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University of Information Science and Technology “St. Paul the Apostle” – Ohrid, Macedonia

Technical University of Varna, Bulgaria

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An Overview of Local Approach for Time Series Analysis and Prediction

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Abstract—The most commonly used methods to forecast time series is to build a mathematical model based on the available information for the process to be modeled. In this paper the details and characteristics are examined of the local approach for univariate time series prediction based on historical data. The local modeling is presented as an improvement of the traditional global approach and as future work a hierarchical structure is shortly considered.

Keywords—Local models, time series, forecasting, prediction

I. INTRODUCTION

Time series prediction is important in many fields of human activity. It is important because people want to take informed decisions and the predictions provide precious information for the behavior and trend direction of the development of the process under consideration. Even that the predictions could not come true they can be successfully used for analysis of the development of the given process in the past and facilitate taking proper and explained decisions. The prediction is important not only for the theory but also of the practical point of view. The concept for the investment for example is overall based on prediction. The task here is to overview the local approach for time series prediction based on different local prediction models.

The time series is defined as a sequence of observations x_t , $t = 1, 2, \dots, n$ ordered in time or space [1]. The values of the time series x_1, x_2, \dots, x_t are called real or measured values (observations), and $x_{t+1}, x_{t+2}, \dots, x_{t+s}$ are predicted (or forecasted) values, where s is prediction time horizon. The aim of time series prediction is using and analyzing the values x_1, x_2, \dots, x_t , to determine x_{t+k} , $k = 1, 2, \dots, s$. The prediction x_{t+k} , produced in moment $t + k - 1$, is denoted as \hat{x}_k and it is an approximate estimation of the value x_k .

$$\hat{x}_k = x_k + \varepsilon \quad (1)$$

where ε is error.

This kind of prediction is called univariate or single factor prediction and in order to determine \hat{x}_k only the historical values of the time series are used. This kind of prediction is especially important mainly in the modelling of processes in

which a causal connection of the values in the time exists. It is widely used especially in cases where the influencing factors are hardly identified or measured.

Here the models work based on data obtained from the time series by the “sliding window” [2]. The models can be both linear and non-linear, each working with its own group of similar subseries. These models are called local, because each of them is built and works with local sub-space of all available data values [3] [4]. The union of all local models here is called compound (or global compound) model.

The model for prediction built from the available observations could be considered as assessment $\hat{f}(x)$ of an unknown function $f(x)$. In the local approach the space of the unknown values x is separated in local sub-spaces and for every sub-space a model is built, so that the whole function is represented as a union of the local models (or functions).

A variety of models could be used as local models, including some hybrid systems. The separation of the data can also be done by different techniques but here should be taken into account that in practical realization this separation causes some additional time delay.

In time series prediction methods, the model building is mainly based on the assumption that a given sequence of values causes a given next value as an outcome. The interpretation of the operation is “if the sequence of the last p values is $x_{i+1}, x_{i+2}, \dots, x_{i+p}$ then the next value will be x_{i+p+1} ”. Taking this assumption should also consider that if in another place of the available data, another subsequence $x_{j+1}, x_{j+2}, \dots, x_{j+p}$ exists, similar enough, according to a given measurement criterion, to the sequence $x_{i+1}, x_{i+2}, \dots, x_{i+p}$, and the value x_{j+p+1} is very different than x_{i+p+1} then in the prediction stage a value near to the average of x_{j+p+1} and x_{i+p+1} should be taken. Thus having a local space of these similar subsequences a specific model can be used according to the details of the data sub-space.

Some of the disadvantages of the global model versus local models are as follows.

- In case of adding new or removing old data the whole model must be reset and changed;
- If the time series consists of too many values then more complex model should be used which makes its using more difficult;

- The global model is often considered as a black box, it is difficult to be understood;
- If the model needs some validation data, most often it is obtained from the end of the time series and these last values are not used for the model identification stage.

Instead of using of complex global model, simpler local models are considered here.

II. THE PROPOSED LOCAL MODELS APPROACH

The predicted value \hat{x}_k is generated by a model f taking into account the last l time series values (model order) and m model parameters.

$$\hat{x}_k = f(x_{k-1}, x_{k-2}, \dots, x_{k-l}, \varphi_1, \varphi_2, \dots, \varphi_m) \quad (2)$$

Here $x_{k-1}, x_{k-2}, \dots, x_{k-l}$ are either available from the given time series proceeding the moment k , or partially or overall predicted values after the point k . In order to determine the model parameters φ_i however the model parameters identification must be done. This identification varies depending of the model type. For example, in the autoregressive models these parameters can be achieved by least squares [5], Yule-Walker equations [6], Burg's algorithm [5] or some other method. In case of neural network model, the parameters are the weights of connections between the neurons and they could be computed using either batch or iterative training [7]. The batch training could be considered as non-linear autoregressive model parameters identification. In the iterative training the model is modified at each epoch converging to the desired (trained) state [8]. Generally, the batch training is faster but the iterative learning allows some modifications of the learning rules.

In order to identify the model parameters the available time series data should be organized in a way needed for the desired model. There are generally two approaches to do this: using a "time window" or a "tapped delay line" [8]. When the former is used it could be "sliding time window" or "rolling time window" and when the latter is considered it is similar to the sliding window with some additional extensions. The time window is moved/rolled through the time series and the values in the series at each step are the input-output vectors used to identify the model parameters. The size of the sliding window as well as the dimensions of the input and output vectors are generally determined by a variety of heuristics. One of the most reliable methods is analyzing autocorrelation and partial autocorrelation functions of the time series, similarly to the Box-Jenkins methodology [5] for identification of ARMA models [6], but there are also alternatives like the "brute force" method (the most inefficient method according to the time consumption), Akaike criterion, Schwarz criterion (also known as the Bayesian information criterion), etc.

