ATDs) provide significant possibilities to pilots in the process of training, to learn basic skills and improve advanced skills of flying a plane in all the systems in aviation and to use available time in the most efficient and payable way.

Whether it is about visual or instrumental conditions for flight, aviation relies very much on procedures. In the conditions when a pilot beginner who is getting acquainted with basic skills and procedures that he must learn on a new plane or simply achieve a higher degree of training on the aircrafts that he already uses, simulation technologies can help to maintain or improve the abilities of flying a plane, i.e. the pilot to improve a precise control of the instruments, flight height and air speed [4].

No matter whether it is about a beginner or an experienced traffic pilot, time can be well used on flight simulators in order to improve the technique and become a pilot. The advantages are indisputable, because of which the Federal Aviation Administration (FAA) increasingly work on the issue to help companies create modern technologies for the improvement of flight safety. In addition to the data for the training and certification, the analysis enabled new, more logical regulations for the categorization of the devices for flight training [5]. Several various devices classified in many categories are used in modern flight trainings. Basically, the Federal Aviation Administration (FAA) of the USA and the authorities of the European Union (EASA – European Aviation Safety Agency) have accepted different classifications and levels of flight simulators.

Flight simulators approved by the Federal Aviation Administration (FAA):

The Aviation Training Device or ATD is the most frequent option for flight training in general aviation on small planes. In 2008, the FAA issued the Approval for application of aviation training devices and their use for training and practice, which helped in defining the differences between a home flight simulator in the form of video games and an aviation training device.

That was done by introducing two new terms: Basic ATD and Advanced ATD level of aviation training device, together with the appropriate standards of performances and directions for users.

The Basic aviation training device: Although it is similar to the software intended for home video games, the Basic aviation training device generally has more improved hardware and software functions which enable the Federal Aviation Administration to approve its use for training, practice and testing the qualification of a pilot. The application is limited to the certification for a pilot for obtaining pilot licenses for recreation, sports and private pilots, as well as the license for instrument flight in the aspect of a preparation for a flight. However, the Basic aviation training device cannot be used for testing the qualification for flying in instrumental conditions [6].

The demands that every Basic aviation training device has to fulfill are in the parameters of aircraft performances (flight speed, maximum climbing speed, cruise speed etc.). The results have to be comparable to a representative plane [7].

The Advanced aviation training device: as the name itself says, there are many standards for the Advanced aviation training device, together with the criteria of design which demand more realistic appearance and the feeling of a plane. Firstly, the Advanced aviation training device has to fulfill all the criteria for approving the Basic aviation training device as well as to unite additional properties and reliability of the system that significantly exceed the Basic aviation training device.

Among these regulations it includes the unification of the “representatives” of ergonomics in the category and class of airplane flight cabin, GPS system with mobile mapping system, a two-axis autopilot, an independent visual system which can provide real visual and instrument conditions for flying, a separate room for the instructor and the ability of simulation all emergency procedures which are contained in a pilot manual for flying a plane [8].

A flight training device FTD: The following categories are flight training devices or FTD. These devices are designed to represent a specific configuration of an airplane and depending on the level of the qualification of a flight training device, they can include a close cockpit and real visual situation. They are not always capable to realize a movement, but they are sophisticated enough to provide the training for preparation of a pilot to obtain the certificate for commercial and air transport, as well as other estimations.



Flight training devices are frequently used at universities and colleges that educate personnel in aviation. Aviation industry also use these devices a great deal for training new candidates before getting employed or by changing the professional title from a copilot to a captain, as well as for a transit training (for example the plane Boeing B737 to Boeing B747). Flight training devices are divided into the levels from 4 to 7. The levels 4, 5, 6, refer to fixed devices while the level 7 refers to helicopters. By the way, the levels 1 to 3 apply to older devices which are no longer used, or which are transferred to lower categories as Aviation Training Devices.

A Full Motion Flight Simulator FFS: is a term used by civil aviation organs for a high technical level of flight simulators. Such advanced flight training simulators are present both in the division at the Federal Aviation Administration USA and the European Aviation Safety Agency.

There are currently four levels of full motion flight simulators, from the level A to the level D. The level D is the highest and is certified for training the pilots with zero classes of flight experience on a specific type of aircraft.

This standard is used for initial and transitional flight training in commercial air traffic. Initial training is for the pilots who transfer to a new type of a plane, and the transitional training is for all other commercial pilots who have to realize it in regular intervals every six months in order to maintain their qualifications for flying in air traffic

Flight simulators approved by the European Aviation Safety Agency (EASA):

A Full Motion Flight Simulators FFS, a full motion platform, are approved by American and European aviation authorities as a common project so their certification and identification of various levels goes in the same direction as it has been said before.

European requirements in the certification of flight simulators are a little more strict on the lower levels of the platforms they identify[9]: As the lowest level platform of flight training simulators and navigation procedures:- EASA FNPT Level I; EASA FNPT Level II; EASA FNPT Level III- MCC- It is not a real certified level platform but it is approved within the previous three levels with special additions for realization of Multi Crew Cooperation Training. Flight simulators are similar to American flight training devices, with the fact that the difference is again in the level classification: EASA FTD Level 1; EASA FTD Level 2; EASA FTD Level 3- only for helicopters.

The latest flight simulators

The biggest flight simulator in the world is Vertical Motion Simulator (VMS) in the research center NASA Ames, south of San Francisco. The system can realistically present a vertical movement- moving to 60 feet and to demonstrate the vibration of simulator. This design enables fast transition of various types of aircrafts on which the flight simulations will be done. The possibilities of simulation move from commercial and military airplanes to the Space Shuttle [10].

4. CRISIS MANAGEMENT IN AVIATION

The first decade of the third millennium, for most theoreticians, is the decade of global crisis which covers politics, economy, education, traffic, energetic, or to make it simpler, it covers completely all social activities. Although humans nowadays have fascinating knowledge and abilities, crises of immense dimensions happen for the reasons of natural disasters (floods, droughts, fires, glacier melting, famine etc.) as well as for the reasons of imperfections of technologies or human errors there occur the crises related to land, rivers - seas and oceans, or air; unfortunately as a result of the crises we have a loss of human lives and destruction of material properties. A crisis is a follower but also a frame of life of a modern human, according to many wise men. And really, nowadays, nothing is for certain as it is crisis which has become the environment in which an individual, and organization and a society as a whole function [11].

In scientific as well as in professional circles, the term crisis is used when describing a condition with potentially negative consequences in which a modern society is. A crisis, no matter in which part of a society it happens, introduces us in the area of acting with risk. Aviation as a social activity, from its beginning until nowadays, has continuously been related to crises and acting in situations of crises. Global competition in air traffic is related to the needs of using the services with the increased quality of transport of passengers and goods, which strengthens the necessity for flexibility and creativeness by air companies [12].

Managements of air companies solve the issues of crisis management in every moment because their basic activity is a high-risk activity of air transport of people and goods. Since its complete activity occurs in a zone of high risks, air companies have essential existential necessity to function in a well-organized environment, in order to precisely plan all their activities for the purpose of realizing their strategic objectives, and within which a



key position is occupied by the transport of people and goods, and the realized results of work in such a way provide a high competition at market and within which managing a crisis on the level of the complete business occupies a special position. In order that the idea of activities or business operation become successful in the conditions of high competition, the risk has to be constantly analyzed and controlled from all the aspects: productive, commercial, financial, market, marketing, social, political, institutional, international etc. because practically, all the mentioned risks can affect the realization of objectives and results [13]. It is indisputable that a risk as a phenomenon has existed as long as a mankind. It is a complex, constant and inevitable and uncertain phenomenon which follows the activity of every organization and in the area of aviation it follows every activity (both in the air and on land). Every air company contains risks, and they are specially pointed out during the transport of passengers and goods. They can be kept under control and minimized by introducing better organization, control and quality, improvement and rationalization of business, appropriate selection, training and simulation of pilots, choice and selection of crews, as well as the selection of personnel on land that do the support and maintenance and their constant education and training, protection at work and other measures. As a synonym to a risk, our disbelief and inability to completely predict any event, even the most certain one, occur.

Basically, there are two types of crises, “those that are managed by you and those that manage you”. Proactive planning and reacting by air companies enables the managers to control and to influence them and to solve them with success, and ignoring the possibility that a crisis could occur, on the other hand, leads to the fact that a crises follow its own inertia. Making key decisions in air companies in the conditions of stress, excitement and danger caused by a crisis, is significantly more difficult than reacting to a crisis within the frames of the previously established plan for such situations. Many theoreticians, in their attempts to define it, equate a crisis management with proceeding in unpredicted situations.

A crisis can be regarded as a danger- a step to an abyss or an opportunity- a way to takeoff- progress. Anyway, there are four key factors which influence the reaction of air companies to crises: adopted strategies, established organizational structure, built organizational culture and character of the employed in an air company.

Our attitude is that the crisis management of an air company does planning in advance in order to have a ready response to all situations and to every question “what if”, i.e. in order to, in case of a crisis, by applying the developed and constantly improved procedures, minimize all the possible loss and harmful consequences, and thanks to which the air company would soon return to normal condition.

The crisis management in aviation can be defined as a collection of functions, procedures or processes of which the aim is to identify, analyze and predict possible situations of crises (in a flight preparation, takeoff, flight itself as well as during landing) and to establish and develop special procedures which will enable air companies to prevent a crisis or to fight it and to overcome it with minimum damage [14]. Good crisis management of an air company has the developed procedures and trained personnel (both on land and in the air) that will apply them in any situation of crisis which can endanger an aircraft i.e. the people and goods in it.

5. ADVANTAGES AND DISADVANTAGES OF FLIGHT SIMULATORS IN THE PROCESS OF PILOTS TRAINING

In aviation, there has never been the question of what more important is: a plane or a flight simulator. Airplanes have indisputably always had the advantages because they do the functions of air transport of people and goods. And flight simulators have always served for training of pilots. As we have demonstrated before, the appearance of airplanes was followed close behind by the development of flight simulators, so even nowadays they are inseparable so many pilots consider them as “twins”. While a plane in the air will not forgive us a mistake we do, a simulator is situated in a classroom (room) and it will enable us to practice resolving dangerous and difficult situation without being exposed to a risk and in completely safe and secure conditions.

- ♦ **Safety – security:** From its appearance long ago in 1910. [15] the basic concept of flight simulators has remained completely the same and it is to train in safe conditions pilots for flying tasks. Instead of explaining the safety and security of simulators it is better to regard the opinions of pilots. I strongly move forward. I reduce the pressure to the steering wheel and monitor the situation on the panels. It is all right. My left hand firmly holds the steering wheel while I am moving the handle of the gas with my right hand.



The runaway stays behind me and I climb up to the distance of 100 feet... 300 feet... The steering wheel is completely on my... The artificial horizon revolves around. A red lights flashes, I try the turn. I have lost an engine. I do my best, I move the steering wheel on the left, I solve the problem of withdrawal and suppression. With the corner of my eye I scan the indicators. It is too slowly. I do not have enough time for another try to land. Or to land on a tree... The steering wheel is heavy, as if it was made of concrete. My hand holds a handle with effort and the pain spreads to my shoulder. I trim! I feel a firm metal wheel on my knee. The altimeter constantly turns downwards. I must not allow to fall...It happened in 1983, I saved the plane. I followed the procedures and saved the plane from an impossible situation and successfully landed. I was the only person in the plane who was hurt. My chest muscle cracked while I was fighting with the heavy commands of the flight. Even during these unrelenting, terrifying long minutes, I completely forgot that I was on the flight simulator. Yes, and all the time I was sitting on the ATC 810, in the classroom of the Aims Community College. In that period, a flight simulator was much simpler than nowadays. There were no motions, no simulation of the view outside cockpit; there were no sound effects, it was more like a box, that was a complete squadron of simulators, arranged on long desks in front of a folding chair, and their result was brilliant. They immensely helped my colleagues and me to become captains in a safe and secure way. That was more important experience than all those ones in real airplanes” [16].

- ◆ **Price:** The average price of a flight simulator for the planes Airbus A320 and Boeing 737 is between 10 to 12 million dollars. The average price of the planes Airbus A320 is from 100 to 125 million dollars and of Boeing 737 is approximately the same. The price of wide-body passenger airplanes, such as Airbus A350 and Boeing B787, is averagely 300 to 350 million dollars, while the flight simulators which are their support cost between 15 to 17 million dollars [17].
- ◆ **The value of an hour of flight:** The average value of an hour of flight on Full Motion Flight Simulators (Airbus or Boeing) is 600 dollars, contrary to it the price of an hour of flight for Boeing B737-700 costs around 2,900 dollars, and for Airbus A320 costs approximately 3,200 dollars per an hour, and Boeing 757 costs approximately 8,380 dollars per hour. The price of an hour of flight on four engine aircrafts is over 10.000 dollars [17].
- ◆ **Maintenance:** The average price of maintenance of flight simulators is monthly around 1.000 dollars which is annually around 12.000 dollars, while the average price of maintenance of Boeing B737-700 monthly around 270.000 while annually it is around 3.000.000 million dollars [17].
- ◆ **The possibility of use without limits:** The concept of application of simulators is intended for using during 24 hours without limits. Crews and instructors change and the real time of using are determined by a company. Contrary to this, planes are intended to, after certain periods of time, within the resources of usage, go overhaul. These periods of times are 50, 100 and 200 hours of work [18]- Possibility of upgrading and improving the system: The concept of using a flight simulator is defined by the possibility of continuous software upgrading during the use without the interruption of engagement. On the contrary, in order to upgrade and expand the possibilities of a plane, it becomes out of use, go overhaul and upgrading of the system, which, as a consequence has the expansion of flight performances [18]- What does a flight simulator offers in training what a plane cannot: Modern simulation technologies provide the possibility of the programmed training of future pilots through gradual improvement of skills, permanent development of abilities and continuous adoption of procedures. We can do training ourselves or with instructors, who could point out how much we have made a progress, where we made mistakes, what we should pay attention to and to tell us which lessons to work out again. Modern flight simulators provide us the chance to fly to our destination a week before the planned flight, and then we can practice any approach, changing the conditions of the flight, we can even change weather conditions. Such training develops the experience of a pilot, no matter it happens in a virtual world. And instructors themselves point out that a continuous plan of skill development is much more practical in a virtual world. We can practically fly to any airport in the world by several clicks of mouse in simulation.



The candidates have many opportunities for less time and invested money. Every training can be realized through four or five approaches in simulation, which could not be possible in a real flight. It is indisputable that the experience of real flying still represents a golden standard, but it is also true that simulation is the excellent means to learn much, to practice and adopt knowledge and skills in limited time. By maximum optimization of training on a simulator the conditions for reducing the risk of learning in real aircraft are created. Flight instructors, during the training on modern simulators, have a unique opportunity to use the pause button “Control-frick”, reset the trainer for a given process, task or procedure, and to provide additional instructions, encourage and motivate a candidate, and to repeat the simulation many times, until the candidate learns it, and what is impossible to be done in a real situation of a training flight by plane [19].

6. CONCLUSION

Although air transport is the safest form of transport of people and goods, the example of the aircraft “Cessna 340” on the flight from Thessaloniki to Innsbruck flown by an Austrian professional pilot with the license for instrument flights, is a typical instructional example how a harmless situation, low clouds with precipitation can cause crisis situation. Since the pilot did not pass from visual flight to instrument flight, because of the absence of his prompt reaction, the crisis got out of control.

Unfortunately, this crisis situations, which happened near Skopje, had tragic consequences. The findings of aviation investigation organs in this and in similar accidents is warning: a pass from visual conditions of flying to instrument flying is a very complex process, which is indicated by a great number of accidents that happen to the pilots out of simulators and solid training on simulators, when they try to pass from visual flying to instrumental flying.

When such and similar accidents happen, the issues related to training and practice of pilots and obtaining some aviation licenses and certificates open. Europe and America have completely appropriate law regulations regarding training and certifications for individual categories of flight as well as the categorized simulation technique by which pilots realize practice and training. Although there are clear law regulations, functional and very modern simulators and a complex procedure of obtaining aviation licenses and certificates, crisis situations in air transport that end with accidents are not rare.

That is why the findings of North Macedonian Investigation Aviation Committee warns “insufficient practice of the pilot in instrument flight is the main reason of the fall of the plane “Cessna 340” and killing the pilot and passengers” as well as the destruction of the aircraft. The logical question “How to prevent such accidents?” comes by itself.

Applying crisis management by air companies, every activity involved in the preparation of the crew and the aircraft for flight becomes more serious and more important. Crisis management in aviation can be defined as a collection of functions, procedures or processes of which the aim is to identify, analyze and predict possible situation of crisis (during the preparation of a flight, takeoff, flight itself, as well as during landing) and to establish and develop special procedures which will enable air companies to prevent crisis or to fight it and overcome it with a minimum damage.

In performing a flight, the captain of the aircraft is the key person who will apply the procedures, make the decisions and according to his/her trainings and practice, with success resolve every situation of crisis. Captains of aircrafts who are trained well and who are in top practice can experience a crisis during a flight, of course, but they have knowledge, tools, instruments and procedures of crisis management by which the crises can be recognized, fought and in the end defeated and the transport itself done accurately and on time.

The authors have the attitude that flight simulators have irreplaceable importance in the prevention of any aviation crisis situations. Not questioning the fact that training and practices on real planes still remain “golden standards”, we express the opinion that modern simulators have some indisputable advantages to real planes in the process of making captains. Experienced pilots have given them the nickname “twins” wanting to point out how using modern planes is not possible without safe and secure simulator on land which supports it. Inspecting all the facts relating training planes and simulators we can make a conclusion that the practice on simulators is safer- more secure by the price of the device itself it is much cheaper, by the value of the hour of flight it is many times cheaper, by maintenance a simulator- a plane, several hundred times cheaper, they have the possibility to be used twenty-four hours a day, they have the possibility to be upgraded in a simpler way and to be improved without interrupting their functioning, they are equipped with many options of advanced training with the simulation of a great number of situation that a plane itself can perform [20].



The authors are conscious that they for sure haven't given all the answers related to this issue. Many questions have remained hidden and the authors themselves do not have the answer. Maybe the words of Jovo Grbic, a great expert in aviation, are the best conclusion to this project: ***“Aviation is not unsafe, but it is like a sea, unforgivable to any carelessness or negligence.”*** [21].

REFERENCES

- [1] Z. Vereš, “When the engines shut down”, “Kad motori utihnu”, KIA More, Beograd, 2007.
- [2] A. Kusovac, “News in a training of flight technicians”, “Novine u školovanju vazduhoplovnih mehaničara”, Aeromagazin, vol. 4, 1988, pp 13.
- [3] Federal Aviation Administration, “FAR 121 Subpart N-Training Programe”, FAA, Washington D.C, 2013.
- [4] S. Parson, “In Celebration of Simulation”, FAA Safety Briefing, 2017, pp. 7-8.
- [5] T. Hoffmann, “Sorting the Lot of Flight Simulation Devices”, FAA Safety Briefing, 2017, pp. 8-13.
- [6] Federal Aviation Administration, “AC-61-136A Appendix 1 and 2”, FAA, Washington D.C., 2014.
- [7] T. Hoffmann, “Sorting the Lot of Flight Simulation Devices”, FAA Safety Briefing, 2017, pp. 8-13.
- [8] Federal Aviation Administration, “AC-61-136A Appendix 1 and 2”, FAA, Washington D.C., 2014.
- [9] Joint Aviation Authority, “Aeroplane Flight Training Devices”, JAA, Hoofddorp, Netherlands, 2008.
- [10] S. D. Beard, “Space Shuttle Landing and Rollout Training at the Vertical”, American Institutet of Aeronautics and Astronautics, 2014, pp. 16.
- [11] V. Grujić, G. Vukadinović, “Crisis management of small and midium bussineses”, “Krizni menadžment malih i srednjih preduzeća”, “Management 2012”, MESTE FBIM Transaction, Belgrade, Serbia, 2012, pp. 236-243.
- [12] V. Grujić, D. Lazić, “The Final Phase of the Flight of the Aircraft as an Element of the Crisis Management in Aviation”, “Završna faza leta vazduhoplova kao element kriznog menadžmenta u vazduhoplovstvu“, vol I, FBIM Transaction, Belgrade, Serbia, 2013, pp. 111-121.
- [13] V. Grujić, D. Lazić, “The Significante of the Crisis Management in Preparation of the Pilot”, “Značaj primene kriznog menadžmenta u pripremi pilota”, FBIM Transaction, Belgrade, Serbia, 2014, pp. 141-154.
- [14] V. Grujić, D. Lazić, “The Significante of the Crisis Management in Preparation of the Pilot”, “Značaj primene kriznog menadžmenta u pripremi pilota”, FBIM Transaction, Belgrade, Serbia, pp. 2014, 141-154.
- [15] C. E. Crossman, “Dry Shooting for Airplane Gunners”, Popular Science, 2019, pp. 13-14.
- [16] W. E. Dubois, “Rusty Pilot Seminars”, Retrived from <http://planetaless.net>, 2012.
- [17] Airbus Group, “New Airbus aircraft list prices for 2016”, Retrieved from: <http://www.airbus.com/newsroom/press-releases/en/2016/01/new-airbus-aircraft-list-pricesfor-2016.html>.
- [18] W. E. Dubois, “Rusty Pilot Seminars”, Retrived from <http://planetaless.net>, 2012.
- [19] Federal Aviation Administration, “The Limits of Simulations”, FAA Safety Briefing, 2017, pp. 12-13.
- [20] J. Wiliams, “ A Virtual Plan for the Real World How Simulation Can Help You Mitigate Risk”, FAA Safety Briefing, 2017, pp. 21-23.
- [21] J. Grbic, “Flight Safety”, “Bezbednost vazdušne plovidbe“, JAT Airways, Belgrade, Serbia, 1978.



USAGE OF IT IN THE PROCESS OF TOPOGRAPHIC MAP CREATION IN MGI

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Abstract:

Usage of GIS in MGI is a standard in the production process of the geographic and cartographic information considering geospace and maps. This paper main scope is a review of the central geospatial database as a base for a technological process which main purpose is production of topographic maps. In the central geodatabase environment, MGI has developed its own technological production line, which is based on family of Microsoft Windows operating systems (standard desktop license and the server license). In some production phases, it is necessary to use additional specialized software to achieve rounded production process which is capable of dealing with such a complex task.

Keywords:

Military geographical institute (MGI), GIS, map, geodatabase, geospace.

1. THE INITIAL CONSIDERATION ABOUT MGI INFORMATION SYSTEM

In the information system of MGI (IS MGI), the client-server architecture is implemented, where the network is service oriented. This concept is beneficial in multiple ways, and, as for the main advantage of such approach, we can point at: centralized management of services and clients and network administration, centralized security policy, easier backup of the entire system as well as backup on the local workstations [1]. Out of the many network services which exist in IS MGI, two services have the greatest impact on the process of topographic map production. These services are Microsoft Active Directory and Image Services.

The Active Directory has become a necessary service for the contemporary business. It serves as a central spot for the information storage about the users identity, workstations, services, authentication of users and workstations and provides the mechanisms, with which, users and workstations are able to gain access to the network resources (printers, plotters, file sharing, databases etc.).

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The main role of the Active Directory is to provide the complete identity and access infrastructure, which consists of tools and technologies necessary for the integration of persons, processes and technologies within a single organization. The basic functions of such directory are:

- Authentication – every single user, workstation or some other predefined entity in the network, has to confirm its identity to the Active Directory before it is allowed to function as a part of the Active Directory domain;
- Controlled access – The Active Directory keeps all of the data (files and folders, the Active Directory objects) and the resources (workstations, printers, services etc.) which are placed inside the domain, ensuring that the access is allowed only to those identities which are meant to gain access to them;
- Monitoring – The Active Directory has the tools and mechanisms which enables surveying, corrections and reporting;
- Increased security – By the usage of the Active Directory, the security of the both network and the data is significantly increased, because the data considering identities and their passwords are kept inside encrypted database. All of the common users have limited access to both workstations and the network. For example, they are unable to install any additional software, which is the main source of the malicious software.
- Simplified deployment – Installation and reinstallation of the client operating systems and applications, for the entire groups of workstations, can be performed from the one location and at a given time;
- Expanding the possibilities of the Active Directory – Some applications have the possibility to be implemented directly into the Active Directory, so their management and administration becomes a part of the Active Directory.

The Image Services are, so far, shown up to be the best and the most economical solution for the publishing of the aerophoto images, which serves as a base map for the further processing. For that purpose, the extension Image for the ArcGIS Server is installed, and it is used for publishing of the image services, as the addition for desktop version of the used software, or as a WEB service. This server component addition, enables the creation of the dynamic mosaics, and, in the real time, processing of a large number of the aerial images. Publishing of the aerial images over the image service, gives the extra quality to the aerial images, it simplifies their management, maintenance and provides faster and easier access for the users.

The advantages of the implementation of image services are: simplified management of the aerial images; enables publishing of the large amount of the aerial images without the need for them to be pre-processed; possibility to create mosaics of the aerial images in different file formats, projections, locations and resolutions; processing of the data is performed in the real time on the server, which frees the resources of the client workstation; publishing of the special services at the meta data level; defined area of the interest can be sliced out from the image service and then used on the workstation while offline.

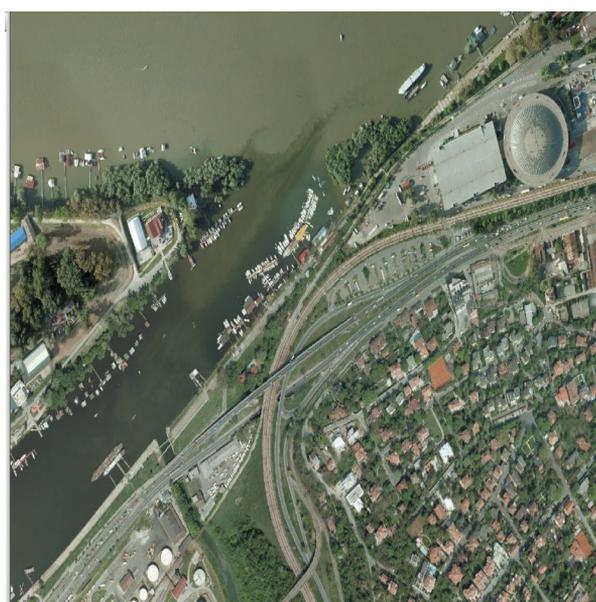


Fig. 1. Published image service in IS MGI
(Pavlović A., 2014)

2. SPATIAL DATA AND TECHNOLOGICAL PROCESS OF TOPOGRAPHIC MAP CREATION

Usage of the IT technologies, makes the production process of topographic maps a lot easier and faster. The contemporary trends in the sphere of the data acquisition, organization and manipulation of the spatial data, imposes the existence of the central geodatabase. In practice, it means the unification of all geospatial data into a single database, from which, a variety of topographic and overview map scales can be created or derived. The significance and usefulness of the production process based on the central database can also be observed through the improved data availability, possibility of the multiscalar presentation, easier administration, elimination of the data and the process redundancy and standardization. All of the above mentioned advantages, reduces the time necessary for creation of maps, as well as lowering the total cost of final product - the map.



The creation and definition of the central database [1], and the entire production process of topographic maps based on the central database, is a demanding and complex task. It requires multidisciplinary approach. In the favor of this statement, there is a fact that many developed countries did not yet completely develop their own solutions for this problem. It is necessary to create the central database in a way that supports the definition of the production process, which will resolve the problem of multiscalar view of the spatial data and enables support for all phases in the production process of the map creation.

MGI has created the central database and defined the production process in the 2012. The central database is used as a base for the creation of the entire scale array of the digital topographic maps, which are supposed to be produced in MGI. Those map scales are 1:25000, 1:50000, 1:100000 (topographic maps) and 1:250000 (overview topographic map). [2]. While defining the production process based on the central database (Fig. 2.), it was planned that the initial data acquisition will be conducted using contemporary methods of photogrammetric restitution, direct mapping over digital ortophoto and cartographic processing of the content collected that way in the GIS environment, with the usage of the corresponding alphanumeric data and the data collected and verified on the field.

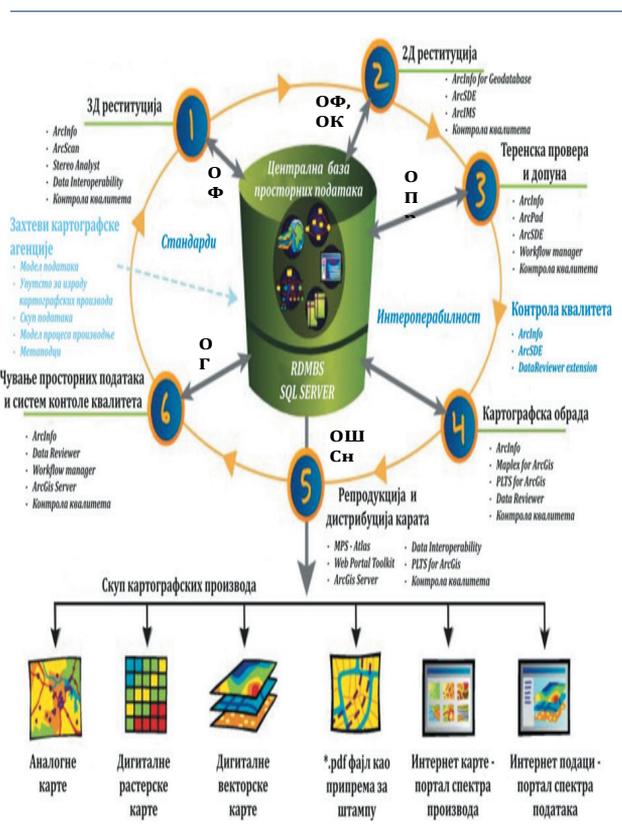


Fig. 2. The production process of topographic maps in the MGI (MGI, 2015)

The entire process of map production in MGI, was conducted with the consideration of the end user needs. Those users are mainly Serbian Armed Forces, different business entities as well as interested civilians. The specific requirements of the different users are involved into the central database, from which, we can get visualized (mapped) data, according to the user request. From the given schema of the production process of the topographic maps in the central database environment, can be noticed that, in the production process, all departments are included and supported [2]. Those departments, in the production sector, are namely: Photogrammetric department (OF), Survey department (OPr), Cartography department (OK), and in the support sector: Geoinformatic department (OG), Publishing and supplement department (OŠSn). Functions and responsibilities are narrowly and clearly defined by the order and connection of the every phase in the production process.

The main source of the data acquisition in the central database are data obtained by the digital technological process for aero photogrammetric imaging in the MGI [3]. Digital technological line in the MGI consists of the airplane Piper Seneca, digital aero photogrammetric camera Leica ADS80, with additional equipment, and photogrammetric workstations with the software for the 3D restitution. Digital technological line for aero photogrammetry in the MGI is shown in figure 3. The data obtained with the method of the aero photogrammetry imaging (digital aero photogrammetric camera), are processed on the photogrammetric workstations with the usage of the specialized 3D software, directly in the central geodatabase. With the procedure of the ortorectification, aero photogrammetric images, with the usage of the collected 3D spatial data and the orientation points, are transformed from central to the orthogonal projection, and the final result is a digital ortophoto.



Fig. 3. Technological line for aerophoto imaging (MGI)



The phases of the technological process are all conducted in the central database environment. The different phases in the production process require additional software, but, almost the entire production process is based on the ESRI's ArcGIS platform [4].

After the creation of the digital ortophoto, first phase of the production process is the 3D restitution. The 3D restitution is conducted with the usage of the Stereo Analyst extension for ArcGIS. Usage of this extension allows us to perform 3D editing in the central database environment, without the need for usage of the third party software. It also allows us to use internally standardized data model and simplifies the entire production process. The 3D restitution is followed by 2D restitution. The 2D restitution introduces the cartographic modeling of the content obtained by 3D restitution method and the additional content which was not treated in the 3D restitution process. This phase of the production process of the creation of the maps is completely conducted in the ArcGIS software environment (the editor version), by direct vectorisation over the digital ortophoto in the SQL database, which is a part of the entire workflow as a distributed database. The map content that passed the phases of 3D and 2D restitution has to be field checked, so the next phase of the production process is a field check and the addition of the data. For this phase we use the ArcPAD software and the tablet devices. This approach allows us to stay within defined environment of the central database even while disconnected from the MGI LAN [5]. That means that field checked and updated data, are automatically integrated in the central database.

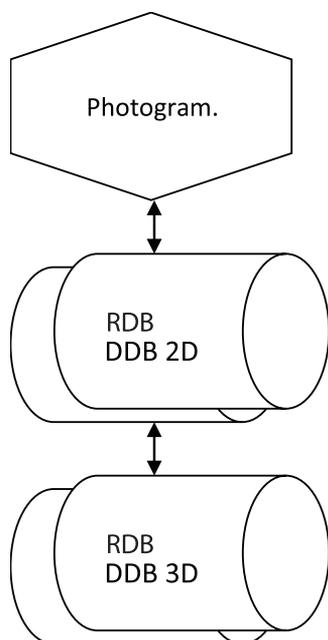


Fig. 4. Part of the production proces based on the distributed databases

That means that field checked and updated data, are automatically integrated in the central database. The final phase of the production process which includes data manipulation, is the cartographic processing of the previously collected and partly processed data. For the cartographic processing we use, like in the 2D restitution, ArcGIS software, and it is based on the interactive processing of the generated content, with the usage of the cartographic modeling methods [5]. In this phase of the production process, the map is completely generated in the means of the visualized content and supported SQL database as well. This is the last phase of the production process for the GIS content. The last phase of the production process that considers the creation of the hard copy map, is printing. Printing process is partially based on the central database, from which the data is visualized and exported in the PDF file format, and partially on the third party software such as Adobe Illustrator and Map Publisher. This is necessary because the final result, or hard copy map, has to be printed on the analog offset printing machine.

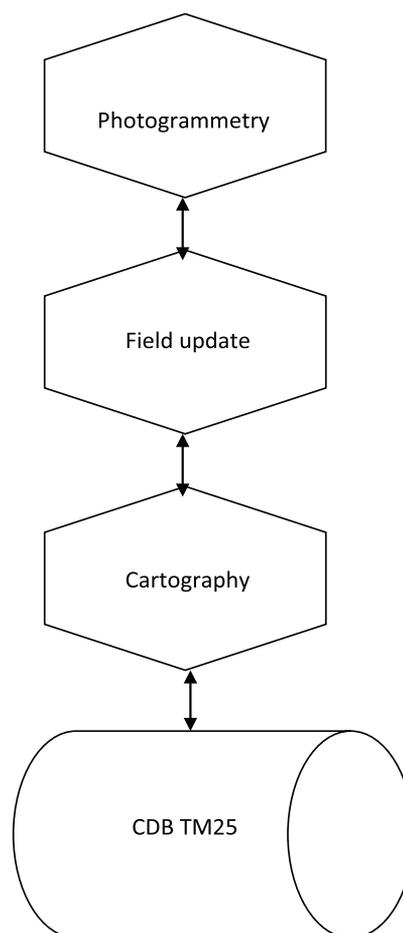


Fig. 5. The Schematic representation of the production process at the central database level



3. CONCLUSION

The MGI of the Serbian Armed Forces is bound to its tradition of the map creation, topographic maps especially, since 1876. In comparison to the previous epochs, nowadays IT and the influence of the informatics revolution has the significant impact on the way that topographic maps are created. That led to the evolution of the production process of topographic maps in the MGI as well. According to the implementation of the IT, the entire production process of the topographic maps in the MGI is implemented. In the very beginning, the expenses were much higher than with usage of classic approach of the topographic maps production, due to the high investment into hardware and software. As the time passes, the expenses are lowering and in a certain moment, they become lower than classic cartographic map production approach. The improved quality of nowadays topographic maps produced in the MGI, is a large advantage of the IT based production process in comparison to the traditional production process [6]. That is achieved by the centralization of the production process, unification of the symbology and quality control and many other technical solutions based on the IT. By these unified and centralized steps of the production process, the possibilities of the arbitrariness and inconsistency are almost eliminated.

Using the contemporary technological solutions in the sphere of the map production, as a main product, now we have a geospatial database. Different kinds of the hard copy maps and digital maps are only the types of the layout of the geospatial database.

Beside these traditional layouts (maps), geospatial database also enables publishing of the map content on the WEB, and as our main goal for the future, updates of the map content in the real time, over the WEB.

The map production process, which is shown in this paper, is not unchangeable and final. It is intentionally left open for the future expansions of the capabilities, according to the advances in the IT. Because of that, it is necessary to keep track on the newest IT achievements, even when they are not primarily intended for mapping purposes.

REFERENCES

- [1] Vojnogeografski institut, "Tehnička dokumentacija VGI," Beograd, 2014.
- [2] V. Marković, A. Pavlović, D. Radosavljević, "Proizvodni proces DTK25 u VGI," Beograd, 2017.
- [3] S. Tatomirović, R. Banković, V. Marković, "Tehnološki proces izrade digitalne topografske karte 1:25000," Conf. Oteh 2009 Beograd, pp. 748-751, 2009.
- [4] <http://www.esri.com>
- [5] V. Marković, "Opšti principi logičkog modelovanja strukture podataka za potrebe izrade DTK25," in Zbornik radova VGI, Beograd, pp. 23-31, 2009.
- [6] S. Tatomirović, R. Banković, Lj. Nikoloski, S. Milošević, "Quality control of digital topographical map 1:25.000," Conf. Oteh 2011 Beograd, pp. 711-719, 2011.



USING THE INTERVAL TYPE-2 FUZZY INFERENCE SYSTEMS TO DETERMINE A RELATIONSHIP BETWEEN THE ROAD CHARACTERISTICS ASSESSMENT AND ROAD TRAFFIC ACCIDENTS

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Abstract:

There are several Type-2 fuzzy inference systems (T2FISs) tested in the research described in this paper. These models use one, two, or three input variables and all of them are described by one output variable. Input variables relate to the assessment of dangerous places on the observed road section, assessment of road characteristics, and frequency of driving. The assessment of dangerous places is obtained as an average score from assessing nine dangerous spots on the considered road section in Serbia called "Ibarska magistrala". Assessment of road characteristics is based on seven scores, which means that participants assessed seven predefined road characteristics in the same road section. The frequency of driving is an input variable based on the criterion of how many times a week or a month the examinee drives on the observed road section. Output variable is The number of road traffic accidents that a driver had experienced. T2FISs are tested on a sample of 305 drivers and most of them are professional drivers. The results are perceived through the cumulative error that T2FISs make in the description of empirical data.

Keywords:

Type-2 fuzzy inference systems, road traffic accidents, road safety, dangerous spots assessment, road characteristics assessment.

INTRODUCTION

Road traffic accidents (RTAs) cause around 3700 deaths in the world every day [1]. Thousands of people are also injured every day. In addition, the RTAs generate significant economic costs. It is evident that there is a need to examine the reasons for the occurrence of RTAs, which would facilitate the design of programs for traffic safety improvements.

By reviewing the literature, it is possible to conclude that there are three general causes of RTAs. They relate to the driver, i.e. human factor, vehicle, and road [2,3]. Sam, Velanganni, and Evangelin [4] report that human errors are recognized as the far most common influential factor causing more than 90 % of RTAs. Some of the most common driver behaviors that lead to the occurrence of RTA are: unadjusted speed, wrong assessment of the traffic situation, and the performance of improper actions in traffic [5].

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It is proven that the drivers who do not respect the traffic rules in one segment, usually do not behave properly also in some other segment. For example, the drivers in Serbia are forbidden to talk on the phone while driving, except when using a hands-free device. A study by Čubranić-Dobrodolac et al. [6] showed that the participants who violate this rule, are prone to drive under the influence alcohol as well, especially the group of drivers who experienced more than three RTAs in their driving experience. This points to the conclusion that the human factor as a cause of RTAs and general driver behavior can be explained to a large extent by the corresponding psychological traits. There are studies that confirm a relationship between certain psychological traits that lead to risky behavior and the propensity for RTAs [2,7]. Besides, there is also evidence that the skills of drivers, such as speed estimation or spatial abilities, affect the likelihood of being involved in an RTA [8].

In this paper, we examine also a relationship between certain skills of drivers and the number of experienced RTAs. Here, the assessment of dangerous places on the road, as well as the road characteristics assessment are considered as skills of drivers. In addition, the frequency of driving is also taken into consideration.

For the purpose of quantification of relationships between the considered variables, both individually and jointly, and the number of experienced RTAs, seven Type-2 fuzzy inference systems (T2FISs) are designed and tested [9,10]. The T2FIS models are tested on a sample of 305 drivers. This paper can be seen as an extension of the research presented in the paper by Čubranić-Dobrodolac et al. [11] where Type-1 fuzzy inference systems were tested; however, with the different aim, to compare the effects of various shapes of membership functions on the performance of the fuzzy system.

1. MODEL DEVELOPMENT – USED VARIABLES

The model proposed in this paper is based on the design and testing of the performance of seven T2FISs. These T2FISs use one, two, or three input variables, and all of them have the same output variable. Input variables relate to The assessment of dangerous places on the observed road section, Assessment of road characteristics, and Frequency of driving on the road section. The output variable is The number of accidents that a driver had experienced by his or her fault. An additional explanation of designed T2FISs is offered in Table 1.

TABLE I. TESTED TYPE-2 FUZZY INTERFERENCE SYSTEMS

T2FIS No.	Used variables	Name of used variables
I	x_1, y	Dangerous places – Accidents
II	x_2, y	Road characteristics – Accidents
III	x_3, y	Frequency of driving – Accidents
IV	x_1, x_2, y	Dangerous places, Road characteristics – Accidents
V	x_1, x_3, y	Dangerous places, Frequency of driving – Accidents
VI	x_2, x_3, y	Road characteristics, Frequency of driving – Accidents
VII	x_1, x_2, x_3, y	Dangerous places, Road characteristics, Frequency of driving – Accidents

The chosen road section is in the Republic of Serbia, road category IB, number 22, marked as road E-763, which is colloquially known as „Ibarska magistrala“. The first variable x_1 named *Dangerous spots* is formed based on the assessment of nine dangerous places on the considered road section which are previously noticed by the authors. These dangerous places are determined based on the official statistic about the most frequent location of traffic accidents in the past (Fig. 1).



Figure 1. Dangerous places at route E-763 marked with the triangles [12]



Dangerous spots that were assessed by the participants are the following: Žarkovo, Orlovača, Ripanj, Šiljakovac, turn to the Barajevo, Stepojevac, Šopić, Lazarevac roundabout, and Čelije. Each of the 305 examinees from the sample gave scores about the aforementioned nine dangerous places. The participants gave the marks according to the level of risk they perceive considering these places, i.e. to what extent are the considered dangerous spots really dangerous. The final value of the first input variable is a sum of all nine scores.

Input variable *Dangerous spots* refer to the sum of estimates of nine hazardous sites that could be rated by a score of 1 to 10, which means that the domain of this variable is from 9 to 90. It can be displayed using 5 fuzzy sets and their membership functions (Fig. 2): VLAR – very low assessment of risk, LAR – low assessment of risk, MAR – medium assessment of risk, HAR – high assessment of risk, VHAR – very high assessment of risk.

As can be seen from Fig. 2, the fuzzy sets that describe the input variable *Dangerous spots* do not cover the same intervals, as a result of the fact that these fuzzy sets are defined based on the empirical data of 305 respondents (Table 2). Although the minimum value for the assessment of nine points is 9, the observed sample showed that the minimum value was 35. Based on this, it can be concluded that in the average driver population, the lesser values are rarely met and therefore, a relatively large interval for potential values of risk assessment remains uncovered. Accordingly, the fuzzy set VLAR has the largest interval compared to the remaining 4 fuzzy sets.