When the size of the window is determined the next step is to identify the model parameters which depend on the model type. Additionally, as it was mentioned earlier, the model building is not quite accurate and it should be validated. This is done by predicting values in a time period for which there are available observations and comparing them using some error measuring criteria [1][2]. This step may also be performed in the time of the iterative model identification, thus allowing taking into account the computed error in the identification process. After the parameters identification and validation, the model is ready to predict. The most recent values of the time series are used as input vector and the model generates the output vector that is a sequence of predictions.

This approach can be further developed by grouping the sub-series (input-output vectors) in local groups similarly to the divide-and-conqueror algorithms and for every group a different forecasting model could be build. Taking into account that the most difficult and time-consuming stage is the model parameters identification the grouping of the sub-series will facilitate this stage allowing a parallel implementation. Moreover, breaking the problem of the parameters identification into sub-problems of the same type, allows additional control and freedom to choose many more modifications and improvements of the general algorithm. The idea behind the sub-series grouping is similar in some sense to the concept of the Self-Exciting Threshold Auto Regressive (SETAR) method [9] in which a set of different autoregressive models is used according to the regime changed by the time series values.

In the local modeling the recursive prediction is performed as follows. In moment k the values $x_{k-1}, x_{k-2}, \dots, x_{k-l}$ are taken and classified in the group f_j which becomes the active group in current step (activated group or activated cluster). The values $x_{k-1}, x_{k-2}, \dots, x_{k-l}$ and the parameters of model f_j are used to generate the first prediction \hat{x}_k according to (2). In the next step the values $\hat{x}_k, x_{k-1}, \dots, x_{k-l+1}$ are classified to model f_q , that can be the same or different from f_j , and it generates the next prediction \hat{x}_{k+1} and so on until s values are predicted. The classification of the last values can be done using different criteria for measuring distance between vectors, as in our case the last subseries is compared to all cluster centers and the closest one is chosen. This method for time series prediction is called local iterative prediction.

In practical solutions the time series must be pre-processed before the training of the model in order to remove some trend and seasonality and to transform it into the range of the allowed model values. Transformation coefficients are used for this purpose like scale and shift [10] which must be used after generating the predictions to transform them back to the original range. These transformations can also vary according to the specific characteristics of the local model.

III. CLUSTERING

With incorporating the grouping stage some problems arise. First of all the grouping (clustering) algorithm should be chosen. Iterative algorithms like K-means [11] and Self-organizing map [12] [13] are commonly used for the local modeling

Some other algorithms [14] like hierarchical clustering (with a variety of criteria for clusters merging as the Ward's method, average linkage, etc.), Iterative Self Organizing Data Analysis Techniques (ISODATA), Adaptive Resonance Theory (ART) [15], etc. could also be used although the most of them need more parameters to be adjusted in order to work properly. Another important question is in how many groups the training patterns to be clustered. There is not a reliable method, for all situations and all kinds of data, for determining the number of groups when clustering is performed. There is so called "Rule of thumb" but it could only be used to direct the efforts toward the supposed optimal number of clusters. Instead, performing clustering in k clusters where $k=1,2,\dots,r$ and calculating a criterion for clustering quality is better to be used. The clustering quality could be within or between cluster distances, cluster variances, R-squared, adjusted R-squared or some other indicators [16]. When this approach is used the chosen indicator is presented as a function of the number of clusters and the point in which the marginal gain of this function (error) drops, should be considered as an optimal number of clusters. For example, the sequence of errors (computed as $1-\text{AdjRsquared}$) 0,212 0,115 0,072 0,065 0,064 shows that the number of clusters should be the one corresponding to the third value 0,072 because it is the end of the sharp drop.

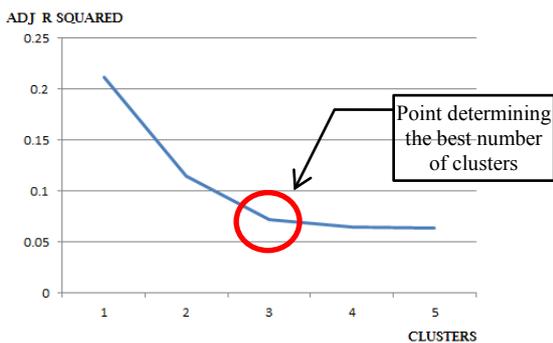


Figure 1. Determining the optimal number of clusters

The separation of the data space into sub-spaces must be done using as fast method as possible in the practical solutions. This stage is considered as a preparation stage and trade-off must be done between the speed and accuracy. There are different criteria that can be considered for this purpose [16].

IV. IDENTIFICATION OF LOCAL MODELS PARAMETERS VALUES

Each model should work with sequences associated to other sequences:

$$\begin{aligned}
 X_{11}, X_{12}, \dots, X_{1l} &\rightarrow Y_1 \\
 X_{21}, X_{22}, \dots, X_{2l} &\rightarrow Y_2 \\
 \dots & \\
 X_{m1}, X_{m2}, \dots, X_{ml} &\rightarrow Y_m
 \end{aligned}
 \tag{5}$$

In the general case the second sequences comprises of arbitrary number of values but in the case of time series prediction considered here they consist of only one value each. All these input-output sub-sequences are obtained by the sliding time-window approach. The model parameters should be identified such that passing the input values x through the model, values as close as possible to y should be produced. The number of model parameters may be different from l and they can be identified in a way according to the model specifics.

Separation of the whole data into such input-output sub-sequences of groups leads to the following advantages of the compound model:

- Possibilities for parallel model identification in distributed hardware and software environment;
- Possibility for more detailed analysis of some specific sub-spaces of input data. After separating groups such sub-spaces can be found easier. For example, according to the details of the task under consideration, an analysis of the events could be done, preceding some financial crises or machine damages and prediction with different approaches could be performed with further comparison, combination of different approaches, etc.;
- Every local model is processed in the same way, which allows better control to be done not depending on the time series size;
- Easier interpretation of the work of the local models compared to the global model. Possibility of following the positions and characteristics of the activating groups with their centers, dispersion, frequency of activation, spatial trajectory of the activating groups in the subsequent steps, etc.;
- In case of adding new data or removing some parts of the existing data, changes are made only in corresponding local model, but the others stay unchanged;
- Possibilities for using different kind of model for every group. Also, for some groups linear and for the others non-linear models can be applied;
- Possibility for additional separation of the groups in smaller sub-groups. Thus, a hierarchical structure can be built and complex compound models can be introduced.

The compound model also has disadvantages, some of the most important of which are the following:

the compound model. That is why it is needed to coordinate the number of the clusters with the expected size of the prediction time horizon. The less the number of the cluster is the more probable is each one of them to be activated and the longer the prediction horizon is the more probable is the subsequence of the last values to be classified to all groups in the process of the recursive prediction. If for example prediction of only three values is needed it is not reasonable to separate the input data in four groups and to build a separate model for each group because it is sure that there will be at least one not activated group. The number of the groups must be less than the number of the points in the prediction time horizon. Thus, if every local model is activated approximately equal number of times this would lead to better model adequacy.

VI. CONCLUSIONS AND FUTURE WORK

The proposed approach is developed and considered step by step with detailed analysis. Although it is more flexible compared to the traditional approaches there are some disadvantages as well. First of all, when grouping (clustering) is performed in the forecasting stage the models associated to the groups might be irregularly activated. This means that some of them may never be activated and the data in the corresponding group is not used at all. Moreover, the validation and testing of the algorithm is not as easy as when the entire data is in one group.

A further development of the proposed method could also be that a complex structure to be developed as hierarchical local models in which the data grouped data to be grouped again in another hierarchical level and other models to be used for the subgroups. This is a promising approach that needs further analysis and investigation.

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Comparative Analysis of Algorithms for Classification of Text in the Bulgarian Language in Machine Learning

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Abstract — The topic of the publication is the research and comparative analysis of algorithms for the classification of text in the Bulgarian language using Machine Learning methods. The algorithms examined are: naive bayes classifier, multinomial bayes classifier, C4.5, k-nearest neighbours, support vectors with optimization. The results are depicted analytically and graphically, and show that with 2 classes or fewer, and a low volume of data support vectors and C4.5 give the highest results. If the number of classes are doubled, the naive bayes classifier and the multinomial bayes classifier give similar results and are ahead of the other results. Running the algorithms with 20 or more classes results in poor accuracy scores across the board. The best performers with circa 55% are the naive Bayes classifier and support vectors with optimizing. The lowest accuracy is obtained from k-nearest neighbours.

Keywords- naive Bayes classifier, multinomial Bayes classifier, k-nearest neighbours, support vectors with optimization, C4.5 (J48), text classifying, machine learning

I. INTRODUCTION

In recent years, thanks to the ease of internet access, a vast amount of data has accumulated in various knowledge repositories. These resources become useless if it is not possible to obtain up-to-date and useful information on a particular topic. The use of classification allows you to shorten the time required to search for the necessary information presented as electronic texts.

Formal definition of the classification task:

Let:

- $X \in R^n$ – a set of objects (input)
- $Y \in R$ – a set of results (output)

We will look at the pair (x, y) as a realization of $(n + 1)$ - dimensional random variables (X, Y) set in probability space.

The distribution law $P_{XY}(x,y)$ is not known, all we have is a training set:

$$\{x^{(1)}, y^{(1)}, x^{(2)}, y^{(2)}, \dots, x^{(N)}, y^{(N)}\} \quad (1)$$

where $(x^{(i)}, y^{(i)})$, $i = 1, 2, \dots, N$ are independent.

The goal is to find the function $f: X \rightarrow Y$, which by using the values of x , can predict y . We call the function f a decision function or a classifier. [2]

In other words, the formal definition of the task of classifying a text can be shown thusly: Let there be a set of

classes $C = \{c_1, c_2, \dots, c_k\}$ and a set of set of documents $D = \{d_1, d_2, \dots, d_k\}$. The end function $f: D \times C \rightarrow \{0, 1\}$ for every pair $\langle \text{document}, \text{class} \rangle$ is unknown. We need to find a classifier f' , i.e. a function as close as possible to the function f . [1]

A primary goal in the classification of text using a set of features. Traditionally, the frequency of number of words is used for that goal.

II. EXPOSITION

A. Naive Bayes classifier

One of the classical algorithms in machine learning is the Naive Bayes Classifier, which is based on the Bayes theorem for determining the a posteriori probability of an event occurring. Assuming the "naive" assumption of conditional independence between each pair of attributes, the Naive Bayes classifier deals effectively with the problem of having too many features, i.e. the so-called "Curse of dimensionality".

Bayes' Theorem [5]

$$P(y = c | x) = \frac{P(x|y=c)P(y=c)}{P(x)} \quad (2)$$

where:

$P(y=c|x)$ is the probability for an object x to belong to a class C (a posteriori probability)

$P(x|y=c)$ – class conditional density

$P(y=c)$ – class prior

$P(x)$ – unconditional probability of x

The purpose of the classification is to determine the class to which the object x belongs. Therefore, it is necessary to find the probabilistic class of the object x , i.e. it is necessary to choose the one that gives the maximum probability $P(y = c | x)$.

$$c_{opt} = \arg \max_{c \in C} P(x|y = c)P(y = c) \quad (3)$$

B. Multinomial Bayes Classifier

The multinomial Bayes classifier makes the assumption that the features are distributed multinomially.