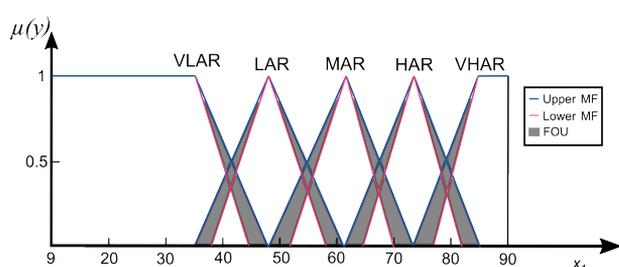


Figure 2. Input variable Dangerous spots

TABLE II. DOMAIN INTERVALS FOR USED VARIABLES AND DESCRIPTIVE STATISTICS OF THE SAMPLE

Variable	Domain	Descriptive statistics of the sample		
		Minimum	Mean	Maximum
x_1	[9,90]	35	60.91	85
x_2	[7,70]	32	43.84	65
x_3	[1,7]	1	2.58	7
y	[0,8]	0	1.46	8

On the other hand, the mean value of the assessment of the hazardous locations of all respondents who participated in the study was 60.91; on the basis of which this value was taken as part of fuzzy set MAR with the highest value of upper membership function (equal to 1).

The second input variable x_2 named *Road characteristics* contains an evaluation of seven characteristics of the observed road section. These are: The shape of the route and general perspective, roadway condition, state of horizontal signaling, state of vertical signaling, condition of the protective fence, sideroad part - drainage channels, etc, and traffic safety on connecting roads.

The input variable *Road characteristics* refers to the sum of the estimates of seven road characteristics that could be estimated from 1 to 10, which means that the domain of this variable is from 7 to 70. It can be displayed using the 5 fuzzy sets and their membership functions, as shown in Fig. 3: VLAC – very low assessment of road characteristics, LAC – low assessment of road characteristics, MAC – medium assessment of road characteristics, HAC – high assessment of road characteristics, VHAC – very high assessment of road characteristics.

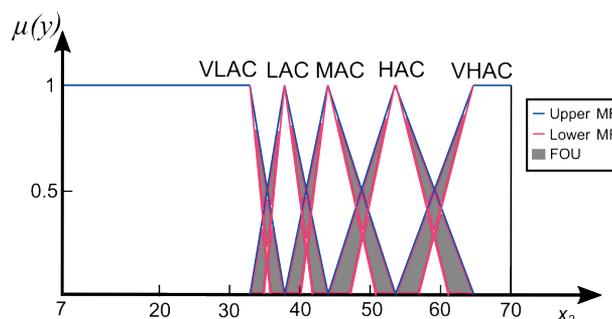


Figure 3. Input variable Road characteristics



It can be noticed that the fuzzy sets that describe the input variable *Road characteristics* do not cover the same intervals. Empirical data showed that the sum of grades ranges from 32 to 65. The mean value of the assessment of all respondents who participated in the study was 43.83; based on which this value was taken as the value of the fuzzy set SPK with the highest membership degree.

The third input variable x_3 named *Frequency of driving* refers to the characteristic of how often the driver drives at the observed road section. The following marks are introduced: 1 – every day, 2 – drives 3-4 times a week, 3 – drives 2 times a week, 4 – drives once a week, 5 – drives 2-3 times a month, 6 – drives once a month, and 7 - drives once in a couple of months. The mentioned values are described by the seven fuzzy sets as follows: VHF – very high frequency, HF – high frequency, MHF – medium-high frequency, MF – medium frequency, MLF – medium-low frequency, LF – low frequency and VLF – very low frequency, as shown in Fig. 4.

The output variable y named *Accidents* relates to the number of traffic accidents that respondents had experienced. In the sample, the participants reported the number of RTAs from 0 to 8; however, drivers who participated in more than 5 accidents are relatively rare. Therefore, the output variable y is defined as shown in Fig. 5. The following fuzzy sets are introduced: VSNA – very small number of accidents, SNA – small number of accidents, MSNA – moderately small number of accidents, MNA – medium number of accidents, MHNA – moderately high number of accidents, HNA – high number of accidents, VHNA – very high number of accidents.

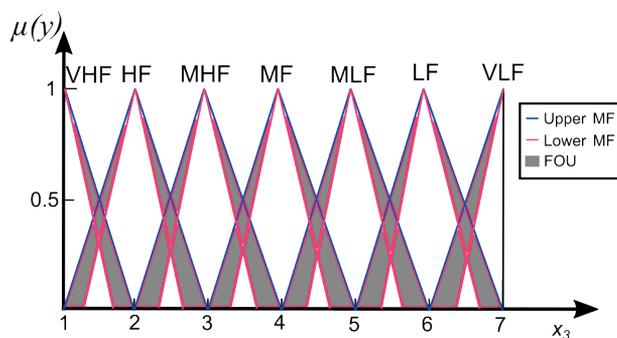


Figure 4. Input variable Frequency of driving

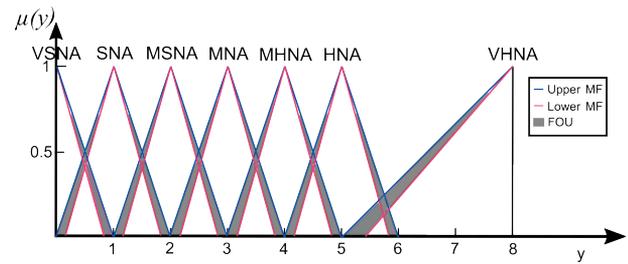


Figure 5. Output variable Accidents

2. MODEL DEVELOPMENT – FORMING FUZZY RULES BASED ON EMPIRICAL DATA

To design a T2FIS, it is necessary to set the fuzzy rules base. Here, we use a well-known approach for defining fuzzy rules based on empirical data proposed by Wang and Mendel [13].

The Wang-Mendel method consists of five steps. Step 1 divides the input and output spaces of the given numerical data into fuzzy regions. For each of the used variables, the domain interval is determined, i.e. the interval of the possible values of variables. Each domain interval is divided into $2N+1$ regions, as shown in figures from 2 to 5.

Step 2 generates fuzzy rules from the collected data. One data pair is used for the construction of one fuzzy rule. Because there 305 respondents in the sample, in this step we generated 305 fuzzy rules. IF part of the fuzzy rule is composed of the names of regions with the maximum membership degree for input variables and THEN part from the name of the region with the maximum degree for the output variable. However, considering 305 designed rules, some of them are the same. The same fuzzy rules should be excluded and remained just one as their representative.

In Step 3, a problem of conflicting rules should be solved. These are the rules that have the same IF part, but a different THEN part. For this purpose, each of the formed rules should be assigned a degree, defined by the Eq. (1) for the case when a rule is defined as following: “IF x_1 is A and x_2 is B, THEN y is C”.

$$D(Rule) = \mu_A(x_1) * \mu_B(x_2) * \mu_A(y) \quad (1)$$

where $D(Rule)$ is a degree of a rule, $\mu_A(x_1)$ is a value of the membership function of the region A when the



input value is x_1 , $\mu_B(x_2)$ is a value of the membership function of the region B when the input value is x_2 , and $\mu_A(y)$ is a value of membership function of the region C when output value is y . In a conflict group, only the rule that has a maximum degree should be accepted.

Step 4 makes a combined fuzzy rule base which consists of rules obtained from empirical data and linguistic rules of a human expert. Finally, Step 5 determines a mapping from input to output space using a defuzzification procedure.

To get fuzzy rules based on the Wang-Mendel approach, we applied the programming code that is prepared based on the code presented in the paper by Čubranić-Dobrodolac et al. [2].

3. RESULTS AND DISCUSSION

After the creation of seven T2FISs according to the aforementioned methodology, their performance should be tested. This is done based on Eq. 2 [2,8,14]:

$$CD = \sum_{i=1}^{305} |y^{(i)} - Propensity(i)| \quad (2)$$

where CD is Cumulative deviation, $y^{(i)}$ is the number of accidents which drivers from the sample experienced, and $Propensity(i)$ is the result of T2FIS.

Cumulative deviation (CD), as a measure that describes how well the T2FIS describes the empirical data. It is calculated as an absolute value of the difference between the number of RTAs that the drivers from the sample experienced and the corresponding result of T2FIS. The result of T2FIS for a participant number i in the Eq. (2) is marked as $Propensity(i)$.

After the required calculations, the final results are presented in Fig 6. Here, the values of CD for each considered T2FIS can be noticed.

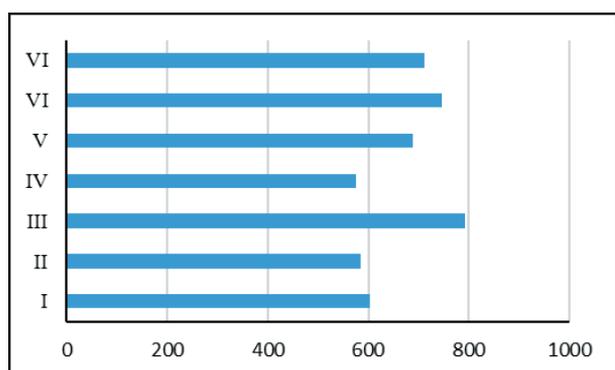


Figure 6. Comparison of various fuzzy inference systems based on the obtained CD values

It should be kept in mind that smaller values of CD characterize the T2FIS that gives better results. Therefore, from seven considered T2FIS, the best performance is achieved by T2FIS No. IV ($CD= 574.61$).

This result indicates that the T2FIS with two input variables is the most convenient. These two variables are related to the assessment of dangerous places on the road and the assessment of road characteristics. Therefore, a useful decision-making tool for measuring the propensity for RTAs can be formed by analyzing the driver's characteristics related to these two aforementioned variables.

To discuss the general quality and performance of this T2FIS, it is meaningful to carry out further research about the causes of RTAs, and to test new T2FIS using some other variables.

In this paper, we tested the various combinations for input variables of T2FIS. However, some other methodological approaches related to testing would be welcome as a direction for further research. For example, it is possible to optimize the performance of the current T2FISs. This should be done by using some other method for generating the fuzzy rules, intervals, and shapes of membership functions, and by modifying the method of defuzzification.

Finally, it can be concluded that the proposed research can be very useful in the field of traffic safety. By analyzing the driver's assessment of dangerous places on the road and road characteristics, it is possible to get an impression about his or her propensity towards RTAs. This information would facilitate the design of adequate educational programs tailored to the needs of a particular driver, with the final aim to improve the skills of drivers, and by that to contribute to fewer RTAs on the roads, saving the lives of people and contributing to their wellbeing.

REFERENCES

- [1] World Health Organization, "The Global status report on road safety 2018." (2018). https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/ Accessed 18 June 2020.
- [2] M. Čubranić-Dobrodolac, L. Švadlenka, S. Čičević, M. Dobrodolac, "Modelling driver propensity for traffic accidents: a comparison of multiple regression analysis and fuzzy approach", International Journal of Injury Control and Safety Promotion, vol. 27, issue 2, pp. 156-167, 2020. <https://doi.org/10.1080/17457300.2019.1690002>



- [3] M. Karacasu, B. Ergül, A.A. Yavuz, "Estimating the causes of traffic accidents using logistic regression and discriminant analysis", *International Journal of Injury Control and Safety Promotion*, vol. 21, issue 4, pp. 305-313, 2014. <https://doi.org/10.1080/17457300.2013.815632>
- [4] D. Sam, C. Velanganni, T.E. Evangelin, "A vehicle control system using a time synchronized Hybrid VANET to reduce road accidents caused by human error", *Vehicular Communications*, vol. 6, pp. 17-28. 2016. <https://doi.org/10.1016/j.vehcom.2016.11.001>
- [5] M. Čabarkapa, M. Čubranić-Dobrodolac, S. Čičević, B. Antić, "The influence of aggressive driving behavior and impulsiveness on traffic accidents", *International Journal for Traffic and Transport Engineering*, vol. 8, issue 3, pp. 372 - 389. 2018. [https://doi.org/10.7708/ijtte.2018.8\(3\).09](https://doi.org/10.7708/ijtte.2018.8(3).09)
- [6] M. Čubranić-Dobrodolac, S. Čičević, M. Dobrodolac, M. Nešić, "The risks associated with using a mobile phone by young drivers", *Transport*, vol. 26, issue 4, pp. 381-388. 2013. <https://doi.org/10.3846/16484142.2013.865672>
- [7] M. Čubranić-Dobrodolac, K. Lipovac, S. Čičević, and B. Antić, "A model for traffic accidents prediction based on driver personality traits assessment", *Promet - Traffic & Transportation*, vol. 29, issue 6, pp. 631-642. 2017. <https://doi.org/10.7307/ptt.v29i6.2495>
- [8] M. Čubranić-Dobrodolac, L. Švadlenka, S. Čičević, A. Trifunović, M. Dobrodolac, "Using the Interval Type-2 Fuzzy Inference Systems to Compare the Impact of Speed and Space Perception on the Occurrence of Road Traffic Accidents", *Mathematics*, vol. 8, no. 1548. 2020. <https://doi.org/10.3390/math8091548>
- [9] E.H. Mamdani, S. Assilian, "An experiment in linguistic synthesis with a fuzzy logic controller", *International Journal of Man-Machine Studies*, vol. 7, issue 1, pp. 1-13, 1975. [https://doi.org/10.1016/S0020-7373\(75\)80002-2](https://doi.org/10.1016/S0020-7373(75)80002-2)
- [10] L.A. Zadeh, "The Concept of a Linguistic Variable and Its Application to Approximate Reasoning-1", *Information Sciences*, vol. 8, issue 3, pp. 199-249, 1975. [https://doi.org/10.1016/0020-0255\(75\)90036-5](https://doi.org/10.1016/0020-0255(75)90036-5)
- [11] M. Čubranić-Dobrodolac, T. Molková, L. Švadlenka, "The Impact of Road Characteristics Assessment on The Traffic Accidents Occurrence" *The Proceedings of Sinteza 2019 - International Scientific Conference on Information Technology and Data Related Research*, Belgrade, Singidunum University, Serbia, 2019, pp. 26-31. <https://doi.org/10.15308/Sinteza-2019-26-31>
- [12] JP "Putevi Srbije", Dangerous places at the road sections in the Republic of Serbia, available at: <http://www.putevi-srbije.rs>
- [13] L. Wang, and J. Mendel, "Generating fuzzy rules by learning from examples", *IEEE Transactions on Systems, Man and Cybernetics*, vol. 22, issue 6, pp. 1414-1427. 1992. <https://doi.org/10.1109/21.199466>
- [14] S. Jovčić, P. Průša, M. Dobrodolac, L. Švadlenka, "A proposal for a decision-making tool in third-party logistics (3PL) provider selection based on multi-criteria analysis and the fuzzy approach", *Sustainability*, vol. 11, issue 15, no. 4236, 2019. <https://doi.org/10.3390/su11154236>



**INFORMATION TECHNOLOGY IN
SPORT AND RECREATION SESSION**





POSSIBILITY OF FUNCTIONAL MOVEMENT SCREENING IN PHYSICAL EDUCATION

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Abstract:

It is very important that pupils have appropriate level of basic movement patterns in order to deal with motor tasks properly. Proper movement patterns can be affected by overweight, obesity, physical inactivity, injury or clinical pathologies. The Functional Movement Screen (FMS) is one of the most popular injury risk and movement proficiency assessment tools. This tool is composed of 7 movement tests that rely on mobility, stability and balance. There are a number of well-designed interventions that enhance motor skills, motor control, stability, and mobility and usually they are prescribed as individualized programs. However, since this problem is widespread it might be more effective if it is addressed within the school setting on a larger scale. FMS is reliable, affordable and practical tool that could be an answer to many functional movement deficiencies that plague our children and youth. Implementing FMS program instead of the traditional dynamic warm-up in preparation for physical education class might be an effective solution for improving movement imbalances in primary school pupils. Furthermore, data collected from a large number of schools may be a base for establishing National database for children and youth functional movement proficiency standards.

Keywords:

Movement proficiency, Physical inactivity, Movement dysfunctions, Pupils..

INTRODUCTION

Physical Education (PE) programs in primary schools in Serbia contain diverse contents [1], including sports fundamentals, motor ability conditioning, school sport competitions, activities in nature, etc. All of these activities require that students have a basic level of physical fitness and physical literacy in order to successfully complete the PE as a school subject. The PE programs become increasingly complex and more demanding as school years increase. Consequently, it is very important that pupils have appropriate level of basic movement patterns in order to deal with them properly. Proper movement patterns can be affected by obesity.

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It is well-known fact that overweight and obesity in childhood persist as a huge health problem throughout the world. It has been confirmed that children show adjustments in their movement patterns because of the overweight [2]. That can affect every day physical activity routines and significantly restrict functional performance [3]. Improper functional movements due to excessive weight and obesity problem in early life may be the cause of a postural imbalance in later life and inefficiency to perform everyday tasks. Hence, it has been indicated that minimizing improper movement patterns observed in overweight and obese children should be addresses as soon as possible [4].

PE is a context where injuries occur quite often [5, 6]. To minimize the risk of injuries, it is necessary to identify physical dysfunctions exposing to injury and to create an injury prevention program. Several movement oriented tests have been established to assess injury risk during various physical activities [7–10]. One of the most popular injury risk assessments is the Functional Movement Screen (FMS).

Although movement dysfunctions are often associated with injury or clinical pathologies, functional movement limitations can affect the youth. A recent research with the FMS testing of the seven functional movements, conducted on adolescent population confirmed that more than 45% of respondents scored ≤ 14 . The score of 14 is considered as a cutoff score that indicates higher chances for suffering an injury due to the improper movement patterns [11].

Considering the simplicity and practicality of FMS, authors think that it has a significant potential to be applied in the school setting as a tool in the efforts for improvement of movement proficiency.

1. FUNCTIONAL MOVEMENT ASSESSMENT

A numerous studies have been published in recent years about Functional Movement Screen (FMS) and its benefits and reliability in diverse populations and with different purposes [12-14]. The FMS screening tool is consisted of seven movement tests that rely on mobility, stability and balance. These tests are: Deep Squat, Hurdle Step, In-line Lunge, Shoulder Mobility, Active Straight-Leg Raise, Trunk Stability Push-Up, and Rotary Stability.

Findings of very recent reliability study suggested that the FMS overall score had moderate to good interrater and intrarater reliability, including sufficient levels of measurement error [15].

The movement patterns used for the FMS give a fitness professional observable performance of basic functional movements by positioning the clients in required stances and movements where imbalances, asymmetries and weaknesses can be noted. The FMS was not designed to be a training tool but an instrument for movement assessment. The usefulness of the FMS lays in its practicality, simplicity, and ability to complete the toolbox used to estimate a performance. The FMS does not detect the cause of a dysfunctional movement pattern but discovers which patterns are making a problem [16].

General screening guidelines

To execute the FMS properly, an examiner needs to know about the following anatomical landmarks.

- The most distal wrist crease
- Anterior superior iliac spine (ASIS)
- Lateral and medial malleolus
- The joint line of the knee/Mid-Patella
- Tibial tuberosity

It is essential to remember that the FMS screen should be performed without any kind of prior warm-up. Reason for that is because it is of vital importance to know what a client's normal state of functional movement is when he approaches the test. In that way we get the best picture of the client's current level of movement competency in everyday activity. An examiner should make enough space between himself and the client in order to see the whole picture of the entire movement. Each test can be performed three times, and the examiner should move around the client during the test to get the best view. Typical order of the FMS screen is when client goes from the standing positions to the ground-based positions. The order that clients move from one test to another should not affect the results and it can be made in any sequence.

Seven fundamental movement tests are incorporated in the FMS screen, and the score is registered on a scale from 0 to 3. The sum all scores creates an overall score that ranges from 0 to 21 points. A score of 3 is indication that the movement was properly performed in a functional way. A score of 2 is given when a functional movement is executed in acceptable way but with compensation. A score of 1 is assigned in case when a client is unable to execute the movement. There are three variables of interest: (1) the FMS overall score, (2) the number of asymmetries, and (3) number of dysfunctions. Previous studies indicated that individuals with an overall score ≤ 14 on the FMS have a positive likelihood to suffer a time-loss injury [17, 18].



2. FMS TESTS

The FMS Test Kit is a tool invented to use when performing the FMS screen. Simple rating system to assess client's movement is included. The FMS Test Kit consists of measuring stick – dowel, measuring device, and hurdle (Figure 1). All of these items can be self-made and every PE teacher can easily learn and perform the FMS tests.

In the following section there will be given basic information about each FMS test, and full details regarding the FMS testing procedure can be found at www.functionalmovement.com [19].

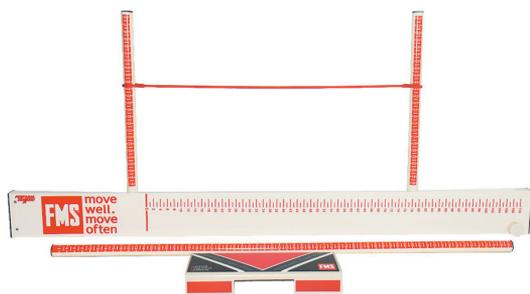


Figure 1. FMS Test Kit

- Deep Squat

The Deep Squat movement is functional movement that appears in many sports such as rugby, volleyball, American football, etc. It requires well-coordinated mobility and stability, where hips and shoulders function in a symmetrical positions (Figure 2C).

- Hurdle Step

The Hurdle Step is functional movement test that estimates compensations or asymmetries in stepping movement patterns. It should be performed slowly with controlled movement. (Figure 2B).

- In-line Lunge

The In-line Lunge test is intended to explore the movements and control of the right and left functions in the basic movement pattern. It challenges mobility and stability in the counterbalance movements of the upper and lower limbs (Figure 2A).

- Shoulder Mobility

The idea of this test is to estimate the mobility of the shoulder girdle, thoracic spine, and a rib cage during simultaneous upper limb movements. This movement pattern usually is not seen in daily activities but it gives good picture of the movement ability (Figure 2F).

- Active Straight-Leg Raise

This test was designed to explore the mobility of the flexed hip as well as constant core stability during the movement execution, and extension of the opposite hip. It is challenging for the ability to separate lower limbs without external loading (Figure 2E).

- Trunk Stability Push-Up

This test targets the reflex core stabilization (the spine and hips) when the upper limbs initiate the push-up movement (Figure 2G). The examiner should look for the compensatory movements. This test has different starting positions for men and women.

- Rotary Stability

The intention of this test is to estimate the movement stability of the shoulder girdle, the core, and pelvis while executing simultaneous upper and lower limb movements (Figure 2D). It is forbidden to manipulate set up positions manually.



Figure 2. FMS tests. (A) In-line lunge, (B) Hurdle step, (C) Deep squat, (D) Quadruped rotary stability, (E) Active straight leg raise, (F) Shoulder mobility, and (G) Trunk stability push-up [16].

3. APPLICATION IN SCHOOL SETTING

As mentioned earlier, the occurrence of the functional movement limitations is often associated with overweight and obesity, physical inactivity, injury, or clinical pathologies. These factors probably play a major role in a lack of efficiency in the fundamental motor skills of children and adolescent youth. Findings of the recent study indicate that the overall motor skill performance was rather poor among adolescents, and only



11% of the respondents in that study showed mastery or near mastery in a range of basic motor skills [20].

The motor abilities and skills of primary school pupils can also be viewed in the context of the results of recent research carried out on primary and secondary school pupils in Serbia where comparative analysis with the results of children from certain EU countries showed that the results of Serbian pupils were mostly under average [21]. The tendency of physical inactivity of children and youth has a direct impact on the level of motor abilities, which occurs not only in Serbia but also in the neighboring countries as well as in developed countries [22].

Apparently, there is an urgent need to pursue solutions and tackle fundamental motor skill weakness among children and youth populations. There are a number of well-designed interventions that enhance motor skills, motor control, stability, and mobility and usually they are prescribed in the form of individual programs. These programs usually consist of corrective exercises that are focused on an individual's "weakest link," and studies confirmed their efficiency [23, 24]. However, since this problem is widespread it might be more effective if it is addressed within the school setting on a larger scale. Despite the justified doubt whether such a program is well suited for each client's needs and deficiencies, its overall effectiveness for the class is proven [25].

The easiest way to implement a functional movement program during PE classes would be during warm-up routines since that would not interrupt regular PE curricular activities. There are several goals [26] of the warm-up exercises in PE:

- Optimizing mechanical and physiological conditions for the loco motor apparatus functioning.
- Injury prevention.
- Maintenance of the fitness and good posture.
- Compensation (activation of less active muscles).
- Cumulative effect of shaping exercises.

Many exercises in the "traditional" PE warm-up routines have a lot in common with FMS corrective exercises and PE teachers in our country would not have any difficulties to implement such a program. The warm-up of the FMS experimental group would be made of:

- Mobility exercises – These exercises include various forms of stretching or joint mobility work.
- Stability/Motor Control Exercises – The main target of these exercises is improvement of the postural control of initial and ending positions.

- Movement Pattern Retraining – These exercises should enhance stability and mobility into desired movement patterns.

Although the FMS scoring system might look complex, the authors provided a very basic scoring sheet format that every PE teacher can handle easily. The FMS scoring sheet is consisted of a Raw Score, Final Score, and a Total Score. Depending on the score, a fitness professional (or a PE teacher) determines an intervention strategy. The scores are used and interpreted differently depending on the context, whether a fitness/health professional is working individually with a client or as a PE teacher working with a group of pupils, or a strength and conditioning coach working with a sports team. When working one-on-one, a fitness professional may use the Raw Score to establish the order of intervention exercises. In a case where there are large groups (like a school class), the Final Score may be more valuable at the beginning when deciding the next steps for the whole group. The Total Score might have more importance when fitness professional makes comparisons to the other groups or other individuals [19].

Using the data

Further steps and benefits of using FMS in schools could be in setting up a National database of children and youth's functional movement proficiency standards for different age groups (grades). This might sound too ambitious, but the FMS is a practical, reliable, and affordable tool that could be an answer to many functional movement deficiencies that plague our children and youth. The majority of schools in Serbia already have esDnevnik (electronic school book) where PE teachers can add an FMS score for each pupil. Once the data are loaded into the system it would be easy to perform adequate statistics and acquire the standards.

4. CONCLUSION

As indicated earlier, the motor abilities and motor skills of primary school pupils in our country are mostly under average compare to the children from certain EU countries. Generally, the declining tendency of physical activity of children and youth has a direct impact on the level of motor abilities, and that is observed as a worldwide phenomenon.

There are a number of relevant interventions designed in an effort to tackle movement deficiency issues among children and youth. Usually, those interventions are individualized programs focused on improvement



of motor skills, mobility, stability, and motor control. However, since the widespread problem of fundamental motor skill deficiencies among children and youth population, the logical place for addressing these problems in school children and youth is within PE context, a setting that is usually well suited for group activities.

Implementing the FMS program instead of the traditional dynamic warm-up in preparation for PE activity might be a plausible solution for correcting movement deficiencies in primary school pupils. Furthermore, data collected from a large number of schools may be a base for establishing a National database for children and youth functional movement proficiency standards.

REFERENCES

- [1] Gadžić, A. "Theory and method of teaching in physical and health education," Belgrade: Singidunum University, 2019.
- [2] Hills, A.P., Hennig, E.M., Byrne, N.M., Steele, J.R. "The biomechanics of adiposity – structural and functional limitations of obesity and implications for movement," *Obes Rev*, 3, pp. 35–43, 2002.
- [3] Nantel, J., Mathieu, M-E, Prince, F. "Physical activity and obesity: Biomechanical and physiological key concepts," *J Obes* 2011, 2011:650230.
- [4] Rozendal, R.H. "Biomechanics of standing and walking," In *Disorders of Gait and Posture*, Bles W, Brandt T, Eds. Amsterdam: Elsevier Scientific Publishers; 1986, pp.3–18.
- [5] Nationwide Children's Hospital. (2009, August 20). New National Study Finds Increase In Physical Education Class-related Injuries. ScienceDaily. Retrieved September 7, 2020 from www.sciencedaily.com/releases/2009/08/090803083640.htm
- [6] Gutiérrez-Castañón, E., Martínez-de-Haro, V., Ramos-Álvarez, J.J. y Cid-Yagüe, L. "Injuries in Physical Education of High School. A Problem?," *Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte* vol. 18 (72), pp. 709-722, 2018.
- [7] Cook, G., Burton, L., Hoogenboom, B.J., Voight, M. "Functional movement screening: the use of fundamental movements as an assessment of function - part 1," *International Journal of Sports Physical Therapy*, 9(3), pp. 396–409, 2014.
- [8] Gribble, P.A., Hertel, J., Plisky, P. "Using the star excursion balance test to assess dynamic postural-control deficits and outcomes in lower extremity injury: A literature and systematic review," *Journal of Athletic Training*. National Athletic Trainers Association, 47, pp. 339– 57, 2012.
- [9] Harris-Hayes, M., Van Dillen, L.R. "The Inter-Tester Reliability of Physical Therapists Classifying Low Back Pain Problems Based on the Movement System Impairment Classification System," *PM&R*, 1, pp. 117–26, 2009.
- [10] Kritz, M., Cronin, J., Hume, P. "The bodyweight squat: A movement screen for the squat pattern," *Strength and Conditioning Journal*, 31(1), pp. 76–85, 2009.
- [11] Abraham, A., Sannasi, R., & Nair, R. "Normative values for the functional movement screen in adolescent school aged children," *International Journal of Sports Physical Therapy*, 10(1), pp. 29–36, 2015.
- [12] Schneiders, A. G., Davidsson, A., Hörman, E., & Sullivan, S. J. "Functional movement screen normative values in a young, active population," *International Journal of Sports Physical Therapy*, 6(2), pp. 75–82, 2011.
- [13] Perry, F. T., & Koehle, M. S. "Normative Data for the Functional Movement Screen in Middle-Aged Adults," *Journal of Strength and Conditioning Research*, 27(2), pp. 458–462, 2013.
- [14] Gonzalo-Skok, O., Serna, J., Rhea, M. R., & Marín, P. J. "Relationships between functional movement tests and performance tests in young elite male basketball players," *International Journal of Sports Physical Therapy*, 10(5), pp. 628–38, 2015.
- [15] García-Jaén, M., Sellés-Pérez, S., Cortell-Tormo, J. M., Ferriz-Valero, A., & Cejuela, R. « Assessment of fundamental movement patterns in children: a gender comparison on Primary School students," *Nuevas Perspectivas de Educación Física, Deporte y Recreación.*, 34, pp. 282–286, 2018.
- [16] Teyhen, D.S., et al. "The Functional Movement Screen: A Reliability Study," *Journal of Orthopaedic & Sports Physical Therapy*, 42 (6), pp. 530-540, 2012.
- [17] Kiesel, K., Plisky, P.J., Voight, M.L. "Can serious injury in professional football be predicted by a preseason functional movement screen?" *North American Journal of Sports Physical Therapy*, 2, pp. 147-158, 2007.
- [18] O'Connor, F,G,, Deuster, P.A., Davis, J., Pappas, C.G., Knapik, J.J. "Functional movement screening: predicting injuries in officer candidates," *Medicine & Science in Sports & Exercise*, 43, pp. 2224-2230, 2011.
- [19] Cook, G. "Functional Movement Screen: Level 1 Online version," *Functional Movement Systems and Gray Cook*, 2015.
- [20] O' Brien, W., Belton, S., & Issartel, J. "Fundamental movement skill proficiency amongst adolescent youth," *Physical Education & Sport Pedagogy*, 21, pp. 557–571, 2016.



- [21] Gajević, A. "Physical development and physical abilities of elementary school pupils," Belgrade: Republic Institute for Sport.
- [22] Gadžić, A., Marković, M., Kraljević, R. "The correlations of certain environmental factors with motor abilities in 6th grade elementary school pupils," Sport - Science & Practise, 3 (2), pp. 5-16, 2013.
- [23] Bodden, J. G., Needham, R. A., & Chockalingam, N. "The effect of an intervention program on functional movement screen test scores in mixed martial arts athletes," Journal of Strength and Conditioning Research, 29(1), pp. 219-225, 2015.
- [24] Kiesel, K., Plisky, P. J., & Voight, M. L. "Can serious injury in professional football be predicted by a preseason Functional Movement Screen?," North American Journal of Sports Physical Therapy, 2, pp. 147-158, 2007.
- [25] Coker, C. "Improving Functional Movement Proficiency in Middle School Physical Education," Research Quarterly for Exercise and Sport, 89 (3), pp. 367-372, 2018.
- [26] Gadžić, A. "Anthropomotor and method aspects of shaping exercises," Belgrade: Singidunum University, 2016.



THE IMPACT OF INFORMATION TECHNOLOGIES ON THE SCOUTING PROCESS IN SPORTS GAMES

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Abstract:

Although it has attracted the attention of experts only in the last decade, sports analytics has its roots since the existence of organized sports. Any records of players or situations in the game that contribute to later decision-making during the competition can be considered as some kind of analytics. As an important part of these processes, scouting is at the core of coaching in sport games at all levels of competition. Coaches and managers try to enable improvements in competitive activity by exploring the key factors and mechanisms on which success in competition depends, both at the individual level as well as at the level of the entire team. The aim of this paper is to describe how technological development and ultimately information technology have influenced these processes, and specifically how modern tendencies affect performance management in sports games. Primarily, the development of data collection methods, from manual, through video, to the use of modern digital technology has led to an "explosion" of the amount of data collected. The huge amount of available data has resulted in the emergence of expert data systems specific to each sport game, which provides analytical support to coaches and managers in decision-making.

Keywords:

decision, analytics, feedback, system, data.

1. INTRODUCTION

Participation in sports is usually undertaken with the intention of improving the level of activity. One of the most important variables that influence learning and later performance of a skill is feedback. In order to provide meaningful feedback, the coach must somehow observe and evaluate performance [1, 2]. Practice in coaching includes conclusions and subjective observations on coaching perception, bias, and previous experiences. However, numerous studies have found that this kind of observations could be incorrect and unpredictable. Memory capacities in humans are somehow limited and it is nearly impossible for us to remember in details all the important events that happened during the entire match.

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So far, it was shown that top football coaches remembered just 30% of the key factors of successful football performances and were less than 45% accurate in their post-match assessment [3, 4]. In fact, more experienced coaches even reported a non-existent difference in performance. In addition, they were very confident in their decisions, even when they were making mistakes [5].

Considering how people process information, the aforementioned results are not surprising. Memorizing certain information and retrieving it later is a complex process with great potential for interference. Impressive parts of the competition (e.g. controversial decisions, exceptional technical performances, free kicks, etc.) are easy to remember, while less impressive moments are mostly forgotten. Moreover, all actions that take place in the field are almost impossible to view, assimilate and store, due to the limitation in our system. As a result, coaches are generally focused on just a few critical parts, while other actions generally remain neglected [1, 5, 6].

Surprisingly, it appears that standard or predefined system for monitoring and evaluating performance does not exist. If reliance on a human information processing system is problematic, another way of gathering information during sports competitions must be determined. It is obvious from the previous text that this information must be objective, unambiguous and as comprehensive as possible. Therefore, the aim of this paper is to describe how technological development and ultimately information technology have influenced these processes, i.e. how modern tendencies affect performance management in sports games.

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: sport games, analytics, scouting, technology, and data.

3. RESULTS AND DISCUSSION

Technological development has improved the data collection systems during the competition and made it easier for statistical analysis. The emergence of video, and then digital technology, has been shown to have two effects on the type of activity data collected. First, there is much more actions on which data can be collected. Second, g of the nature of data collected by technological

advances change the possibilities on data analysis, providing the means to collect data on deeper aspects of activities. The analysis of competitive activity includes not only the frequency of different types of actions performed, but also data on the more fundamental dimensions of performance on which actions are observed. These more fundamental aspects of performance can be summarized as technique, tactics, fitness and psychology. The impact of technology on the collection of data on athlete activities is discussed using a three-step scheme: (a) manual method, (b) video analysis and (c) digital technology [7, 8, 9].

Regardless of the level of technology, player tracking systems had to provide data on four key elements of the analysis. The basic key elements in system analysis are PLAYER, POSITION, ACTION AND TIME [1]. Each advanced system improved the data collection of the previous system.

Phase 1 - Manuel method

The manual method, as the oldest and unavoidable method of data collection, is a suitable system for structurally simple sports games such as baseball, tennis, and volleyball to some extent.

The structure of the game, divided into a series of individual parts, facilitates the collection of key data on activities during the game. The game is played according to the rules of the break between points, the ball is returned to the server, which starts a new segment. That way, there is enough time to record the basic details of the past activities. In addition, this game is viewed from two angles: the angle of defense and the angle of attack. Although this method is effective in sports games such as baseball, its use is limited in sports games with the conquest of space, such as football, basketball, handball, ice hockey or rugby.

Scatter diagrams are frequently used to collect data during a match and provide instantaneous feedback athletes and coaches. They are usually used in the form of drawings on the scheme of the field of the sports game that is observed, and then actions of interest are recorded on the positions that have taken place [1]. For example, consider a football coach who wants to know where his team is losing possession (Fig. 1a). Second, coach wants to know which player loses the most balls (Fig. 1b). Third, maybe the most important are the actions that players perform when losing possession. In order to record actions, it is necessary to define the most common actions and assign them a symbol: P - pass, S - shot, D - dribble, C - cross, K - kick-off. This level is the most complicated and requires the most practice (Fig. 1c).

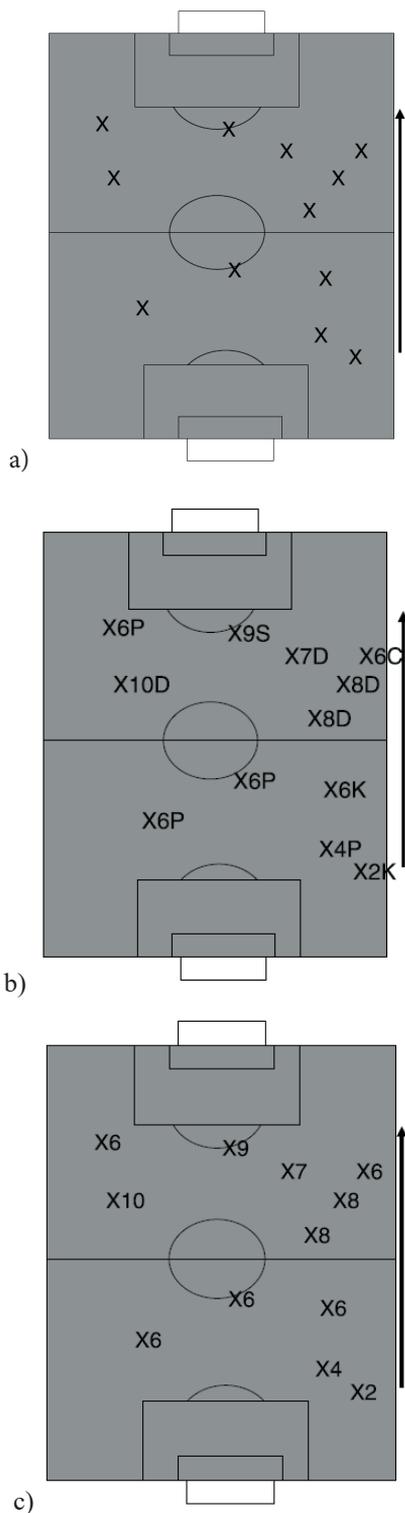


Fig. 1. Scatter diagrams in football

Frequency tables are another common form of data collection that allows quick, easy analysis of the activities of athletes and teams. Using a frequency table (Fig 2) below, the analyst can easily record the frequency of each player's action in the line-up during basketball game [1].

Actions	1	2	3	4	5	6
Pass	*****		***	****		
Dribble	****		*	**		
2-pt Shot	****		****	**		
3-pt Shot	**			*		
Assist	****		****	*		
Lost possession	*		**			

Fig. 2. Frequency table for basketball

The main characteristics of these systems are:

- Easy and fast
- Precise (with proper practice)
- Used during competition
- Gives instant feedback
- Efficient, no need for analysis
- No sequence of events.

It must be noted that there are dangers in the interpretation these data. Namely, not only that they lack in accuracy, they can be only analyzed by the simplest procedures. Attempts at in-depth analysis with this kind of data only lead towards problems [1, 2, 10].

Phase 2 – Video recording

The main characteristic of sports games with the conquest of space is the attempt of the team to move through the space to get into a situation to place a certain object in a certain place (basket, goal) that is defended by the opposing team. Additionally, these games are time-dependent, i.e. the result of the match is determined by the cumulative result for a certain time. The main feature of these games is tactics and all players on the field are directly or indirectly involved in every action. Consequently, players in decision-making during the match must be both spatially and tactically aware [7].

In comparison to the baseball or tennis, in more complex sport games, a much more compound structure is noticed. Specifically, there is a much more indirect connection between the individual contribution of the players, the achievement of goals and the results of the match. Attack and defense are much more interdependent, because the possession of the ball by the attacking team also has a defensive function (e.g. depriving the opposing team of opportunities). Therefore, ball possession and time are key resources in these sport games. For example, in order to score a goal, the ball must move forward into areas of the field where opportunities to score can be created, thus proving a high interdependence of different attack actions.



This structural hierarchy of interdependent player actions creates serious problems for analysts, especially when there are joint actions [7, 10,11].

Not surprisingly, the manual method can only collect limited amounts of data during sports games. Appearances, results, disciplinary warnings and player exclusions are the only data consistently recorded through the history. Game recordings greatly facilitated the collection of data on activities in sports games with the conquest of space and enabled more detailed analysis. Instead of limiting themselves to collecting data during the match collect data by applying the manual method to video reproductions of matches (Fig. 3). This process was very slow and time consuming. As a result, the teams were focused only on the critical moments. Therefore, the video analysis was mostly qualitative with reconstructions of certain parts, often only those in which the result changed. Quantitative data for these games proves to be quite restricted in range [7].

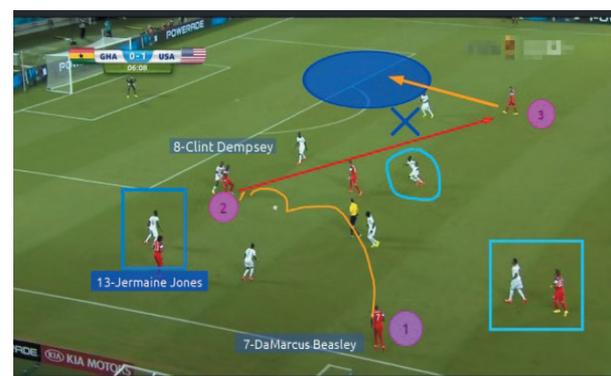


Fig. 3. Video analysis in football

Phase 3 – Digital technology

The arrival of digital technology and cheap computers increased the speed of data collection in various sports games. Digitization of video images enabled the development of computer software for encoding and editing videos, so that the process of data collection became much faster. Specifically, image recognition software became somehow automated, with limited human intervention only. Due to digital technology, data is available for all actions of different players in space-conquering sports games [1, 7, 12-14]

The digital revolution in activity analysis has led a number of commercial companies to offer data collection and analysis services to a certain number of sports teams. All of these systems provide detailed numerical data on all aspects of the game.