Let $x_i \in \{1, \dots, K\}$, have emission probabilities $\theta_1, \dots, \theta_K$ [7]

Then, the probability for an event x to occur when θ is given is:

$$P(x|\theta) = \frac{n!}{x_1! \dots x_K!} \prod_{i=1}^K \theta_i^{x_i} \quad (4)$$

$$\text{where: } n = \sum_{i=1}^K x_i \quad (5)$$

The multinomial Bayes classifier calculates the frequency of occurrence of each word in the documents. Again, a naive assumption is made that the likelihood that a word will occur in the text is independent of the context and the position of the word in the document. [6]

C. K-nearest neighbours – KNN

The K-nearest neighbours algorithm is an object classification algorithm that calculates the distance between each pair of objects from the training set, by using an appropriate function to measure the distance between the two points. The algorithm uses a majority vote of the k nearest neighbours of the object to classify it.

Function for measuring distance:

Euclidean

$$\rho(x_i, x_j) = \sqrt{\sum_{k=1}^m w_k} \quad (6)$$

where:

$x_i = (x_i^{(1)}, x_i^{(2)}, \dots, x_i^{(m)})$ – vector of m-features of the i-th object

$x_j = (x_j^{(1)}, x_j^{(2)}, \dots, x_j^{(m)})$ – vector of m-features of the j-th object

Other known functions for measuring distance between two points are: L_p – metric, L_∞ – metric, L_1 – metric, Lance-Williams function.

An important question when using the k-nearest neighbor algorithm is the choice of the number K - this is the number of the nearest neighbors. Heuristic techniques, such as cross validation, can help with obtaining the appropriate K values.

If the K value is high, the classifier is precise and more new data sets are correctly classified, but the recognition takes long time. In case of low K value the algorithm completes fast, but produces great recognition error. The common conclusions are, that the choice of K depends on the specific problem and its optimal value is determined experimentally.[8]

D. Support Vector Mashines - SVM

The Support Vector Machines (SVM) method represents training examples as n-dimensional points. The examples are projected into space in such a way as to be linearly separable. When working with two classes, a line is drawn to separate data along two classes. The line that divides the data is called a maximum-margin hyperplane. This hyperplane must be chosen in such a way as to be as close as possible to the examples of both classes.

The function $f(x)$ of the linear classification is as follows: [3]

$$f(x) = w^T x + b \quad (7)$$

where: w^T is a weight vector, and b is the displacement

The goal is to find the values of w^T and b , that will determine the classifier. In order to do this, it is necessary to

find the points with the least variance that should be maximized.

In non-linearly divisible data, the basic idea is to achieve linear separation by passing the data to another higher dimensional functional space through a function of the input non-linear data. This is accomplished by the so-called kernel function K, which is defined as follows:

$$K(x_i, x_j) = f(x_i).f(x_j) \quad (8)$$

Some of the most commonly used kernel functions are: Polynomial kernel function, Gaussian radial basis function, Exponential radial basis function, Multiple layer perceptron, etc.

Modification of the algorithm using the Support Vector Method is the so-called SMO (Sequential Minimal Optimization), which at each optimization step selects two Langrange multipliers. This algorithm is faster and has better scaling properties than the standard SVM algorithm. [9]

E. C4.5 algorithm

The C4.5 algorithm is an algorithm for constructing a decision tree from a learning set. Classes must have a finite number of values, with each example referring to a particular class. C4.5 is an extension of the ID3 classification algorithm, which divides recursively into subtrees, using an information significance index, i.e. a feature with the highest information utility is selected.

The C4.5 algorithm calculates "normalized information significance," i.e. when constructing the classification tree, the nodes with the most useful information are selected.

To avoid a strong division into subsets, a kind of normalization is used, where a criterion called gain is calculated. [10]

$$split\ info(X) = - \sum_{i=1}^n \frac{|T_{i1}|}{|T|} \times \log_2 \left(\frac{|T_{i1}|}{|T|} \right) \quad (9)$$

where: T – the test set; T_1, T_2, \dots, T_n – subsets; n – number of results

III. RESEARCH, RESULTS AND ANALYSIS

The study uses the WEKA software package, which is open-source software released under the GNU General License. The analyzed algorithms are: Naive Bayes classifier, Multinomial Bayes classifier, C4.5, k-nearest neighbors method, method of Support Vector Machines using optimization - SMO with a polynomial kernel function.

The results of the text classification by the closest K neighbor are best for the corresponding example and are obtained experimentally at different K values (the number of closest neighbors).

The tables use the name J48, which is the working name of the C4.5 algorithm rewritten in Java.[4]

The report introduces the following abbreviations of the algorithms used in the text:

- Naive Bayes classifier – NB (Naive Bayes)
- Multinomial Bayes classifier - MNB
- K-nearest neighbours - IBk

- Support Vector Machines using optimization– SMO (Sequential Minimal Optimization)
- C4.5 algorithm - J48

Initially, 2 authors Peyo Yavorov and Dimcho Debelyanov were classified with 21 poems and approximately equal number of words - 2018 words for the first author and 2031 words for the second author. The two poets lived and worked in approximately the same period - the late 19th and early 20th centuries.

The results show that SMO and J48 have classified the authors 100% correctly, with the worst result being the K-nearest neighbors. The difference in percentage between the first and the last of the algorithms analyzed is $\approx 21\%$, while the difference between the first placed and the second one is $\approx 7\%$. (Table 1)

TABLE 1 Classification of 2 authors with 21 poems each and with ≈ 2000 number of words each

Authors	Number of poems	Number of words	Number of accurately classified poems				
			NB	MNB	J48	IBk	SMO
Peyo Yavorov	21	2018	21	17	21	18	21
Dimcho Debelyanov	21	2031	18	20	21	15	21
Accuracy - Percentage of accurately classified poems			92.85 %	88.09 %	100 %	78.57 %	100 %

With an almost double increase in the number of words, J48 is again at the top, and IBk is the last. Significant differences in J48, IBk and SMO scores were observed when compared to the previous study -5%, -9.8214%, -6.25%, while the difference in the case of NB was only $\approx 0.3571\%$. (Table 2)

TABLE 2 Classification of two authors with \approx equal number of poems and with ≈ 4000 number of words

Authors	Number of poems	Number of words	Number of accurately classified poems				
			NB	MNB	J48	IBk	SMO
Peyo Yavorov	38	4024	36	32	35	27	35
Dimcho Debelyanov	42	4017	38	38	41	28	40
Accuracy - Percentage of accurately classified poems			92.5 %	87.5 %	95 %	68.75 %	93.75 %

With an almost double increase in the number of words, now 16 040, MNB and NB show the best result among the algorithms tested. The difference between the MNB and NB is only $\approx 0.1379\%$ in favor of the MNB. (Table 3)

TABLE 3 Classification of two authors with \approx equal number of poems and with ≈ 8000 number of words

Authors	Number of poems	Number of words	Number of accurately classified poems				
			NB	MNB	J48	IBk	SMO
Peyo Yavorov	73	8023	55	62	55	73	60
Dimcho Debelyanov	68	8017	18	20	51	3	52
Accuracy - Percentage of accurately classified poems			84.25 %	84.39 %	75.17 %	53.90 %	79.43 %

With a double increase in the number of authors from two to four (Table 4), i.e. the number of classes with approximately equal number of words (≈ 2000), MNB emerges as the winner, followed closely by NB, with SMO in third position by percentage of properly classified poems. IBk is again the last one, and it is notable that the percentages are extremely low and only one of the authors is recognized, while another two are not recognized at all.

TABLE 4 Classification of 4 authors with \approx equal number of poems and with ≈ 2000 number of words

Authors	Number of poems	Number of words	Number of accurately classified poems				
			NB	MNB	J48	IBk	SMO
Peyo Yavorov	21	2009	14	15	10	2	15
Dimcho Debelyanov	21	2031	18	18	17	0	15
Hristo Fotev	20	2022	18	19	9	20	18
Petko Slaveykov	21	2000	16	15	13	0	11
Accuracy - Percentage of accurately classified poems			79.51 %	80.72 %	59.03 %	26.50 %	71.08 %

With an increase in the number of authors to eight, the highest percentage of properly classified poems is MNB, which is $\approx 4.84\%$ better than the next two – NB and SMO, which have identical results.

TABLE 5 Classification of 8 authors with \approx equal number of poems and with ≈ 2000 number of words

Authors	Number of poems	Number of words	Number of accurately classified poems				
			NB	MNB	J48	IBk	SMO
Peyo Yavorov	21	2009	14	12	16	2	13
Dimcho Debelyanov	21	2031	10	12	10	0	12
Hristo Fotev	20	2022	15	16	9	18	17
Petko Slaveykov	21	2000	14	15	10	0	11
Pencho Slaveikov	20	2020	8	9	2	1	9
Geo Milev	21	2000	7	9	7	6	8
Lyuben Karavelov	19	2020	12	15	10	5	13
Nikolai Liliev	21	2000	19	19	11	0	16
Accuracy - Percentage of accurately classified poems			60 %	64.84 %	45.45 %	19.39 %	60 %

In the classification of two other authors Petko Slaveikov and Nikolay Liliev with 21 poems and with 2000 equal number of words, who lived and worked in different time periods: the first - the middle and the end of the 19th century, and the second - the beginning and the 20th century we receive different results (Table 6). The Naive Bayes classifier and J48 have only erred with a single poem, while SMO has erred with three poems.

TABLE 6 Classification of other 2 authors with 21 poems and with 2000 number of words

Authors	Number of poems	Number of words	Number of accurately classified poems				
			NB	MNB	J48	IBk	SMO
Petko Slaveykov	21	2000	20	21	21	9	20
Nikolai Liliev	21	2000	21	18	20	21	18
Accuracy - Percentage of accurately classified poems			97.67 %	92.85 %	97.61 %	71.42 %	90.47 %

In the study (Tables 1, 2, 3, 4, 5, 6) the number of poems and number of words is roughly equal for each author. When the number of poems and words are reduced significantly, J48 classifies authors 100% correctly. (Table 7) The accuracy of the SMO is almost 20% lower than the case, where the number of poems and the number of words of the two authors are equal (Table 1).

TABLE 7 Classification of 2 authors with ≠ number of poems and with ≈ equal number of words

Authors	Number of poems	Number of words	Number of accurately classified poems				
			NB	MNB	J48	IBk	SMO
Peyo Yavorov	5	2018	2	3	5	1	0
Dimcho Debelyanov	21	2031	21	21	21	15	21
Accuracy - Percentage of accurately classified poems			88.46 %	92.30 %	100 %	61.53 %	80.76 %
Peyo Yavorov	15	4020	6	5	15	7	4
Dimcho Debelyanov	42	4017	42	42	42	31	42
Accuracy - Percentage of accurately classified poems			84.21 %	82.45 %	100 %	66.66 %	80.70 %

In the case where the number of poems is equal, and there is a difference in the number of words in an order of magnitude, J48 emerges again with the highest accuracy. All classifiers, except J48, increase their precision from 3% to 10% when they are given a larger number of words. (Table 8)

TABLE 8 Classification of 2 authors with equal number of poems and with ≠ equal number of words

Authors	Number of poems	Number of words	Number of accurately classified poems				
			NB	MNB	J48	IBk	SMO
Peyo Yavorov	20	5129	11	18	19	17	16
Dimcho Debelyanov	20	1937	20	18	20	11	20
Accuracy - Percentage of accurately classified poems			77.5%	90%	97.5%	70%	90%