They combine numeric data with graphics and video from the game. These systems also allow a certain degree of interactivity so that the analyst can control some parameters when reporting [7]. Usually teams rely on these systems to get detailed statistical reports after the game, as a source of data on future opponents and scouting reports to recruit players (Fig. 4). Additionally, teams often try to create databases on their own (e.g. SportsCode, InStat etc.) to encode and edit footage of their matches. Because of the time pressures that are quite evident, analysts can encode only several real time features. As a result, the focus is merely on the important data that can put some pressure into the tactical changes [2, 10, 14].

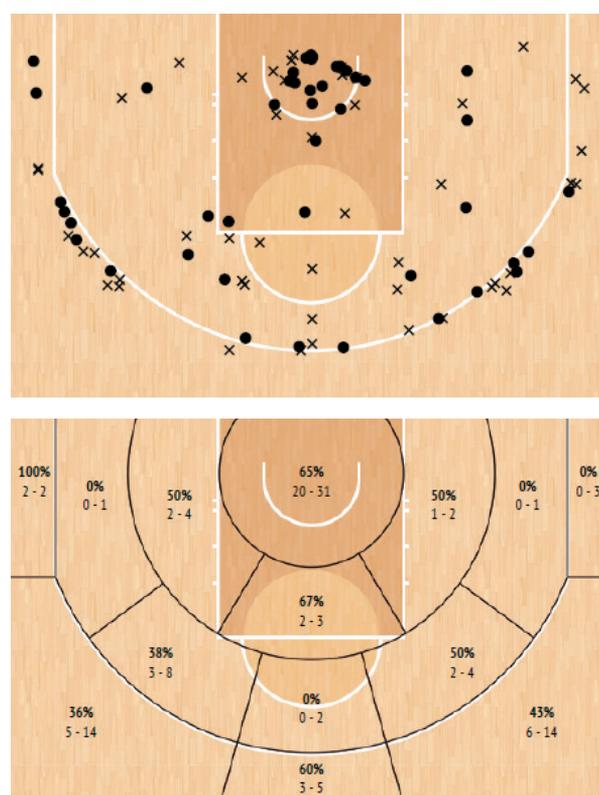


Fig. 4. Part of InStat basketball game report

The digital systems development has led to the immense expansion in numerical data provision, as well as to the availability of activity tracking data (including the continuous data on the player's position). Primarily, these types of data were obtained by a multiple cameras triangulation in order to place the precise player's positions. This provided data on the sections covered and, in combination with the weather data, the speed at which the players move. Finally, the teams had obtained consistent data on at least one feature of the players' physical activities throughout the matches [7, 11, 14].



The use of global positioning systems (GPS) proves to be an alternative approach to the video activity tracking systems.. Recently, the most of sports games have included GPS devices to obtain activity tracking data. Nevertheless, probably the most ground-breaking utilization of GPS devices (Fig. 5) is tracking sections covered and speeds in training [7, 11-13].

Future (or present) – Expert data systems

Methods for collecting sports data has continuously advanced, thus allowing the teams to quickly encode and edit match videos by themselves. That led to creating the possibility data systems in which data are defined and interpreted by trainers, and do not rely on commercial providers (i.e. expert data systems). That way, trainers can evaluate choice of actions (decisions) as well as their execution (itechnique). In general, that refers to “doing the right things” (choosing) or “doing things right” (doing).

An important component of tactical decision-making in sports games is the spatial positioning of players. Players constantly have to make decisions about where to position themselves when their team attacks and defends. For instance, attackers must supply with opportunities for the player in possession. That can be obtained by moving to the receiving positions of the ball or by making movements to create space. Defensive players, on the other hand, must make position decisions to face a particular attacking player or some exact field part. In addition, tracking technology has greatly helped coaches assess players’ decisions about a position [10, 11, 15].

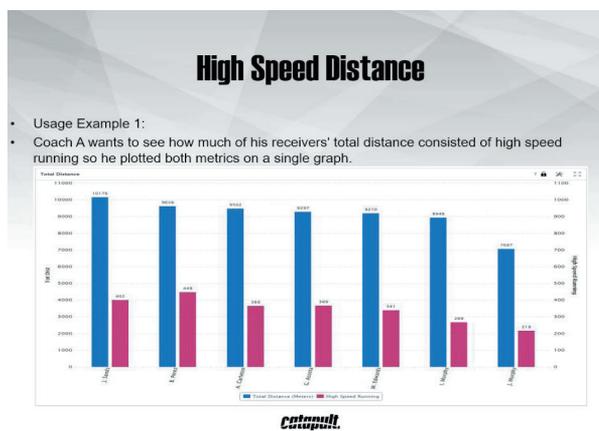


Fig. 5. Part of Catapult system report

CONCLUSIONS

The technology impact on data collection in professional sport has provided an exponential increase in the amount of collected data, which inevitably amplified the requirement for qualitative to quantitative data analysis. Qualitative data analysis is complemented by a quantitative analysis - initially by summarizing statistics and, by using other quantitative techniques, such as statistical analysis to analyze models in different activities. Technological development sport related data acquisition, has quite considerably influenced sports games through a dominant conquest of space, which has really become possible with the advent of digital and information technology.

REFERENCES

- [1] M. Hughes and I. Franks (Eds.), “Notational Analysis of Sport”, London and New York: Routledge, 2004.
- [2] MD. Hughes and RM. Bartlett, „The use of performance indicators in performance analysis“, Journal of Sports Sciences, vol. 20, pp. 739-754, 2002.
- [3] IM. Franks and G. Miller, „Eyewitness testimony in sport“, Journal of Sport Behavior, vol. 9, pp. 39–45, 1986.
- [4] IM. Franks and G. Miller, „Training coaches to observe and remember“, Journal of Sports Sciences, vol. 9, pp. 285-297, 1991.
- [5] IM. Franks, „The effects of experience on the detection and location of performance differences in a gymnastic technique“, Research Quarterly for Exercise and Sport, vol.64, no. 2, pp. 227–231, 1993.
- [6] IM. Franks, D. Goodman, and G. Miller, “Analysis of performance: Qualitative or Quantitative?”. SPORTS, March, 1983.
- [7] B. Gerrard, “Analytics, Technology and High Performance Sport”. In: Critical Issues in Global Sport Management, N. Schulenkorf and S. Frawley, Eds. London and New York: Routledge, pp. 205-218, 2017.
- [8] P. O’Donoghue, (Ed.), “Research methods for sports performance analysis”. London: Routledge, 2010.
- [9] C. Carling, MA. Williams and T. Reilly, “Handbook of soccer match analysis”, London and New York: Routledge, 2005.
- [10] L. Nelson and R. Groom, “The analysis of athletic performance: some practical and philosophical considerations”, Sport, Education and Society, vol. 17, no. 5, pp. 687-701, 2012.



- [11] "5 steps to success in video analysis", Catapult E-books, Downloaded 15.02.2020. from <https://go.catapultsports.com/five-steps-to-success-video-analysis>
- [12] RA. Den Hartigh, MS. Niessen, WGP. Frencken and RR. Meijer, "Selection procedures in sports: Improving predictions of athletes' future performance", *European Journal of Sport Science*, vol. 18, no. 9, pp. 1191-1198, 2018.
- [13] H. Sarmiento, R. Marcelino, MT. Anguera, J. Campanico, N. Matos and JC. Leitao, "Match analysis in football: a systematic review", *Journal of Sports Sciences*, vol. 32, pp. 1831-1843, 2014.
- [14] InStat reports. Downloaded 15.09.2020. from https://instatsport.com/basketball/instat_reports
- [15] "5 steps to success in athlete monitoring", Catapult E-books, Downloaded 15.02.2020. from <https://go.catapultsports.com/five-steps-to-success-athlete-monitoring>



THE IMPORTANCE OF CREATING DIGITAL BRANDS IN SPORTS

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Abstract:

The purpose of this paper is to emphasize the importance of developing a digital brand for sports organisations. The use of digital technologies had changed the sports industry. New technologies and fast changing trends demand a deeper understanding of specific sports markets and customer needs, and this work will try to identify those needs. This paper relies on a literature review and theoretical framework related to sports brands and customer behavior. The findings imply that sports organizations and athletes had recognized the benefits of having a strong digital brand, but they still do not exploit the brand attributes' full potential. They are highly active and present on social media, but there is still a lot of room for improvement when it comes to the use of their digital channels. The conclusions of this paper should bring about a better understanding of digital sports brands and their impact on sport business.

Keywords:

digital brand, sports brand, fan engagement, social media.

1. INTRODUCTION

Importance of Sport

From its very beginnings, sport has always been an activity that entertains and attracts an audience. It is not just about exercising or competition, it is about connecting people, developing loyalty, and improving physical and mental health. People have always been interested both in participating in sports and physical activities, and in consuming sports products as athletes, spectators, or even business partners. Sport has already become a serious industry that affects many other aspects of life. According to Eurostat [1] in 2018, more than 1.7 million people found employment in the sports industry, within the EU. This number is constantly rising, and it includes just those people employed directly in sport. However, the sports industry has an impact on the catering industry, tourism, entertainment, and leisure industry, as well as the retail and fashion industry.

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Importance of Digital in Changing the Way of Following Sports

In order to better understand the importance of changing behavior, it is essential to understand what the behavior of sports consumers entails and signifies. Describing sports customer behavior, Funk et al. explains it with the phrase “Sports consumer behavior is about the journey, not the destination” [2]. All the actions that an individual takes have only one goal – to satisfy their needs. Sometimes those are simply concerned with feeling a part of the crowd, and sometimes with identifying with the teams and/or athletes, feeling the team’s wins and losses as their own. New technologies have changed the way of watching and following sports. A fast-changing environment demands fast reactions and adaptability to different situations. The popularity of certain sports organizations and athletes transcends their domicile countries and becomes global. The digital experience opened completely new markets for sports and new possibilities to increase their revenues. Sport is no longer watched live or on TV, there is a need to be engaged through different digital channels. Moving sports online – watching live streams, following on social media – all that reflects a need to make a good strategy. To understand this phenomenon better, we can take the ESPN Digital platform as an example. This platform is a leading platform in sports – they had an average of 128 million global users per month. In September 2019, they even made a record of 143 million users. This number is constantly growing (+17% year-on-year growth). ESPN is holding the record in sports in the average minute audience, total minutes of usage, and total visits. Besides, the ESPN mobile app is considered as the most popular sports app, reaching more US users in September 2019 than any other sports app has ever reached [3] If we look back to 2013, we will see that back then ESPN’s digital platform at the time had an average of 75.7 million users a month [4].

However, the rising interest for the sports streaming service makes room for the development of a new one. DAZN is a sports streaming subscription platform and they became a serious competitor to the ESPN’s app. DAZN had achieved 950% year-on-year revenue growth. In May 2019 – this app had almost US\$11.5 million in revenue. This revenue is more than nine times its income for May 2018. [5] In December 2019, Amazon Prime streamed online the whole round of fixtures of Premier League, for the first time. They created extra value for spectators, offering more options than the classic TV broadcast – providing options to see the statistics

at any moment, as well as to choose whether to listen to the commentator, or just the stadium atmosphere. [6]

In 2013, 63% of people in the USA followed sports content online, and two years later, that percentage increased to 65% [7].



Figure 1. [Online]

Available at: https://www.globalwebindex.com/hubfs/Downloads/Sports_Around_the_World.pdf
Accessed: 2020-03-02

According to Global Web Index, Figure 1 shows the percentage of people who watched sports coverage or highlights online, by using their mobile phones. The research was divided into regions and it was observed quarterly, from 2017 until the second quarter of 2019. The results show that in every region, the percentage had increased. In some regions, like North America, that percentage increased by just 2% (from 20% to 22%), while the Asia Pacific and the Middle East and Africa region saw an increase of 11%. In the Asia Pacific region, almost half of the population use their mobile phones to watch sports (44%).

How Digital is Changing Sport Business

Social media has revolutionized audience behavior [8]. In the modern world, it is extremely hard to imagine the sport without digital platforms or informational technologies in general. If we look closely – informational technologies are so deeply implemented in almost every segment of the sports business. Now there is an equipment that tracks, measures, and improves athletes’ performance, many different gadgets that collect data, highly-developed technologies that review referees’ decisions (VAR in football, or Hawk-Eye in several sports), broadcasting matches in 3D, improved ticketing systems, etc. Informational technologies have become unavoidable resources for sports organizations [9]. In 2020, during the COVID-19 pandemic, we are all faced with a lot of changes. Due to medical issues and keeping social distance, all industries had to adapt to the new



circumstances. Sports industry suffered a lot of cancellations or postponing of sports events, like the Olympics. On the other hand, most of the competitions have been continued without the audience. Excluding spectators on sports events means that sport is losing an important component and suffers a significant financial loss. Everything was happening behind closed doors and sports organizations are now forced to increase the usage of digital channels to stay connected with fans. TV broadcasting is not good enough to replace the live experience. This situation just speeds up the development of new technologies. Digital stadiums are a new concept that provides the fans with an utterly new experience from home. This has created an urgency to accelerate digital transformation within sporting organizations, which are increasingly looking to go direct-to-consumer [10]. Installing the improved equipment that decreases production costs, every club has an opportunity to become a broadcaster for itself. Buying tickets online, or scanning them at the entrance from a smartphone, or even a smartwatch has become normal years ago. However, if clubs are able to broadcast their matches, they can sell digital tickets – for the current match or even the whole season. Digital revolution caused the transformation from traditional to digital branding.

2. BRAND AND TRANSFORMATION TO DIGITAL BRAND

Brand Definition and Importance of Creation

“A brand is a name, term, symbol, design, or combination thereof that identifies a seller’s products and differentiates them from competitors’ products.” [11]. Lamb, Hair and McDaniel (2017) defined three main purposes of branding: product identification, repeat sales, and new product sale. Among these three, most authors are always insisting on product identification as the most important. A brand needs to communicate a certain message to the customers. However, when changing life habits and transforming to digital, it is demanding for the brands to find a way to interact with all their customers. It is not enough just to identify with a brand, it is important to make a connection. Digital channels are an ideal tool to create an impression of availability.

Working in an environment with strong competition means that one company should find a way to create an image of exclusiveness. It is crucial to create a belief in customers’ minds that a certain product is irreplaceable and better than any other. A brand is an impression

that certain product leave on potential customers. It is not about buying a product; it is about buying an emotion that the product generates. When a company has a strong brand presence, that means they are wanted and recognized as desirable. A strong brand means more potential buyers on one hand, and on the other hand, that makes a lot of opportunity for partnership and collaboration with other brands. A strong brand is also considered more valuable, which means that customers are ready to pay more.

Definition of a Digital Brand and the Elements of a Digital Brand

“Digital brand is the identity, visibility, and credibility among consumers who discover, relate to and interact with a brand on the digital platform”[12].

Digital branding is the way you present your brand in digital space. It is the best way to present your brand to different audiences. Branding in a digital environment is different than in the traditional one. (DeLane)



Figure 2. The main components of digital branding; Available at: <https://dbinstitute-wpengine.netdna-ssl.com/wp-content/uploads/digital-branding.png> Accessed: 2020-03-03

However, as Figure 2 shows, a digital brand is built on three components: identity, visibility, and credibility. It is always important to start with an identity - having a strong traditional brand makes things easier when it comes to creating a digital identity. Still, having a digital identity means trying to build, live, and communicate brand values through two immensely powerful mediums – content marketing and social media (DBI). Content marketing is about telling a story about the brand. Content should present the brand to the audience, to provide values, not just to convince them of why it is better than any other. Content marketing is a particularly important step in the process of digital branding.



Content is what the audience is identifying with and what makes the brand visible. After the digital identity is created and recognized, the next step is - how to improve visibility? The first step is certainly targeting the audience. When we know with whom to communicate, we should choose the most efficient tool. One of the solutions is – digital ads. If the audience is well-targeted, this tool can be extremely useful. However, the most important tool in visibility is search engine optimization (SEO). Good SEO is important for several reasons – being in the top search results practically guarantees good visibility, it also means that the organization understands the needs of their audience and besides all of that, being positioned on the top gives brand credibility.

Credibility is the sum of all activities, attitudes, and all messages that the brand communicates to the audience. Credibility is a component that makes the digital brand strong. A good way to raise credibility is by ratings and reviews on different websites. New consumers like to read about previous experiences with a certain product (brand). On the other hand, one of the most important parts of digital branding and creating credibility is social media. Social media are the channels to communicate with the audience, to personalize the experience, to improve loyalty to the digital brand. The way of interactions on social media, the content, and the engagement rate are determinants of how strong the voice of a digital brand is (De Lane). This means that, by creating content and choosing how we communicate with the audience - we create our digital brand. That brand that we first create is strongly related to our traditional brand. However, since the relationship with customers is much closer than the one we have when we communicate through traditional channels, the digital brand became in a certain way independent from the traditional one.

3. SPORT BRAND AND DIGITAL PLATFORMS

Definition of a Sports Brand

Among many definitions of a brand, the one that fits the best in the context of sports is: “A brand is the set of expectations, memories, stories and relationships that, taken together, account for a consumer’s decision to choose one product or service over another.”[13]. Branding is a process that differentiates one sports organization, team, or athlete and adds value in the eyes of consumers.

In the literature, brand associations are categorized as brand attributes (product-related and non-product

related), benefits that the brand gives to the customer, and attitudes that customers have about the brand [14]. This was used for the creation of the Team Associations Model – 16 dimensions of brand associations divided into these three categories [15]:

- Attributes: success, head coach, star player, management, stadium, logo design, product delivery, and tradition
- Benefits: identification, nostalgia, pride in place, escape, and peer group acceptance
- Attitudes: importance, knowledge, and affect

Consumers are usually attached to sports brands, especially when it comes to sports clubs. There is a high level of loyalty in the sport. From that point, it is an extremely important emotional bond between the sports brand and fans. Brand love is divided into 5 dimensions: passion, connection with the brand, intrinsic rewards, emotional attachment, thinking, and frequent use [16]. Furthermore, this research showed that brand love affects loyalty, willingness to invest, and word-of-mouth communication. All these elements can and should be used through digital platforms to enhance brand loyalty.

The Importance of Creating a Sports Brand on Digital Platforms

The sports business is a complex term and it is not always easy to make priorities when it comes to marketing strategies. It is desirable to have the best players and staff as possible, but it is also extremely important to develop and manage the team’s brand [17]. Exploring the connection between digital channels and brand love, Baena (2016) claims that traditional media does not greatly affect fan identification, while online media increase their perception of connection to the clubs and to the other fans. Customer experience is always a primary concern. Having a strong digital presence means having a global market, a billion possibilities to exploit your brand and increase earnings. The stronger the digital brand is, it will have more attention from digital customers. That gives the brand a chance of creating a digital fan base, clustering fan bases, and personalizing the content. More interaction between the brand and the fans means more information about them. Creating a consumers’ base is an excellent opportunity for developing and leveraging brand loyalty [18]

Creating a digital brand is the easiest and the fastest way to reach to the people. The values promoted through the digital doesn’t have to be strictly correlated with sports teams.



They should entertain the audience and attract the ones that traditional brand cannot reach. Unlimited digital space gives an opportunity even for the not so well-known organizations or athletes to create an identity that can diversify them from others.

Sports Brands and Social Media

Sports organizations have recognized the importance of the use of social media. There was much research about the impact of social media and the effects they have on sports in general. Using social media can be a good way for sports organizations to strengthen the professional, personal, and community relationships with their fans [19]. Social media are defined as “the tools, platforms, and applications that enable consumers to connect, communicate and collaborate with others”[20].

Researching the relationship between sport fan identification and addiction to digital sports media [21] discovered that social media can be best used to create new fans and to enhance the relationship with the “casual” or less involved ones. Speaking of the highly identified fans, they prefer personalized contact, to get an impression that they are more important and more engaged.

However, social media are a powerful medium for strengthening relationship management, but most of the sports organizations do not use its full potential [22]. Social media is making relationship marketing more “affordable, practical and meaningful” [23]. Still, sports organizations are not utilizing the full potential of the main advantage of social media – two-way communication.

Social media sites are amongst the most popular sites on the Internet, along with search engines [24]. Some of the most popular social networks that sports organizations use to communicate with their followers are:

Facebook – to share content with selected friends; Twitter was essentially a broadcast medium; LinkedIn is a professional site [25]; Instagram usually communicates with pictures, and YouTube is a platform to broadcast videos. All these networks have their specific audience and it is important to adjust the content and the frequency of posts to the targeted audience.

Being present on popular social media platforms is not just about increasing popularity. That is the easiest and the most affordable way to reach out to the customers. Sports organizations use these channels to inform the audience about events, ticket sales, and different offers. Creating different membership programs, organizing online fan shops, and charging access to exclusive content and creating other new online products should

become one of the club’s main ordinary revenues. More followers and better engagement on social media mean more potential customers and earnings.

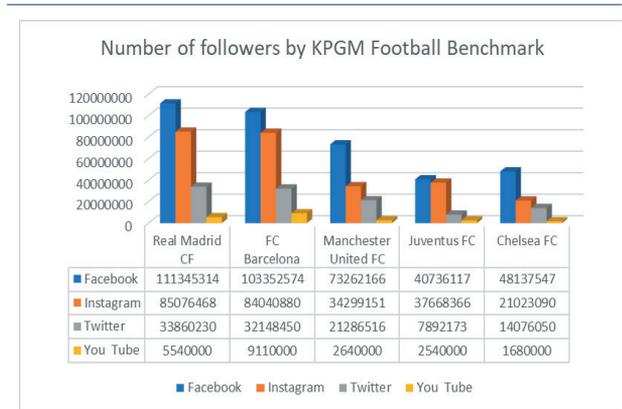


Figure 3. Number of followers by KPGM Football Benchmark

Figure 3 features five of the most followed football clubs and the number of followers on the four different social networks. This data shows that the most followed club in total is Real Madrid CF, having the most followers on every social network except YouTube. But when it comes to total engagement, FC Barcelona is dominant as it is shown in Figure 4.



Figure 4. Total engagement for period 07.02.2019-05.03.2020 by KPGM Football Benchmark

Given results are showing that, although Facebook brings the largest number of followers, their engagement cannot compare with the engagement of Instagram. One of the explanations is that Facebook is losing its popularity [26] and followers are not as active as before. On the other hand, Instagram’s engagement is constantly increasing, showing a much better engagement rate than any other network. Among all these networks,



Instagram become the most popular and most significant network especially when it comes to building brand awareness. Speaking of sports, Instagram has a positive effect on the loyalty of fans [27]. Anagnostopoulos, Parganas, Chadwick and Fenton (2018) [28] were examining how the use of Instagram is related to branding and how fans' engagement impacts an organization's Instagram activity. Using the Keller's model, they were following the activity of two English Premier League clubs (Manchester United FC and Liverpool FC) and the engagement of their fans. This study showed that most of the content was about product-related attributes such as Star Players, Team Success and Head Coach (70% of content in Liverpool FC posts and 56% of Manchester United's post) The least communicated content were non-related attributes such as Sponsors and Management. With this knowledge, it is obvious that for sports organizations, it is better to use disguised advertising than to communicate directly about the sponsor.

This research results were contrary with the research about teams in North America. This leads us to the conclusion that we cannot apply the same principles for each market, and there is no one pattern that fits all sports organizations or athletes.

Athletes' Digital Brands and Sport Business

If we speak about a successful digital sports brand, we should speak about Cristiano Ronaldo. He is not just one of the best footballers in the world, he is also the most followed footballer on social networks. His digital brand exceeded his extraordinary football skills. He has almost twice the followers of any football club. His transfer to Juventus paid off for the club, not just in the context of football. That was one of the best marketing moves that the club could have made. He is followed by almost five times as many people as Juventus FC [29]. When it was announced that Cristiano Ronaldo signed for Juventus, they got 2.2 million new followers in a day [30]. Within 24 hours of the news' release, Juventus sold 520,000 Ronaldo jerseys worth over \$60 million [31]. Juventus became the 4th most followed club, increasing its popularity around the world. The value of the CR7 brand increased the value of his club.

CONCLUSION

Overall, this work offers several conclusions. Due to the fast development and implementation of informational technologies in the sports industry, it is necessary to understand the urgency of creating a digital sports brand. Opening a new door in the digital space sports brands ensure their place in the global market and an infinite opportunities to expand their business and to increase their revenues. Sports organization still does not use the full benefits of their digital presence. Digital sports brand makes extra value for sports organizations, as well as the athletes. Expanding the market, e-commerce, exploiting the data of a fan base, creating new sponsorships and, co-branding partnerships are some of the possibilities to improve their business. Although they recognize the importance of their presence in social media, they are still more oriented toward informative posts rather than involving the audience and encouraging them to interact. With good analytics tools and hiring sports marketing experts, they can personalize the content, cluster the customers, and improve the interaction between them. The sports industry on digital channels becomes the entertainment industry, and the content they publish on digital channels should be diversified and should offer more than just a piece of news. Following the development of the sports industry and digital, we can conclude that soon there will be no strong sports brand without a strong digital identity.

REFERENCES

- [1] Eurostat, Employment in sport, 2020 [Online]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Employment_in_sport [Accessed: 2020-02-05]
- [2] Funk, D., Alexandris, K., & McDonald, H. (2008). *Consumer behaviour in sport and events*. Routledge.
- [3] R. Arden, ESPN, Inc.: 2019 in Review, 2019 [Online]. Available at: <https://espnpressroom.com/us/press-releases/2019/12/espn-inc-2019-in-review/> [Accessed: 2020-02-25]
- [4] T. Couch, ESPN, Inc.: 2014 in Review, 2015 [Online]. Available at: <https://espnpressroom.com/us/press-releases/2015/01/espn-inc-2014-in-review/> [Accessed: 2020-02-25]
- [5] E. Dixon, Study: DAZN is the top revenue-generating sports app, SportsPro, 2019 [Online]. Available at: <https://www.sportspromedia.com/news/dazn-sports-app-revenue-growth-espn-mlb-streaming> [Accessed: 2020-09-11]



- [6] BBC Sports, Premier League streaming on Amazon Prime – was broadcaster’s debut a success?, 2019 [Online]. Available at: <https://www.bbc.com/sport/football/50677121> [Accessed: 2020-09-11]
- [7] The Global Sports Media Consumption Report 2014, US Overview, 2014 [Online]. Available at: https://sportsvideo.org/main/files/2014/06/2014-Know-the-Fan-Study_US.pdf [Accessed: 2020-09-14]
- [8] J. Weston, How digital is transforming sports sponsorship, We are Social, 2018 [Online]. Available at: <https://wearesocial.com/blog/2018/05/how-digital-is-transforming-sports-sponsorship> [Accessed: 2020-06-04].
- [9] Živković, A., Ratković, T., Marković, S., Primena informacionih tehnologija u modernom sportu, Univerzitet Singidunum, Beograd, 2020, doi:10.15308/Sinteza-2019-676-681
- [10] InPlayer, Football’s New Normal – Preparing your digital stadiums, 2020 [Online]. Available at: <https://inplayer.com/footballs-digital-stadiums/> [Accessed: 20-08-15]
- [11] Lamb, C.W., Hair, J.F., & McDaniel, C. (2017). MKTG 11, Cengage Learning.
- [12] J. DeLane, What is Digital Branding, Digital Branding Institute, 2017 [Online]. Available at: <https://digitalbrandinginstitute.com/digital-branding/> [Accessed: 2020-03-03]
- [13] S. Godin Define: Brand, Seth’s blog, 2009 [Online]. Available at: <https://seths.blog/2009/12/define-brand/> [Accessed: 2020-07-22.]
- [14] Keller, K. L. (1993). Conceptualizing, measuring, and managing customer-based brand equity. *Journal of marketing*, 57(1), 1-22.
- [15] Gladden, J. M., & Funk, D. C. (2002). Developing an understanding of brand associations in team sport: Empirical evidence from consumers of professional sport. *Journal of Sport management*, 16(1), 54-81.
- [16] Martín, F. V., Toledo, L. D., & Palos-Sanchez, P. (2020). How deep is your love? Brand love analysis applied to football teams. *International Journal of Sports Marketing and Sponsorship*.
- [17] Baena, V. (2016). Online and mobile marketing strategies as drivers of brand love in sports teams. *International Journal of Sports Marketing and Sponsorship*.
- [18] Filo, K., Funk, D. C., & Alexandris, K. (2008). Exploring the role of brand trust in the relationship between brand associations and brand loyalty in sport and fitness. *International Journal of Sport Management and Marketing*, 3(1-2), 39-57.
- [19] Wang, Y, & Zhou, S. (2015). How do sports organizations use social media to build relationships? A content analysis of NBA clubs’ Twitter use. *International Journal of Sport Communication*, 8(2), 133-148.
- [20] Williams, J., & Chinn, S. J. (2010). Meeting relationship-marketing goals through social media: A conceptual model for sport marketers. *International Journal of Sport Communication*, 3(4), 422-437.
- [21] Clark, J. S., & Maher, J. K. (2019). Exploring the relationship between sport fan identification and addiction to digital sports media. In *Multigenerational Online Behavior and Media Use: Concepts, Methodologies, Tools, and Applications* (pp. 1018-1030). IGI Global.
- [22] Abeza, G., O’Reilly, N., Seguin, B., & Nzindukiimana, O. (2017). Social media as a relationship marketing tool in professional sport: A netnographical exploration. *International Journal of Sport Communication*, 10(3), 325-358.
- [23] Abeza, G., O’Reilly, N., & Reid, I. (2013). Relationship marketing and social media in sport. *International Journal of Sport Communication*, 6(2), 120-142.
- [24] Chaffey, D., & Smith, P. R. (2017). *Digital marketing excellence: planning, optimizing, and integrating online marketing*. Taylor & Francis.
- [25] Young, A. (2014). *Brand media strategy: Integrated communications planning in the digital era*. Springer.
- [26] The infinite dial 2019, Edison research, 2019 [Online]. Available at: https://www.edisonresearch.com/infinite-dial-2019/?mod=article_inline [Accessed: 2020-03-09]
- [27] Popp, B., & Woratschek, H. (2016). Introducing branded communities in sport for building strong brand relations in social media. *Sport Management Review*, 19(2), 183-197.
- [28] Anagnostopoulos, C., Parganas, P., Chadwick, S., & Fenton, A. (2018). Branding in pictures: using Instagram as a brand management tool in professional team sport organizations. *European Sport Management Quarterly*, 18(4), 413-438.
- [29] KPGM Football Benchmark, The Changing Face of Football Sponsorship – Key Players, 2020 [Online]. Available at: https://www.footballbenchmark.com/library/the_changing_face_of_football_sponsorship_key_players [Accessed: 2020-08-12]
- [30] S. Dupare, Top 10 Football Clubs with the Highest Social Media Following, Sportskeeda, 2020 [Online]. Available at: <https://www.sportskeeda.com/football/top-10-football-clubs-highest-social-media-following> [Accessed: 2020-08-05]
- [31] The Forbes #4 Cristiano Ronaldo, 2020 [Online]. Available at: <https://www.forbes.com/profile/cristiano-ronaldo/#79fa3e3f565d> [Accessed: 2020-04-17]



THE PSYCHOLOGICAL BASIS BEHIND NEW MEDIA AS AN IMPETUS BEHIND THE REDUCTION IN PHYSICAL ACTIVITY

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Abstract:

The aim of this paper is to attempt to respond to the issue of the relationship between the reduction in movement and the consumption of new media, as well as the psychological grounds behind such behavior. Through the theoretical analysis of relevant literature, the intention was to primarily extend the conceptual understanding of this important topic. First of all, the nature of digital media and the novelty it brings in relation to analogue media is analyzed. The psychological aspects of new media practices were also analyzed similarly. It was concluded that new media do not contribute anything new in the qualitative sense when it comes to their psychological roles, but that its uniqueness lies in the quantity and intensity of the functions which had previously been carried out by other media. Furthermore, it is incorrect to attribute a reduction in movement of the consumer of new media to the nature of the media themselves. Instead, the solution should be found in the nature of the psychological apparatus and functioning of the consumer. Finally, the need for interdisciplinary study of this important topic was pointed out.

Keywords:

Movement, Physical Activity, New media, Digitalization, Psychology.

INTRODUCTION

The time period from the end of the twentieth and especially the beginning of the twenty-first century stand out when compared with all other previous historical periods primarily due to the radical social changes that took place under the influence of the accelerated development of digital technologies [1]. This is why today's manner of living is unique because, among other things, it brought about the great influence of telecommunications technologies and new media, which have transformed leisure time for children and youth [1], that is, an enormous amount of time spent socializing and entertainment by means of computers, mobile phones, social networks, the Internet, and similar activities which are physically static and often insufficiently challenge the mind, in addition to being asocial [2]. All of this takes place to the detriment of free time spent doing physical activities and physical exercise [3].

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Physical inactivity is one of the greatest health risk factors [4]. A second significant factor is an excessive and unhealthy diet [5,6]. Inactivity in combination with an excessive and unhealthy diet are among the most basic bad habits characteristic to the to aforementioned present-day unhealthy lifestyle, is the most important prerequisite for the origins of obesity, the disruption of postural status and numerous diseases related to the functioning of all tissue and organic systems [4,5,6,7]. Technological and societal progress, along with an increase in quality of life, paradoxically, turn the thus-far efficient adaptation mechanisms against the health and well-being of both the individual and society.

Naturally, apart from directly threatening physical health as a consequence of the aforementioned social changes, additional consequences can also be witnessed on the mental health of children and youth. The number of children diagnosed with ADHD (attention deficit hyperactive disorder) has been rising rapidly over the years in the United States of America, where it affects over 11% of preschool and elementary school-aged kids [8]. The number of children with similar symptoms who are not registered in the healthcare system or who live with milder symptoms of the disease is significantly higher. Hyperactivity and the inability to focus one's attention negatively impact learning and success in schools [9], as well as functioning in social situations, and can lead to increased aggression [10]. Regardless of whether the issue is a diagnosed syndrome or a milder case of attention disorder, more work and stimulation must be invested in children in order to avoid poor development. Although studies indicate that physical activity has a positive effect on children with ADHD [11,12] and work on the development of attention and other cognitive capabilities [13], not enough detailed research has been carried out on the connection between concrete cognitive and motor skills [14]. As such, even though physical activity is proclaimed by institutions, the media, and education workers, as an efficient mode of changing negative behavioral manifestations, particularly in a scholastic environment, it is easy to realize that there is a lack of specification of such recommendations, namely, what type, how much, and other questions related to physical activities, ought to be practiced. On the other hand, although the cause behind these changes is still uncertain, it could be sought within the trend of a reduction in physical activity and an increase in the amount of time children spend in front of televisions, computers, mobile phones, and similar media gadgets [15]. Some experimental studies suggest the same out-

come [16]. Since it is unlikely that the trend of increased media presence in everyday life will change anytime soon, it can be concluded that the number of children with problems focusing will continue to increase in the future.

Given the aforementioned reasons, the question is posed as to the psychological motivations behind the production and consumption of media content, bearing in mind how widespread this behavior is, as well as the psychological implications such behavior has on the development of individuals and of society itself. The COVID-19 pandemic has led to an even further reduction in movement, and to an increase in the significance the media has on and influences everyday life. This has updated the need for its further deliberation, as well as for seeking new methods for combatting said problems.

The aim of this paper is to attempt to respond to the question of the relationship between movement and the consumption of new media, as well as the psychological grounds behind such behaviour, through the theoretical analysis of relevant literature. Given that the aspects of social change brought about by new media have already been thoroughly described in earlier studies, emphasis in this work shall be placed on the individual psychological aspects and their implications..

1. THE DIGITAL NATURE OF NEW MEDIA AND MOVEMENT IN THE PHILOSOPHY OF MEDIA

When considering the process of digitalization, which is an integral process for the subject matter of this paper, the question of the nature of knowledge and existence (as a basic ontological question) can additionally be re-formulated as a question of the digital and analogue in relation to the process of movement and cognition – the eternal question of the relation between spirit and body. Reflecting on the nature of the virtual, which in and of itself is inaccessible to the senses yet originates within an act of imagination, Brian Massumi describes the concepts of topology and probability. In fact, in addition to topology and probability, Massumi uses the term potential, which is derived from probability, that is, it represents one of the variations of its expression. “When most attentive to the virtual, qualification deforms into the topo-ontological exercise of contingent reason (thought bending back to participate in its own emergence from sensation; imagination, or intuition in Bergson's sense)” [17:136]. The conclusion can be reached that moving one's body through space



while thinking is an analogue process, while the body in motion paints thoughts, that is, it reflects. On the other hand, digital codification, which lacks the continuity of topology and transformation, is merely a probability. “Nothing is more destructive for the thinking and imaging of the virtual than equating it with the digital“ [17:137]. However, although at first glance this sharply demarcates the virtual and the digital, Massumi is aware that the analogue processes may rely on digital coding, and that the process of digitalization is a two-way street, and does not necessarily exclude analogue processing. “The digital is sandwiched between an analogue disappearance into code at the recording and an analogue appearance out of code at the listening end“ [17:138]. This refers to the recording and listening of sounds, which is used as a metaphor for the digital recording of analogue signals and the analogue processing of digital signals. Hence, the roles of neither of the two modalities of recording and processing of information, that is, their complementary roles in the origins of the virtual, should be neglected.

Unlike Massumi, who recognizes the connection between the body and cognition because “[t]here is no thought that is not accompanied by a physical sensation of effort or agitation“ [17:138], yet hands the advantage to analogue processing (and recording) in the description of the body in motion, Mark Hansen, through the “theorize the correlation of new media and embodiment“ [18:11] in the process of digitalization finds a new qualitative leap towards the body as an active participant in the process of constructing the meaning and understanding of reality. „[R]ather than selecting preexistent images, the body now operates by filtering information directly and, through this process, creating images“ [18:10]. This primarily refers to the possibility of generating digital information (images) without the need for physical (external) references. „[T]he “image” has itself become a process and, as such, has become irreducibly bound up with the activity of the body“ [18:9]. Still, although digital technologies may be labelled as evidence of the processing nature of images, as well as the creative roles of the body in its construction, it would be wrong to link these functions solely with digital media. When approaching analogue signals, the body makes contact with information, which it filters. Even if information could be constructed as an existing image, the creative nature of the body in its processing is not much different to that of the digital signal. Perception is, as a cognitive process, equally reliant upon the body in both a digital and analogue environment. The same is true for its constructivist nature.

The newly created change is a change in the stress, the stripping down of, and the awareness of these processes, which are made possible thanks to interaction of the human body with a digital environment. “In sum, the image can no longer be restricted to the level of surface appearance, but must be extended to encompass the entire process by which information is made perceivable through embodied experience“ [18:9]. This should particularly be kept in mind when the term post-screen [19] images is postulated and used. Digital technologies have, to some extent, enabled the transcendence of the screen as a technological necessity, but this did not change the nature of the concept of images. Instead, the nature of a lower concept of media images has become closer to the nature of the basic concept. Or, perhaps more radically, it could be claimed that the transcendence of screens did not lead to an ontological change, but rather a clearer observation into the nature of the concept. Regardless of the designation towards the nature of change, the subject discovers that the instance of appearance of the image becomes a relevant subject for researching the theory of media (through which it also bridges the gap with cognitive sciences).

Theory and the philosophy of media are often too critical and neglect the numerous positive consequences of the development of technology. As such, negative consequences are often attributed to the nature of new media. “Rather than being a neutral medium of presenting information, the screen is aggressive. It functions to filter, to screen out, to take over, rendering non-existent whatever is outside its frame“ [20:100]. Nevertheless, numerous examples lead to the conclusion that the human subject is capable of habituating irrelevant stimuli even more aggressive and life-threatening than the media screen, including explosions or the sound of guns shooting during prolonged war situations. Understanding the attractive nature of the screen is insufficient without understanding the psychological (particularly the conative and emotional) grounds of the consumption (and production) of media content.

2. THE PSYCHOLOGICAL INFLUENCE AND ROLE OF NEW MEDIA

What is new in the psychological sense which new media and new technologies bring about with them? Is it that their widespread use is connected with the radically different psychological functioning of the subject and new media discourse? Or have new technologies “merely“ enabled the easier and simpler fulfilment of age-old psychological desires?



Firstly, it merits observing that the production of online video clips and similar new media content, as well as their sharing on the web as a means of expression and communication, have a psychological basis and function similar to those of traditional media. In addition to expression and communication, informing oneself, creativity, and a reduction in uncertainty could be listed as further themes. This is coupled with the desire to earn money – and fame – which designates them as a practice on the border between the professional and the amateur. As new media content is most often a part of social media, the themes of belonging, gratification, distraction, self-representation and self-promotion can also be observed [21,22]. Self-actualization, learning, entertainment, and spending one's free time are just some more in a long line of important features of the production and consumption of online video clips that traditional and new media share. Finally, the fulfilment of exhibitionist and voyeuristic needs, as well as narcissism [23] are all something they have in common with other media, which deserves to be mentioned as well.

Nonetheless, given that they represent an expression of democratization and the widespread practice of audio-visual production, online video clips and similar new media content represent the continuation of the process of grammatization, that is, the spatialization of the course of time dating back all the way to the Neolithic period [24]. Similar as the appearance of letters allowed for the copying and reproduction of speech, audio-visual production represents the next stage in the reproduction of the course of time, which will allow for a new stage in the psychological individuation of humankind and society [24]. Thus, it can be concluded that the development and creation of one's own identity and its separation from the collective identity typical for a childish character [25], that is, maturing, can at an individual level be achieved (or at least supported) through recording primarily one's self and one's surroundings, but also in the browsing of others' content. The role of new media content is, therefore, greater and more important among the youth and adolescent population, while its significance should drop through the process of maturing.

Finally, new media content must be mentioned as a practice for the archiving of one's own life [22] in an attempt to overcome the fear of death, as well as its therapeutic effect in overcoming bad experiences and emotions [26]. However, roles similar to that of new media content, identity creation, the process of individuation, the archiving of one's own life, overcoming

bad emotions and events, can be found in the writing of diaries or in filming, photographing one's self – or surroundings or families, as was common practice in the pre-digital age.

The consumption of new media represents a type of addiction and emotional investment which can be clearly observed once access to new media is enabled [27]. Mobile telecommunications devices in the life of the modern man attain the feature of a transient object, both as its externally clear and noticeable function of relieving stress and uncertainty in the process of individuation and testing reality, as well as in mediating between the inner (subjective) and outer (objective) world [28]. New technologies and new media, far more so than their traditional antecedents, have the capacity to allow their subject the regressive (and autoerotic) illusion of creating reality, which somewhat drain their addictive power. The virtual reality of new media (discussed earlier through the issues of critiquing their ontologies) enable the subject to get closer to the phantasmatic reality of their early childhood, which was created exclusively by instinct, without the intervention of the outside world [29]. In this capacity of the first subject's reality, a deep conative basis can be sought in the need for constructing virtual realities which are fulfilled (or at least attempt to) by the consumption of media content [30]. This aspect, often insufficiently analyzed or completely neglected, is essential to the true understanding of new media practices, their development, and the nature of human beings. Similarities between primary (instinctual) reality and virtual reality can be observed easily in dreams [31], whose nature is still not satisfactorily explained. These media constructed realities become equally of the subject of interest in of study in psychology as in the theory of media and film.

3. CONCLUSION

When it comes to workers in sports and physical education, knowledge of the theoretical settings of other social-humanistic disciplines, especially the neglected theories of media and film, is necessary in order to properly confront the aforementioned challenges that technological progress brings.