By increasing the number of authors to 20, the poems to 585, (Fig. 1), the words to 103377 and eliminating the “equal numbers of poems and words for each author” requirement, none of the five classifiers produce good results. (Fig. 2)

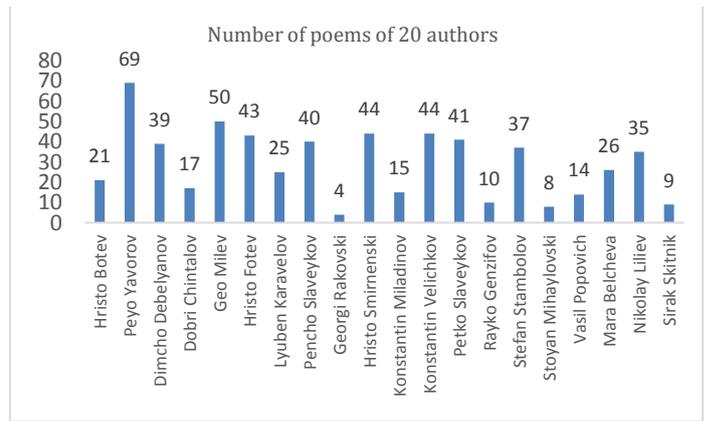


Figure 1 Number of poems of 20 authors, used in classification

The accuracy of the Naive Bayes classifier and the accuracy of the method of Support Vector Machines are the highest and approximately equal, about 55%. The J48 and MNB algorithms have almost tripled their accuracy in comparison with two-class cases. IBk is nearly 10 times less accurate than NB and SMO (Fig. 2)

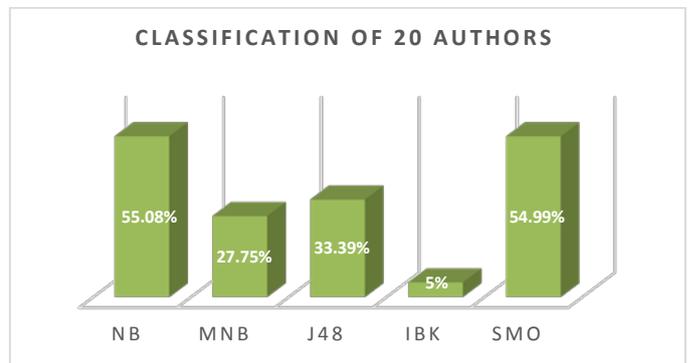


Figure 2 Classification of 20 authors using the algorithms: NB, MNB, J48, IBK и SMO

IV. CONCLUSION

The conducted studies show that in the classification of two classes and a small amount of data the algorithms with the highest accuracy are C4.5 (J48) and SMO; the accuracy decreases with a larger volume of data. When given 4 and 8 classes the Multinomial Bayes Classifier is the most accurate. When given 20 classes, the naive bayes classifier and the method of Support Vector Machines with optimization using two Lagrange multipliers and a polynomial kernel function have the highest accuracy of about 55%. The K-nearest neighbours (IBk) show the lowest scores throughout the entire study.

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Two-finger touch on wearable device bezel method for user pose recognition

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Abstract— In the current paper we research if there is a relation between the user pose (standing, sitting or lying) and the position of two-finger touches on the wearable device bezel caused by the user hands posture differences. Finding and proving such relation will open many opportunities for improving computer-human interfaces of the wearable devices and the user experience. It could give the possibility for the devices itself “to learn” (via Machine learning methods) user behaviors not based only on the time when the interface is activated but also counting on the user pose. Applying such algorithms could push the device interface not to follow the pre-ordered and coded into the device OS or software menus’ flow but to start with the applications or the device settings which are typical for the user based on user pose recognition. It will reduce the device interaction time and the user efforts to complete the needed device input tasks. Knowing in which pose is the user and the day time it could be managed also the device display brightness, interface colours, icon style, etc. in order to provide better user experience and save the device energy.

Keywords - wearable, interface, smartwatch, pose recognition

I. INTRODUCTION

While in the last 3 years wearable devices have reached the mainstream [1] and their functions and features have become more and more complex and respectively with more rich menus, their computer-human interfaces have been more or less non-changed. The early smartwatch interfaces were a combination between side push buttons taken from the traditional digital watches and touchscreen interfaces typical for the smartphones. Such kind of computer-human interfaces are still the most used in the wearable devices even in those with rich interface features. The common disadvantages of touchscreen interfaces applied on relatively to the user fingers (as the fingers are the main input “tool”) small displays are the fact that the target icons have to be smaller and user fingers hinder the target icons and their response status/action to successful or unsuccessful user action. These two problems were defined by the researchers as “fat finger” problem [2]. The leading vendors in smartwatches and fitness trackers verticals as well as many researches have been trying to solve the “fat finger” problem using different approaches. Some of the vendors have applied alternative to buttons + touch screen interfaces like rotating bezel [3], digital crown [4], software simulated rim around the display and side touch strips [5]. The researchers in the area of wearable device interfaces have explored various fields like using of display taps [6] or slides instead touches [7], around the device gestures based

interactions [8], skin touch interfaces [9], on-device applied forces based interfaces like side pushes, tilts, rotations and movements of the device around its band [10]. Some of them have researched touch based interfaces on various device surfaces like the device band [11], chassis sides [12], back side [13]. In that field of activity are our research also.

II. RELATED WORK

Different areas have been researched for pose recognition using wearable devices. They are mainly based on device accelerometer features and registering of the transitions between different poses [14]. All of them required constantly using device sensors which could cause an unnecessary battery drain and a shorter device life between charging cycles. There are research about the usage of the body pose as a part of the device input method [15] which is also related to our ones.