Based on all of the above, the conclusion is that new media do not contribute anything new in the qualitative sense when it comes to their psychological roles, but that its uniqueness lies in the quantity and intensity of the functions which had previously been carried



out by other media. However, this novelty, because it is so widespread, must bring about with it changes in the psychological functioning of the individual and, simultaneously, social change as well. Furthermore, it is incorrect to attribute a reduction in movement of the consumer of new media to the nature of the media themselves. Instead, the solution should be found in the nature of the psychological apparatus and functioning of the consumer.

Reliance upon new media for the development of technology is a guarantee of its future influence. The current COVID-10 pandemic implied as much. Still, although technological development cannot be prevented, what is assured is that, nowadays, it could derail the development of humanity. A noticeable reduction in movement as a consequence of the consumption of media content can also be fatal for the subject – at least until the still very unlikely possibility of body transcendence is not achieved. Societal-humanistic sciences have an obligation to indicate these possibilities in order for their influence to go beyond critique and for the message to be one of prevention they must increase their social influence and relevance. This paper is an attempt to move in that direction.

Integrating new technologies into healthy lifestyles appears to be a much more appropriate and realistic solution than fighting technological progress, or outright banning the use of technology.

REFERENCES

- [1] Milošević, M. (2019). Srpski film u doba novih medija (2010-2016). Beograd: Fakultet dramskih umetnosti.
- [2] Milošević, M., & Čolović, M. (2019). RAZVOJNA I PEDAGOŠKA PSIHOLOGIJA, sa primenom u sportu i fizičkom vaspitanju. Beograd: Univerzitet Singidunum.
- [3] Marković, V., Živković, A., & Milošević, M. (2019). Plivanje u fizičkom vaspitanju dece. 1. Nacionalna naučna i stručna konferencija, Aktuelnosti u teoriji i praksi sporta, fizičkog vaspitanja i rekreacije. Fakultet sporta i fizičkog vaspitanja Univerziteta u Beogradu
- [4] World Health Organisation. (2018). World health statistics 2018: monitoring health for the SDGs, sustainable development goals. Luxembourg: World Health Organization.
- [5] Popović, J., Grbić, S., Milošević, M., Ilić, R., & Kilibarda, N. (2019). Food Flavour as Influence Factor for Balanced Diet for Children. *Quality of Life*, 10(1-2): 55-59.
- [6] Stanišić, S. (2019). *Ishrana i zdravlje*. Beograd:Delfi.
- [7] Ilić, R., Popović J., Marković V., Nemeč V., & Milošević, M. (2019). Work-Related Stress Among Primary Healthcare Workers. *Vojnosanitetski preglad, OnLine-First* (00):20-20. DOI: <https://doi.org/10.2298/VSP181228020I>
- [8] Visser, S.N., Danielson, M.L., Bitsko, R.H., Holbrook, J.R., Kogan, M.D., Ghandour, R.M., Peroru, R., & Blumberg, S.J. (2014). Trends in the parent-report of health care provider-diagnosed and medicated attention-deficit/hyperactivity disorder: United States, 2003–2011. *Journal of the American Academy of Child and Adolescent Psychiatry*, 53(1):34–46. e2. doi: 10.1016/j.jaac.2013.09.001.
- [9] Barry, T.D.S., Lyman, R.D., & Klinger, L.G. (2002). Academic Underachievement and Attention-Deficit/Hyperactivity Disorder: the Negative Impact of Symptom Severity on School Performance. *Journal of School Psychology*, 40(3):259 –283. doi: 10.1016/S0022-4405(02)00100-0.
- [10] Mannuzza, S., Klein, R.G., Abikoff, H., & Moulton, J.L. (2004). Significance of Childhood Conduct Problems to Later Development of Conduct Disorder Among Children with ADHD: a Prospective Follow-Up Study. *Journal of Abnormal Child Psychology*, 32(5):565–573.
- [11] Hartanto, T.A., Krafft, C.E., Iosif, A.M., & Schweitzer, J.B. (2016). A Trial-by-Trial Analysis Reveals More Intense Physical Activity is Associated With Better Cognitive Control Performance in Attention-Deficit/Hyperactivity Disorder. *Child Neuropsychology*, 22(5):618-26. doi: 10.1080/09297049.2015.1044511.
- [12] Cornelius, C., Fedewa, L.A., & Ahn, S. (2017). The Effect of Physical Activity on Children With ADHD: A Quantitative Review of the Literature. *Journal of Applied School Psychology*. , 33:2, 136-170. doi: 10.1080/15377903.2016.1265622.
- [13] Lambourne, K., & Tomporowski, P. (2010). The Effect of Exercise-Induced Arousal on Cognitive Task Performance: a Meta-Regression Analysis. *Brain Research*, 1341:12–24. doi: 10.1016/j.brainres.2010.03.091.
- [14] Gapin, I.J., Labban, D.J., & Etnier, L.J. (2011). The Effects of Physical Activity on Attention Deficit Hyperactivity Disorder Symptoms: The Evidence. *Preventive Medicine*, 52:70–74. doi: 10.1016/j.ypmed.2011.01.022.
- [15] Eaton, D.K., Kann, L., Kinchen, S., Shanklin, S., Flint, K.H., Hawkins, J., Harris, W.A., Lowry, R., McManus, T., Chyen, D., Whittle, L., Lim, C., & Wechsler, H. (2012). Youth risk behavior surveillance - United States, 2011. *MMWR Surveillance Summaries*, 61(4):1-162.



- [16] Swing, L.E., Gentile, A.D., Anderson, A.C., & Walsh, A.D. (2010) Television and Video Game Exposure and the Development of Attention Problems. *Pediatrics*, 126(2): 214–221. doi: 10.1542/peds.2009-1508
- [17] Massumi, B. (2002). *Parables for the Virtual: Movement, Affect, Sensation*. Durham: Duke University Press.
- [18] Hansen, M. (2004). *New Philosophy for New Media*. Cambridge: MIT Press.
- [19] Bosma, J. (2013). Post-Digital is Post-Screen: Arnheim's Visual Thinking Applied to Art in the Expanded Digital Media Field. A Peer-Reviewed Journal About Post-digital Research: <http://www.aprja.net/post-digital-is-post-screen-arnheims-visual-thinking-applied-to-art-in-the-expanded-digital-media-field/?pdf=1892>. Accessed May 1st, 2020.
- [20] Manovich, L. (2001). *The Language of New Media*. Cambridge: MIT Press
- [21] Peek, H. (2014). The Selfie in the Digital Age: From Social Media to Sexting. *Psychiatric Time*,: <http://www.psychiatrictimes.com/cultural-psychiatry/selfie-digital-age-social-media-sexting>. Accessed May 1st, 2020.
- [22] Yongjun, S., Jung-Ah, L., Eunice, K., & Sejung, C. (2016). Why We Post Selfies: Understanding Motivations for Posting Pictures of Oneself. *Personality and Individual Differences*, 97: 260–265.
- [23] McCain, J., Borg, Z., Rothenberg, A., Churillo, K., & Weiler, P. (2016). Personality and selfies: Narcissism and the Dark Triad. *Computers in Human Behavior*, 64:126-133.
- [24] Stiegler, B. (2009). The Carnival of the New Screen: From Hegemony to Isonomy. in Snikkars, P., & Vonderau, P (eds). *The You Tube Reader*. London: Wallflower Press, 40-60.
- [25] Jung, C. (1971). *Psychological Types (The Collected Works of C. G. Jung, Vol. 6)*. London: Routledge.
- [26] Chang, JH., Huang, CL., & Lin, YC. (2013). The Psychological Displacement Paradigm in Diary-Writing (PDPD) and its Psychological Benefits. *Journal of Happiness Studies*, 14 (1):155-167.
- [27] Luskin, B. (2017). The Media Psychology Effect. *Psychology Today*: <https://www.psychologytoday.com/blog/the-media-psychology-effect/201609/explaining-media-psychology-in-2017>. Accessed May 1st, 2020.
- [28] Winnicott, D. (1953). Transitional Objects and Transitional Phenomena. *International Journal of Psycho-Analysis*, 34:89-97.
- [29] Klein, M. (1930). The Importance of Symbol-Formation in the Development of the Ego. *International Journal of Psycho-Analysis*, 11:24-39.
- [30] Milošević, M. (2019). Digital moving image as the subject of digital film, media and culture studies. *NEW HORIZONS Culture, Arts and Media in the Digital Environment* (pp.108-109). Fakultet dramskih umetnosti, Beograd.
- [31] Milošević, M. (2017). Film i san. *Zbornik radova fakulteta dramskih umetnosti*, 32:27-42.



THE ROLE OF SPECIFIC TECHNOLOGICAL SOLUTIONS IN THE CREATION OF WELLNESS PROGRAMMES

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Abstract:

Changing of bad habits and the desire for a healthy lifestyle direct people into wellness centres which are providing programmes focused on individuals, which lead to optimized physical and mental condition. Using only precise information obtained by measuring and through assessment of the complete body status and through detailed analysis, can provide the creation of relevant wellness programmes and necessary treatments in the process of eliminating misbalance and improving the overall conditions. InBody 770 used to measure body composition and the different ratios between tissues, is proven to be a highly accurate device compared to a reference device, and as such, it is necessary in the creation of specific programmes and assessment of the effects of selected activities. Analysis of possibilities of the already proven Templo software has demonstrated its abilities in the assessment of postural status, analysis of foot structure, as well as in the functional analysis of movement. Portable devices for monitoring users' daily activities proved to be precise, compared to the reference model. Use of technological solutions proved to be unavoidable when it comes to reaching the optimal goals and positive change of the overall condition and habits of users, in combination with correctly created wellness programmes.

Keywords:

wellness and health, recreation, InBody, Smartwatch.

1. INTRODUCTION

Due to the modern lifestyle, people are often orientated towards taking care of their physical and mental health. Wellness centres provide a way of achieving adequate conditions by designing specially created services such as weight-loss programmes, personal fitness training, group exercise classes, spa services, massage therapy, physical therapy, corrective body treatments, wellness education classes [1].

Wellness and recreational centres, as well as all the facilities oriented towards the promotion of healthy lifestyle by applying specific procedures and activities, in order to provide adequate wellness contents, need to adjust activities to their users, based on their physical condition, desires and needs [1].

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Only through correctly and precisely designed programmes and activities the user will feel the benefits of wellness programmes [2]. A satisfied user will bring benefit to the service provider, and thus to popularisation of wellness as a lifestyle that has a positive impact on the quality of life itself. Efficient programmes, focused on individuals, result in an increase in the wellness industry in general, including the development and popularisation of wellness-based tourism, which has strong pre-dispositions to be among the most sought after tourist attractions in the Republic of Serbia [3].

The wellness programmes must be applicable and useful for the user, which is achieved by offering properly prepared client-centered solutions. These solutions must enable progress for the user in the most efficient, safe and the fastest way, in line with their expectations and beyond this, so that by using those solutions, the user feels positive changes and commitment to the centre where they exercise. This is achieved by collecting, analysing and interpreting the necessary and adequate information about the user, including a physical health check of the user, bearing in mind that they can be recreational, amateur and professional athletes, convalescents, older persons, children, and overall, all those who want to improve their quality of life and adopt healthy habits that can help them [4]. If there is knowledge about the current status of the body, and all the found deficiencies, individual programmes that help eliminate those problems can be created, prevention can be exercised, and the result will be the improvement of psychosomatic and functional status. Different problems and deficiencies can occur due to poor lifestyle, inadequate nutrition, weak or insufficient physical activities, as well as inherited or developed deformities, injuries, or other factors [2].

Technological progress and finding of different technological solutions, as well as development and optimization of the existing technologies, provide for optimal collection and analysis of the information and monitoring of all the processes aimed at achieving the desired goal. This paper will show and describe the validity of different technological solutions applied in diagnostic examination in wellness, sport and recreation, enabling as precise information as possible, based on which, through analysis and interpretation, relevant wellness and sports and recreational programmes can be created.

2. TECHNOLOGICAL SOLUTIONS IN THE WELLNESS INDUSTRY IN THE DIAGNOSTICS AREA

Bioelectrical impedance InBody 770

The evaluation and analysis of the body composition and different relations between tissues are necessary in order to properly design different wellness programmes and treatments which will bring the client to optimal condition [5]. The modern technological solution InBody 770 offers high precision in measurement, providing necessary information to determine the client's psychosomatic status [6]. It enables a detailed analysis of the data used by experts in the field of recreation, sports, medicine, therapy to be certain when prescribing the best solutions, which include nutrition, hydration, training and therapy processes for the achievement of the optimal overall condition of the client.

The device is based on the reactivity analysis method, it uses six different frequencies through five different body segments, discerning each and their mutual relation, providing relevant data about more than 50 parameters regarding body composition [6]. Qualitative and quantitative data about electrical conductivity of tissue enable assessments for full-body, its segments, the amount and distribution of body fat, muscles, proteins, minerals, the total water levels, as well as the ratio between fluids in and outside of the cells, which enables assessment of the possible presence of edema in certain segments of the body [7].

The information gained through measurement is subject to further analysis in order to prepare adequate nutrition, training programmes and other therapy procedures which can help the client get into the desired condition.

A number of research studies have confirmed high accuracy of InBody device by comparing it with a reference device, the DXA – Dual-energy X-ray absorptiometry (bone density scanning) [8], [9], [10]. DXA is considered a standard in the measurement of body composition and its usage is confirmed in many clinical trials [11], [12]. The device enables measurement of the entire bone mass, percentage of bone and muscle mass, where the percentage of the body fat is specified, providing precise data which are used in the preparation of different obesity treatments, to follow up on losing of body mass with recreational and professional athletes.



Bioelectrical impedance analysis – BIA is widely used because it is non-invasive, easier to use, faster, cheaper and its efficiency is established by many studies which confirm its high accuracy [13]. Wen-Hui Fang et al. conducted a research [8] on the population of the elderly persons in Taiwan, where they tested the accuracy of the displayed body composition parameters of test subjects by applying the BIA InBody 720. DXA has been used as a reference device and BIA as a model which has been considered accurate enough when it comes to measurement of the body composition of the elderly. The research has shown that information provided by BIA InBody 720 have a high correlation with the information provided by the DXA device. The correlation coefficient of those two devices for the muscle mass was 0.969 and for fat tissue 0.935. Comparison of the BIA and DXA methods has been a part of the research conducted by Antonio Jose et al. [9], which provides a comparative analysis of the data received by using methods of different technologies (DXA and BIA InBody 770) in four weeks' treatment of the men and women in training. The examinees have been advised to conduct an identical workout programme and reduce energy input by using specific nutrition, in order to measure the value of changes in body composition. They have been measured before and after the programme and it was established that the percentage of weighted fat component, the percentage of fat tissue, has dropped, and at the same time the muscle component was above values measured by DXA method. The changes in percentages of the fat component, before and after the measurement done by DXA compared to those done by BIA, was – 1.1 % and – 1.5%, respectively. The results of the mentioned components did not show statistically significant differences vis-a-vie DXA method and, although is they showed higher variability level, they have confirmed the high accuracy of the BIA method applying the InBody 770 apparatus, and it was concluded that BIA is a solid replacement for the DXA method when it comes to measurement of the body composition of males and females regularly performing physical activities. Similar results have been reached by Schoenfeld et al. [10], who have compared DXA and BIA by measuring younger male examinees after ten days of resistance training process. It has been shown that there is no significant statistical difference between these two methods (fat tissue percentage in DXA – 1.05%, 1.28 % in BIA method).

By analysing the collected data, the experts are gaining precise data based on which they can create specified programmes which contribute to the positive changes in clients by providing the best ways to solve certain issues [14].

Wellness programmes created this way are becoming more severe and they contribute to the trust of clients in the wellness centre. For example, my measurement experts determine obesity levels of the client and by performing detailed tests, they get an overview of the complete body condition and decide where it is necessary to give relevant advice and a specified program of activities, nutrition and recovery. Many individuals attempt starvation, where the elimination of sugar and processed food from one's diet can have short term result. Instant weight loss with inadequate activities is not good, because very soon all the weight will come back, even more than before [15], [5]. For a stable process of weight loss, stable burning of calories is only provided through adequately prepared, dosed physical activity combined with adjusted nutrition, the establishment of healthy habits and introduction of proper methods of recovery from stressful daily activities, by respecting the current body status and genetic predispositions [16].

Wellness centres can be in non-stop contact with their clients by using Cloud database about clients with advanced analytics, as well as InBody mobile application via which the clients can see the results and follow the progress, and that helps them stay motivated and focused on achieving their desired fitness [17]. Connection with friends and family is also enabled, as well as the link with their personal trainer so that they can exchange information and have an overview of the condition.

Contemplas Templo professional motion analysis software

For assessment of the postural status, Templo software is using a system of three cameras which detect markers on certain anthropometrics body points in all three planes. The developed 3D analysis provides precise information about postural disorders and curves of the spine. With a platform that detects pressure distribution under the foot during standing and walking, eventual deformities of the feet can be noticed [18]. Figure 1 shows the 3D analysis of posture done by Templo software.

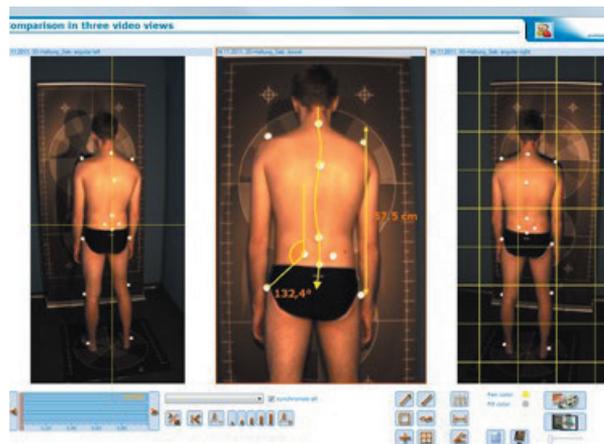


Figure 1. 3D posture analysis [19].

The importance of the collection of this specific data is demonstrated with precise diagnostics of the current condition of the client and adequate determination of the kinesiotherapy treatment, as well as the providing of correct advice during the performance of different physical activities, so that they don't have a negative effect on the body or create bigger issues. In order for activities to be efficient and effective, it is necessary to perform them in accordance with biomechanical principles [20]. Templo software allows diagnostics by the FMS (Functional Movement Screen) method, which has significant usage in functional assessment of locomotor apparatus and it determines the stability and mobility of certain body parts [21]. It has extensive usage in team sports as well as in recreation, wellness and kinesiotherapy. The system consists of a computer, a flashlight and two cameras - frontal and back, a special platform and a measuring terminal that simplifies its operation. The method allows for evaluation of the correctness of movement during the performance of seven tests, which are used to determine limitations of stability and mobility of the client's movements, as well as to determine asymmetry [22].

Analyses of movement and running are very complex [20] and, thanks to these technological solutions it is possible to collect precise data for analysis of the condition of a large number of clients. Templo software is designed as a modular platform which can be upgraded with different functions, depending on the preferable analysis of posture or movement which are necessary for the preparation of the required programmes, as well as, depending on the wellness centre, in rehabilitation or other medical facilities, sports and recreational centres, sport clubs. Sport University Cologne [18] has confirmed the preciseness and importance of the Contemplas

Templo technology and found its applicability in both commercial and scientific field.

Portable device for daily activities monitoring

With the promotion of a healthy lifestyle, the popularity of portable devices for the monitoring of an individual's daily activities is increasing, and that is also confirmed by major tech companies like Samsung, Apple, Garmin, Fitbit - they are producing multifunctional solutions and permanently developing them. For an individual to have a healthy lifestyle, the World Health Organization recommends physical activity at least 60 to 150 minutes per week for adults between 17 and 64 years of age [23]. So-called smartwatches and Fitness trackers (fitness bracelets) have become popular because it's possible to use them paired with smartphones via matching applications, and the tracking of different daily activities provides detailed information about every activity of the user during one day. Apart from different functions that they offer, the most common and most popular features of different smartwatches are the heart rate measurement, step counter, calorie burn, sleep tracker, running tracker, stairs counter [24]. All the information can be seen and analysed with matching apps on a smartphone or computer. That kind of monitoring is enabled thanks to different sensors, such as [25]:

- Accelerometer - the most important sensor which can detect wide spectre of activities: detect movement or inaction of the device, inclination, shaking, step counter.
- Gyroscope - for the navigation and angular velocity measurement
- Geomagnetic sensor - used as the compass in devices, it measures the surrounding magnetic field in all three physical axes.
- Barometer - based on measured atmosphere pressure, velocity and mode of movement, it can calculate calories burn
- Heart rate sensor - heart rate monitoring, used for information about the intensity of the activity, lassitude, and quality of sleep.

The reliability and preciseness of portable devices in the collecting of valid information about user activities are confirmed in various studies [26], [27]. Those studies had to compare it with the device Actigraph GT3X, which has the status of a reference device when it comes to the accuracy



of the data on user activities within clinical studies [28]. The conclusion was that devices such as Apple smartwatch and Fitbit are precise enough for the monitoring of daily physical activities of the user, but they cannot be an adequate replacement for clinical usage and research.

Use of daily activities monitoring devices provides information significant for the experts in wellness centres, kinesiology and medical facilities, sports clubs so that they can be in constant communication with the clients with the help of apps [29], [30]. In that way, they can analyse the information adequately and timely and use this to prepare relevant wellness programmes and other activities and treatments that follow the daily regime of the client and their business and private commitments, trips, hobbies, to achieve the best possible results.

The users who want to practise different physical activities need to conduct consultations with the experts from the fields of sport, recreation, kinesiotherapy, medicine and conduct a detailed diagnostic examination in the wellness centre and medical facilities. These facilities have the most modern and precise methods for determining the overall physical condition, based on which the clients can receive individually adjusted programmes which can bring them into the desired condition. Smartwatches and similar devices can be useful for monitoring purposes, as a motivation to fulfil the goals, in communication with the wellness service providers, as well as in the analysis of daily activities of the clients. That way, they can track progress, as well as the influence of selected activities to changes in the condition of the body [31]. In a population with obesity problems or cardiological issues, usage of smartwatches can be a default addition to the physical activities due to the timely sent signals about heart rate and control of activities in order to avoid side-effects such as sudden loss of energy and premature fatigue, nausea, muscle cramps, etc. [16]. The constant development of wellness tourism, which bases part of its offer on outdoor activities, smartwatches facilitate communication with users and wellness centres, as well as the implementation of planned field programmes and constant monitoring of different activities conducted in different conditions, providing the opportunity to receive timely and correct information necessary for control of the prescribed programmes.

It is mandatory to confirm the validity of this type of devices through different studies, along with the possibilities for development of a system which can enable them to reach the standard to be used for clinical purposes. With relevant studies, it is possible to differentiate devices that justify its purpose and those that are less

functional and less precise, and with this the user can be protected from the manipulation and will be safe to improve his physical condition to the desired level.

3. CONCLUSION

A healthy lifestyle and achieving optimal body condition is a result of efforts to change one's bad habits and of orientation towards the performance of different activities which enable that change and the reaching of the designated goal. Wellness centres, kinesiology and sports and recreational centres, specific medical facilities can provide the most optimal approach to this problem and its elimination by applying individually designed wellness programmes based on relevant information. In order to provide that, it is necessary to have the correct diagnostics of the overall body condition of the client using precise measuring devices to collect information for analysis and to prepare the proper programmes. The advancement of technology allows the development of precise devices which can receive necessary information about the body and functional deficiencies in a non-invasive way, so that they can be removed in the fastest and most optimal manner, but they can also improve the overall condition to make permanent changes.

The use of InBody device, of bioelectrical impedance, has proven to be an unavoidable method in the measurement and analysis of body composition of the client, enabling insight in the overall body structure and a very precise display of percentages of different types of tissue. This enables the preparation of a diet and recommendations for the planning of the needed practises and other wellness activities.

To avoid side effects of exercises, it is necessary to move by following biomechanical principles and to assure efficient and correct performance of movement to make the right changes which will not leave consequences on bones and joints or the muscular system. Only by performing a precise determination of the postural status, foot structure, analysis of movement and establishing all types of present disbalances, it is possible to design optimal and individually focused wellness and kinesiology programmes and other needed treatments and activities.

Contemplas Templo has proven itself as a very accurate and scientifically confirmed solution, as a professional software for the analysis of motion which, as a modular platform, can be upgraded with different functions, depending on the current needs.



The desire for a healthy lifestyle has been recognised by major technology companies as an opportunity to offer to the market devices which can monitor daily activities of the user, by using their technology such as smartwatches and fitness trackers. These multifunctional devices are designed to measure different activities of the user, like distance, heart rate, calories deficit, sleep quality and similar. Use of specially designed apps on mobile phones and computers and implemented tools for daily activities analysis and communication, provides the user, as well as the wellness centres, with the necessary insight into the current status, results and progress in achieving the desired goals. One should keep in mind that those devices are made exclusively for monitoring of activities so that they can influence the motivation of the users and fulfilment of the set goals and their communication with friend, family and wellness centres. Various studies have confirmed the reliability of some of the devices, but they cannot be substituted for clinical usage in research. It is also mandatory, through further research and development, to strive for that kind of possibilities.

We can conclude that it is necessary to use modern technological solutions which are intentionally designed to enable the recording of the overall status of clients as well as the monitoring of activities in the implementation of the prescribed programmes and treatment in achieving the desired goals. This way, the user is permanently informed and timely advised by the selected facilities that offer wellness programmes and specified treatments for eliminating deficiencies and introducing a positive change in the lifestyle. Although the conducting of tests within facilities is often more appreciated, it is not recommended to carry out the programmes on your own without consultations with professionals, because the relevance of the data and expert advice enable the safest and most secure way of eliminating deficiencies and achieving the desired results, along with the minimising of side effects.

REFERENCES

- [1] S. J. Hoffman, D. V. Knudson. Introduction of kinesiology: Studying physical activity. 5th Edition. USA: Human Kinetics. 2018.
- [2] D. Mitić. Značaj fizičke aktivnosti u prevenciji i terapiji gojaznosti u detinjstvu i adolescenciji. Medicinski glasnik Specijalne bolnice za bolesti štitaste žlezde i bolesti metabolizma 'Zlatibor'. 2011, 16(39):107-112.
- [3] Strategija razvoja turizma Republike Srbije za period 2016-2025., 2016, dostupno na <https://mtt.gov.rs/download/3/strategija.pdf> dana 18. 2. 2020.
- [4] C. E. Garber, B. Blissmer, M. R. Deschenes, B. A. Franklin, M. J. Lamonte, I. M. Lee, D. C. Nieman, D. P. Swain. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. American College of Sports Medicine position stand. 2011, 43(7): 1334-1359.
- [5] S. Stojilković, D. Mitić, S. Mandarić, D. Nešić (2005). Fitness. Beograd: Fakultet sporta i fizičkog vaspitanja. 2005.
- [6] InBody Technology. <https://inbodyusa.com/general/technology/>, Accessed 19 February 2020.
- [7] InBody Body Composition Analysers, http://inbody.net.au/wp-content/uploads/2018/09/InBody_770_Information_pack_04.pdf, Accessed 19 February 2020.
- [8] W. H. Fang, J. R. Yang, C. Y. Lin, P. J. Hsiao, M. Y. Tu, C. F. Chen, D. J. Tsai, W. Su, G. S. Huang, Chang H, S. L. Su. Accuracy augmentation of body composition measurement by bioelectrical impedance analyzer in elderly population. *Medicine* 2020; 99:7(e19103).
- [9] J. Antonio, et al. Comparison of Dual-Energy X-ray Absorptiometry (DXA) Versus a Multi-Frequency Bioelectrical Impedance (InBody 770) Device for Body Composition Assessment after a 4-Week Hypoenergetic Diet. *Journal of Functional Morphology and Kinesiology*. 2019, 4(2), 23.
- [10] B. J. Schoenfeld, et al. Comparison of Multifrequency Bioelectrical Impedance vs. Dual-Energy X-ray Absorptiometry for Assessing Body Composition Changes After Participation in a 10-Week Resistance Training Program. *Journal of Strength and Conditioning Research*. 2020; 34(3): 678-688
- [11] C. Verdich C., et al. Changes in body composition during weight loss in obese subjects in the NUGENOB study: Comparison of bioelectrical impedance vs. dual-energy X-ray absorptiometry. *Diabetes & Metabolism*. 2011; 37 (2011) 222-229.
- [12] K. H. Pietila, S. Kaye, A. Karmi, L. Suojanen, A. Risananen, K. A. Virtanen. Agreement of bioelectrical impedance with dual-energy X-ray absorptiometry and MRI to estimate changes in body fat, skeletal muscle and visceral fat during a 12-month weight loss intervention. *British Journal of Nutrition*, 2013, 109 (10): 1910-1916.
- [13] P. L. Cox-Reijven, B. Van Kreel, P. B. Soeters. Accuracy of Bioelectrical Impedance Spectroscopy in Measuring Changes in Body Composition During Severe Weight Loss, *Journal of Parenteral and Enteral Nutrition*. 2002, 26(2): 120-127.



- [14] D. Riebe, J. Ehrman, G. Liguori, M. Magal, (Eds.). ACSM's guidelines for exercise testing and prescription. Tenth edition. USA: LWW. 2017.
- [15] B. Bushman, (Ed.). ACSM's complete guide to fitness & health. Second edition. USA: Human Kinetics. 2017.
- [16] N. Dikić, S. Živanić. Osnove monitoringa srčane frekvencije u sportu i rekreaciji. Beograd: Dikić Nenad- Živanić Slobodan. 2003.
- [17] InBody kraj teksta aplikacija (InBody App. <https://inbody.net.au/inbody-app/> , Accessed 19 February 2020.
- [18] D. Madić. et al. Improving testing abilities on postural and spinal column status. Novi Sad: Alfa-Graf NS, 2014.
- [19] TEMPLO 3D posture analysis protocols. Dostupno na https://www.contemplas.com/posture_analysis_3d_schemes.aspx , dana 23. 2. 2020.
- [20] P. Grimshaw, N. Fowler, A. Lees, A. Burden. BIOS Instant Notes in Sport and Exercise Biomechanics. USA: Taylir & Francis Group. 2006.
- [21] C. Agresta , M. Slobodinsky , C. Tucker. Functional Movement Screen TM – Normative Values in Healthy Distance Runners. International Journal of Sports Medicine. 2014, 35(14): 1203-1207.
- [22] Templo Functional Screening. Dostupno na https://www.contemplas.com/motion_analysis_functional_screening.aspx , dana 23.2.2020.
- [23] Physical activity. Dostupno na <https://www.who.int/news-room/fact-sheets/detail/physical-activity> , dana 24. 2.2020.
- [24] N.Aitken. Most Used Features of Smartwatches. <https://whatphone.com.au/guide/most-used-features-of-smartwatches> , Accessed 21 March 2020.
- [25] B. Reeder, A. David. Health at Hand: A Systematic Review of Smart Watch Uses for Health and Wellness. Journal of Biomedical Informatics. 2016. 63: 269-276.
- [26] M. Breteler, J. Janssen, W. Spiering, C. J. Kalkman, MD, W. W. van Solinge, D. AJ Dohmen. Measuring Free-Living Physical Activity With Three Commercially Available Activity Monitors for Telemonitoring Purposes: Validation Study. JMIR Form Res. 2019 Apr-Jun; 3(2): e11489.
- [27] P. Semanik, J. Lee, C. A. Pellegrini, J. Song, D. D. Dunlop, R. W. Chang. Comparison of Physical Activity Measures Derived From the Fitbit Flex and the ActiGraph GT3X+ in an Employee Population With Chronic Knee Symptoms. ACR Open Rheumatology. 2020. 2(1): 48-52.
- [28] J. E. Sasaki, Dinesh John, P.S. Freedson. Validation and comparison of ActiGraph activity monitors. Journal of Science and Medicine in Sport. 14 (2011) 411-416.
- [29] Fitbit App. <https://www.fitbit.com/eu/app> , Accessed 21. February 2020.
- [30] Health App. <https://www.apple.com/ios/health/> , Accessed 21. February 2020.
- [31] C. Dobbins, R. Rawassizadeh, E. Momeni. Detecting physical activity within lifelogs towards preventing obesity and aiding ambient assisted living. Neurocomputing. 230 (2017): 110-132.



ADVANCED COMPUTING SESSION





AN ALGORITHM FOR THE MULTIDIMENSIONAL ANALYSIS OF THE OVERESTIMATE AND UNDERESTIMATE OF PROPERTY RENTAL VALUE

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Abstract:

Multidimensional attributes related to a real estate property interfere with the cognitive ability of potential real estate property user to process all available information in order to determine the real rental market rate and make a fully informed decision. Although there are various web platforms for property leasing, it is difficult for a potential user to find two equivalent real estate properties and thus make relevant comparisons. This paper proposes a potential solution for the rental price estimate of a property to be leased, as well as scaling and comparison of its overestimated or underestimated value to all other available properties. This example is developed on the basis of real estate market in Sarajevo. Random Forest algorithm was used for the development of regression model. The principle aim of this paper is to offer an applicative module, based on Data Science methodology, for automatic scaling and the comparison of property overestimated or underestimated rental rates to other residential buildings and taking in consideration multidimensionality of their physical and geolocation attributes.

Keywords:

Real Estate, Price Estimation, Random Forest Regression.

INTRODUCTION

Information as a resource has become an important commodity in every business and its importance is reflected in aiding, that is enabling quality decision making for a decision maker. Unequal availability of information to service providers and service users, also known as information asymmetry, is also found in a real estate market. Information asymmetry can be seen in different economic transactions mostly in situations when one party on the market possesses greater material knowledge than the other and where the better-informed party is a service provider [1]. The importance of information in a decision-making process increases with the value of goods / services and this is particularly pronounced in a real estate market. Also, the decision-making process becomes more

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complexed with the increased attributes dimensionality of products / services and such decisions are made more slowly by the users compared to decisions made when purchasing low-value products/services. Multidimensional attributes related to a real estate property interfere with the cognitive ability of potential estate property user to process all available information in order to determine the real market rental rate and make a fully informed decision. When researching properties, users usually make their estimates based on personal experience, interest and sometimes even include emotional aspect. Although there are various web platforms for property leasing, it is difficult for a potential user to find two equivalent real estate properties and thus make relevant comparisons. In regard to the described problem, the subject of this paper is an analysis and modeling of rental value taking in consideration geolocation and physical attributes of the property. This paper proposes a potential solution for the rental price estimate of a property to be leased, as well as scaling and comparison of its overestimated or underestimated value to all other available properties. This example is developed on the basis of real estate market in Sarajevo. Random forest algorithm was used for the development of regression model. The principle aim of this paper is to offer an applicative module, based on Data Science methodology, for automatic scaling and the comparison of rental properties and their overestimated or underestimated value rates to other residential buildings and taking in consideration multidimensionality of their physical and geolocation attributes. Model development consists of two steps. The first step is to predict a real estate property value using random forest algorithm, while the second step is to conduct the scaling of the overestimate or underestimate of the property value based on the rating of the obtained residual values in regression and their discretization.

1. PREVIOUS RESEARCH

Recently a lot of research has been conducted on housing price forecasts either for sale or leasing (houses and apartments). Models for property price estimate were developed through different regression algorithms, using either traditional statistical algorithms, such as multiple linear regression or neural networks and deep learning algorithms. So, the group of authors [2] has done a research on the predictive performance of the random forest algorithm in comparison to commonly used hedonic models based on multiple regression for

the prediction of real estate property prices in the city of Ljubljana, the capital of Slovenia. All performance measures (R^2 values, sales ratios, mean average percentage error (MAPE), coefficient of dispersion (COD)) revealed significantly better results for predictions obtained by the random forest method. In a paper on a similar topic [3] it was proven that compared to linear regression model, random forests model can better capture hidden nonlinear relations between the price and features of a real estate property and in overall give a better estimate. The absence of multiple linear regression analysis in property price estimation is confirmed in paper [4], where authors suggest using hierarchical linear model (HLM) instead of standard linear model. Joshua Gallin [5] used standard error-correction models and long-horizon regression models to examine how well the rent-price ratio predicts future changes in real rents and prices and found evidence that the rent-price ratio helps predict changes in real prices over 4-year periods, but that the rent-price ratio has little predictive power. In one of the papers [6] author examined the determinants that significantly influence apartment prices that are located within housing estates of Nairobi metropolitan area. Author used multiple regression analysis and the findings indicated that land value and size of the apartments had a significant influence on apartment pricing. A machine learning algorithms trained on big data have a great potential for prediction of property price estimate compared to small datasets [7]. Also, artificial neural network (ANN) has better predictive accuracy in property valuation in comparison to estimations made using traditional hedonic pricing model [8].

2. RANDOM FOREST REGRESSION

Random forest algorithm is becoming increasingly popular in many scientific fields because it can cope with so called "small n large p" problems, complex interactions as well as highly correlated predictor variables [9]. Due to its performances, random forest is more robust compared to multiple linear regression which complies with statistical assumptions such as homogeneity of variance, lack of multicollinearity, linearity of variables, etc. Random forest algorithm belongs to the group of algorithms for supervised machine learning.

Random forest algorithm can be used either for categorical response variable, when algorithm solves "classification" problem or continuous response variable, when algorithm deals with "regression" problem. Similar to that, predictor variable can be either continuous or categorical.



From an application standpoint, random forest algorithm is appealing because it [10]:

- naturally handle both regression and classification problems;
- are relatively fast to train and to predict;
- depend only on one or two tuning parameters;
- have a built-in estimate of generalization error;
- can be used directly for high-dimensional problems;
- can easily be implemented in parallel.

Statistically, random forest algorithm is appealing because of the additional features it provide, such as [10]:

- measures of variable importance;
- differential class weighting;
- missing value imputation;
- visualization;

- outlier detection;
- unsupervised learning.

Random forest algorithm is a type of additive model that makes value predictions by combining decisions from a sequence of base models.

Formally we can write this type of models as [11]:

$$g(x) = f_0(x) + f_1(x) + f_2(x) + \dots \quad (1)$$

where the final model g is the sum of simple base models f_i . Here, each base model is a simple decision tree algorithm. This technique of using multiple regression or classification models to obtain better predictive performance is called model ensembling. In random forest algorithm all the base models are constructed independently using a different subsample of the data.

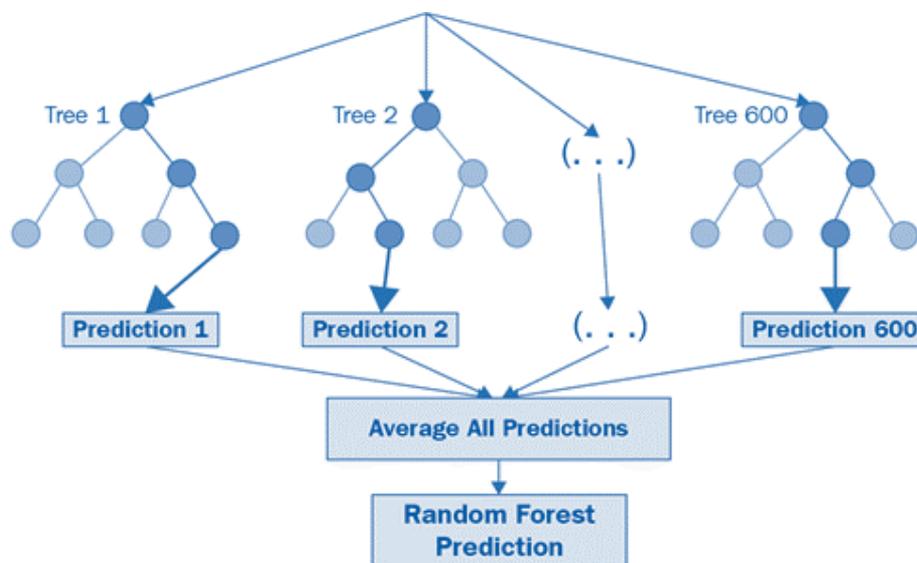


Fig 1. Random Forest Structure

Random Forests is a multipurpose tool, applicable to both regression and classification problems, including multiclass classification. It give an internal estimate of generalization error so cross-validation is unnecessary. It can be tuned, but often work quite well with default tuning parameters. [10]. Random forest method is an effective tool in prediction. Because of the *Law of Large Numbers*, it do not overfit. Injecting the right kind of randomness makes it accurate classifiers and regressors [12].

3. MODEL DEVELOPMENT

Data Collection

For the purpose of developing multidimensional analysis model to determine overestimated and underestimated rental price, data were collected from two sources. The first dataset was collected by web scraping of a website that advertises real estate properties selling and renting in larger cities in Bosnia and Herzegovina [13], and the data extracted refer to available real estate properties and their features such as:



- Type of a real estate property (apartment, house, office space)
- Address
- Price
- Area
- Number of rooms
- Number of bathrooms
- Year of construction
- Adaptations
- Floor
- Amenities (storage room, parking space, garage, AC, Internet access, elevator, etc.)

Data on the website were scraped in the R programming language with “rvest 0.3.4” library [14]. In total 629 rental properties were collected that were located in the city of Sarajevo.

The second dataset was obtained by calling Google Maps API [15] and gathering different geolocation data for every real estate property, as well as the distance of each real estate property from the set reference points:

- The geographic coordinates of a real estate property
- The altitude of a real estate property
- The number of universities in a 2,000-meter radius
- The number of primary and secondary schools and other educational centers (other than universities) in a 700-meter radius
- The number of shopping malls in a 500-meter radius
- The distance of a real estate property from reference points (from Bascarsija, from Vjerna Vatra Monument and from University Campus in Sarajevo).

Places API, Geocoding API, Elevation API and Distance Matrix API were used.

Data Preprocessing

There were some gaps in the data collected that may influence the quality of the final model. For example, from the total of 629 real estate properties, 166 were business offices that were not in the scope of modeling and were removed from the dataset. A smaller number of real estate properties that were located 20 km outside of Sarajevo were also removed. Also, there were 122 real estate properties that did not have quoted price (price on application) and as such could not be used for model review and were removed from the dataset. The final dataset consisted of 343 real estate properties (houses = 61, apartments = 282) located in Sarajevo.

Text data type (string) was converted by parsing and modified into usable modeling attributes. Data obtained with Google Maps API were checked and if necessary, cleared from illogical objects, that were aggregated on each real estate property and using datasets connected to properties.

After we connected datasets, we had 71 attributes that were related to different physical features of real estate properties and their geolocation, as well as specific characteristics of their surroundings.

Feature Engineering

A one hot encoding procedure was conducted for all categorical variables to obtain binary variables usable for random forest algorithm. The date attribute *year of construction* was set by calculating the age of the building as the difference between the current year and listed year of construction (age of the building = 2020 – year of construction).

Outlier Detection

Presence of extreme values in the data was analyzed using Cook’s distance method. Cook’s Distance (D_i) is an influence measure based on the difference between the regression parameter estimates and what they become if the i -th data point is deleted. There are numerical rules for assessing Cook’s distance but the rules tend to be rough guidelines, and textbook authors differ in their advice [16]. Real estate properties that had Cook’s distance 4 times bigger than arithmetic average of the distance were considered extreme. Fig 2 represents cases that had extreme values of certain variables (above the red line). In such cases, detected extreme values of some attributes are replaced with missing values.

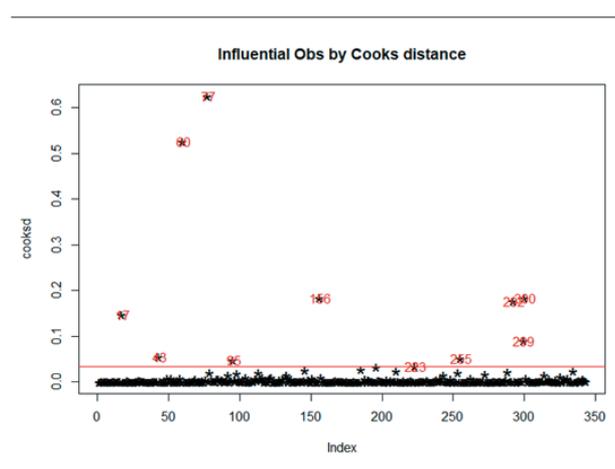


Fig 2. Influence measure with Cook's Distance



Transformation Data

In order to normalize values, all numerical attributes were transformed before the modeling. As some attributes had negative values, we decided to use Yeo-Johnson transformation. If values are strictly positive, then the Yeo-Johnson transformation is the same as the Power Cox transformation [17]. An example of transformation of one attribute is shown in Figures 3 and 4.

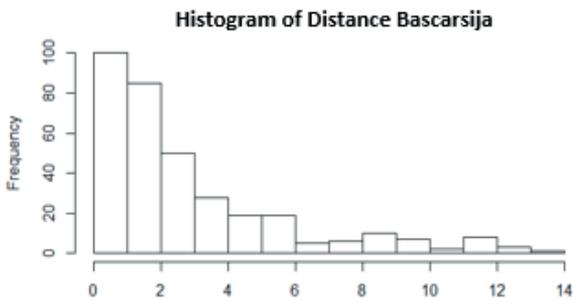


Fig 3. The distribution of the distance values of a real estate property from Bascarsija before Yeo-Johnson transformation

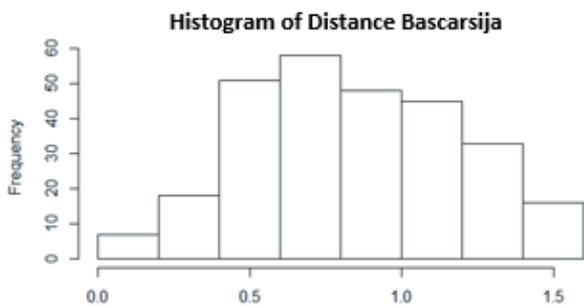


Fig 4. The distribution of distance values of real estate property from Bascarsija after Yeo-Johnson transformation

Model Training

The "caret 6.0-85" R library was used to run the Random forest algorithm [18]. The process of training a model for the rental price estimate, on the basis of random forest algorithm, was conducted on 80% (n = 276) random observations. Random Forest is initiated with n=130 of trees to grow. The 10-fold cross-validation procedure is repeated 3 times. Root Mean Square Error (RMSE) parameter was used for the selection of optimal model. Table 1 shows resampling results across random forest parameters with cross-validation procedure.

The final number of variables for splitting a node, and that were used for the model, was mtry = 26 and that number represents the final optimal value with the smallest Root mean squared error (RMSE=1.042) and parameter R-squared of 0.69542.

Figure 6 shows top 12 variables that are the most important in determining variables in rental price estimate in the model. Property area has by far the biggest influence on property value. The number of rooms in the property is the second important variables for rental price estimate. Distance of property from Bascarsija is also important variable for determining the rental price, but also the distance from Vjecna Vatra Monument as the second reference point. The number of universities in 2,000-meter radius from the property is also one of top 12 variables that determine property value. Important variables are number of bedrooms, altitude as well as the floor of the property.

mtry	RMSE	Rsquared	MAE
2	1.198122	0.6673015	0.9653732
5	1.089086	0.6896604	0.8731576
8	1.067655	0.6929206	0.8517182
12	1.059462	0.6916996	0.8415689
15	1.058859	0.6887428	0.8430591
19	1.048629	0.6942377	0.8321179
22	1.048378	0.6924978	0.8290187
26	1.042050	0.6954187	0.8279170
29	1.055678	0.6846355	0.8314533
32	1.051792	0.6870910	0.8287001
36	1.042958	0.6924899	0.8196449
39	1.053497	0.6845814	0.8260079
43	1.058534	0.6806108	0.8248516
46	1.046557	0.6879252	0.8196265
50	1.064484	0.6769833	0.8322964

Fig 5. Resampling results across tuning parameters

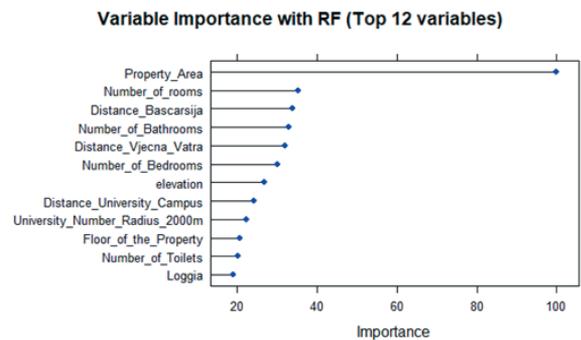


Fig 6. Variable Importance with Random Forest (Model Training)



Model Evaluation

Model evaluation was conducted on the other 20% randomly selected dataset observations. A prediction of rental price was made on a test dataset during random forest model training. A value of Root Mean Square Error obtained was 1.0566 between actual prices and predicted prices with model with training dataset. Scatter plot on Figure 7 shows the relationship of actual prices and predicted prices with the model.

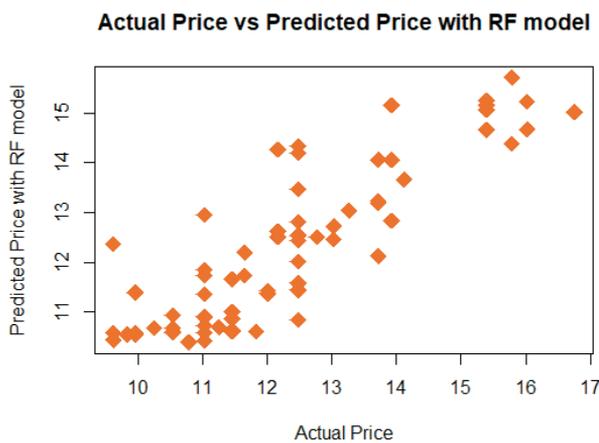


Fig 7. Relationship of actual prices and predicted prices with Random Forest model

4. THE APPLICATION OF MODEL FOR THE SCALING OF OVERESTIMATED AND UNDERESTIMATED RENTAL PROPERTIES

After the prediction of rental price estimate, the next step is normalization and discretization of residuals. In the context of this research, residuals represent the differences between rental actual prices and predicted prices with the model, that is:

$$e = y - \hat{y} \tag{2}$$

where:

e – residual

y - actual price

\hat{y} – predicted price with the model

Therefore, predicted price with the model \hat{y} represents the value determined by multidimensional influence of variables in the model which are responsible for determining the rental price. Positive residual value of

the property shows us the increase of actual price (over-estimated) in comparison to expected price determined by the model, while negative residual value shows the decrease of actual price (underestimated) in comparison to expected price determined by the model. Realized residual values are further normalized by Z-score in order to compare certain properties with others in the data base. Finally, in order to determine whether the rental price of property is overestimated or underestimated, depending on its characteristics and compared to other properties and their characteristics, Z-score is discretized in 5 groups ranging from “Very good price” to “High price”. Figure 8 shows an example of the scaling of overestimated and underestimated rental value.

Real Estate	Obs.	Pred.	Resid.	Z	Status
A	9.62	12.30	-2.68	-3.33	Very Good Price
B	9.62	11.08	-1.46	-1.80	Good Price
C	10.26	10.10	0.16	0.22	Fair Price
D	15.40	13.55	1.85	1.48	Increased Price
E	10.79	9.00	1.79	2.03	High Price



$$z = \frac{x - \mu}{\sigma}$$

X= Residual (Observed - Predicted)

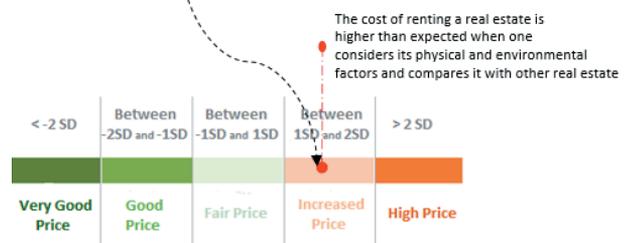


Fig 8. A scaling example of the over- and underestimated rental value

5. CONTRIBUTION OF RESEARCH, LIMITATIONS AND FUTURE RESEARCH

Implementation of presented algorithm on web platforms, which act as intermediaries between real estate service providers and users, will help users (property seekers) with cognitive reduction of the amount of in-



formation as an alternative to filtering of different attributes (location, number of rooms, floor, etc.) in order to make comparison and determine property value. One of the limitations is the development of the proposed solution on a relatively small dataset, which influenced model performances and gave a slightly larger estimation error (RMSE) in the rental value of property. Different researches have shown that the model performances can significantly increase. In future research we should have at our disposal large dataset that would enable us to apply deep learning algorithm. In order to improve model performance in estimation of property value, we should include additional variables that would further provide an explanation to the variability of property prices.

REFERENCES

- [1] M. Parkin, *Economics* (11th Edition), University of Western Ontario, 2014.
- [2] M. Čeh, M. Kilibarda, A. Lisec, B. Bajat, Estimating the Performance of Random Forest versus Multiple Regression for Predicting Prices of the Apartments, *International Journal of Geo-Information*, 2018.
- [3] C. Wang, H. Wu, A new machine learning approach to house price estimation, *BISKA- International Open Access Journals*, 2018.
- [4] I. Arribas, F. Garcia, F. Guijarro, J. Oliver, R. Tamošiūnienė, Mass appraisal of residential real estate using multilevel modelling, *International Journal of Strategic Property Management*, Volume 20, p. 77-87, 2016.
- [5] J. Gallin, *The Long-Run Relationship Between House Prices and Rents*, *Real Estate Economics*, 2008.
- [6] J.N. Ndegwa, Determinants of Apartment Prices within Housing Estates of Nairobi Metropolitan Area, *International Journal of Economics and Finance*; Vol. 10, No. 6, 2018.
- [7] J. I. Pérez-Rave, J. C. Correa-Morales, F. González-Echavarría, A machine learning approach to big data regression analysis of real estate prices for inferential and predictive purposes, *Journal of Property Research*, p. 59-96, 2019.
- [8] R. B. Abidoye, A.P.C. Chan, Improving property valuation accuracy: a comparison of hedonic pricing model and artificial neural network, *Pacific Rim Property Research Journal*, Volume 24, p. 71-83, 2018.
- [9] C. Strobl, A.L. Boulesteix, T. Kneib, T. Augustin, A. Zeileis Conditional variable importance for random forests, *BMC Bioinformatics*, 2008.
- [10] A. Cutler, D. R. Cutler, J. R. Stevens, Random Forest, C. Zhang, Y. Ma (Editors), *Ensemble Machine Learning (Methods and Applications)*, p. 157-175, Springer, 2012
- [11] Turi Machine Learning Platform User Guide. [Online]. Available: <https://turi.com/learn/userguide/index.html>
- [12] L. Breiman, *Random Forests*, Kluwer Academic Publishers. Manufactured in The Netherlands, 2001.
- [13] Company "Prostor" Ltd. Sarajevo, [Online]. Available: www.prostor.ba
- [14] H. Wickham, rvest library for scrape information from web pages, [Online]. Available: <http://rvest.tidyverse.org/>
- [15] Google Cloud, Google Maps Platform, [Online]. Available: <https://cloud.google.com/maps-platform>
- [16] B. McDonald, A Teaching Note on Cook's Distance – A Guideline, *Institute of Information and Mathematical Science, Massey University at Albany, Auckland, N.Z.*, 2002.
- [17] S. Weisberg, Yeo-Johnson Power Transformations, Department of Applied Statistics, University of Minnesota, St. Paul, MN 55108-6042, 2001.
- [18] M. Kuhn, J. Wing, S. Weston, A. Williams, C. Keefler, A. Engelhardt, T. Cooper, Z. Mayer, B. Kenkel, R. Core Team, M. Benesty, R. Lescarbeau, A. Ziem, L. Scrucca, Y. Tang, C. Candan, T. Hunt, Classification and Regression Training, [Online]. Available: <https://cran.r-project.org/web/packages/caret/caret.pdf>



ANOMALIES DETECTION IN THE APPLICATION LOGS USING KOHONEN SOM MACHINE LEARNING ALGORITHM

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Abstract:

Internal fraud in the financial sector are difficult to detect since fraudulent transactions are indistinguishable from ordinary transactions, and standard checkpoints, in the form of transaction documentation and authorization, are skillfully avoided. Well-designed software has available and machine-readable application logs that can be analyzed to detect anomalies in application usage. This paper presents a data preparation technique using path analysis and Kohonen SOM clustering algorithm that can help better profile users of an application to reduce the number of cases that will be further investigated.

Keywords:

internal fraud, Self-Organizing Mapping, Kohonen, path analysis, detection anomalies.

1. INTRODUCTION

Traditional internal fraud detection techniques are complex, time-consuming, and require expertise. It incorporates knowledge from economy, finance, law and other relevant fields. Internal fraud detection techniques are usually based on prior experience, applying specific *if-then* rules within an expert system. Fraud is a “profitable” business, so fraudsters are constantly finding new ways to avoid detection systems and stay undetected. *If-then* rules are static, easily bypassed and quickly deprecated. In addition, after system setup, some rules can be expired. So, the rules show that all or at least the vast majority of employees are suspicious or no employees are suspicious. Therefore, the challenge, and research questions are: Whom to check first? How to fine-tune the system to reduce the number of “*false-negatives*” i.e. to reduce the time spent on deeper investigation?

The ability to describe business processes clearly and unambiguously through application logs enables us to understand and anticipate the behavior of users at the lowest level, observing the user through every aspect and part of the transaction, and then, grouping users by activity, profiles the user groups of interest for the analysis [1].

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This type of analytics is called behavioral analytics. *Behavioral analytics* uses machine learning techniques to group users according to their activity, identify the most important user groups, and detect atypical patterns and anomalies.

These analyzes of application logs may be used to improve user experience, enhance the application, and detect malicious use of the application.

2. LITERATURE REVIEW

Types of anomalies

There are 3 basic types of anomaly [2]: contextual anomaly, point anomaly, and collective anomaly.

Contextual anomaly is a behavior atypical in the appropriate context, while in another context it represents a correct behavior. For example, air temperature of 18 degrees in January in Belgrade is a contextual anomaly relative to the average temperature, while 18 degrees in May is not an anomaly.

When a particular data instance deviates from the usual data instances, it can be considered a *point anomaly*. For example, 3 online purchases over 2 hours from a person who never or rarely purchases online is a point anomaly.

A *collective anomaly* is an atypical behavior of similar data instances relative to the entire dataset. For example, frequent insights into balance of certain accounts by some bank tellers can be a collective anomaly. It may happen that a single atypical instance of the data is not an anomaly itself, but together with other data instances it forms a collective anomaly. So, insight into the account balance is not an anomaly because it is part of the transaction, but together with some other transactions it may be a collective anomaly.

Main challenges in anomalies detection

The problem of detecting anomalies by analyzing deviations from normal behavior is not trivial. There are many challenges that modelers face to:

- ◆ There are no general techniques in anomaly detection. What is typical and what is atypical depends on the view of the data, business and problem. So, some speculative activities on the stock market can be seen as both fraud and common behavior.
- ◆ The data contains noise that looks as an anomaly, so it is difficult to separate the noise from the anomaly itself. The same techniques that detect

anomaly in a business context are also used to detect noise in the data quality checking.

- ◆ The small number of detected fraudulent cases vs. the large number of transactions executed limits the choice of machine learning method. Therefore, the technique of unsupervised machine learning is used while the technique of semi-supervised or supervised machine learning is less common. Some techniques have also been described in earlier works [3,4].
- ◆ Normal behavior changes, therefore what was considered normal may no longer be considered and vice versa. For example, the reference values some biochemical analyzes change over time, and thus the context of their application changes.
- ◆ Malicious behavior aspires to become normal by imitating normal behavior.

Choice of machine learning technique for anomaly detection

Cluster analysis is the grouping of a set of objects in such a way that objects in the same group (called cluster) are similar to each other (in a sense) than to those in other groups (clusters). The cluster analysis itself is not some specific algorithm, it is a general task that needs to be solved using the obtained clusters. This may be achieved by a variety of algorithms that differ significantly in understanding what constitutes clusters and how to find them effectively. Popular explanation for clusters involves groups with small distances between cluster members, dense data space, intervals or certain statistical distributions, various projections that keep distances between data instances, etc. Clustering is an iterative process of knowledge discovery or an interactive, more objective, optimization that involves trials and failures. It is often necessary to change the model parameters until the result reaches the desired effects.

Clustering is an unsupervised machine learning technique that does not require labeled data to find rules for grouping similar data instances. It is a basic technique for understanding unlabeled data and the most commonly used technique for anomaly detection. The aim of clustering is not only to determinate clusters, it includes the interpretation of clusters by analyst, who provides meaningful insight into data instances by analyzing each cluster separately, and depending on the results, appropriate actions may be taken.

The choice of a clustering algorithm is a very important part of the model development.



Different clustering algorithms have different measures of similarity/dissimilarity, using measures of distance from the cluster, which are based on the similarity of two data instances. The choosing depends on the assumption of the relationships of the data instance. Therefore if there are the following assumptions:

- ◆ Common data instances belong to data clusters, while anomalies do not belong to any of the clusters. The following algorithms are suitable: DB-SCAN, ROCK i SNN.
- ◆ Common data instances are located close to the centroid within the cluster while anomalies are not so close to the centroid and located on the perimeters of the cluster. Suitable algorithms are: Self-Organizing Maps (SOM), K-means and Expectation Maximization (EM).
- ◆ Common data instances belong to large and dense clusters, while anomalies belong to small and sparse clusters. Suitable algorithm is Cluster-Based Local Outlier Factor (CBLOF).

3. RESEARCH METHODOLOGY

Dataset

The dataset contains application logs of banking core application. Logs are grouped into sessions whereby the session represents the work of an employee at the position over one day in the branch. Except for the session which incorporates date, employee, branch and position in the branch, the analysis uses time of the transaction and transaction type. In total, more than 30 million logs (basic transactions) were considered, accounting for approximately 3 million banking transactions.

In order to avoid additional complexity, the dataset is further limited to:

- ◆ logs in one month outside the holiday season,
- ◆ conduct of employees in the same position by doing the most basic banking transactions, assuming that everyone uses the application in the same manner, following clearly defined rules of usage.

Steps in analyzing logs

Step 1. Data preparation:

- ◆ Transformation of data into a structure suitable for path analysis.
- ◆ Recognition of behavioral patterns. Conducting path analysis and detect sequential usage patterns.

- ◆ Transformation of path analysis results into session vectors.
- ◆ Making fingerprint of each user by calculating statistics of session vectors.

Step 2. Fingerprints analysis and collective anomaly detection using Kohonen SOM learning.

Application logs paths analysis

Path analysis is an analytical technique used to identify sequential patterns in event history [5]. The sequential pattern found in this way is called *path or rule*. Each path contains one or more sequential events that relate to one application session. Path analysis may help in better understanding of application user behavior and business processes. This technique is most commonly used in analyzing visitor traffic through an e-commerce site, in determining the most commonly used paths, as well as the paths to purchase. The results of these analyzes are used to create for example association models used by Amazon, recognition of shopping preferences that are further used in CRM campaigns, personalization site content and direct marketing, and other.

Preparing data for path analysis is simple. It is necessary to transform the existing log table into the form as shown in Figure 1.

SESSION_ID	TRANS_DT_TM	PREV_TRANS_TYPE	TRANS_TYPE	DURATION
2400371	07/07/2018 08:00:00	Change redaj mesta	Change redaj mesta	0
2400371	07/07/2018 08:00:00	Change redaj mesta	Otvorica delatstva od Tesera/Flagera	420
2400371	07/07/2018 08:00:20	Otvorica delatstva od Tesera/Flagera	Ured u stariju salu	140
2400371	07/07/2018 08:00:33	Ured u stariju salu	Ured u stariju salu	13

Figure 1. Table of application log

The table has to contain session identifier, transaction datetime, previous and current transaction type and transaction duration. Now, the rows contain all the information of both the current and the previous event, whereby the row represents a simple rule.

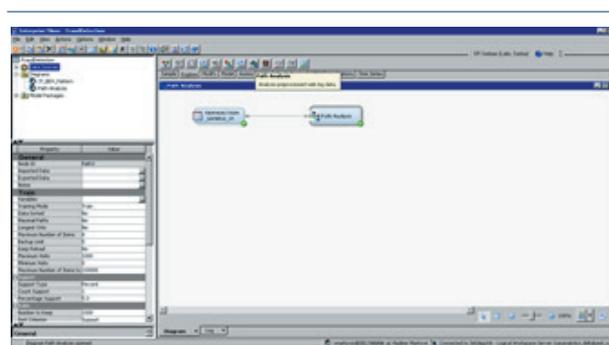


Figure 2. Path analysis using SAS Enterprise Miner



For each session, all subarrays of session events are found, with max length of the subarrays that is limited to predefined value. This restriction is introduced due the complexity of the algorithm.

Rule Identifier	Chain Size	Count	Support	Confidence	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8
1	2	12569	85.0877	89.6170	Ulcina v stari	Golobesnica						
2	2	32409	84.8182	90.1647	Golobesnica	Ulcina v stari						
3	3	32385	84.2276	89.2479	Ulcina v stari	Golobesnica	Ulcina v stari					
4	2	32017	83.3872	87.8521	Ulcina v stari	Ulcina v stari						
5	2	31956	82.1963	86.2419	Ulcina v stari	Ulcina v stari						
6	3	31745	81.6467	87.9071	Ulcina v stari	Ulcina v stari	Ulcina v stari					
7	2	30595	79.6932	87.5139	Ulcina v stari	Ulcina v stari						
8	2	30571	79.6306	83.8829	Ulcina v stari	Ulcina v stari						
9	2	30452	79.2185	83.6482	Ulcina v stari	Ulcina v stari						
10	3	29654	77.2681	87.8321	Ulcina v stari	Ulcina v stari	Ulcina v stari					
11	2	29523	77.1813	87.2883	Ulcina v stari	Ulcina v stari						
12	3	28476	76.6251	86.7259	Ulcina v stari	Ulcina v stari	Ulcina v stari					
13	3	28230	76.1376	86.1919	Ulcina v stari	Ulcina v stari	Ulcina v stari					
14	4	28016	75.3187	86.3750	Ulcina v stari	Golobesnica	Ulcina v stari	Golobesnica				
15	2	28791	74.9841	78.9885	Ulcina v stari	Ulcina v stari						
16	4	27684	72.1927	84.7189	Golobesnica	Ulcina v stari	Golobesnica	Ulcina v stari				
17	2	27476	71.9589	84.9521	Ulcina v stari	Ulcina v stari						
18	3	27452	71.9063	89.7271	Ulcina v stari	Ulcina v stari	Golobesnica					
19	5	27340	71.2354	84.9774	Ulcina v stari	Golobesnica	Ulcina v stari	Golobesnica	Ulcina v stari			
20	3	27128	70.8572	84.2789	Ulcina v stari	Ulcina v stari	Ulcina v stari					
21	3	26323	68.9855	81.2213	Golobesnica	Ulcina v stari	Ulcina v stari					
22	4	26287	68.4879	86.8481	Ulcina v stari	Ulcina v stari	Ulcina v stari	Golobesnica				
23	4	25954	67.8544	86.2182	Ulcina v stari	Golobesnica	Ulcina v stari	Ulcina v stari				
24	2	25761	67.1917	84.2177	Ulcina v stari	Ulcina v stari						

Figure 3. Result of path analysis – rules and their statistics

The following measures are calculated for each rule:

- ♦ *Count* – number of rules in the sample
- ♦ *Support* – percent of occurrence rule r in total number of rules in the sample R.
- ♦ *Confidence level*. Percent of occurrence rule B after A in $A \rightarrow B$ including all rules which contain $A \rightarrow B$.

The result of the path analysis can be graphically represented as shown in the Figure 4. The size of nodes and colors determine the number of B after A in rules $A \rightarrow B$, while the thickness and color of the edges determine the confidence level. The basic idea behind path analysis is to transform a transaction logs into a pattern suitable for further research. For each session, except basic variables, new variables of rules are introduced.

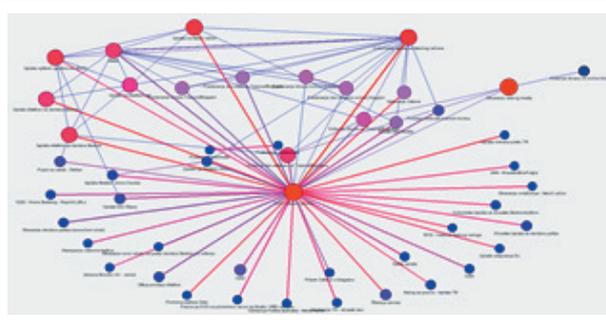


Figure 4. Result of path analysis – link graph visualization

Variables of rules are signed as <RULE><rule identifier>, whereby rule identifier taken from result of the analysis (Figure 3). To simplify, the variable is binary i.e. the value 1 means that the rule is appeared in the session, and otherwise the value is 0 (Figure 5).

EMPLOYEE_ID	SESSION_ID	RULE1	RULE2	RULE3	RULE4	RULE5	RULE6	RULE7	RULE8
1542	12796400	0	0	0	0	0	0	0	0
15450	17060020	1	1	1	1	1	1	1	1
15450	170602048	1	1	1	1	1	1	1	1
15450	170603753	0	0	0	0	0	0	0	0
15450	170603117	1	1	1	1	1	1	1	1

Figure 5. Analytical base table on granularity of the session

Instead of the binary identificatory, it is possible to use number of occurrences of rules in the session, or some other weighting of occurrences in order to favor some rules and change shape of data instances before clustering. The weighting is based on expert knowledge and previous fraud surveys. Also, sessions can be parts of the day, but not all day as in the sample.

It has been identified 508 different rules in the sample. Usually, the analysis takes the rules that satisfy that the Support or Confidence Level is higher than the predefined percentage (trash hold) in order to cut “less” important rules. Since, the aim is to detect anomalies in this paper, all rules were taken regardless of the number of occurrences. Rarely used rules represents the fine-tuning of using the application because the usage of the application is clearly defined trough business processes.

Making user fingerprints

The goal of the analysis is not to profile sessions or application logs, but to profile application users. Therefore, further aggregation of the session table into the user table is needed to create an analytical base table (ABT) at the user level, where an observation (row) describes how user uses the application for defined time period.

Two statistical measures are used to aggregate the sessions. These are the arithmetic mean and the coefficient of variation (CV).

EMPLOYEE_ID	CV_of_RULE1	MEAN_of_RULE1	CV_of_RULE2	MEAN_of_RULE2
1542		0		0
15450	45.614304805	0.9295714266	45.614304805	0.9295714266
22236	23.56172767	0.9480519481	23.56172767	0.9480519481
22480	27.966810491	0.9295714266	41.194292044	0.9571426571
22458	58.640495705	0.7456666667	58.640495705	0.7456666667

Figure 6. User fingerprints – vector space which describes using application

The coefficient of variation is a relative measure, usually in the interval [0,100], which shows the extent of variability in relation to mean of the population. It is used to compare the variability of two different samples with different arithmetic means.



As shown in the Figure 6, there is a significant difference in usage of RULE1 between employees 15450 and 22480. Variability of RULE1 for employee 15450 is 1.6 times greater than variability of employee 22480. The arithmetic mean represents the number of days the rule was used. So, employee 22236 uses the rule 95% of the day at least once.

An employee's ABT has been created with measures of using some rules (paths) for predefined time period. The ABT has 1016 variables (508 for CV and 508 for arithmetic mean). Now, the matrix (1800x1016) determines vector space of application usage where a column is a vector for a rule and a row is a vector of using application by a user called *fingerprint of the application usage*.

4. KOHONEN SOM CLUSTERING ALGORITHM

Self-organizing mapping (SOM) is a competitive neural network that provide topological mappings from entry space to clusters [6]. SOM algorithm evolved from early neural network models, especially models of associative memory and adaptive learning [7], trying to explain the spatial organization of brain functions, which is especially observed in the cerebral cortex. Nevertheless, SOM was not pioneer in the area, there were also the spatially ordered von der Malsburg line detectors (1973) and the neural field model of Amari (1980). However, SOM is strong formal with defined convergence of the algorithm [8].

SOM was originally developed to visualize metric vector distributions, such as measurement values or statistical attributes, while later was shown that SOM mapping can be defined for any data instance, where distance can be defined.

Examples of non-vector data that can be adapted to this method are strings and arrays of segments in organic molecules. The first area of application of SOM was speech recognition. SOM has found widespread use in data analysis and data exploration [9-15].

The idea of the mapping is to group, visualize, and abstract a multidimensional space into usually two-dimensional, rarely one-dimensional, three-dimensional, or higher. SOM is an ordered mapping, a kind of projection of a multidimensional space into a two-dimensional, where an instance of the data will be mapped to a node whose model is the "most similar" data instance, i.e. it has the smallest distance from the data using specific metrics [16].

Using the SOM algorithm, it is tried to find clusters such that any two clusters that are close to each other originate from points of input space whose potential clusters are also close [17]. Vice versa it is not case. Points close to each other do not necessarily correspond to clusters that are close in the SOM network. Thus, the SOM is a discrete smooth mapping between regions of the input space into nodes (neurons) that determine the lattice in two-dimensional space [18].

SOM works as smoothing in a manner similar to the kernel estimation method, except that smoothing is performed in two-dimensional space rather than in the input space [19].

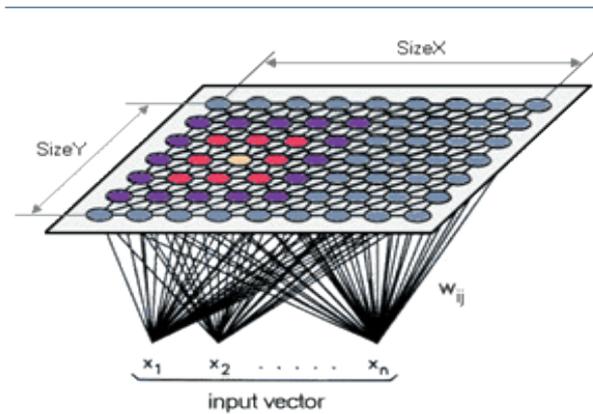


Figure 7. The projection of multidimensional space into two-dimensional [20]

Mathematical model definition

Let n -dimensional vectors in the Euclidean n -dimensional space.

$$x(t)=[x_1(t), x_2(t), \dots, x_n(t)] \quad (1)$$

where t denotes the index of the data instance.

Let m_i , i^{th} model (prototype)

$$m_i(t)=[\mu_{i1}(t), \mu_{i2}(t), \dots, \mu_{in}(t)] \quad (2)$$

where t denotes the sequence of data used to train the model.

Next value $m_i(t+1)$ is calculated using previous $m_i(t)$ and next data instance $x(t)$:

$$m_i(t+1)=m_i(t)+\alpha(t)h_{ic'(x)}(t)[x(t)-m_i(t)] \quad (3)$$



$\alpha(t)$ - positive scalar called learning rate which is decreased for each next step

$c^t(x)$ - cluster which has the smallest Euclidean distance in relation to $x(t)$ called *best matching unit i.e.*

$$c^t(x) = \text{arg min}_{i \in \{1, \dots, c\}} \|x - m_i(t)\|^2 \quad (4)$$

$h_{ic^t(x)}(t)$ - smoothing function ("neighborhood function").

The function h is equal 1 when $i=c$, and h decreases as the distance between models m_i i m_c increase. Also, h decreases for each step t . The function h ensures convergence and must be carefully chosen [6]. Problem of initialization $m_i(1)$ is specifically considered at Kohonen [6, 12].

The result is a data space partition (Figure 8), called *Voronoi tessellation*, with a neighborhood structure between the clusters. The Kohonen map is the representation of the prototypes or of the cluster contents displayed according to the neighborhood structure [8].

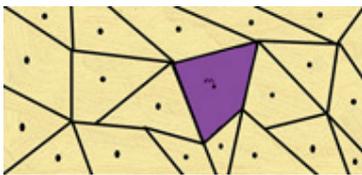


Figure 8. $c^t(x)=i \Leftrightarrow m_i$ is the *winning prototype of x*

Although the above iterative algorithm has been used successfully in many applications. It has also been proven in practice that the algorithm called *Batch Map* gives similar results but converges faster [5].

The basic idea is that for each node j determines mean of $x(t)$ denotes as \bar{x}_j , whereby m_j is the winning prototype for $x(t)$. The next formula can be used

$$m_i = \frac{\sum_j n_j h_{ij} \bar{x}_j}{\sum_j n_j h_{ij}} \quad (5)$$

where:

n_j - number of input instances mapped to a node j

j - represents all indexes near i .

m_i - for m_i update this schema has several iterations using the same group of input data instances to determine \bar{x} .

5. KOHONEN SOM ANALYSIS – EXPERIMENT

The analysis has been carried out on the dataset of 1800 employees for whom the application usage footprint has been calculated in one month (Figure 6) using SAS Enterprise Miner and Kohonen SOM node. Nadaraya-Watson smoothing method was used, where the convergence criterion is 0.0001 and the maximum number of learning iterations is 10.

Principal component analysis w(PCA) was used to initialize the two-dimensional plane, using split into 6x6 segments in which 1800 employees will be grouped - average of 50 employees per segment.

The reason for choosing this method lies in the desire to intersect the multidimensional plane with a two-dimensional plane defined by the principals. It represents the "best" projection, with the aim to maximize in keeping the distance between points in both directions - original space to two-dimensional space and vice versa.

In business terms, the desire is to get coherent clusters as soon as possible, i.e. that employees who do not use the application for the entire period be in separate clusters, and that we may look for potential fraudsters on the perimeter of the clusters that have the highest total distance points relative to the centroid.

At the beginning it was considered to use "Outlier" as method of plane initialization which is default in SAS Kohonen SOM node. That means using points "distant" from each other. This idea was abandoned because additional analysis is shown that outlier fingerprints belong to employees who were on sick leave or vacation. Based on experience, employees who do internal fraud usually do not go on vacation, come the first at the branch and leave the last.

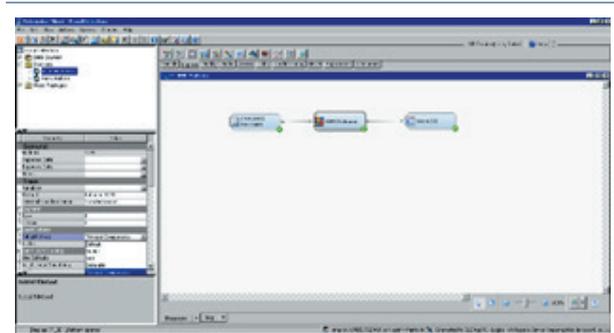


Figure 9. Kohonen SOM analysis using SAS Enterprise Miner



6. INTERPRETATION OF THE RESULT

The result of the analysis is to group each employee into one of 36 (6x6) segments and calculate the distance of each employee from the cluster center as well as the distance between the clusters. This result set provides a very efficient visual presentation of the results using a heat map.

The most commonly used measures for analysis:

- ◆ frequency of cluster - number of observations in each cluster
- ◆ root-mean-square error standard deviation
- ◆ maximum distance from cluster seed
- ◆ nearest cluster
- ◆ distance to nearest cluster

There are 4 heat maps which show 4 different measures (Figure 10). The first what is seen is the number of clusters (1,1) that is separated from other clusters and has employees far from the center of the cluster. The analysis of cluster (1,1) revealed that these were newcomers who had not worked for a full month and employees who had been absent for at least 7 days. Therefore, they are not subject to further analysis. The second is to analyze cluster (6,1) where frequency of cluster is the biggest. The challenge for the cluster is its coherence and all employees are so close to centroid. If there are some fraudsters it is hard to detect it because they have as same behavior as normal employees. So, we will skip this cluster and conduct some other type of analysis for it.

Assuming that fraudulent pretend to be ordinary employees and they don't want to be discovered, further research should be focused on clusters close to each other, with the average distance from the center being approximately the same in these clusters, i.e. we should observe a region surrounded by clusters (4,3) and (6,6) - a total of 12 clusters.

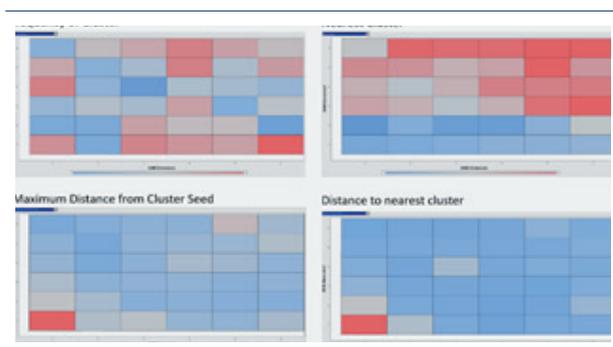


Figure 10. Visualization of Kohonen SOM clustering results

All of these clusters are close to (6,1) for which we assume that is normal behavior. We note that cluster (5,6) is the most numerous and clusters (4,5), (4,6) are the farthest in the group, so anomalies should be sought among them.

Based on analysis, a group of 10 employee may be extracted for which behaviors are anomalies (outliers in the clusters) and then fraud detection experts may conduct detailed analysis (investigation) using all available employee data as well as descriptive statistics methods. The results of the analysis are shown in Figure 11.

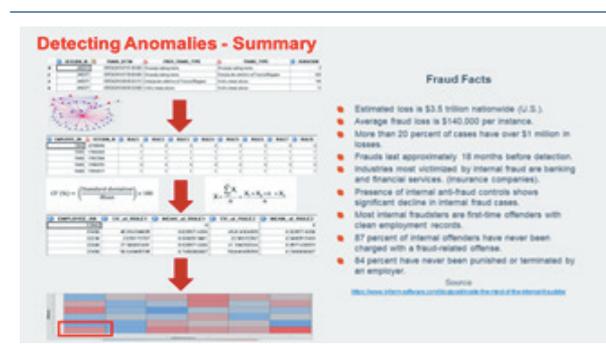


Figure 11. Data flow – from raw logs to the final result

7. CONCLUSION

Based on previous surveys, only 3% of frauds are detected using data analytics. Analyzes of application logs based on unsupervised machine learning to detect anomalies are usually the first step in fraud detection. Modern internal fraud detection systems are increasingly using the results of these analyzes to create general disclosure rules, as these analyzes may reduce the number of cases that will be the subject of further investigation. The paper shows the complex transformation of raw logs to employee's footprints i.e. defining session, finding prior transaction, analyzing paths, and finally aggregating session-level data into an employee's footprint. The cluster analysis was performed on employee's footprints using the Kohonen SOM learning, and the results of the analysis were interpreted in a business sense.

REFERENCES

- [1] R.J. Bolton and D.J. Hand, "Unsupervised Profiling Methods for Fraud Detection", Technical Report (Department of Mathematics, Imperial College, London) 2002.
- [2] V. Chandola, A. Banerjee, and V. Kumar, "Anomaly detection: A survey", *ACM Computing Surveys*, vol. 41, iss. 3, Article No. 15, July 2009.



- [3] M. Ahmeda, A.N. Mahmood, M.R. Islam, "A survey of anomaly detection techniques in financial domain", *Future Generation Computer Systems*, vol. 55, pp. 278-288, February 2016.
- [4] A-S. K. Pathan, *The State of the Art in Intrusion Prevention and Detection*, 1st Edition, Auerbach Publications, MA, United States, 2014.
- [5] SAS Institute, *SAS/STAT 15.1 User's Guide*. Cary, NC: SAS Institute, 2016. Available at: <https://documentation.sas.com/?docsetId=statug&docsetTarget=titlepage.htm&docsetVersion=15.1&locale=en> (23.07.2020)
- [6] T. Kohonen, *Self-Organizing Maps*. Third Ed. Springer, Berlin, Heidelberg, New York, 2001.
- [7] T. Kohonen, „Essentials of the self-organizing map“, *Neural Networks*, vol. 37, pp. 52–65, 2013.
- [8] H. Yin, „The Self-Organizing Maps: Background, Theories, Extensions and Applications“, In: Fulcher J., Jain L.C. (eds) *Computational Intelligence: A Compendium. Studies in Computational Intelligence*, vol 115. Springer, Berlin, Heidelberg, 2008.
- [9] Ł. Brocki, D. Koržinek, „Kohonen Self-Organizing Map for the Traveling Salesperson Problem“. In: Jabłoński R., Turkowski M., Szewczyk R. (eds) *Recent Advances in Mechatronics*. Springer, Berlin, Heidelberg, pp. 116-119, 2007.
- [10] J. Faigl, „An Application of Self-Organizing Map for Multirobot Multigoal Path Planning with Minmax Objective, *Computational Intelligence and Neuroscience*, vol. 2016, pp. 2720630:1-15, 2016.
- [11] S. Kaski, J. Kangas, and T. Kohonen, „Bibliography of self-organizing map (SOM) papers: 1981-1997“, *Neural Computing Surveys*, vol. 1, no. 3&4, pp. 1 – 176, 1998.
- [12] M. Oja, S. Kaski, and T. Kohonen, „Bibliography of Self-Organizing Map (SOM) Papers: 1998-2001 Addendum“. *Neural Computing Surveys*, vol. 3, pp. 1-156, 2003.
- [13] M. Pöllä, T. Honkela, and T. Kohonen, „Bibliography of Self-Organizing Map (SOM) Papers: 2002-2005 Addendum“, *Neural Computing Surveys*, 2007.
- [14] I.I. Priezzhev, P.C.H. Veeken, S.V. Egorov, A.N. Nikiforov, U. Strecker, „Seismic waveform classification based on Kohonen 3D neural networks with RGB visualization“, *First Break*, Vol. 37, Iss. 2, pp: 37-43, 2019.
- [15] P. Stefanovič, O. Kurasova, „Outlier Detection in self-organizing maps and their quality estimation“, *Neural Network World*, vol. 28, iss. 2, pp. 105-117, 2018.
- [16] Q. Deng and G. Mei, "Combining self-organizing map and K-means clustering for detecting fraudulent financial statements," *IEEE International Conference on Granular Computing*, Nanchang, pp. 126-131, 2009.
- [17] D. Brugger, M. Bogdan and W. Rosenstiel, "Automatic Cluster Detection in Kohonen's SOM", *IEEE Transactions on Neural Networks*, vol. 19, no. 3, pp. 442-459, March 2008.
- [18] T. Kohonen & T. Honkela, „Kohonen network“, *Scholarpedia*, vol. 2., no. 1, pp. 1568, 2007.
- [19] R. Wehrens, R. Kruisselbrink, „Flexible Self-Organizing Maps in Kohonen 3.0“, *Journal of Statistical Software*, vol. 87, pp. 1-18, 2018.
- [20] J. Burguillo and B. Dorronsoro, „Using Complex Network Topologies and Self-Organizing Maps for Time Series Prediction“. *Advances in Intelligent Systems and Computing*, vol. 210, 2013.



ADVANCED COMPUTING SESSION

CONTEMPORARY APPROACH TO DATA MANAGEMENT IN SOCIAL SCIENCES

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Abstract:

Data management is a set of different activities which ensure the sustainability of scientific work. Data archiving and publishing are the main parts of data life cycle. Good preparation of data before archiving and publishing will allow reuse of the data and provide better scientific engagement. In this paper, authors will be focused on processes that have to be taken before archiving and publishing. Also, some of the main activities will be highlighted, in order to raise awareness about the importance of this topic.