III. STUDY

The goal of the study is to check if there is a relation between user body pose (body posture) and the finger touch points on the touch sensitive bezel of a wearable device (smartwatch). Two-finger touch interface method is when a wearable device (smartwatch) has a touch sensitive area around its display and the user interact (navigate in the menus and enter data) with the device by touching by theirs’ thumb and one more finger (typically index one) two different areas over the touch bezel.

A. Experimental model

The base of the model was a 3D printed model of 46 mm watch, black PLA material, with 4.5 mm wide bezel presented



Figure 1. The Experimental model

on Figure 1.

On the bezel were drilled 12 holes for touch sensors - one per each hour mark of a standard 12-hour watch. For the touch sensors were used 12 pieces of M6 stop screws, oxide steel, black colour. The touch sensors were connected to the MPR121 12 port touch sensor board for Arduino via spoiled cables. In order as mobility for the experiments in different

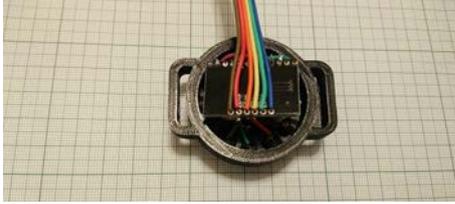


Figure 2. MPR121 Capacitive sensors board inside the model

body positions to be provided the MPR121 board was mounted into the 3D model as shown on Figure 2.

Specially developed for the research purposes software in the Arduino language was used for the experiment. The software detected the starts (touching contact) and the ends (releasing) of the touches made by the participant's fingers independently for each sensor. The Arduino Mega 2560 computer was connected to a notebook via USB interface and sent the data to the Arduino IDE Serial Monitor. The whole experimental set is shown on Figure 3. The raw data was then transferred to MS Excel for further processing.

B. Test group

The test group consisted of 10 people (male 8, female 2), aged from 27 to 49 (average age 37), all right handed, all volunteers.

C. Study process

Each participant was given instructions to wear the experimental model and to take one of the following three poses: standing - to stand in relaxed body position; sitting - to sit on a chair which is in front of a desk, the chair has forearm supports; lying - to lay down in bed on their back with head on



Figure 3. The Experimental set

a high pillow (in the position typically used for watching TV or reading). It was explained that the model had no other input interfaces but the touch sensitive bezel and they could activate the bezel interface by touching it simultaneously by thumb and one other finger. During the touch the user had to have a clear visual contact with the model virtual display. Each user made a trial attempt in each position in order to be sure that the given instructions were clear and understandable. Right after the trial attempt each user made ten attempts in each of the three positions. The IDs of the touched sensors were recorded separately for each attempt, collecting 30 sets of data per each



Figure 4. The Experimental process

participant, respectively 300 sets of data for all 10 participants for the whole study. On Figure 4 is shown the experimental process in the sitting pose.

For each participant separately, in each tested body position, was calculated the probability - P_{xi} (where "x" stands for the body poses as follows - "s" - standing; "c" - sitting; "b" - lying) for each sensor on the device bezel to be touched, using (1), where T_i is equal to 1 if the sensor is touched and to 0 if it is not touched during the Attempt No. j, and N is the number of the all attempts were made by the user.

$$P_{x_i} = \frac{\sum_{j=1}^N T_i}{N}. \quad (1)$$

After the measurement process, in order to determine if there are differences in the typical touch areas over the wearable device bezel in the different body poses, three "delta" values were calculated separately for each user. The descriptions and of the "deltas" are:

Dsc - the difference between fingers position in standing (P_s) and sitting (P_c) poses calculated as per (2)

$$D_{sc} = \sum_{i=1}^{12} |P_{s_i} - P_{c_i}| \quad (2)$$

Dcb - The difference between fingers position in sitting and lying poses calculated as per (3)

$$D_{cb} = \sum_{i=1}^{12} |P_{c_i} - P_{b_i}| \quad (3)$$

Dsb - The difference between fingers position in standing and lying poses calculated as per (4)

$$D_{sb} = \sum_{i=1}^{12} |P_{s_i} - P_{b_i}| \quad (4)$$

In order the body pose to be successfully recognized any "delta" value per each sensor separately higher than 0.5 is counted as reliable enough for differentiation between the poses. That is why, when we apply weighted calculation for the

active touch sensors over different sets of data (each set corresponds to a different body pose), if we have a touched sensor per any delta higher or equal to 0.5, the multiplied weight also will be higher or equal to 0.5 which makes enough differences in probabilities calculated in (5-7)

The final methodology for defining in which pose the user body is as follow:

1. The weighted probability for each pose is calculated by (5) for Rs -standing; (6) for Rc - sitting; (7) for Rb - lying

$$R_s = \sum_{i=1}^{12} |P_{S_i} * T_i| \quad (5)$$

$$R_c = \sum_{i=1}^{12} |P_{C_i} * T_i| \quad (6)$$

$$R_b = \sum_{i=1}^{12} |P_{B_i} * T_i| \quad (7)$$

2. Then the highest possible value from Rs, Rc and Rb defines the body pose with the highest probability. As higher the differences between different R are, the higher is the probability for a correct body pose determination.

Despite that just absolute “delta” values are enough to be determinate difference in body poses, additionally the relative differences per each sensor as percentages were calculated RDxy as RDxy is equal to Dxy divided to the greater value from Px and Py. Here again any percentage higher than 50% means that there is enough difference in probability any given sensor to be touched or not in one of the three evaluated body poses.