Keywords:

ICT, archiving, publishing, data, data management.

1. INTRODUCTION

The development of ICT significantly contributes to the improvement of scientific research. Quality research implies a long-term process of collecting and processing the data and presenting the results to the academic community. During the research process, however, data management is crucial, and it is a very long and demanding process. Data management involves defined procedures and methods for data collecting, processing, archiving, and publishing, with the possibility of reuse. Nowadays, many funding agencies require data to be made visible to the public after scientific research is completed, and this is a quite common practice among leading scientific journals. Also, one of the main challenges for the sciences that create the data is facilitating finding and accessing the data, so the need for better infrastructure to ensure better visibility is clear. The researchers from Serbia are still not familiar with the term data archiving and data publishing, or with the benefits of data archiving and publishing. In this paper, the authors present the process of archiving and publishing of the data, their benefits, digital archives that can be used for archiving, possibilities of access, levels of protection, possibilities for using data licenses, and potential for data reuse.

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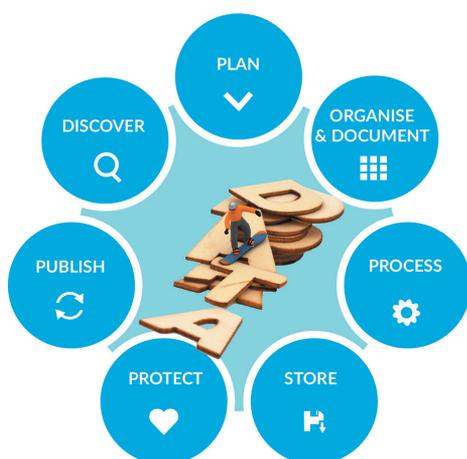
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2. ARCHIVING AND PUBLISHING THE DATA

New requirements in science create the need for expanding and connecting research teams. Scientists can connect on conferences, while collaboration with researchers provides opportunities for them to improve their careers and strengthen their respective scientific fields. However, the development of ICT has made it possible for the researchers to connect because they now have access to the datasets of their colleagues, which were created during scientific research. The need for this kind of connection appeared before 2000, but software solutions were not developed as they are today. Growing consciousness of the importance of making the data public has an effect on the development of better software that can be used for these purposes. If we start from the hypothesis that science is a public good, then it is obvious why new achievements and findings have to be archived and published for future generations. Also, archiving and publishing can be helpful for some future research, and creators of public policies and procedures. Therefore, many theorists claim that scientists do not need to restrict access to their research results, but that they should present their data to the scientific community. According to Bradić-Martinović and Zdravković, researchers from Bosnia and Herzegovina, Croatia and Serbia (BiH 75%, Croatia 51%, Serbia 64%) have stated that sharing research data is very important in their discipline and only 2% (on average) believe that it is not very important [1].



Picture 1: Data life cycle [4]

The practice of data archiving and publishing appeared in the 1950s [2]. Data archiving is storing the data in digital storage. The main goal of archiving is the possibility of referencing and reusing the data in some future research. In data archiving, it is crucial to follow the data management procedures in order to ensure protection in the long term. The data management experts recommend placing the data on Cloud systems or some other digital repository. Also, data should be accompanied by storage documentation, so it can be comprehensible in the future.

Good archiving and publishing of the data have big contributions to the scientific community:

- ◆ Encourage scientific research
- ◆ Promote innovation
- ◆ Provide opportunities for new collaborations
- ◆ Transparency and accountability are maximized
- ◆ Improves research methods
- ◆ The cost of duplicating data collection is reduced
- ◆ The impact and visibility of research is increasing
- ◆ Provides important resources for education and learning. [2]

The awareness of the importance of data archiving and publishing, however, is not at enviable level, especially in Serbia. Because of that, data creators need to be aware of all the benefits of sharing and archiving of the data. On the other hand, according to Bradić-Martinović and Zdravković, the majority of researchers in Bosnia and Herzegovina, Croatia, and Serbia would archive research data if the data would be kept safe with regulated access because 45% of them (on average) answered with *Yes, certainly* and 40% answered with *Yes, probably* [1]. This research shows that the researchers were hesitant because they were not familiar with the process of data sharing and managing. Corti et al. state that researchers often think their results will not be interesting to other researchers; they are biased when it comes to paying for shared data in digital archives [2]. On the other hand, according to Data management expert guide (DMEG), the research conducted by Van den Eynden & Bishop, 2014; Hahnel et al., 2017, shows that some of the main motives for archiving and the publishing are [3]:

- ◆ career benefits – numerous studies show that archiving and publishing lead to increased visibility of researchers and recognition of scholarly work.
- ◆ scientific progress – data archiving and publishing have direct benefits for the research itself



(more robust), as well as benefits for the discipline and science in general by enabling new collaborations, new data usages, and establishing connections with the next generation of researchers.

- ◆ norms – norms of the project, research group, and/or discipline may determine whether a researcher is prone to publishing data. Overall, the availability of research data is at the heart of scientific ethics, as illustrated by the quote below.
- ◆ external drivers – funding agencies and publishers of scientific journals. Many funding agencies require that the data, following the research process, be made available so that users can access and reuse it. On the other hand, scientific journals are increasingly adopting data availability policies that advise or even request authors of manuscripts to make the research data, on which the manuscript is based, available.

According to Fienberg, the benefits of data archiving [4]:

- ◆ Reinforces open scientific inquiry. When data are widely available, the self-correcting features of science work most effectively.
- ◆ Encourages diversity of analysis and opinions.
- ◆ Promotes new research and allows for the testing of new or alternative methods.
- ◆ Improves methods of data collection and measurement through the scrutiny of others.
- ◆ Reduces costs by avoiding duplicate data collection efforts.
- ◆ Provides an important resources for training in research.

Also, many researchers are concerned about the issue of whether their data is good enough, and if it is useful to the research community. The truth is that some data have greater potential for reuse than others. The main questions to pose in order to understand if the data has value are [3]:

- ◆ Does the data have reuse potential?
- ◆ Does the data have national or international importance?
- ◆ Is the data unique and authentic?
- ◆ Is the data original, does it fit into the Big Data concept?
- ◆ Does the data come from some innovative research?
- ◆ Is the data set reusable? Is descriptive metadata available?

- ◆ It is important to point out that even if the data is not sufficiently good at one point, it can always be properly documented later, and shared retrospectively.

Data management experts declare that the most important thing in data archiving and publishing is time, because if the data is archived when the project is over, the project team's knowledge is higher, and the data can be properly described, selected and accompanied by timely documentation. As such, it will take a shorter amount of time to prepare the data for a deposit while simultaneously guaranteeing the highest possible data quality for future users [3].

Data publishing is providing access to data. Also, data publishing is the public distribution of collected data, by which data becomes visible, searchable, accessible, and ready for reuse. Many researchers refuse to make the data public because they do not recognize its benefits or they believe that the data is not of interest or importance to the scientific community, that others may misinterpret it, or that potential misuse may occur.

3. HOW TO ARCHIVE AND PUBLIC THE DATA?

The data may be archived and published on the online platforms designed for it. Depending on the scientific conditions, these online platforms are either national repositories that comply with standards for data storage or institutional repositories. Researchers can choose between self-archiving and archiving with the help of experts, but even if self-archiving is a fast way to publish the data, with the experts' help, the data can be properly treated, protected, and prepared for reuse. According to the researchers from the Institute of Edinburgh [4], good publishing practice is followed with metadata, documentation, control, and review of the experts, furthermore, the data is findable. Although the publishing of the data that does not follow these criteria is not necessarily bad, there is no guarantee that the data will be stored on the same platform after a certain period, that the files will not be damaged, or that access to the data will remain the same.

For good publishing, a digital resource is essential, in the form of a digital repository or digital archive. Although there are many platforms built for this purpose today, it is always advisable to find a qualified archive that follows all standards of data archiving and publishing.



It is recommended that researchers archive their data in national archives, but if they do not exist, they have to find a suitable repository to archive their data. It is always a good practice to follow OpenAire guidelines for digital archives [3]:

- ◆ Choose trusted archive
- ◆ Choose institutional archive
- ◆ If neither of the previous two is available, choose one of public platforms online that has good politics and procedures.

4. HOW TO MAKE YOUR DATA VISIBLE?

This is a major issue that comes after the process of archiving and publishing. Data can be either open access or restricted and publishing the data in the digital archives does not necessarily mean that the data will be open access. For example, sensitive data, in some cases, needs to be restricted, secured from public access. It is always advisable to choose open access where it is possible, but with quality licensing. If open access is chosen, researchers have access to the data, and it is more likely that some will reuse it, and that the data will have an impact on someone else's work.

Access to data:

- ◆ Open Access – data can be accessed by users, whether they are registered users or not. Data in this category do not contain any personal information.
- ◆ Access for registered users only – data in this category do not contain direct identifiers, but there is a possibility of revealing the identities of respondents by linking indirect identifiers, and this represents a high risk.
- ◆ Limited access – access to the data in this category is possible only on request. In most cases, it is very sensitive data that must be restricted due to the delicacy of its nature. Sometimes, these data can have an embargo, which means that they are unavailable for a certain period, and only basic metadata is available during that period; when the embargo expires, the data is available to the users.

For example, Social Science Data Archives from Slovenia (ADP) has a very detailed and rigorous data access policy. ADP data can be open access data - where anyone can use the data, data with standard access - where registration is required, and data access under special conditions - where the users ask for permission from

the data center to use the data [5]. Also, there is special access, where the user signs a contract to access the data and commits that he will use the data only for certain purposes and access it from secure rooms. An example of ADP shows that each archive regulates access to its data following its policies and procedures.

On the other hand, Data Archiving and Networked Services (DANS) also have defined data access policies. Although DANS supports the open access initiative and encourages the movement of public data without any restrictions, that often is not possible, because of the nature of the data. Because of this, DANS also has access categories – open access, access for registered users, and completely restricted access, when the user must ask for written permission to access the data [6].

5. FAIR DATA

Data archiving and publishing should follow a set of specific principles that facilitate data finding. FAIR is a set of crucial principles that make data findable, accessible, interoperable, and reusable [7]. The term FAIR was launched at a Lorentz workshop in 2014, and the resulting FAIR principles were published in 2016 [7]. The European Union, as well as many financiers, faculties, and institutes involved in mass production of data, advocate the use of the FAIR concept. These principles can serve as guidelines for creating data management tools and infrastructures, but also for defining policies and procedures for archiving and publishing scientific data. Following the FAIR principles, a framework of protection and easier recognition is provided [3]:

- ◆ Findable – this principle advocates that the data, produced during a project, has a unique digital object identifier (DOI). Also, in order for this principle to be fulfilled, it is recommended that data is described in metadata.
- ◆ Accessible – this principle is related to the availability of the data. Is the data open access or restricted? Documentation on the software for accessing the data needs to be included. Priority should be given to certified archives.
- ◆ Interoperable – this principle is related to enabling sharing and reuse of the data among researchers, institutions, and organizations. The main question is what kind of data, standards, or metadata methodologies will be followed to make the data interoperable..



- ◆ Reusable – this principle is related to how the data will be licensed and protected to allow reuse. Also, when will the data be available to the public? If there is an embargo, it has to be explained why the embargo exists and how long it will apply. Also, if the reuse of some data is restricted, the reason for it has to be defined.

6. DATA CITING

Data citing is a very important process in enabling easy data identification and connecting data with its creators. According to DMEG, there are two different types of identifiers [3]:

- ◆ A persistent identifier (PID) to your dataset – ensures that the data fulfills FAIR principles.
- ◆ A persistent author identifier – ORCID is the most common. With ORCID, it is easier to identify an individual researcher in the academic community and to connect a researcher to the dataset.

7. PROTECTION OF ARCHIVED AND PUBLISHED DATA WITH LICENSES

Despite the ability to access the data, it is very important to protect archived data with licenses, usually Creative Commons licenses. The choice of license most often depends on the nature and structure of the data. The benefits of Creative Commons licenses - they are very easy to use, they are widely accepted in the scientific community, they are very flexible and their readability and recognition enables finding data [5]. Data management experts point out that the most important thing is determining who owns the copyright. DMEG highlights that one open-access license for data is the Creative Commons license CC0. The copyright owner waives all his rights, including the database right and the right to be identified as the creator [3].

8. THE CURRENT SITUATION IN EUROPE AND SERBIA

The Consortium of European Social Science Data Archives – CESSDA ERIC is one of the most important organizations in this field in Europe. CESSDA provides large-scale, integrated, and sustainable data services to the social sciences. It brings together social science data

archives across Europe, with the aim of promoting the results of social science research and supporting national and international research and cooperation [8]. CESSDA is a good example of a reliable archive, and their experts are always available to help researchers understand all the steps in the process of archiving and publishing the data. On the other hand, by following the CESSDA procedures, research data will be safe, visibility of the data will increase, and it will be easier to find it, while the potential for long term preservation is at a high level. Data is accessible and safe from unauthorized use.

Serbia has a national digital center for data archiving. Data Center Serbia for Social Sciences is an organizational part of the Institute of Economic Sciences, established in 2014. The Center is part of the national infrastructure and provides long-term preservation of scientific data to all researchers in the field of social sciences in Serbia. Also, the Center is a national service provider in this field, supported by the Ministry of Education, Science, and Technological Development of the Republic of Serbia. Data Center is a part of the Consortium of European Social Science Data Archives. Data Center Serbia uses the *Eprints* platform for data archiving and publishing and follows main CESSDA procedures in the process of data management.

9. CONCLUSION

Every research team during a science project should keep in mind two sides of work – first, how the project will be implemented, and second, how to manage data. Data management is a very demanding job and involves a set of skills and knowledge about processes concerning data processing. Also, it is important to improve researchers' awareness of the potentials of data, and of all benefits that can come from properly processing, archiving, and publishing data. In Serbia, researchers are not that familiar with data archiving and publishing, as are the researchers in Europe. The Ministry of Education, Science, and Technological Development has adopted the Open Science Platform in the middle of 2018. This document is based on two postulates – archiving and publishing of scientific papers of researchers from Serbia, which is required; and archiving and publishing of the data, which is still at the recommendation level. It is important to inform the researchers about all processes that they can perform on the data, with the aim of improving and empowering science, and connecting the researchers in Serbia and Europe.



As a national service provider, Data Center Serbia for Social Sciences is available to provide help to the scientific community in Serbia.

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REFERENCES

- [1] A. Bradić-Matinović, A. Zdravković, „Researchers’ interest in data service in Bosnia and Herzegovina, Croatia, and Serbia. IASSIST quarterly, vol. 38, no 2. pp. 22-28. 2014.
- [2] L. Corti, V. Van den Eynden, L. Bishop, B. Morgan-Brett. *Managing and Sharing Data*. Colchester: UK Data Archive. 2011.
- [3] Data Management Expert Guide, CESSDA. <https://www.CESSDA.eu/Training/Training-Resources/Library/Data-Management-Expert-Guide> accessed: 10.3.2020
- [4] S. E. Fienberg. „Sharing Statistical Data in the Biomedical and Health Science: Ethical, Institutional, Legal and Professional Dimensions“. In *Annual Review of Public Health*, 15, 1994.
- [5] Arhiv družboslovnih podatkov: ADP. <https://www.adp.fdv.uni-lj.si/> accessed: 11.3.2020.
- [6] Data Archiving and Networked Services: DANS. <https://www.adp.fdv.uni-lj.si/> accessed: 11.3.2020
- [7] <https://www.force11.org/group/fairgroup/fairprinciples> accessed: 9.3.2020.
- [8] CESSDA. <https://www.CESSDA.eu/> accessed: 8.3.2020.



ADVANCED COMPUTING SESSION

E-NEGOTIATION: CAN ARTIFICIAL INTELLIGENCE NEGOTIATE BETTER DEALS?

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Abstract:

Artificial intelligence can perform many different tasks in negotiation, reducing time and effort on the part of human negotiators. Today there is an increasing number of negotiation support systems and automated negotiating agents, that can assist human negotiators before and during the process. They can serve as simulators and training tools, but also conduct negotiations more or less autonomously. The aim of this paper is to review different forms of electronic negotiations and current issues in this field.

Keywords:

e-negotiation, negotiation support systems, automated negotiation, automated negotiation agents.

1. INTRODUCTION

Negotiation is an interaction between parties who are trying to agree on their opposing interests and find a mutually beneficial outcome. Although negotiation is normally thought of as a human activity, artificial intelligence plays an important part in contemporary business negotiation. Negotiation support systems (NSSs) and software agents were developed not only to help people with repetitive and tiresome tasks, but also to help them overcome unchecked emotions and some common cognitive errors and biases, such as using shortcuts in decision making, selective perception, and framing (making decisions based on positive or negative presentation of options). They can be used to train and/or support human negotiators, to negotiate instead of people, or act as brokers between companies [1]. Employing software agents in negotiations can generate better results, reduce costs, and cause fewer conflicts [2].

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2. ELECTRONIC NEGOTIATION

Electronic negotiation (e-negotiation) can be defined as negotiating via electronic means. Different electronic devices can be used in the process, from simple chat or e-mail, to online negotiation platforms and autonomous software agents. E-negotiation can help human negotiators focus on the subject of negotiation, rather than personal issues [3].

E-mail negotiations

Negotiation over e-mail is ubiquitous in contemporary business. It can save time and costs, but also damage trust and obstruct communication, due to the absence of nonverbal cues. Especially when communicating cross-culturally, it is hard to convey the tone of conversation and respect the norms of polite behaviour of a different culture [4]. The research of Rosette, Brett, Barsness, & Lytle [5] on cross-cultural negotiation showed that, when negotiating over e-mail, people give less favourable opening offers than in traditional negotiation. Typically, when negotiating via e-mail people become more antagonistic and impasses happen more often. Due to a faulty sense of anonymity, people become more hostile and give more ultimatums. Negotiators need more time and effort to build relationship with another party in online negotiations. Different studies have demonstrated that communication media influence the negotiation process and results [6].

Another important issue in cross-cultural e-negotiation happens during the pre-negotiation phase. The first impressions and agreeing on the communication channel to be used in the process affect the relationship and the conclusion of negotiation [7]. Sokolova and Lapalme [8] discovered that in successful negotiations parties tended to use more positive expressions at the start. This shows us that the outcome can be predicted at the very beginning of negotiation, by analyzing the words the parties use.

Negotiation Support Systems

The Internet facilitated the creation and use of decision and negotiation support systems. The group decision support systems (GDSS) were developed to facilitate decision making while avoiding “false consensus”, that way reaching a politically achievable agreement that will actually be implemented. The two main benefits of the GDSS are achieving procedural justice and avoiding groupthink [9].

Participants’ perception of fairness encourages them to behave cooperatively and engage in attaining group goals. This is especially important in negotiations between different organizations. Groupthink happens when a group exerts extensive pressure on an individual to conform to others’ opinions [10]. Groups can then easily fall into the trap of ignoring alternatives, due to psychological pressure for consensus. Other important characteristics of GDSSs are anonymity, face-saving features, and productivity, the last being achieved by generating small-scope agreements at regular intervals. In some forced private-public partnerships, GDSSs enable the negotiating parties to create additional value together, and to go beyond and above their own objectives [9].

The earliest negotiation support systems (NSSs) were created in the 1980s [11], in order to aid human negotiators during different stages of the negotiation process, with the tasks like understanding the issues, deciding on reservation price, choosing the preferences and acceptable alternatives [12]. NSSs can reduce unreasonable behaviour of human negotiators, speed up the process, and create higher gains for both (all) parties included [13]. However, human negotiators still have to administer the process themselves [2].

Some well-known online NSSs are Pocket Negotiator [14], Invite [15], and Smartsettle [16]. They can be employed as negotiation simulators, training tools, research tools, and support during the process. Some of their versions can be used in complex multi-party multi-issue situations.

Pocket Negotiator will be used as an illustration of the use of NSSs. In the preparation phase, the user chooses the domain, i.e. real estate, energy, water management or jobs and then the strategy to be used (e.g. Pareto Optimal Concede, Nice Mover, Tough Negotiator, etc.). The user also defines the position and preferences of the opposing party. In the exploration phase, the negotiators get to know each other and build their profiles. In both preparation and exploration phases users identify their interests and preferences. The system allows qualitative preference identification, based on principled negotiation, created by Harvard Program on Negotiation. It supports human negotiators in identifying their preferences, estimating the preferences of the other party, during the bidding (bargaining) stage and closing the deal. In determining preferences, the user is offered advice and given an opportunity to change some items (Figure 1). In the bidding phase the negotiating parties offer bids to each other and the user gets advice related to when to accept a bid from the other side [17].

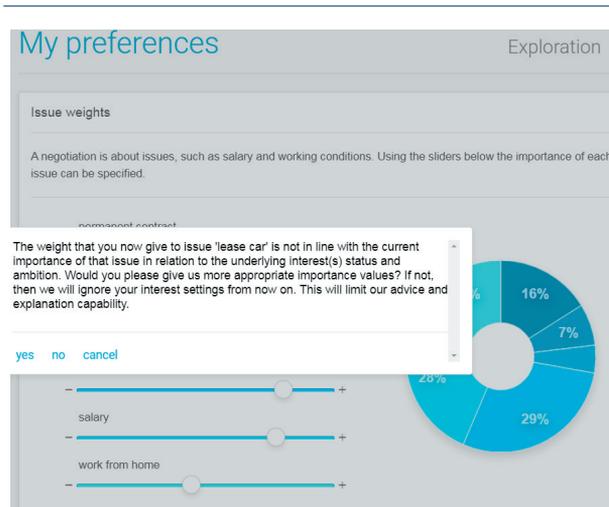


Figure 1. Pocket Negotiator software, personal preferences (exploration phase) [14]

NSSs are employed even in dealing with complicated international natural resource conflicts, e.g. demarcating the Caspian Sea and its implications to the gas, oil, and water exploitation by Russia, Iran, Kazakhstan, Azerbaijan and Turkmenistan. The Caspian Sea Negotiation Support System took into consideration not only established rules for dividing the Sea by area, but also fair distribution of natural resources between interested parties [18].

Game theory is one of the mechanisms for developing NSSs. In game theory the parties choose whether to behave cooperatively or competitively, i.e. to care only about their own interests or to cooperate with the other side to achieve higher mutual gains. Still, in real life situations this joint reward is not always obvious, due to insufficient information. That is why Zandi and Taviana [3] applied fuzzy sets to manage this vagueness. Fuzzy logic mimics human decision making and can include all values between 0 and 1.

Automated Negotiation

Automated negotiation is a process in which autonomous agents interact to reach an agreement. Software agents can conduct negotiations on behalf of humans. The Diplomat Agent, the Colored Trails Agent, the Guessing Heuristic Agent, and the Cliff-Edge Agent are some of the well-known automated agents [19].

Their usage usually generates lower costs, fewer conflicts and higher mutual gains. However, some pieces of research had different findings. For example, comparing negotiations between humans and between automated agents, Filzmoser [20] analyzed three aspects of negotiation outcome: the number of agreements reached,

individual negotiators' efficiency, and fairness. The study showed that agents reached higher outcomes, but they were less fair and with lower mutual gain than human negotiators.

The most noticeable difference between automated negotiations and traditional negotiations with human participants is the number of interactions. While human negotiators usually make just several offers and counter-offers, automated agents interchange hundreds and even thousands of bids in a minute [21].

Various methodologies have been used in agent design, e.g. Gaia [22], MESSAGE [23], Aspects [24], and KEMNAD (A Knowledge Engineering Methodology for Negotiating Agent Development). KEMNAD is made of a generic knowledge model and different standardized templates that can be used repeatedly. Diverse negotiation models are created by incorporating different templates [25].

A negotiation process between two automated agents (A and B) is presented on Figure 2. The setting consists of the agents, the negotiation scenario, and the protocol. An agent can perform only the actions prescribed by the protocol and the scenario. Preference profile shows preferred and feasible outcomes for each party. The negotiation domain defines the sequence of possible outcomes. To come to an agreement, agents must accept a particular value for each issue. Negotiation time is restricted, so that the parties have to accept an offer instead of indefinitely waiting for a better deal [21].

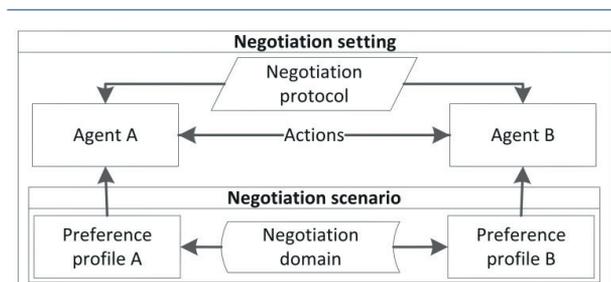


Figure 2. Overview of the defining elements of an automated bilateral negotiation [21]

Aydođan et al. [26] describe two negotiation protocols, called Stacked Alternating Offers Protocol (SAOP) and Alternating Multiple Offers Protocol (AMOP). In both of them, automated agents take turns in making or accepting the bids. The manner of exchange is determined before the negotiation starts. SAOP permits agents to make an offer, accept the latest offer or walk away. On the contrary, AMOP does not allow walking away.



It has a bidding and a voting stage. In both protocols (apart from the walking away option in SAOP), negotiation ends when the agents come to an agreement or the deadline is past. In their empirical research, SAOP was better than AMOP with the same kind of agents.

One of the focal points of agent development is the so-called opponent modeling, i.e. learning about the opponent. Agents get information about the other party from their bidding sequence and communication in general [27]. The agent has to assess the other party's preferences and possible strategy. The opponent modeling techniques can be applied to various negotiation protocols. Different protocols may vary in the domain configuration, accessible information, the number of agents, interaction between issues, etc. [21].

Different learning methods can be used in automated negotiation. Bayesian Learning is the most famous probabilistic approach in opponent modeling. It is normally applied to determine the most probable hypothesis out of a given set of hypotheses. Usually a finite set is assumed [21]. One of the latest is RLBOA, a modular reinforcement learning framework. It is based on trial-and-error learning, where software gets rewards and penalties for its activities [28].

Automated negotiating agents are developed for specific use in particular scenarios, which makes it difficult to compare their effectiveness. The Automated Negotiating Agents Competition (ANAC) is an annual event (since 2010) for evaluation and comparison of automated agents [29]. The competition is carried out within the GENIUS environment (General Environment for Negotiation with Intelligent multi-purpose Usage Simulation), developed by Lin and Kraus [30]. The competition challenges researchers and developers to create automated agents to compete in scenarios with limited information about the opposing party. This competition brought about important advances in agent development.

Because human-agent and human-human negotiation are very different, a separate Human-Agent Negotiation League was established within ANAC in 2017 [27]. This contest is carried out on the IAGO Negotiation platform, designed by Mell and Gratch [31]. IAGO (Figure 3) produces a graphical user interface for human negotiators. IAGO's characteristics enable agents to simulate human communication, such as using different communication media. Several automated agents that participate in this competition use emotion to influence the other party, like positive emotions for building rapport, or negative to get concessions.

Some of them also lie and deceive the other party. Some automated agents can be programmed to show some other human characteristics, such as warmth, or to behave irrationally or vindictively [32]. Then it becomes hard for human negotiators to tell if their opposing party is a human or a computer. However, when they know who they negotiate with, people behave differently towards agents and people. The research of de Melo, Marsella, and Gratch [33] showed that people give better offers to humans than to agents who negotiate instead of humans.



Figure 3. IAGO Research Platform, Client view [27]

3. SOME POTENTIAL PROBLEMS IN E-NEGOTIATIONS

One of the challenges of e-negotiations is creating a fully autonomous agent, capable of negotiating in any setting, in any area. Contemporary agents are mostly developed with specific type of problems in mind and for specific domains. Truly autonomous agents should be able to work with limited information, as is the case with face-to-face negotiation between humans.

Automation is closely related to another challenge, which is expressing preferences by human users. Sometimes people are unwilling or unable to state their preferences when using a NSS, because there are simply too many questions to go through. This issue can be solved by the system requesting preferences gradually, during the course of the negotiation process, rather than all at the beginning. Another issue is trust, which is hard to build even in face-to-face negotiation between humans [34]. There is also the problem of accidentally sending meta-data to the other party, which could contain confidential information.



4. CONCLUSION

Artificial intelligence can help human negotiators with many elements of negotiation process, such as the analysis of preferences and viable alternatives. It can also serve as a training tool or conduct negotiation on behalf of humans. The synergy between a man and a machine can help humans with laborious tasks, while avoiding cognitive errors and unchecked emotions.

There are still many technical matters that have to be resolved before artificial intelligence can be universally used in real-life negotiations. Successful software agents should be able to negotiate with different people in different negotiation settings. Trust and emotions are still key factors when humans are involved in negotiations. Automated agents can be programmed to behave like human beings, to show anger and kindness. But do we really want that?

REFERENCES

- [1] A. van Wissena, Y. Galb, B.A. Kamphorst, and M.V. Dignum, "Human-agent teamwork in dynamic environments," *Computers in Human Behavior*, vol. 28, No. 1, pp. 23-33, 2012. doi:10.1016/j.chb.2011.08.006
- [2] Y. Yang, S. Singhal, and Y. Xu, "Alternate strategies for win-win seeking agent in agent-human negotiations," *Journal of Management Information Systems* [serial online], vol. 29, No. 3, pp. 223-256, 2012. Retrieved January 31, 2014, from Business Source Premier, Ipswich, MA.
- [3] F. Zandi and M. Tavana, "A fuzzy e-negotiation support system for inter-firm collaborative product development," *International Journal of Computer Integrated Manufacturing*, vol. 25, No. 8, pp. 671-688, 2012.
- [4] Pon Harvard, "The pitfalls of negotiations over email." Retrieved December 11, 2019, from <https://www.pon.harvard.edu/daily/conflict-resolution/email-more-cons-than-pros/>
- [5] A.S. Rosette, J.M. Brett, Z. Barsness, and A.L. Lytle, "When cultures clash electronically: The impact of email and social norms on negotiation behavior and outcomes," *Journal of Cross-Cultural Psychology*, vol. 20, No. 10, pp. 1-16, 2011. Retrieved December 11, 2019, from https://www.academia.edu/15507677/When_Cultures_Clash_Electronically_The_Impact_of_Email_and_Social_Norms_on_Negotiation_Behavior_and_Outcomes. doi: 10.1177/0022022111407190.
- [6] R.J. Lewicki, D.M. Saunders, and B. Barry, *Negotiation*, international edition. Singapore: McGraw-Hill, 2010.
- [7] P. Kesting and R. Smolinski R. "Starting from scratch: A multi-stage analysis of remote e-negotiations." In *Proceedings of the Group Decision and Negotiation conference*. Stockholm, Sweden: University of Stockholm, 2013.
- [8] M. Sokolova and G. Lapalme, "How much do we say? Using informativeness of negotiation text records for early prediction of negotiation outcomes," *Group Decision and Negotiation*, vol. 21, pp. 363-379, 2010.
- [9] C. Eden and F. Ackermann, "'Joined-up' policy-making: Group decision and negotiation practice." In *Proceedings of the Group Decision and Negotiation conference*. Stockholm, Sweden: University of Stockholm, 2013. Retrieved December 15, 2019, from https://www.researchgate.net/publication/266149403_'Joined-Up'_Policy-Making_Group_Decision_and_Negotiation_Practice. doi: 10.1007/s10726-013-9375-1
- [10] S. Robbins and M. Coulter, *Management*, 13th ed. Harlow: Pearson Education Limited, 2016.
- [11] L.H. Lim and I. Benbasat, "A theoretical perspective of negotiation support systems," *Journal of Management Information Systems*, vol. 9. No. 3, pp. 27-44, 1992.
- [12] G. Dobrijević and J. Đorđević Boljanović, "Negotiation goes high tech: Can you negotiate with a machine?" In *Proceedings of the International Scientific Conference on ICT and E-Business Related Research SINTEZA 2014*. Belgrade: Singidunum University.
- [13] R. Vahidov, G.E. Kersten, "Design of software agent-populated electronic negotiation system and evaluation of human-to-agent negotiations", *InterNeg Research Papers INR09/12*, 2012. InterNeg Research Center, John Molson School of Business, Concordia University. Retrieved December 2, 2019, from <http://interneg.concordia.ca/index.php?id=paper>.
- [14] TU Delft (n.d.). Pocket Negotiator. Retrieved September 8, 2019, from <http://ii.tudelft.nl:8080/PocketNegotiator/index.jsp>.
- [15] Invite Negotiation Systems (n.d). Retrieved December 13, 2019, from <http://invite.concordia.ca/>.
- [16] Smartsettle, Beyond Win-Win (n.d.). Retrieved December 1, 2019, from: <https://smartsettle.com>.
- [17] C. Jonker, R. Aydoğan, T. Baarslag, J. Broekens1, C. Detweiler, K. Hindriks, A. Huldtgren, and W. Pasman, "An introduction to the Pocket Negotiator: A general purpose negotiation support system," in N. Criado Pacheco, C. Carrascosa, N. Osman N., & V. Julián Inglada, Eds., *Multi-Agent Systems and*



- Agreement Technologies. EUMAS 2016, AT 2016. Lecture Notes in Computer Science, vol. 10207. Cham: Springer. doi: 10.1007/978-3-319-59294-7_2 2017
- [18] K. Madani, O.M. Rouhani, A. Mirchi, and S. Gholizadeh, "A negotiation support system for resolving an international trans-boundary natural resource conflict," *Environmental Modelling & Software*, vol. 51, pp. 240-249, 2014.
- [19] R. Lin, S. Kraus, "Can automated agents proficiently negotiate with humans?" *Communications of the ACM [serial online]*, vol. 53, No. 1, pp.78-88, January 2010. Available from: Business Source Premier, Ipswich, MA, accessed January 31, 2014. doi:10.1145/1629175.1629199
- [20] M. Filzmoser, "Automated vs. Human Negotiation," *International Journal of Artificial Intelligence*, vol. 4, No. 10, pp. 64-77, 2010.
- [21] T. Baarslag, M. Hendriks, K. Hindriks, and C. Jonker, "Learning about the opponent in automated bilateral negotiation: a comprehensive survey of opponent modelling technique," *Autonomous Agents and Multi-Agent Systems*, vol. 30, No. 5, pp. 849-898, 2016. doi: 10.1007/s10458-015-9309-1
- [22] M. Wooldridge, N.R. Jennings, and D. Kinny, "The Gaia methodology for agent-oriented analysis and design", *Journal of Autonomous Agents and Multi-Agent Systems*, vol. 3, No.3, pp. 285-312, 2000.
- [23] G. Caire, F. Leal, P. Chainho, R. Evans, F. Garijo, J. Gomez, J. Pavon, P. Kearney, J. Stark, and P. Masonet, "Agent oriented analysis using MESSAGE/UML", in *Proceedings of the Second International Workshop on Agent-Oriented Software Engineering*, Montreal, Canada, pp. 101-108, 2001.
- [24] M. Cossentino, and N. Gaud, V. Hilaire, S. Galland, and A. Koukam, "Aspecs: An agent-oriented software process for engineering complex systems", *Autonomous Agents and Multi-Agent Systems*, vol. 20, No. 2, pp.260-304, 2010.
- [25] X. Luo, C. Miao, N. Jennings, M. He, Z. Shen, and M. Zhang, "KEMNAD: A knowledge engineering methodology for negotiating agent development", *Computational Intelligence*, vol. 28, No. 1, pp. 51-105, February 2012
- [26] R. Aydoğ̃an, D. Festen, K.V. Hindriks, and C.M. Jonker, "Alternating offers protocols for multilateral negotiation," in K. Fujita, Q. Bai, T. Ito, M. Zhang, F. Ren, R. Aydoğ̃an, and R. Hadfi, Eds, *Modern Approaches to Agent-based Complex Automated Negotiation*, pp. 153-167, 2017. Cham: Springer International Publishing AG. doi: 10.1007/978-3-319-51563-2_10
- [27] J. Mell, J. Gratch, T. Baarslag, R. Aydoğ̃an, R. and C. Jonker, "Results of the first annual Human-Agent League of the Automated Negotiating Agents Competition," in *Proceedings of the International Conference on Intelligent Virtual Agents (IVA '18)*. Sydney, NSW, Australia: DBLP Computer Science Bibliography, 2018. doi: 10.1145/3267851.3267907
- [28] J. Bakker, A. Hammond, D. Bloembergen, and T. Baarslag, "RLBOA: A modular reinforcement learning framework for autonomous negotiating agents," in *Proceedings of the 18th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2019)*, N. Agmon, M. E. Taylor, E. Elkind, and M. Veloso, Eds., Montreal, Canada: IFAAMAS, 2019.
- [29] C. Jonker, R. Aydoğ̃an, T. Baarslag, K. Fujita, T. Ito, and K. Hindriks, "Automated Negotiating Agents Competition (ANAC)," in *Proceedings of the Thirty-First AAAI Conference on Artificial Intelligence (AAAI-17)*, San Francisco, CA, pp. 5070-5072, 2017.
- [30] R. Lin and S. Kraus, "From research to practice: Automated negotiations with people," in A. Krüger and T. Kuflik, Eds., *Ubiquitous Display Environments*, pp. 195-212. Berlin Heidelberg: Springer-Verlag, 2012.
- [31] J. Mell and J. Gratch, "IAGO: interactive arbitration guide online," in *Proceedings of the 2016 International Conference on Autonomous Agents & Multiagent Systems*. Singapore: International Foundation for Autonomous Agents and Multiagent Systems, 2016.
- [32] P. Prajod, M. Al Owayyed, T. Rietveld, J. van der Steeg, and J. Broekens, "The effect of virtual agent warmth on human-agent negotiation," in *Proceedings of the 18th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2019)*, N. Agmon, M. E. Taylor, E. Elkind, & M. Veloso (Eds.). Montreal, Canada: IFAAMAS, 2019.
- [33] C.M. de Melo, S. Marsella, and J. Gratch, "Do as I say, not as I do: Challenges in delegating decisions to automated agents," in *Proceedings of the 2016 International Conference on Autonomous Agents & Multiagent Systems*. Singapore: International Foundation for Autonomous Agents and Multiagent Systems, 2016.
- [34] T. Baarslag, M. Kaisers, E. Gerding, C. Jonker, and J. Gratch, "When will negotiation agents be able to represent us? The Challenges and Opportunities for Autonomous Negotiators," in *Proceedings of the Twenty-Sixth International Joint Conference on Artificial Intelligence (IJCAI-17)*. Melbourne, Australia: DBLP Computer Science Bibliography, 2017.



ADVANCED COMPUTING SESSION

MASTERBOT

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Abstract:

In this paper the web application will be shown that can classify URL using Naïve Bayes and chatbot which is combination of rule-based chatbot and artificial intelligence (AI). Chatbot can answer to user's queries based on URL corpus. Web application is developed for users regardless of their technical knowledge. The paper presents my solution and opens questions for further development in this scientific field..

Keywords:

Chatbot, Naïve Bayes, cosine similarity, classification, TfIdfVectorizer.

1. INTRODUCTION

Technological innovations in the last decade have brought with them changes in almost all aspects of society. The availability of information has been significantly improved, which caused the mentioned changes.

A large part of the company's business has moved to the Internet in terms of sales, advertising and partial or complete provision of services. Today, it can be said that economic entities that are not present on the Internet are almost invisible on the market. Companies that want to be competitive must follow innovations and trends in order to preserve and then improve their position in such a system.

New trends of social networks have emerged, with new platforms, forms and contents every day. The development of social networks has led to new sociological needs of humanity. The strong influence is reflected in the attention caused by posts, comments and every other form of publishing of both celebrity and anonymous personalities, which became sensation almost overnight.

The education system is trying to adapt to the new wave of IT. Technological innovations have created new job positions and scientific fields.

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Today in Serbia there are already computer science subjects in primary school. Due to the need for education of future employee, various IT programs have emerged in high schools and colleges. In addition to regular education, there is an increasing presence of courses and specialist training.

In order for an ordinary person to be able to keep up with the changes, he/she is forced to spend a good part of his time on the Internet. It can be complicated and confusing for the older generations, especially those who are less able to cope with new technologies, while the younger generations find it difficult to grip.

Inspired by the wishes and difficulties of different generations, in this paper I will try to make a practical solution that will be likable, innovative and able to grip users, while on the other hand I will try to make the usage of this application easy regardless of users technical knowledge.

In search of information, users often type a question or keyword into the search engine, after they open one of the offered websites and finally search the content of the page for information that interest them. This way of searching requires time, unnecessary energy consumption and it's boring.

In this paper, I will present my web application with the symbolic name MasterBot. It was named MasterBot because it is a chatbot and was the subject of my master's thesis. MasterBot is designed precisely as a solution to the before mentioned needs and problems of users.

2. WEB APPLICATION

I created a web application, symbolically named MasterBot, using the 3.8.2 version of the python programming language. The final layout of the web application can be seen in Figure 1.

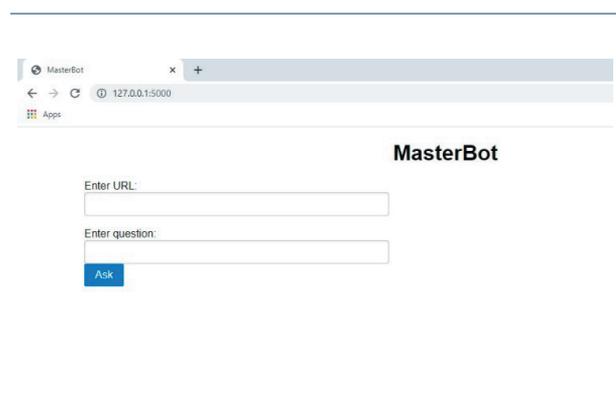


Figure 1. MasterBot

- ◆ Frontend was developed in html and css
- ◆ Backend was developed in python using flask

MasterBot consists of two basic segments:

1. URL classification
2. Chatbot

First steps:

We expect from user to enter the desired URL and we place it in a variable.

After entering the desired URL, user can make a query to the chatbot, that query is placed in a variable.

It is necessary to use some tool for manipulating text in order for the application to be usable. I use the well-known NLTK (Natural Language Toolkit) package. I use packages punkt and wordnet.

When a user enters a URL, we want to use all the text of that URL in the application. To do this, I used the Article library that is applied to the variable in which the URL was placed. The article is downloaded, parsed and nlp content is applied to it.

We're building a corpus. These types of objects typically contain raw strings annotated with additional metadata and details [1].

We do tokenization and we make a list of sentences.

3. URL CLASSIFICATION

The URL classification determines which category the content of the website belongs to. The fetch_20newsgroups library was used for classification, which is a frequently used library for various text analyzes, document classifications and similar purposes. The library is composed of a sample of 18,446 articles. It consists of a training and test subset and is divided into 20 categories.

I open a training set that includes a training subset from the library. The training set consists of 11,314 articles.

I open a test set that includes a test subset from the library. The test set consists of 7,532 articles.

I use pipeline to organize the work so that everything TfIdfVectorizer does fits into the basic model of Multinomial Naive Bayes.

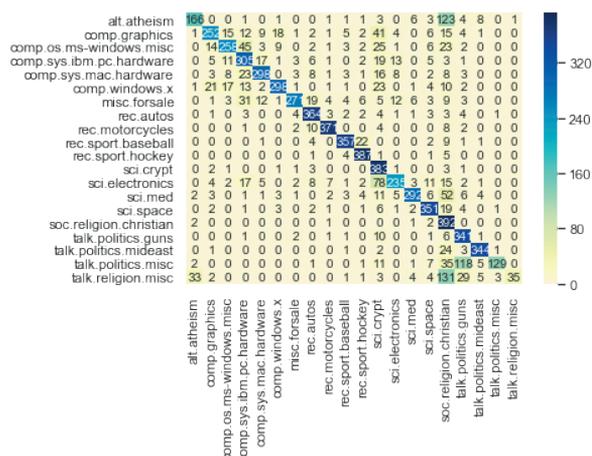
TfIdfVectorizer simply measures the frequency of a word in a document with the intention of showing how important that word is to the corpus. Conjunctions, auxiliary verbs and in general all the words that appear often will not have the same weight as words that are



not used as often as some professional terms or specific terms from different fields.

In a multinomial naive Bayes the features are assumed to be generated from a simple multinomial distribution. The multinomial distribution describes the probability of observing counts among a number of categories, and thus multinomial naive Bayes is most appropriate for features that represent counts or count rates [2].

I trained the model and made a prediction.



Graph 1. Graphical representation of category predictions

I have graphically shown the success of the prediction in Graph 1. On the abscissa (y-axis) there are the predictions, and on the ordinate (x-axis) there are the true values. Both numerically and visually, the colors evoke the accuracy of the model. The highest values are expected on the diagonal of the square and the color should be dark blue. There are minor deviations where the model inaccurately classifies:

- ◆ 'soc.religion.christian' and 'talk.religion.misc',
- ◆ 'talk.politics.misc' and 'talk.politics.misc.guns',
- ◆ 'soc.religion.christian' and 'alt.atheism'.

Since these categories are very similar we can say that the model is quite successful.

I have defined a function in which can be any string sent, that string is pushed into model pipeline and text classification will be made, so as a result it returns a category.

When user enters the URL, the textual content of that page is downloaded, processed and a corpus is created, which is forwarded to a defined function that performs our classification, that is determine the category

to which the URL belongs. The obtained category is displayed with the appropriate message to user.

4. CHATBOT

The chatbot in this paper is a combination of artificial intelligence (AI) and rule-based chatbot. The predicted conversation is in English.

I defined in the variable some of the expected initial messages of users in the form of greetings: "hi", "hello", "greetings", "hey", "howdy", "hey there", "what's up".

Chatbot should respond to this greeting with: "hi", "hey" or "hello".

To make the chatbot a little more intelligent, I made a greeting function. The first thing I wanted was to avoid the trap of users entering in the form of an initial uppercase or lowercase letter, different users have different spelling habits. User input is converted to lowercase. With a simple loop and a logical condition, it is determined whether the entry corresponds to one of the expected greetings. If the greeting is in the list chatbot will respond with a randomly selected greeting from the list.

The next thing that was important to me was to extract all the punctuation marks and make all the text in lower case, which I defined as a function, e.g. if user asks the question: "What is Singidunum University?", it first turns into "what is singidunum university?" than transforms in "what is singidunum university". This will later be used as a tokenizer.

This brings us to the concept of word tokenization, which is simply the process of separating a single string object, usually a body of text of varying length, into individual tokens that represent words or characters that we would like to evaluate further [3].

When a user enters a query which is not predicted it is necessary for the chatbot to give some answer. To make this possible, I defined a response function. The query from user is added to the end of the list of sentences made from the URL. We use TfidfVectorizer to which our defined tokenizer is added and to reduce noise we add "stop_words = 'english'".

What does "stop_words = 'english' actually do? It excludes certain words. NLTK package can exclude words that have little influence on text classification. The words that will be excluded are:



['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', 'you're', 'you've', 'you'll', 'you'd', 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his', 'himself', 'she', 'she's', 'her', 'hers', 'herself', 'it', 'it's', 'its', 'itself', 'they', 'them', 'their', 'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', 'that'll', 'these', 'those', 'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had', 'having', 'do', 'does', 'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'until', 'while', 'of', 'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'during', 'before', 'after', 'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over', 'under', 'again', 'further', 'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'more', 'most', 'other', 'some', 'such', 'no', 'nor', 'not', 'only', 'own', 'same', 'so', 'than', 'too', 'very', 's', 't', 'can', 'will', 'just', 'don', 'don't', 'should', 'should've', 'now', 'd', 'll', 'm', 'o', 're', 've', 'y', 'ain', 'aren', 'aren't', 'couldn', 'couldn't', 'didn', 'didn't', 'doesn', 'doesn't', 'hadn', 'hadn't', 'hasn', 'hasn't', 'haven', 'haven't', 'isn', 'isn't', 'ma', 'mightn', 'mightn't', 'mustn', 'mustn't', 'needn', 'needn't', 'shan', 'shan't', 'shouldn', 'shouldn't', 'wasn', 'wasn't', 'weren', 'weren't', 'won', 'won't', 'wouldn', 'wouldn't']

The idea is for TfidfVectorizer to determine word weights as correctly as possible, and to make the model more accurate. Excluded words are often repeated and have little weight for the entire corpus.

When we convert user's query into vectors, then we measure the similarity of the entered query with the sentences from the URL through cosine similarity. After processing TfidfVectorizer the values can be from 0 to 1, it means that the angle between the vectors can be from 0° to 90° . If the angle is 0° , the value is 1 ($\cos 0^\circ = 1$), which means that the two vectors are identical. If the angle is 90° , the value is 0 ($\cos 90^\circ = 0$), which means that the two vectors have no similarities.

The smaller the angle between the vectors, the greater the similarity of the documents is.

I create a loop that, if the result of cosine similarity is 0, returns a message to user: "I apologize, I don't understand.". In any other case, it returns the most similar sentence, that is sentence with index -2. A sentence with index -1 is actually a user query and it has a similarity of 1, i.e. it is completely identical. I sort the similarity of the sentences so it ranges from the least similar to the most similar, as we said that in the end of list is the query itself, the next most similar sentence is to the index -2 and therefore it is returned to user.

When all the necessary functions have been defined, a loop can be created which actually represents user's communication with application.

If user writes anything except "bye", then a new loop opens, if he writes "bye", then the message will appear "Chat with you later!".

In this new loop, if user enter "thanks" or "thank you", then will appear the message "You're welcome!". In any other case, a different new loop opens.

In this new loop, if user enters any of the defined greetings, he/she will get the response from defined list. If user enters query which is not predicted, application will return the most similar sentence from website or message "I apologize, I don't understand." if cosine similarity is 0.

5. USAGE

MasterBot is developed as an application that will make websites interactive. Instead of reading static content of website with the application, content can become interactive. It is not rare for users to type keywords or questions into a search engine when they need information. Once they find a website with the mention content, it often happens that:

1. The content of the website is large, so users who are less able to search over content can waste a lot of time to extract information that interests them.
2. The page is not related to the area in which they are interested, similar terms are used in different areas.

MasterBot is intended to overcome such difficulties for users.

1. The user does not have to read the content of the page, he/she can ask a specific question. He/she can ask more questions and extract all the information that is potentially of interest to them from a website without too much effort and energy needed for applying to some other method of extracting information. No prior technological knowledge is required to use MasterBot, so users who are less proficient on the Internet can easily use this application.

Example: The current topic, as in previous months, is about COVID-19. In this example, I will present a simulation of a possible user conversation with MasterBot using the URL [access date 09.06.2020.]:

<https://www.aljazeera.com/news/2020/01/coronavirus-symptoms-vaccines-risks-200122194509687.html>

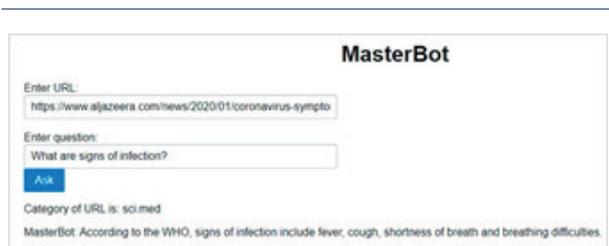


Figure 2. Example 1

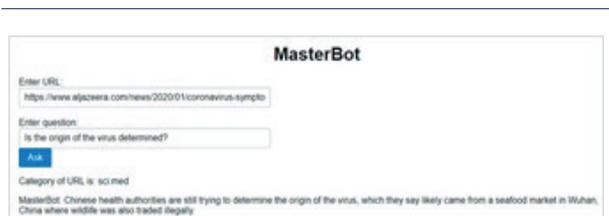


Figure 3. Example 2



Figure 4. Example 3



Figure 5. Example 4

In the figures above we can see the answers of MasterBot from which we can conclude that MasterBot has answered with appropriate sentence from the website to each question. Using chatbot the user quickly has come to the desired information about COVID-19.

2. By classifying the URL, the user can see which category a website belongs to. Classification will save user's time and effort which would be needed to infer from the context of the website to determine category. If the page does not belong to the category that interests them, he/she can quickly continue the search on the Internet.

Example: I entered "danger operation" in the search engine, as keywords that potentially interest the user. On the first page I got websites with different contents.

First URL [access date 09.06.2020.]:

<https://www.scientificamerican.com/article/hidden-dangers-of-going-under/>



Figure 6. Example 5

The content of the website refers to the dangers that anesthesia can cause. The classification of this URL is medicine, which corresponds to its content.

Second URL [access date 09.06.2020.]:

<https://www.asahq.org/whensecondscount/anesthesia-101/anesthesia-risks/>



Figure 7. Example 6

The content of the website also refers to the dangers that anesthesia can cause. The classification of this URL is medicine, which corresponds to its content.

Third URL [access date 09.06.2020.]:

https://en.wikipedia.org/wiki/Able_Danger



Figure 8. Example 7



The content of the page refers to the military operation "Able Danger" aimed at the fight against terrorism by the institutions in the USA. The classification of this URL is a politics-guns that corresponds to its content.

The user could enter "danger operation" in the search engine, with the intention of obtaining content related to a military-political dangerous operation. By classifying the URL, the first two pages related to medicine would be recognized by MasterBot and a message would be printed to the user that the category is medicine. The user could immediately see that it is not the content of interest to him and he/she could continue the search further and come to the third website that potentially is interesting to them.

6. CONCLUSION

In this paper, I presented my solution for the needs and problems of users, which I explained in the introduction. More importantly I pointed out the potential of modifying the way information is obtained. Although I have presented a successful application in the paper, the application has some limitations. Some of the limitations are:

- ◆ The intended language of the application is English. The application can be used in other languages, but with much less success.
- ◆ There is a limit to the classification of URL to twenty categories, because this is the maximum of the library used in the paper.
- ◆ Classification can miss label, i.e. return wrong category, especially for websites that have the theme of religion and politics.
- ◆ If the selected website does not have information that user is interested in, only the appropriate message will be displayed: "I apologize, I don't understand."

These limitations can be overcome, but it requires a lot of knowledge and effort, also for each individual it would be an endeavor.

The project can go a step further, my vision for further improvement of the project is reflected in several aspects:

- ◆ The application should not be limited to one page, but should have access to all content on the Internet.
- ◆ When user enters a query, he/she should not receive an answer based on cosine similarity of the

documents, but much more sophisticated techniques and methods of machine learning should be applied.

- ◆ URL classification was just idea of showing the category as a user guide about the content of the page. This idea arose due to the use of similar terms in different areas. In a more advanced application, after user makes a query, a chatbot sub-question could be asked in order to profile user's query, i.e. to determine a category.

Undoubtedly, text mining will become increasingly important. The paper presents my solution and opens questions for further development in this scientific field. This paper is a solid starting point for further improvement of chatbots, all with the aim of obtaining a better and more interesting application, but also easier to use.

REFERENCES

- [1] Julia Silge, David Robinson, Text Mining with R, O'REILLY, 2017., pp. 2
- [2] Jake VanderPlas, Python Data Science Handbook - Essential Tools for Working with Data, O'Reilly, 2017., pp. 386
- [3] Taweh Beysolow II, Applied Natural Language Processing with Python - Implementing Machine Learning and Deep Learning Algorithms for Natural Language Processing, Apress, 2018., pp. 44-45



MULTI-LAYER PERCEPTRON TRAINING BY GENETIC ALGORITHMS

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Abstract:

In this paper, the authors are presenting one of the ways to train Artificial Neural Networks (ANN) using a predefined set of weights as biases as input parameters, generated by the Genetic Algorithm (GA). This approach solves the problem of hyperparameter tuning for ANN, which is an NP-hard space search problem and will be further explained in the paper. The genetic algorithm generates a population of potential solutions in each iteration and then after a series of solutions variables modification (crossover, mutation, etc.) ranks them based on their fitness values. The algorithm itself is tested on a standard Multi-layer Perceptron (MLP) artificial neural network and results are similar compared to other techniques of training.

Keywords:

ANN, neural networks, training, genetic algorithm.

1. INTRODUCTION

Artificial neural networks (ANNs)[1] can learn and is used to overcome very complex problems in science or engineering[2]. ANNs have proven to be a good model and have been widely used in working with problems such as shape recognition, classification, clustering, and also prediction undertakings. For example, for medical purposes, researchers have used different types of ANNs to master troublesome classification and disease detection assignments [3], [4]. They likewise utilized ANNs to order biomedical data, for example, coronary heart disease and diabetes. The huge accomplishment of those techniques can be attributed to the ability of neural networks to process vast amounts of information during the training stage and to reduce the time needed for the diagnosis [5].

For each problem, it is necessary to do network training. Network training means adjusting weights and biases, which is why it is an NP-hard problem because the search space is too large.

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Nature-inspired algorithms can be used to train the network. They are partitioned within two groups. The primary group comprises of Evolutionary Algorithms (EA) while the rest is known as Swarm intelligence algorithms (SI). The most famous representative of Evolutionary Algorithms is the Genetic Algorithm (GA).

The second group of algorithms consists of algorithms based on the observation of the social behavior of swarms of insects, flocks of birds, packs of animals. What all these animals have in common is that they do not show excessive intelligence as individuals, but when they join groups due to, for example, finding food, they show a high level of intelligence and that encouraged researchers to make mathematical models of these behaviors and apply them to real-life problems [6], [7], [8], [9], [10].

In this paper, we utilized an MLP neural network that we hybridized by a genetic algorithm with our selection model to get better results. When training and testing the network we used publicly available breast cancer datasets. The accuracy of such a system is between 96-98%. We compared our results with the results of the author of the paper in which the Swarm Intelligence algorithm was used together with the MLP neural network [11].

ANN training

The artificial neural network is a collection of nodes, also called artificial neurons, that mimic neurons in the organic mind. Every association, just as neurotransmitters in the mind, can send signals to other neurons. They receive these signals and process them. These signals are represented by real numbers and the yield of every neuron is determined based on some nonlinear function. Neurons and connections usually have their weights that are adjusted during network learning. During these adjustments, the neural network will begin to produce results that are very similar to the desired output. After a sufficient number of weight adjustments, the training can be stopped based on some criteria.

One of the most famous types of ANN models that can detect and estimate computational models utilizing their superior parallel layered structure is Feedforward neural networks (FFNNs) [12].

A multilayer perceptron (MLP) is a type of FFNNs. MLP comprise at least three layers that are sorted out in a one-directional mode. In the beginning, we have an input layer, at that point at least one hidden layers, and finally an output layer. Each of these layers consists from nonlinear-activation nodes. Each node in one layer connects with a certain weight with all other nodes in the next layer.

MLP with a solitary hidden layer, as per Kolmogorov's theorem, is equipped for approximating different continuous functions [13]. Figure 1 shows an MLP network with only one hidden layer. The associations among the layers ought to be portrayed by certain weights that are situated within $[-1, 1]$. Every node in the MLP can perform two purposes: summation and activation. An activation function used in this paper is the S-shaped curved sigmoid function. This function is described as:

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

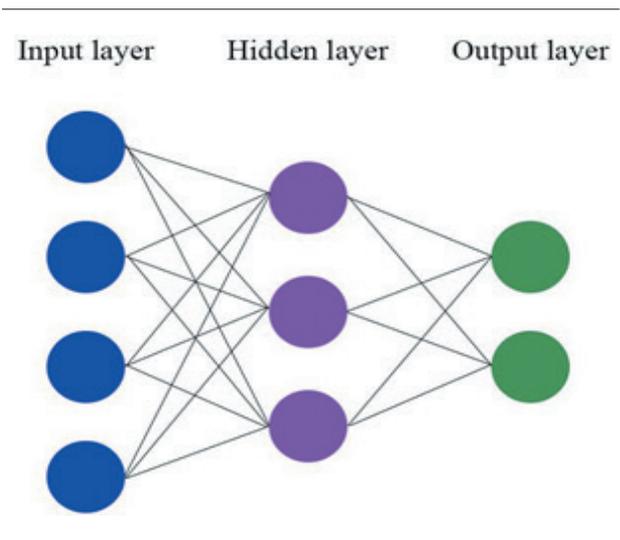


Figure 1. MLP neural network.

When talking about the optimization algorithm, the way we can assess a solution that can be a candidate (in the case of this paper we will be using a set of weights) is utilizing one type of a function that in literature is called the objective function. The objective function can be maximized or minimized, depending on the problem, implying that we search for a solution that has the best or the worst score. Typically, when using neural networks, we try to reduce the error. In essence, the objective function is often called loss function. In this paper, we used Mean Squared Error loss (MSE), which is computed as the average of the squared differences among prognosticated and present values. The result is invariably positive regardless of the sign of the prognosticated and present values. A mathematical perfect value is zero. If we have optimization for a maximizing problem, we can still minimize the loss value by making the score negative.



2. PROPOSED METHOD

Genetic algorithm (GA) [14] is a method propelled by the cycle of natural selection that has a place with the bigger class of evolutionary algorithms (EA). Genetic algorithms are regularly employed to create excellent solutions to optimization and search problems by depending on operators like selection, mutation, crossover which are driven by nature. In genetic algorithms, the population of candidate solution is evolving towards better solutions. Each member of the population has its own set of traits that can change and mutate. Evolution usually begins with the initial formation of a population composed of individuals that are randomly generated. Evolution is by its nature an iterative process and on account of genetic algorithms, a population in each iteration has named a generation. The fitness of each member of the group is calculated. In GA fitness is normally the value of the objective function in the issue to be unraveled. After that, members with greater fitness are chosen from the present population and their properties are combined in order for the offspring to inherit those properties.

Regarding the model of a selection of parents from the population of solutions, we decided on the selection according to the principle of the two best. In this type of selection, two parents are chosen who have the highest fitness values in the current population. This selection is good because the highest-quality specimens of the population are selected and reproduced to improve the genetic algorithm and its convergence.

A dose of mutation is also inserted in order to increase the uncertainty and in some cases to get better solutions. The mutation is achieved by giving a certain number in the range that serves as the certainty of whether the mutation will occur or not. In our case, we called that variable mutation rate. The higher the mutation rate, the more probable it is that the given solution will mutate. If a mutation occurs, the properties of the solution change randomly. The offspring obtained after one iteration changes the existing population and the next iteration begins. The genetic algorithm can be described by the following pseudo-code:

- (1) **Begin**
- (2) Initialize maximum number of generations
- (3) Generate a random population of n solutions
- (4) **while(!maximum number of generations)**
- (5) Calculate fitness $f(x)$ for each solution in the population

- (6) **while(!number of offspring created)**
- (7) select the pair of parents from the current population (roulette wheel)
- (8) apply the crossover operator to the selected parents with the probability p and create two offspring
- (9) Utilize mutation operator to the produced offspring with mutation rate as the chance for it to happen
- (10) **End while**
- (11) substitute the current population with the new
- (12) **End while**
- (13) **End**

In this part, the suggested GA-based MLP trainer (GAMLP) algorithm is portrayed in detail. As referenced previously, the single hidden layer MLP network is being trained with GA. Population members are represented as one-dimensional vectors of randomly generated real numbers within $[1, 1]$.

Every solution depicts a candidate ANN. The proposed encoding vector includes three parts which are a set of bias terms and two collections of association weights between the layers. For the absolute quantity of biases and weights in the network, we can get the range of those vectors. A related encoding procedure is used for GAMLP. We must also pay attention to which functions that will represent fitness we will select. To successfully get results of solutions fitnesses, we need to send them to the MLP network as the association weights. The network can assess those numbers as indicated by a dataset we used for training. At long last, the network will acquire the fitness estimations of the analogous solutions. In this paper, the MSE is utilized as the loss function in the GAMLP trainer for evaluating networks fitnesses. As for the training units, the MSE metric can be gotten utilizing the fluctuation of the real and anticipated solutions by the produced members of population (MLPs). The most important thing is to reduce the value of the MSE however much as could reasonably be expected [11].

General steps for GAMLP trainer can be represented by:

- (1) Initialization the GAMLP begins by making a random population
- (2) Map the solutions the members of the GA population are attached to the weights and biases of a possible MLP network.
- (3) Evaluation of the fitness the nature of the produced MLPs is assessed utilizing the MSE function for all samples in the training dataset.



- (4) The GAMLP should discover the MLP with the most minimal MSE value. These MLPs with smaller MSEs are better than those with bigger MSEs.
- (5) Selection and crossover operators of GA
- (6) Iterate rounds 2-4 till the end

- (7) Ending and reviewing the cycle is ended and MLP with the smallest MSE is being examined on the test dataset.

The general workings of the GAMLP system are exhibited in Figure 2.

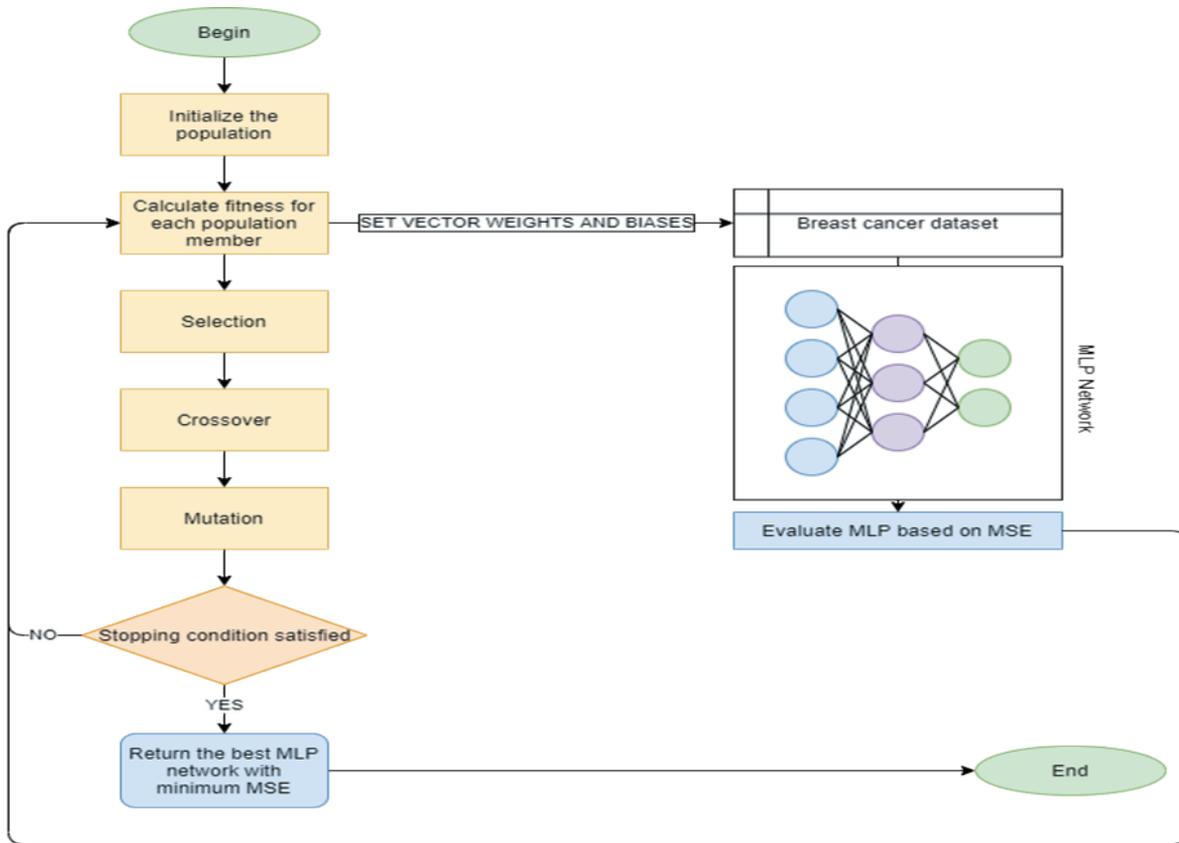


Figure 2. Optimizing MLP network using GA

3. EXPERIMENTS AND DISCUSSION

Publicly available breast cancer dataset was used during network training and evaluation of results. This set of information is initially gotten from Dr. William H. Wolberg, the University of Wisconsin Hospitals, Madison. This dataset consists of 699 cases where each case depicts a patient that had gone through the medical procedure for breast cancer. Four factors are estimated for every patient and marked as either malignant or benign [11][15]. To validate the findings of the advised GA-based trainer, it is correlated with a collection of known and established algorithms. The well-established algorithms are the PSO, bat algorithm (BAT/BA) [16], the firefly algorithm (FF/FA) [17], and artificial bee colony (ABC) [18] algorithm. In all trials, the size of the population

and number of iterations are set to 5 and 100, respectively [11]. The number of runs of the GAMLP is set to 10.

To assess the execution of the classification models that are developed in those analyses, we utilized accuracy. Accuracy of the rate of classification calculates the rate of the rightly classified specimens (either negative or positive) to the real absolute number of specimens. The accuracy is determined by the accompanying condition [11]:

$$Accuracy = \frac{TP + TN}{TP + FN + FP + TN} \tag{2}$$

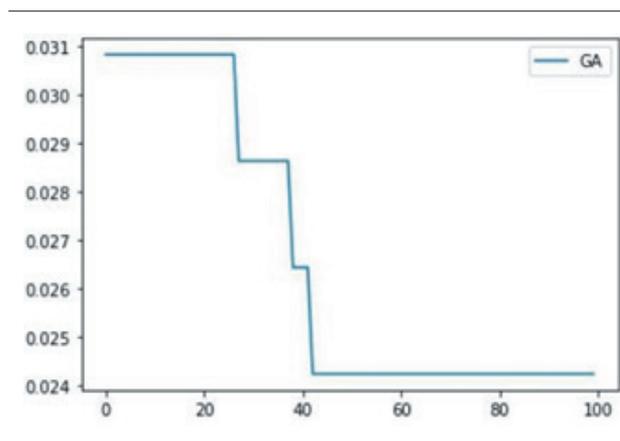


Figure 3. Convergence graph.

Figure 3 shows a graph of the convergence of the training system after the evaluation of the results.

Results of the evaluation of the intended GMLP and other MHA-based MLP structures can be viewed in Table 1. The standard deviation, worst, best and average of each audit measure is and labeled as STD, WORST, BEST, and AVG. Giving the achieved outcomes, it very well may be seen that every algorithm can accomplish huge rates in all analyses [11].

Table 1. Breast cancer dataset results of the experiments of training MLP networks

	<i>Metric</i>	<i>Accuracy</i>
PSO	AVG	0.97045
	STD	0.00752
	BEST	0.97899
	WORST	0.95378
ABC	AVG	0.96891
	STD	0.00793
	BEST	0.98319
	WORST	0.94958
BAT	AVG	0.96218
	STD	0.01422
	BEST	0.98319
	WORST	0.92437
FA	AVG	0.97311
	STD	0.00324
	BEST	0.97899
	WORST	0.96639
GA	AVG	0.95175
	STD	0.01195
	BEST	0.97807
	WORST	0.92982

CONCLUSION

This paper used a well - known and exploited genetic algorithm to locate the ideal values of the MLPs parameters. Based on the training and testing of the entire training system on the breast cancer dataset, it was shown that such a system is as competitive and efficient as the others on which a comparative analysis was performed.

REFERENCES

- [1] McCulloch, Warren S., and Walter Pitts. "A logical calculus of the ideas immanent in nervous activity." *The bulletin of mathematical biophysics* 5.4 (1943): 115-133.
- [2] Heidari, Ali Asghar, and Rahim Ali Abbaspour. "Enhanced chaotic grey wolf optimizer for real-world optimization problems: A comparative study." *Handbook of Research on Emergent Applications of Optimization Algorithms*. IGI Global, 2018. 693-727.
- [3] Esteva, Andre, et al. "Dermatologist-level classification of skin cancer with deep neural networks." *Nature* 542.7639 (2017): 115-118.
- [4] Bezdán, Tímea, et al. "Glioma Brain Tumor Grade Classification from MRI Using Convolutional Neural Networks Designed by Modified FA." *International Conference on Intelligent and Fuzzy Systems*. Springer, Cham, 2020.
- [5] Faris, Hossam, et al. "Optimizing the learning process of feedforward neural networks using lightning search algorithm." *International Journal on Artificial Intelligence Tools* 25.06 (2016): 1650033.
- [6] Bezdán, Tímea, et al. "Multi-objective Task Scheduling in Cloud Computing Environment by Hybridized Bat Algorithm." *International Conference on Intelligent and Fuzzy Systems*. Springer, Cham, 2020.
- [7] Bacanin, Nebojsa, et al. "Whale Optimization Algorithm with Exploratory Move for Wireless Sensor Networks Localization." *International Conference on Hybrid Intelligent Systems*. Springer, Cham, 2019.
- [8] Strumberger, Ivana, et al. "Dynamic search tree growth algorithm for global optimization." *Doctoral Conference on Computing, Electrical and Industrial Systems*. Springer, Cham, 2019.
- [9] Zivkovic, Miodrag, et al. "Wireless Sensor Networks Life Time Optimization Based on the Improved Firefly Algorithm." 2020 *International Wireless Communications and Mobile Computing (IWC-MC)*. IEEE, 2020.
- [10] Zivkovic, Miodrag, et al. "Enhanced Grey Wolf Algorithm for Energy Efficient Wireless Sensor Networks." 2020 *Zooming Innovation in Consumer Technologies Conference (ZINC)*. IEEE, 2020.



- [11] Heidari, Ali Asghar, et al. "An efficient hybrid multi-layer perceptron neural network with grasshopper optimization." *Soft Computing* 23.17 (2019): 7941-7958.
- [12] Ojha, Varun Kumar, Ajith Abraham, and Václav Snášel. "Metaheuristic design of feedforward neural networks: A review of two decades of research." *Engineering Applications of Artificial Intelligence* 60 (2017): 97-116.
- [13] Cybenko, George. "Approximation by superpositions of a sigmoidal function." *Mathematics of control, signals and systems* 2.4 (1989): 303- 314.
- [14] Mitchell, Melanie. *An introduction to genetic algorithms*. MIT press, 1998.
- [15] Wolberg, William H., and Olvi L. Mangasarian. "Multisurface method of pattern separation for medical diagnosis applied to breast cytology." *Proceedings of the national academy of sciences* 87.23 (1990): 9193-9196.
- [16] Yang, Xin-She, and Amir Hossein Gandomi. "Bat algorithm: a novel approach for global engineering optimization." *Engineering computations* (2012).
- [17] Yang, Xin-She. "Firefly algorithm, stochastic test functions and design optimisation." *International journal of bio-inspired computation* 2.2 (2010): 78-84.
- [18] Karaboga, Dervis, Bahriye Akay, and Celal Ozturk. "Artificial bee colony (ABC) optimization algorithm for training feed-forward neural networks." *International conference on modeling decisions for artificial intelligence*. Springer, Berlin, Heidelberg, 2007.



ADVANCED COMPUTING SESSION

ON QUASI-CYCLIC CODES OF INDEX $1\frac{1}{3}$

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Abstract:

The main subject of this paper are quasi-cyclic codes of index $1\frac{1}{3}$. We show how to obtain generator matrices of such codes. Generator matrices are not uniquely determined. At the end of this paper we illustrate the result by examples. It should be also mention that generator matrices have wide application in encoding and decoding.

Keywords:

Quasi-cyclic code; generator matrices of a code.

1. INTRODUCTION

Suppose that F is a finite field (i.e. the field with a finite number of elements) and n is a natural number.

In that case,

- a word over F is any $(c_0, c_1, \dots, c_{n-1}) \in F^n$,
- a linear code of length n over F is any subspace C of F^n ,
- code words are the words in C ,
- a generator matrix of the linear code C is the $r \times n$ matrix

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

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assuming that a basis of the linear code C consists of

$(c_{0,0}, c_{0,1}, \dots, c_{0,n-1}), (c_{1,0}, c_{1,1}, \dots, c_{1,n-1}), \dots,$

$(c_{r-1,0}, c_{r-1,1}, \dots, c_{r-1,n-1}),$

- the fraction $\frac{\dim(C)}{n}$, where $\dim C$ is the dimension



of C , is called *the rate of* C and denoted by $R(C)$.

Let us point out that the dimension of C is equal to the rank of its generator matrix i.e.

$$\dim(C) = r \quad (2)$$

The subject of our research are quasi-cyclic codes of index $1\frac{1}{3}$.

First, we shall recall the definition of a cyclic code.

Now, we consider the index set $\{1, 2, \dots, n\}$ of coordinates of F^n , the permutation group S_n on that set and the linear code C (in F^n) that satisfies the following:

$$\forall \sigma \in S_n, \forall c \in C, \sigma(c) \in C. \quad (3)$$

In that case we say that C is an S_n -acted code or an S_n -permutation code (see [1], [2], [3] and [4]).

Definition 1. (A cyclic code) ([5]) If S_n is a cyclic group generated by the $(12\dots n)$ i.e. $S_n = \langle (12\dots n) \rangle$ and C is an S_n -acted code, then C is called a cyclic code of length n . ∇

Suppose that m is also a natural number.

Definition 2. (A quasi-cyclic code of index m and co-index n) ([5]) If Π is the permutation group generated by the product of m disjoint cycles of length n . Then, the subspace C of

$$\underbrace{F^n \times \dots \times F^n}_m \quad (4)$$

which is invariant by Π is called a quasi-cyclic code of index m and co-index n . ∇

The main result and the examples are given in the next section.

2. A QUASI-CYCLIC CODE OF INDEX $1\frac{1}{3}$

If we do not mention otherwise, n is an odd natural number and F is the field with only two elements - 0 and 1 (i.e. the binary field). The operations $+$ and \circ (in F) are defined as follows:

+	0	1
0	0	1
1	1	0

\circ	0	1
0	0	0
1	0	1

(5)

Let the quotient ring $F[X]/\langle x^n - 1 \rangle$ is denoted by $F_n[X]$.

We consider the product:

$$F_{3n}[X] \times F_n[X]. \quad (6)$$

Each element of (6) is represented (uniquely) as $(c(x), c'(x))$ where

$$c(x) = \sum_{i=0}^{3n-1} c_i x^i \quad \text{and} \quad c'(x) = \sum_{j=0}^{n-1} c'_j x^j. \quad (7)$$

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

$$(c_0, \dots, c_{3n-2}, c_{3n-1}, c'_0, \dots, c'_{n-1}) \in F^{3n} \times F^n. \quad (8)$$

Suppose that π is a permutation of the coefficients of $F^{3n} \times F^n$ which is the product of 2 disjoint cycles of length $3n$ and n such that

$$\begin{aligned} \pi(c_0, \dots, c_{3n-2}, c_{3n-1}, c'_0, \dots, c'_{n-2}, c'_{n-1}) = \\ (c_{3n-1}, c_0, \dots, c_{3n-2}, c'_{n-1}, c'_0, \dots, c'_{n-2}) \end{aligned} \quad (9)$$

Hence, the permutation π (on $F^{3n} \times F^n$) is corresponding to the operation by multiplying X (on $F_{3n}[X] \times F_n[X]$).

$$\begin{aligned} X(c(x), c'(x)) = \\ (Xc(x) \pmod{x^{3n}-1}, Xc'(x) \pmod{x^n-1}). \end{aligned} \quad (10)$$

According to Definition 2. the following can be obtained:

If a linear subspace C of $F_{3n}[X] \times F_n[X]$ is invariant by the permutation π i.e.

$$\forall (c(x), c'(x)) \in C \quad X(c(x), c'(x)) \in C, \quad (11)$$

then C is called a quasi-cyclic code over F of index $1\frac{1}{3}$ and co-index $3n$.

The operation (10) can be extended in the following way:

For any $f(x) \in F[X]$ and any

$$(c(x), c'(x)) \in F_{3n}[X] \times F_n[X]$$

$$\begin{aligned} f(x)(c(x), c'(x)) = \\ (f(x)c(x) \pmod{x^{3n}-1}, f(x)c'(x) \pmod{x^n-1}). \end{aligned} \quad (12)$$

The operation (12) can be abbreviated (on $F_{3n}[X] \times F_n[X]$) as follows:

$$f(x)(c(x), c'(x)) = (f(x)c(x), f(x)c'(x)) \quad (13)$$



Remark 1. Let $(c(x), c'(x))$ be any element of (6), then the set

$$\{(f(x)c(x), f(x)c'(x)) \in F_{3n}[X] \times F_n[X] \mid f(x) \in F_{3n}[X]\} \quad (14)$$

is a quasi-cyclic code of index $1/3$ and co-index n generated by $(c(x), c'(x))$ and will be denoted by $C_{c(x), c'(x)}$.

The main question, in relation to $C_{c(x), c'(x)}$, is:

How can a generator matrix of $(C_{c(x), c'(x)})$ be obtained? (15)

The generator matrix of $C_{c(x), c'(x)}$ will be denoted $\hat{C}[c(x), c'(x)]$ by. Before we represent the answer to the previous question, let us point out that generator matrices have wide application in encoding and decoding.

Let

$$c(x) = c_0 + c_1x + \dots + c_{3n-1}x^{3n-1}$$

and

$$c'(x) = c'_0 + c'_1x + \dots + c'_{n-1}x^{n-1}.$$

Then, from $(c_0, c_1, \dots, c_{3n-1})$ (a $3n$ -dimensional vector i.e. a word of length $3n$) and $(c'_0, c'_1, \dots, c'_{n-1})$ (a n -dimensional vector i.e. a word of length n) the following matrices of the order $3n$ and n , respectively, are constructed:

$$C[c(x)] = \begin{bmatrix} c_0 & c_1 & \dots & c_{3n-1} \\ c_{3n-1} & c_0 & \dots & c_{3n-2} \\ \vdots & \vdots & \ddots & \vdots \\ c_1 & c_2 & \dots & c_0 \end{bmatrix} \quad (16)$$

And

$$C'[c'(x)] = \begin{bmatrix} c'_0 & c'_1 & \dots & c'_{n-1} \\ c'_{n-1} & c'_0 & \dots & c'_{n-2} \\ \vdots & \vdots & \ddots & \vdots \\ c'_1 & c'_2 & \dots & c'_0 \end{bmatrix}. \quad (17)$$

Before we continue, let us mention that (16) and (17) represent circulant matrices – matrices having the following property: its second row is obtained from its first row by moving one place to the right, its third row is obtained from its second row by moving one place to the right and so on. Namely, its i -th row is obtained from its $(i-1)$ -th row by moving one place to the right. Circulant matrices have a wide range of applications in many areas. Some of them are signal and image processing, communications, coding theory, probability, statistics,

numerical analysis, engineering model and economy. More information about circulant matrices can be found in [6] and [7].

From (16) and (17) the following matrix is constructed:

$$C[c(x), c'(x)] = \begin{bmatrix} c_0 & c_1 & \dots & c_{3n-1} & c'_0 & c'_1 & \dots & c'_{n-1} \\ c_{3n-1} & c_0 & \dots & c_{3n-2} & c'_{n-1} & c'_0 & \dots & c'_{n-2} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ c_{2n+1} & c_{2n+2} & \dots & c_{2n} & c'_1 & c'_2 & \dots & c'_0 \\ c_{2n} & c_{2n+1} & \dots & c_{2n-1} & c'_0 & c'_1 & \dots & c'_{n-1} \\ c_{2n-1} & c_{2n} & \dots & c_{2n-2} & c'_{n-1} & c'_0 & \dots & c'_{n-2} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ c_{n+1} & c_{n+2} & \dots & c_n & c'_1 & c'_2 & \dots & c'_0 \\ c_n & c_{n+1} & \dots & c_{n-1} & c'_0 & c'_1 & \dots & c'_{n-1} \\ c_{n-1} & c_n & \dots & c_{n-2} & c'_{n-1} & c'_0 & \dots & c'_{n-2} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots \\ c_1 & c_2 & \dots & c_0 & c'_1 & c'_2 & \dots & c'_0 \end{bmatrix}$$

i.e. the $3n \times 4n$ matrix that has the following form:

$$C[c(x), c'(x)] = \begin{bmatrix} C[c(x)] & C'[c'(x)] \\ C[c(x)] & C'[c'(x)] \\ C[c(x)] & C'[c'(x)] \end{bmatrix}. \quad (18)$$

It is easy to see that

$$C_{c(x), c'(x)} = \{(f_0, f_1, \dots, f_{3n-1})C[c(x), c'(x)](f_0, f_1, \dots, f_{3n-1}) \in F^{3n}\}.$$

But, the rank of the matrix (18) does not have to be equal to $3n$ i.e. the matrix (18) does not have to be a generator matrix of $C_{c(x), c'(x)}$. The answer to the question (15) is given by the following theorem proving by Y. Fan and H. Liu in the paper [5].

Before we give that theorem and its proof, let us recall the following symbols:

- ◆ $Ker(f)$ - the symbol for the *kernel of f*
- ◆ $gcd(q(x), w(x))$ - the symbol for the greatest common divisor of $q(x)$ and $w(x)$.

Theorem 1. (Theorem 3. [5]) Suppose that $q_{c(x), c'(x)}(x)$ and $w_{c(x), c'(x)}(x)$, for any $(c(x), c'(x)) \in F_{3n}[X] \times F_n[X]$, are defined as follows:

$$q_{c(x), c'(x)}(x) = gcd(c(x), x^{2n} + x^n + 1) \cdot gcd(c(x), c'(x), x^n - 1)$$

and

$$w_{c(x), c'(x)}(x) = \frac{x^{3n} - 1}{q_{c(x), c'(x)}(x)}.$$



Then, $(c(x), c'(x))$ induces an $F_{3n}[X]$ -homomorphism $h_{c(x), c'(x)} : F_{3n}[X] \rightarrow F_{3n}[X] \times F_n[X]$ such that:

$$f(x) \xrightarrow{h_{c(x), c'(x)}} (f(x)c(x), f(x)c'(x))$$

and $\text{Ker}(h_{c(x), c'(x)})$ is equal to $\langle w_{c(x), c'(x)}(x) \rangle_{F_{3n}[X]}$ i.e.

$$\dim(C_{c(x), c'(x)}) = \deg(w_{c(x), c'(x)}(x)).$$

Proof.

Namely, $v(x) \in \text{Ker}(h_{c(x), c'(x)})$ if and only if

$$v(x)c(x) \equiv 0 \pmod{x^{3n} - 1}$$

$$v(x)c'(x) \equiv 0 \pmod{x^n - 1}$$

$$\hat{C}[c(x), c'(x)]$$

if and only if

$$v(x)c(x) \equiv 0 \pmod{x^{2n} + x^n + 1}$$

$$v(x)c(x) \equiv 0 \pmod{x^n - 1}$$

$$v(x)c'(x) \equiv 0 \pmod{x^n - 1}$$

if and only if

$$v(x)c(x) \equiv 0 \pmod{x^{2n} + x^n + 1}$$

$$v(x)\text{gcd}(c(x), c'(x)) \equiv 0 \pmod{x^n - 1}$$

if and only if

$$v(x) \equiv 0 \pmod{\frac{x^{2n} + x^n + 1}{\text{gcd}(c(x), x^{2n} + x^n + 1)}}$$

$$v(x) \equiv 0 \pmod{\frac{x^n - 1}{\text{gcd}(c(x), c'(x), x^n - 1)}}$$

if and only if

$$v(x) \equiv 0$$

$$\pmod{\frac{x^{2n} + x^n + 1}{\text{gcd}(c(x), x^{2n} + x^n + 1)} \cdot \frac{x^n - 1}{\text{gcd}(c(x), c'(x), x^n - 1)}}$$

i.e.

$$v(x) \in \langle w_{c(x), c'(x)} \rangle_{F_{3n}[X]}$$

Especially,

$$\begin{aligned} \dim(C_{c(x), c'(x)}) &= \dim(F_{3n}[X]) - \dim(\text{Ker}(h_{c(x), c'(x)})) \\ &= 3n - \deg(q_{c(x), c'(x)}(x)) = \deg(w_{c(x), c'(x)}(x)). \diamond \end{aligned}$$

Based on the previous theorem, we can obtain a generator matrix of $C_{c(x), c'(x)}$ in the following way:

I step: Determine (for given $c(x)$ and $c'(x)$) the matrices (16) and (17);

II step: Construct the matrix (18);

III step: Determine $r = \dim(C_{c(x), c'(x)})$;

IV step: Construct the matrix $\hat{C}[c(x), c'(x)]$ using the rows of the matrix (18) i.e. using any r rows of the matrix (18) (for example, using the first r rows of the matrix (18)).

At the end of this paper, we shall give two examples and illustrate how to get a generator matrix of $C_{c(x), c'(x)}$.

Namely,

• in the first example: a generator matrix of $C_{c(x), c'(x)}$ will be equal to the matrix (18);

• in the second example: a generator matrix of $C_{c(x), c'(x)}$ will not be equal to the matrix (18);

Example 1. Let $c(x) = 1 + x^2$ and $c'(x) = 1$ then,

$$C[1 + x^2] = \begin{bmatrix} 1 & 0 & 1 \\ 1 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix} \text{ and } C'[1] = [1]$$

i.e.

$$C[1 + x^2, 1] = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 0 & 1 & 1 & 1 \end{bmatrix} \quad (19)$$

Since,

$$q_{1+x^2, 1}(x) =$$

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

and

$$w_{1+x^2, 1}(x) = \frac{x^3 - 1}{q_{1+x^2, 1}(x)} = \frac{x^3 - 1}{1} = x^3 - 1,$$

based on Theorem 1., it follows that

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

i.e. the generator matrix of $C_{1+x^2, 1}$ is equal to the matrix (19).



Therefore,

$$\hat{C}[1+x^2, 1] = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 0 & 1 & 1 & 1 \end{bmatrix} \cdot \diamond$$

Example 2. Let $n=3$, $c(x) = x + x^2 + x^3 = x(1 + x + x^2)$ and $c'(x) = 1 + x + x^2$. Then,

$$C[x + x^2 + x^3] = \begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

and

$$C'[1 + x + x^2] = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

i.e

$$C[x + x^2 + x^3, 1 + x + x^2] = \begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \end{bmatrix}$$

Since,

$$q_{x+x^2+x^3, 1+x+x^2}(x) = \gcd(x^3 + x^2 + x, x^6 + x^3 + 1) \cdot \gcd(x^3 + x^2 + x, x^2 + x + 1, x^3 - 1) = x^2 + x + 1$$

and

$$w_{x+x^2+x^3, 1+x+x^2}(x) = \frac{x^9 - 1}{q_{x+x^2+x^3, 1+x+x^2}(x)} = \frac{x^9 - 1}{x^2 + x + 1} = x^7 + x^6 + x^4 + x^3 + x + 1,$$

based on Theorem 1., it follows that

$$\dim(C_{x+x^2+x^3, 1+x+x^2}) = \deg(w_{x+x^2+x^3, 1+x+x^2}(x)) = 7$$

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

$$\hat{C}[x + x^2 + x^3, 1 + x + x^2] = \begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \cdot \diamond$$

REFERENCES

- [1] P. J. Cameron, Permutation codes, European Journal of Combinatorics, vol. 31, no. 2, 2010, pp. 482-490. <https://doi.org/10.1016/j.ejc.2009.03.044>
- [2] W. Chu, C. J. Colbourn, P. Dukes, Constructions for permutation codes in powerline communications, Designs, Codes and Cryptography, vol. 32, no 1-3, 2004, pp. 51-64.
- [3] Y. Fan, Y. Yuan, On self-dual permutation codes, Acta Mathematica Scientia., vol. 28, no. 3, 2008, pp. 633-638. [https://doi.org/10.1016/S02529602\(08\)60065-X](https://doi.org/10.1016/S02529602(08)60065-X)
- [4] H. Tarnanen, Upper bounds on permutation codes via linear programming, European Journal of Combinatorics, vol. 20, no. 1, 1999, pp. 101-114. <https://doi.org/10.1006/eujc.1998.0272>
- [5] Y. Fan, H. Liu, Quasi-cyclic codes of index $1\frac{1}{3}$, IEEE Transactions on Information Theory, vol. 62, no. 11, 2016, pp. 6342 - 6347. <https://doi.org/10.1109/TIT.2016.2602842>
- [6] P. J. Davis, Circulant matrices, AMS Chelsea Publishing, 1994.
- [7] I. Kra, S. Simanca, On circulant matrices, Notices of the American Mathematical Society, vol. 59, no. 3, 2012, pp. 369-377.



PREPROCESSING IMAGE DATA FOR DEEP LEARNING

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Abstract:

Neural networks require big amount of input data in order to be properly trained, and the output and its accuracy depend on the quality of the input dataset. Most of the images used to train these networks either contain too much or not enough information, and therefore need to be preprocessed so as to reduce or even remove the noise from them, extract useful information and remove the useless ones, or apply other techniques that improve input quality for a neural network, such as super-resolution. With suitable input provided, it will be possible to create prediction models with higher precision and better accuracy. This paper gives an overview of state-of-the-art techniques for image preprocessing for different convolutional neural networks, and describes an application that demonstrates one of them.

Keywords:

deep neural network, image preparation, super-resolution, noise removal.

INTRODUCTION

Given the fact that the amount of image and video data that is being generated and used on a daily basis is increasing, the need for better and more efficient techniques for image manipulations is also increasing. Recent developments in the field of image processing have led to a renewed interest in neural networks. One subset of neural networks called Convolutional Neural Network is particularly interesting in the area of image processing because it gives a new approach in understanding image data. Since it is very hard to determine all functions that should be performed over the input images so as to extract useful information, the new idea appeared where those functions could be determined by the neural network itself. This cannot be done with a small number of layers in traditional neural networks because of the complexity of the functions that must be represented; there is a need for additional layers in the neural network. That is how the idea of deep neural networks was born.

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It was shown later that deep neural networks can even outperform regular neural networks in many domains. Nowadays, thanks to the development related to the hardware, both the field of neural and deep neural networks is emerging and new and improved standards in network architectures are being generated continuously. Many of them are tailored to the needs of image processing. However, this is still an open challenge. In order to improve the performance of neural networks, including deep neural networks, additional preprocessing of the input images is required. On one hand, various types of the input data, especially images, contain certain amount of useless data and in order to achieve better performances this information should be removed. On the other hand, instead of removing information, there could be a need to add certain information to the input data. For example, it is possible to combine multiple input images to produce one, more detailed one, as it is done in super-resolution. The scenario when this is appropriate solution is when the frame extraction is performed over an input video and none of the extracted frames contains the crucial information, but some of them together contain some interpretation that could be used. In this manner, it is possible to create a good input from a combination of different data that can be marked as non-complete. Various preprocessing techniques can be used to advance the input data for the neural network, from basic operations such as blur, sharpen, erosion and dilatation, to more complex ones that are tested and developed for other purposes, such as processing of medical and microscopy imagery.

This paper gives a brief overview of some of the state of the art techniques that could be performed in order to provide better input for deep neural networks (DNN). Furthermore, it describes one of the mentioned techniques and presents its implementation as well as the obtained results. The remainder of this paper is organized as follows. Section one gives an overview of the related papers. Section two describes some of the techniques for image preprocessing that can be used on input images for neural networks. Section three describes the developed application and shows the results in form of the resulting images. Section four concludes the paper.

1. RELATED WORK

Image preprocessing often includes morphological operations such as opening and closing. Paper [1] gives an example where these two techniques are used to preprocess astronomical images so as to identify rings,

fronts and sunspots. Morphological image processing techniques among which are erosion and dilation are described in [2]. This paper also gives appropriate examples of when any of the techniques is a good choice to make. Different techniques for image reconstruction methods for structured illumination microscopy are presented in [3], such as scaled subtraction, Bayesian estimation and square-law detection. It also shows the results of the algorithms for different evaluating criterias. Paper [4] gives an overview of a super resolution by a factor of two algorithms with the use of spatially structured illumination in a wide-field fluorescence microscope. It describes how to extract high-resolution information from an image that can't be normally processed and gives an overview why is this method better than using conventional or confocal microscopes. The presented algorithm can be modified and applied to the wide range of images so as to enhance them. Deep learning can be used to augment microscopy images. Techniques such as super resolution can reduce the number of raw images required for an input. In [5] it is described how SR-SIM algorithm can be used in deep neural networks with low light images that are forwarded to the network input and by using deep neural networks for augmentation to provide enough input data for super-resolution with structured illumination microscopy. Paper [6] also describes concepts of SR_SIM algorithm but gives an overview of an open-source plugin called fairSIM which uses ImageJ and demonstrates how this algorithm actually works. Super resolution with SIM is most commonly used in terms of medical images, including the imaging of the living brain [7]. The mentioned algorithm can be used in brain imaging in vivo since it can give an insight that can't be given with conventional microscopy. It shows the results of the algorithm performed over the brains of live zebrafish larvae and mice.

2. IMAGE DATA PREPROCESSING

Improving input data quality for neural networks can highly contribute to better prediction results and higher accuracy, which are the main goals when using any kind of neural networks. Some of the techniques that can be used for image data preprocessing for the purpose of improving inputs for neural networks are erosion, dilation, opening, closing and super-resolution. Erosion and dilation are two fundamental morphological operations. Firstly, they were used only over binary images and later on grayscale images. Binary image is actually a matrix containing only 1's and 0's.



Erosion operation has two input arguments – one is the picture over which the erosion will be applied and the second is structuring element, or kernel. Kernel is a set of pixels that define what will be the effect of the operation over given image. Erosion calculates local minimum in each area affected by the kernel. Since dark pixels are represented with 0, if the region overlapping with kernel contains at least one 0 it will be forwarded to the output. Simulation of erosion could be as follows: With input image I and kernel C, resulting image will be actually the result of logical operator AND performed over I and C in each iteration given that matrix traversal is with constant offset either row wise or column wise. The purpose of this is to remove thin links between components and object bulges. This can be used when processing medical images which show a plenty of connected cells and almost always is necessary to detect which are actually connected and which only appear to be connected. In order to show how different operations affect image, we use a basic image drawn in Paint (Fig.1.). The effect of erosion is shown in Fig. 2a, where it can be seen that operation removed the link between two squares and the edges of a square became thinner. The used kernel is ellipse with dimensions (5,5). Unlike erosion which detects local minimum, dilation detects local maximum. It has the same input arguments as erosion, but here the output is the result of logical operator OR performed over input image and kernel. The main usage of dilation is when there is a need for filling existing holes in image subset and object enlargement. When kernel is overlapped with image partition, the output is pixel with largest value and this way all pixels that are by chance set to 0 are annulled. For example, it can be used when input image is processed somehow that resulted with irregular object shapes and all object shapes need to be of the regular shape. The result of dilation of previously shown input is given in Fig. 2b. It can be seen that the edges after the dilation are thicker.

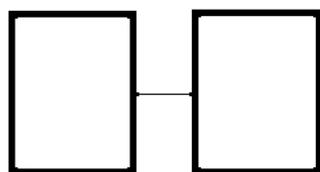


Fig. 1. Input image

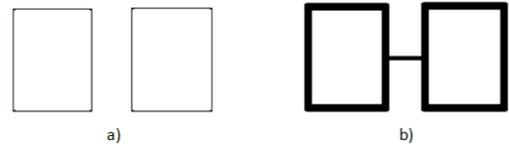


Fig. 2. Resulting image after a) erosion, b) dilation

Combining previously described erosion and dilation it is possible to define some of the most significant operations such as opening and closing. Opening represents erosion followed by dilation with the same structural element. Opening is idempotent operation, reapplying always gives the same result. If input object is some polygon and structuring element circle “rolling around” the edges on the inside of the given polygon. It is used for removing noise since annuls small points that don’t carry any useful information. The result of this morphological operation is shown in Fig. 3a. Since opening is equal to firstly performing erosion followed by dilation expected output is firstly removed edges and after that resulted edges were highlighted. Closing is reverse operation to opening. First, dilation is applied and after that erosion with the same structural element. This is also idempotent operation. It is useful in removing small holes from the inside of the object which is also categorized as noise. This operation can be used when segmentation is needed. Furthermore, when converting image to a binary format, thresholding operation is performed, and based on the thresholding ratio some pixels can be excluded from the result and closing solves this problem. The effect of this operation over given image is shown in Fig. 3b.

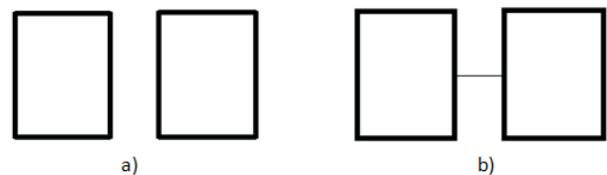


Fig. 3. Resulting image after a) opening, b) closing



Previously described techniques are morphological ones. There are various more complex operations used for image preprocessing that are not morphological. One of them is super-resolution whose main aim is to improve image quality and if possible – extract more information from given input image. A special type of super-resolution called super-resolution with structured illumination microscopy or shortly, SR-SIM is described in [8]. The main idea with this algorithm is to take several low quality images and use them in order to create a new image with better quality and higher resolution. The use of SR-SIM is actually a combination of Moire effects or overlapping large-scale interference patterns. Basic input to the SR-SIM algorithm is an image with specific grid that is overlapped with it and that grid is actually the described pattern. One of the parameters for this algorithm is number of directions which defines how many axes will be used when generating output image. Each direction has 3 images – central image, which is same for every direction and two more that are symmetric to the central one but have different patterns. The output image resolution can be improved maximum twice and that is the case when generated images are sequentially one next to another on given axis. This is done in spectral domain using Fourier transformation. Input images are represented as Fourier specters, their combination is created also in Fourier domain and output image is achieved with inverse Fourier transformation. The actual effects of super-resolution on an image cannot be seen using simple shapes. For that manner, example images for super resolution will be provided in the following section.

Choosing the right enhancement method for an image is not a trivial task – one must take into account the origin of the image, the content and available features, similarity with other images, different types of noise, both spectral and spatial domain, but also the purpose of the enhancement. Each method, if applied correctly and when needed, can significantly improve the outcome of the algorithms that follow, whether they are a neural network or different computer vision algorithms.

3. IMPLEMENTATION

For the purpose of demonstration of the described super-resolution technique, a demo application is created. Entire application was written in python programming language using numpy and OpenCV libraries, and it is a console application as graphical user interface was not needed.

The developed application has five arguments including input image, number of directions, initial phase, radius and center. Input image represents an URI for location of the image that will be processed. Image can be in .jpg or .png format. Number of directions is parameter that, along with the initial phase, defines which parts of the Fourier domain will be taken to create input dataset. Radius and center parameters define a circle that will be taken from the image.

First part of the algorithm creates the input dataset for super resolution algorithm while the second one performs actual resolution enhancements. The first step in part one is to load the input image in grayscale and transform it to Fourier domain. The result will be used for generating multiple images which will be used as an input dataset for the algorithm itself. After switching the input image to Fourier domain, input dataset is generated by specific masking of the input image, meaning that some parts of the spectrum are used and others are not. Which parts of the domain are used is defined with input parameter that determines how many directions will be used. Since all slices are not centered, the next step is to return them to the center of the image. This must be done in order to correctly perform the rest of the algorithm. After the image centering, the next step is to create their combination by putting all the slices to the exact same position from where they were cut. This step is very important because with image centering we achieve the correct shape of grid that basically simulates the moiré effects and by putting them back together we achieve the right results. Finally, it is important to perform inverse Fourier transformation so as to retrieve the output image in spatial domain. Resulting image is a grayscale image.

We tested the application on random image downloaded from the web. The input image and its spectral domain representation are shown in Fig. 4. The number of directions parameter is set to three, phase to zero, radius to 100 while center is equal to the image center (image width/2, image height/2). In this example, there are two slices for each direction and one central slice, as shown in Fig. 5. Not whole specter is necessary since the central part contains most of the information and resulting image can be reconstructed with this tiny part (as brightened the pixel is – the more information contains). Centralized slices are shown in Fig. 6. The result of the inverse Fourier transformation performed on centralized slices is shown in Fig. 7. This step is performed so as to see the actual results of these transformations. Since inverse Fourier transformation returns two-channel signal it couldn't be saved locally as it is, both real and imaginary parts were used to create a magnitude



which has only one channel and in this form it is possible to save it directly to hard drive. This was achieved with the use of built in function from OpenCV. Each of the next steps uses the appropriate two-channel inputs. The next phase is to combine slices, again in Fourier domain. The result is shown in Fig. 8. The resulting image in spatial domain is shown in Fig. 9.



Fig. 4. The original image, found on <https://wallpapersafari.com/w/jYg9w6> and the same image in spectral domain

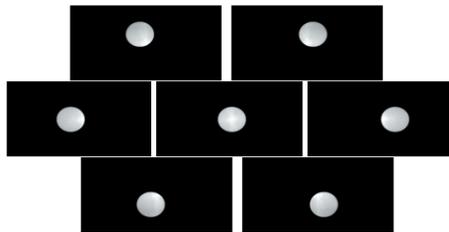


Fig. 5. Slices of the image in spectral domain

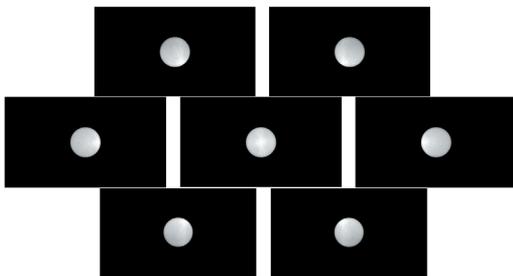


Fig. 6. Centralized slices of the image in spectral domain

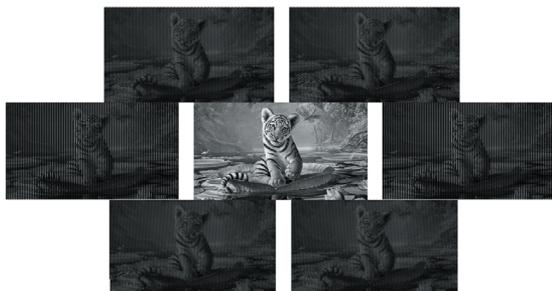


Fig. 7. Centralized slices of the image in spatial domain

As it can be seen from the provided figures, implemented application demonstrates each step in SR_SIM algorithm, and it shows its effect on a random image. It is a technique that imitates the process in which a grid pattern is generated through interference of diffraction orders and superimposed on the specimen while capturing images. The grid pattern originally is shifted or rotated in steps between the capture of each image set. The artificially created grid allows us to extract information from the raw image by creating the resulting image that has a lateral resolution approximately twice that of the original image. Maximal enhancement that can be achieved with this algorithm related to the output image resolution is 2x. The main reason for this is the fact that maximal distance the slices can be moved while creating the grid is equal to the half of the radius of the chosen circle.

However, as it can be seen from resulting image, the brightness and contrast are not the best. Although this would not affect the behavior of neural networks when trained with similar input, in order to present the actual improvements that the super resolution filter can bring, it is necessary to perform a postprocessing filtering. The basic method for improving contrast in images is called histogram equalization which increases the global contrast of the image. Improved method, named adaptive histogram equalization computes different histograms for different sections of the image so as to redistribute the lightness values of the image. However, if an image consists of relatively homogenous regions, it can over-amplify existing noise. This can be solved by limiting the actual amplification. This variant of the algorithm is called contrast limited adaptive histogram equalization. We have chosen this algorithm as a postprocessing step which is performed after SR_SI algorithm. The resulting image is shown in Fig.10.

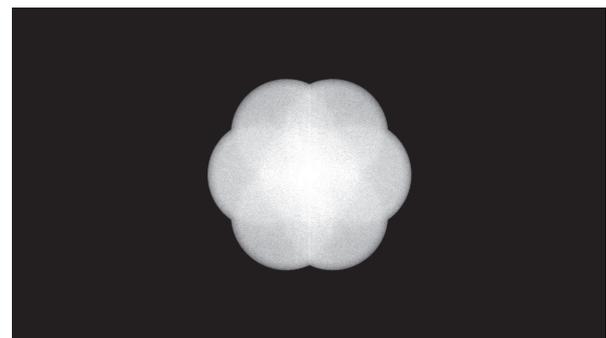


Fig. 8. Resulting image in spectral domain



Fig. 9. Resulting image in spatial domain



Fig. 10. Resulting image after postprocessing step

4. CONCLUSION

The main aim of this paper is to provide an overview of different techniques for image data preprocessing that is to be used as an input data for convolutional neural networks. Furthermore, one of the techniques, super resolution, is implemented, and obtained results are presented in form of images for each step in the algorithm. Super resolution was chosen because it goes beyond the light diffraction limit and collects high frequency information that can't be detected on input images. The super resolution algorithm is demonstrated for number of directions equal to three, and initial phase equal to zero. In our future work we will focus on the effects of image enhancing and preprocessing steps to the outcome of different neural networks. In that way, we will be able to compare different techniques and their effect on the resulting performance of neural networks.

REFERENCES

- [1] M. Lybanon, S.M. Lea, and S.M. Himes, "Segmentation of diverse image types using opening and closing," *Proceedings of 12th International Conference on Pattern Recognition*, pp. 347-351, 9-13 Oct. 1994.
- [2] G. Megha, "Morphological image processing," *IJCST*, vol. 2, issue. 4, pp. 161-165, 2011.
- [3] L. Tomas, H.M. Guy, K. Pavel, S. Zdenek, F. Karel, and K. Milos, "Comparison of image reconstruction methods for structured illumination microscopy," *Proceedings of SPIE - The International Society for Optical Engineering*, vol. 9129, 2014.
- [4] M. G. L. Gustafsson, "Surpassing the lateral resolution limit by a factor of two using structured illumination microscopy," *Journal of Microscopy*, vol. 198, Pt. 2, pp. 82-87, 2000.
- [5] L. Jin, B. Liu, F. Zhao, S. Hahn, B. Dong, R. Song, T. Elston, Y. Xu, and K. M. Hahn, "Deep learning enables structured illumination microscopy with low light levels and enhanced speed," *Nature Communications*, vol. 11, no.1, 2020.
- [6] M. Müller, M. Viola, H. Simon, H. Wolfgang, and H. Thomas, "Open-source image reconstruction of super-resolution structured illumination microscopy data in ImageJ," *Nature Communications*, vol. 7, pp. 1-6, 2016.
- [7] T. Raphaël, L. Yajie, T. Masashi, Z. Qinrong, L. Ziwei, K. Minoru, B. Eric, and L. Na, "Dynamic super-resolution structured illumination imaging in the living brain," *Proceedings of the National Academy of Sciences*, vol. 116, no. 19, pp. 9586-9591, 2019.
- [8] H. Rainer, H. Thomas, "Super-resolution structured illumination microscopy," *Chemical Reviews*, vol. 117, no. 23, pp. 13890-13908, 2017.



SINGIBOT - A STUDENT SERVICES CHATBOT

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Abstract:

Singibot is a restful web application with the intent of providing information to the students of Singidunum University. The web application takes advantage of the Spring framework for Java and the communication logic between the human and the bot is built upon the well-known AliceBot that is based on the AIML technology. The long-term goal is to build a self-learning bot that can adapt to evolving students' requests. In this iteration, we are presenting a pilot version and the implemented functions for this version are the means to respond to questions regarding the information related to the education at this institution and to carry on an informal conversation. The goal for this version is to provide a service for students that will improve their studying experience and the quality of their studies.

Keywords:

bot, communication, utility, aiml.

INTRODUCTION

The personal experience of the authors and consideration of IT trends [1] birthed the idea to produce a communications solution that can vastly improve the quality of the studies at Singidunum University. The vision is to simplify in fullness the administrative requirements for the students in terms of providing unambiguous instructions and information regarding the higher education, before admission and during the studies. The questions presented to Singibot can regard the institution, professors, length of studies, career options, working hours, tuition, academic calendar, etc. Singibot's interface consists of a chat dialog in which the user types their message in English, and after sending it they are presented with a response based on the matched pattern. It was first decided to produce an English version of the chatbot out of the priority to accommodate the requests of the foreign students. Singidunum University offers studies in Serbian and in English and due to these two official versions of the institution's website exist in these languages. To goal is to ease the burden of a novelty for the foreign and exchange students and to make their experience as fluid and as stress less as possible.

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The familiarity of semi-formal conversation paired with an impression of a well-informed person regarding the higher education facility is the core of this program which is supposed to increase the positive impact on the person from the information learned. Whilst the University's website is designed to provide the information in as simplest way as possible the situation in which an exchange student wanders around it aimlessly in search of certain classes in a particular semester of a specific study program is a hindrance even the top universities cannot pride themselves with avoiding. The complexity and the amount of information on the study programs and the classes are complicating the websites of universities. Websites of universities are required to list all information and make it available but a much better way to present information to the students is through a chatbot. With the use of an AI companion like Singibot, this information can be provided by asking for it. Due to the expensive international calls and the difficulty to speak a foreign language through phone being reserved only for the most well-versed polyglots, the situation in which a foreign student calls the facility to get information is very rare. Even if the student is currently residing in the country of studies besides the mentioned problems, the wait time on calls and the human factor are also parts of this communication that the Singibot tends to eliminate. The version of the bot in the Serbian language is part of the phase three goals, right after integrating a machine learning module.

1. BACKGROUND AND MOTIVATION

Chatbots and AIML

Chatbots as communication solutions are increasing in popularity but there are still some ambiguities regarding the use. The concept itself is not new but the advance of computer technologies and the situational opportunity have pushed these types of programs further. Machine learning proved to be a great combination with Artificial Intelligence Markup Language [2] invented by Richard S. Wallace. The language's data storing format provides a good foundation for building encoders and decoders to manipulate the text patterns that need to be processed with a machine learning algorithm and readable after. The stigma encompassing the use of chatbots is due to a couple of reasons. The main reason being the lack of understanding of the technology. This can be separated into two different branches on the base of the users' expertise. For the non-expert users, it is commonly the problem of comprehending the actions that would

be performed by the bot, therefore this blocks the vision of the benefits that could be brought to them, similar to the problem of a non-expert user employing any other technical solution. When it comes to users with computational expertise the dilemma is if a chatbot can benefit their line of work and how much of an improvement it would contribute. The technical flaw regarding chatbots is the constant need for fine-tuning and adjusting to new data. This is a delicate process because the tweaking process can completely break the application.

Similar solutions

Higher education institutions around the globe are already deploying their chatbots or are having them in the works, independently by students and as university organized startups. The primary use of the chatbots for the university's purposes is an advanced admission procedure. The facilities already exploiting the bots pride themselves with the improved statistic of the number of active students. Student companions, as some universities call them, are psychologically analyzing the students' responses in the conversation and are providing the necessary means to the solution of the given problem. Some of them give examples of their bots at work alike when the student is failing at a certain class, the bot suggests helpful books and tutors if needed. This is possible thanks to the bot having access to students' grades to the bot. This particular case is with the bot named Beacon from Staffordshire University [3]. This is a mobile-based application with four hundred preprogrammed responses and the ability to expand to even more. It is A.I. based and supports voice and text input. The application is able to recommend activities that can positively impact students' experiences throughout their studies and send lecture reminders because it has access to each student's timetable thanks to the login process. When judged by Beacon that a student is in the need of a tutor they get informed by a message consisting of an explanation, contact information to a tutor, and an option to contact the tutor on the student's behalf forwarding the transcript of the conversation to the tutor. This and other institutions reported a decrease of students dropping out due to not being able to pass certain exams [4]. The way in which artificial intelligence is enhancing the bot is by evaluating the students' records and non-invasively offering help. Students responded much better to the suggestions of what was easily recognizable as an A.I. than to students' counselors [5]. Taking out humanity from the conversation makes students feel more comfortable opening up about their insecurities and internal struggles.



This other university's chatbot has recognized this opportunity and took their work further. Lancaster University's chatbot named Ask L.U. [6] can talk to students about tuition, their financial situation, and similar problems. These types of conversations with the bot need to be longer so it can gather more information to act on. The idea is to develop ways to provide coaching questions and to help with anxiety management. The other functionalities of the application are timetable access, tutor recommendation, grade reviews, suggestions for finding a free computer on campus, and even an available washing machine. The bot heavily relies on Amazon's Web Services and is implemented in the university's pre-existing student companion app in the form of a voice interface. AWS CloudWatch, AWS Virtual Private Cloud, and AWS Elastic Search are the technologies that provide logging and enable the fuzzy search. Ask L.U. supports Amazon Alexa and it can be activated through it. Due to the amount of data on the students this chatbot collects it is theoretically capable of assisting students in writing essays based on their personality and previous work. Stanford University has developed a chatbot or rather QuizBot with the main purpose of helping students learn. The dialogue-based agent is designed to assist students in learning by providing an attention-grabbing interface. The app was built to compete with existing flashcard applications and the authors claim that students get 20% more correct answers with the use of QuizBot while admitting that this process is more time consuming but still taking into account that the test subjects were more engaged with the QuizBot, spending longer periods rather than using the generic flashcard app created for the study [7]. The interface of the app is based on Facebook's Messenger in which the user can have a casual conversation or answer questions by typing and clicking on a button to select one of the multiple-choice answers. There are also options for revealing the answer, asking for a hint or an explanation after the wrong answers were submitted or the student gave up. The application sends daily reminders which amongst a custom avatar and the informal conversational tone improve the user's engagement. The students' process of learning benefited from typing up answers in the same way as it would from writing them and the app showed the biggest difference in results when testing the students' knowledge after a longer period, in this case, two months. From Leeds Beckett University's comes a Facebook Messenger based chatbot in the form of a desktop as well as a mobile application. Its main motivation comes from the students' extensive use of social networks for communication like WhatsApp

and Facebook Messenger. The goal of the bot is to help the potential students place in the best course for them through Clearing.

Benefits and impact

Battling students dropping out, retention decrease, and troublesome mental health are the fields in which the most benefit from chatbots can be observed. Their focus is also largely on the financial situations of the students and helping them overcome it. Chatbots are becoming a pedagogical tool soon to be a crucial part of every educational facility. The most impact was detected in the admission period of the school year [8]. Communication with an A.I. medium helps students get a better insight into the coming years of their education. The result of this accomplishment is more satisfied students that are better convinced in the study program that they are choosing. Being a financially low maintenance addition to the online presence of a higher education institution chatbots can bring in the profit that justifies the cost of development. The money and energy saved on the hiring process and maintenance of the human staff that the bot is replacing are also undeniably encouraging the implementation of suchlike solutions. It is argued that the synthetic nature of the bots is actually what lets students relax and openly discuss their problems. Even though the natural assumption would be that the as more humanlike the A.I. is the more advanced it is with this scenario that is not the case. It is speculated that the impact was as big as it is because the students better responded to a service knowing that it is not human [9]. The robots that talked to them can be credited for not judging them and even ridiculing them for some trivial problems a human being would consider ridiculous. Acknowledging there are chatbots capable of consideration of serious problems that the education staff needs to be notified of, it is easier for students to confess to A.I. chatbot. The impacts and benefits to mental health should not be overlooked and in the current times, that seems to be the topic for improvement of human performance.

2. METHODS USED AND FUNCTIONALITIES

Methods

Singibot is a chatbot developed in the Spring framework for Java. This framework was the authors' choice for the reasons of straightforward restful development, support of dependency injection that also facilitated library integration needed to run the AIML interpreter,



layered architecture allowing modularity, and most of all Spring's supportiveness of web applications. Singibot is a restful web application that uses STOMP (Simple Text-orientated Messaging Protocol) to send and receive messages in the chat window. The model component of the program is a class able to send and receive messages through the protocol, and it has the AIML interpreter component extracted and modified from AliceBot and it heavily relies on the AB library from the same program by Richard S. Wallace. The interpreter was modified in a way to accept string input extracted from a STOMP message instead of an array of strings. The class returns a string output that is written out in the chat field in the form of a response from another user. The controller is simple and contains two mappings for two types of messages the application is programmed to receive. When the user opens up the application, they are asked for the name which is stored and later accessible. This is a register type message that stores the username in its header and it activates a welcome message in a different font style than the other messages in the chat upon opening the chat. Send is the second and final type of a message the program recognizes and it is forwarding a class type that is representing a chat message as an object. This object contains the message itself and the metadata needed for the program to function properly. The front end of the application is basic HTML, CSS, and JS without using any of the popular front end frameworks which does not mean that in the future that will not be the case.

Functionalities

Every time the application is started the user is greeted with a dialog box that informs them of the action needed from them that is to enter the username and press a button to advance to the chatting window. This is the only message of register type and is initiated by pressing the button. The username is then stored and used to sign messages in the sender field which application uses to identify them. There are only two types of message senders and those are the human that has entered their username for the being of the session and the bot with the response logic behind. The welcome screen can be seen in Figure 1.

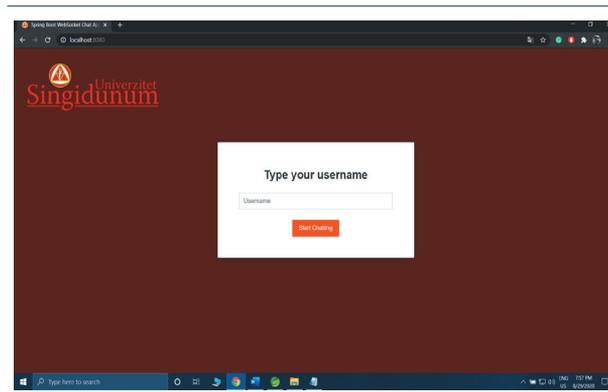


Fig. 1. Example of a welcome screen.

With every username, there is a color assigned to their avatar that is determined by the capital letter of their name. Figure 2 is depicting an example of a basic greeting and response from the bot. The color assigned for the test name "Student" and its capital letter, in this case, was a slightly different shade of red from the Singibot's color is of the Singidunum's shade of red. The bot possesses various ways of greeting and this is an example of the basic response. The function returns, in this case, the plain text which is surrounded by the conversation participant's icon and username. The importance of casual conversational abilities is paramount for the users' experience as proven from similar projects talked about in the first chapter. To rephrase, every successful solution recognized the need for an option for informal conversation, it being for relaxation periods of studying, if that was the bot's purpose, or simply humanizing the process of getting information from an artificial intelligence agent. On the contrary, the bot should not replicate human behavior too much as it decreases the effectivity of information providing due to the distractions that humans are inclined to. The user should be aware that they are talking to artificial intelligence and it should provide them with information on how it is programmed to accept and process data.

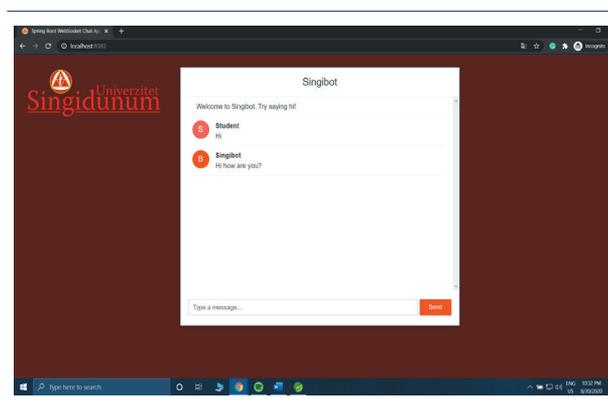


Fig. 2. Start of a conversation.



Singibot is capable of returning live links when necessary as shown in the case in Figure 3. The link is not organically forwarded but rather later surrounded by HTML link tags through a JavaScript function. This is also an example of the robustness of Singibot's pattern recognition. The bot will respond identically to the two different user inputs that are both asking the same thing. Considering the fact there is a large number of combinations to ask the same question this program was designed to cover most of them if not all of them in some cases. The pattern recognition part will massively benefit from the implementation of machine learning as more talked about in the third chapter. The forwarded link in a different style from the chat message in this instance and clicking on it will take the user to the international Singidunum University site to the page where the professors' biographies with pictures and all of their science work can be seen. By providing this type of information students' experience is closer to the goal mentioned in the introductory chapter, familiarizing students with the teaching staff giving them better insight into what their studies will look like.

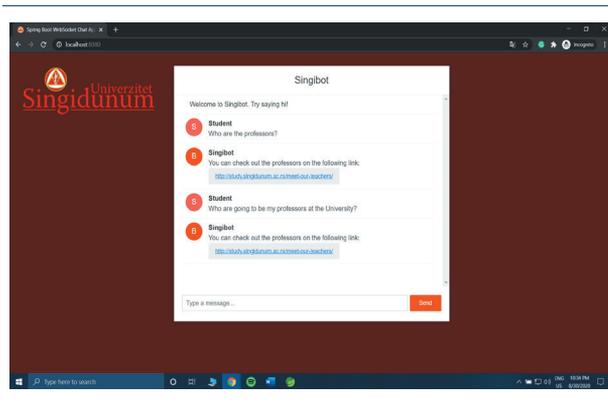


Fig. 3. Different input recognition.

Besides different student messages, the bot itself is capable of returning different responses based on a random factor that is leaving a place for improvement in phase three of the software's development. Figure 4 is depicting such behavior as the student asks in three different ways to see the website of the University and the robot responds in different ways unrelated to the difference in asking the question but to what was the context of the question. This is further improving the user's engagement as the Singibot is heavily relying on the University's website. The main function is to provide critical information faster and easier. The questions regarding this information can be various from the number of years a study program takes to what are

the working hours. Singibot can respond to these basic question and that is fundamental for the implementation of future functions. Singibot is currently capable of casual conversation and returning the most important information on the higher education facility that it was built for. The application is usable in its current state but there will be more word on the future work in the following chapter.

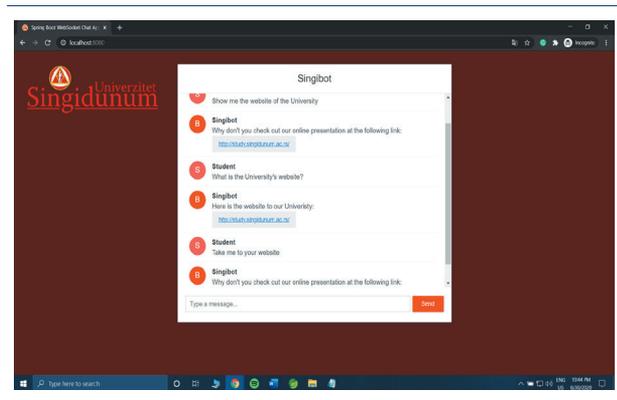


Fig. 4. Different responses and inputs.

3. THE FUTURE

Phase three

The currently concluding phase in the plans for the Singibot consists of implementing advanced conversational abilities, a bigger database of replies and a machine-learning algorithm to further enhance those replies and to give the program the A.I. perspective. Various solutions are being considered and even rewriting the program in Python, since its currently the leading language for machine learning, is considered an option. The chatterbots mentioned in the first chapter of this paper almost without an exception implement some sort of a learning algorithm that fortifies those creations. This is the idea the authors have for this creation also and the one presented in the paper is a pilot version to worked on in the future. It is planned to add functionality to contact a professor directly through the Singibot or put in other words to enable Singibot to contact a professor for the user. This can prove to be very useful while requesting to see a timetable of the professor's office hours to prompt the user to forward the transcript of the conversation between the student and Singibot. Professors will be getting an insight into the thought process of the student and it will make it possible for them to better understand the kind of help the student



is in the need of. Avoidance of repeating the same conversation is also a productivity gain. Sometimes a point is not getting through an elaborate email because of the boundaries of formalities and the individuals' inability to stay within them while clearly explaining the reason for contacting a certain professor. Students should be able to contact the students' services directly through Singibot in the same manner as they will be able to contact professors. The improvements the authors believe will be observable by fulfilling the future goals for machine learning are to enhance pattern recognition and to capacitate the bot for learning new patterns and the responses to them. The effectiveness of creating a pure hardcoded response bot can be very small if not put to good use but that does not discredit the one that is currently available. Even though the limitations are obvious the Singibot is a solution for itself and it is completely usable as-is.

4. CONCLUSION

Singibot is a simple chatbot with a lot of space for improvement which is intended for its lifetime. The ideals of the creators are to create a support system for students that will benefit the students in the first place and after that a solution that is profitable and sustainable. Looking back on the costs and effort needed for development it is clear that the profitability equation still stands and this eliminates the excuse for not developing these types of solutions by the higher education institutions that students trust to teach the fundamentals of the matters their studying and to prepare them for a prospective career. The way the Singibot tends to improve the students' experience at this facility is through an attempt to reduce social anxiety new students experience while having to call the students' services for information. Many of the students never do that out of the said anxiety and rather stay misinformed instead for example walking into the students' services cabinet and asking those questions in person. The second most important benefit of Singibot are the results of better informed students and those are students that are successfully finishing their studies, reduced staff costs, and a better online presence of the University. Having generations that have grown up with modern technology holds some disadvantages that can be easily removed by confronting the problem in this way since the root of the problem is deeply buried in the way parents raise their kids. It was shown that the younger generations rather prefer texting than talking for which the proof is the phone com-

pany operators giving more free minutes per post-paid package and more messages because most of the phone traffic is online through social communication networks and social networks. Most of the traffic the phone operators profit on is the data that is the consequence of the always-online lifestyle. These problems were all taken into consideration before the development process of the Singibot began. The idea is to make a difference no matter how small it is perceived as by the first look.

REFERENCES

- [1] B. R. Ranoliya, N. Raghuvanshi and S. Singh, "Chatbot for university related FAQs," 2017 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Udupi, 2017, pp. 1525-1530.
- [2] R.S. Wallace, "The Anatomy of A.L.I.C.E.," Epstein R., Roberts G., Beber G. (eds) Parsing the Turing Test. Springer, Dordrecht, 2009.
- [3] C. Robinson, "Impressions of viability: how current enrollment management personnel and former students perceive the implementation of a chatbot focused on student financial communication," The University of Southern Mississippi The Aquila Digital Community, higher education doctoral projects, Spring 2019.
- [4] M. T. Nietzel, "How Colleges Are Using Chatbots To Improve Student Retention," Forbes, March 2020.
- [5] R. Winkler, M. Söllner, "Unleashing the Potential of Chatbots in Education: A State-Of-The-Art Analysis," Academy of Management Annual Meeting (AOM) Chicago, USA., 2018.
- [6] A. Mari, "Lancaster University enhances student engagement with cloud-based chatbot, Computer Weekly, blog, 12. April 2019.

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