RAW DATA PER ONE USER

Attempt	Sensor ID											
	1	2	3	4	5	6	7	8	9	10	11	12
Standing pose												
1		1	1				1	1				
2	1	1				1	1	1				
3	1	1				1	1					
4	1	1	1			1	1	1				
5	1	1				1	1	1				
6	1	1				1	1	1				
7	1	1				1	1					
8	1	1				1	1	1				
9	1	1				1	1	1				
10	1	1				1	1	1				
Sitting pose												
1	1	1				1	1	1				1
2	1	1				1	1					1
3	1					1	1	1				1
4	1					1	1					1
5	1					1	1	1				1
6	1	1				1	1					1
7	1	1				1	1					1
8	1	1				1	1					1
9	1	1				1	1					1
Lying pose												
10	1	1				1						1
1						1	1				1	1
2						1	1				1	1
3						1					1	1
4						1	1				1	1
5						1	1				1	1
6						1	1				1	1
7						1	1				1	1
8						1	1				1	1
9						1	1				1	1
10						1	1				1	1

IV. RESULTS

The extraction from the raw data from a single user attempts recorded following study instructions is shown in Table I (where the value of “1” means that the sensor was touched and empty cell means that the sensor was not touched during the pointed attempt).

After all measurements had been made, the data about probability of each sensor to be touched by each user in each of the three different poses were calculated using (1). The probabilities are presented in Table II.

PROBABILITY EACH SENSOR TO BE TOUCHED PER USER PER POSE

User	Pose	Sensor ID											
		1	2	3	4	5	6	7	8	9	10	11	12
User 1	Standing	0.9	1.0	0.2	0.0	0.0	0.9	1.0	0.8	0.0	0.0	0.0	0.0
	Sitting	1.0	0.6	0.0	0.0	0.4	0.9	0.8	0.0	0.0	0.0	0.0	0.6
	Lying	0.0	0.0	0.0	0.0	0.8	1.0	0.1	0.0	0.0	0.0	0.8	1.0
User 2	Standing	0.2	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0
	Sitting	0.4	0.0	0.0	0.0	0.1	1.0	0.1	0.0	0.0	0.0	0.0	0.9
	Lying	0.0	0.0	0.0	0.2	1.0	0.4	0.0	0.0	0.0	0.2	0.8	0.8
User 3	Standing	0.2	0.4	0.1	0.3	0.4	0.2	0.2	0.2	0.3	0.3	0.1	0.0
	Sitting	0.2	0.0	0.0	0.0	0.6	0.3	0.1	0.0	0.0	0.0	0.2	0.4
	Lying	0.5	0.3	0.0	0.0	0.1	1.0	0.0	0.0	0.0	0.0	0.1	0.2
User 4	Standing	1.0	0.6	0.0	0.0	0.1	1.0	0.8	0.0	0.0	0.0	0.0	0.4
	Sitting	1.0	0.0	0.0	0.0	0.9	0.9	0.1	0.0	0.0	0.0	0.0	0.9
	Lying	0.2	0.0	0.0	0.3	1.0	0.7	0.0	0.0	0.0	0.8	1.0	0.0
User 5	Standing	0.9	0.9	0.0	0.0	0.1	0.3	0.9	0.0	0.0	0.0	0.1	0.1
	Sitting	1.0	0.7	0.0	0.0	0.0	0.7	1.0	0.0	0.0	0.0	0.0	0.0
	Lying	0.2	0.0	0.0	0.0	0.9	1.0	0.1	0.0	0.0	0.4	0.9	0.0
User 6	Standing	1.0	0.4	0.0	0.0	0.0	0.3	1.0	0.3	0.0	0.0	0.0	0.0
	Sitting	0.0	0.0	0.0	0.4	1.0	0.3	0.0	0.0	0.0	0.4	0.8	0.0
	Lying	0.0	0.0	0.0	1.0	0.9	0.0	0.0	0.0	0.4	1.0	0.1	0.0
User 7	Standing	1.0	0.4	0.0	0.0	0.1	0.8	0.4	0.0	0.0	0.0	0.0	0.5
	Sitting	0.3	0.0	0.0	0.1	0.6	0.6	0.0	0.0	0.0	0.5	0.4	0.0
	Lying	0.4	0.2	0.0	0.2	0.9	0.5	0.1	0.0	0.0	0.2	0.3	0.5
User 8	Standing	1.0	0.0	0.0	0.0	0.0	0.3	1.0	0.4	0.0	0.0	0.0	0.1
	Sitting	1.0	0.1	0.0	0.0	0.0	0.4	1.0	0.5	0.0	0.0	0.0	0.3
	Lying	1.0	0.0	0.0	0.0	0.0	0.8	0.7	0.1	0.0	0.0	0.0	0.6
User 9	Standing	0.9	0.3	0.0	0.0	0.0	0.2	1.0	0.7	0.0	0.0	0.0	0.3
	Sitting	0.7	0.1	0.0	0.0	0.0	0.8	0.8	0.2	0.0	0.0	0.2	0.6
	Lying	0.2	0.0	0.0	0.0	0.6	0.9	0.4	0.1	0.0	0.0	0.6	0.6
User 10	Standing	0.9	0.6	0.0	0.0	0.0	0.2	1.0	0.7	0.0	0.0	0.0	0.2
	Sitting	0.7	0.1	0.0	0.0	0.0	0.3	0.8	0.7	0.1	0.0	0.0	0.1
	Lying	0.2	0.0	0.0	0.0	0.6	0.9	0.2	0.1	0.0	0.0	0.5	0.8

“DELTA” AS ABSOLUTE VALUES PER USER PER TWO DIFFERENT POSES

User	Delta	Sensor ID											
		1	2	3	4	5	6	7	8	9	10	11	12
User 1	Dsc	0.1	0.4	0.2	0.0	0.4	0.0	0.2	0.8	0.0	0.0	0.0	0.6
	Decb	1.0	0.6	0.0	0.0	0.4	0.1	0.7	0.0	0.0	0.0	0.8	0.4
	Dsb	0.9	1.0	0.2	0.0	0.8	0.1	0.9	0.8	0.0	0.0	0.8	1.0
User 2	Dsc	0.2	0.0	0.0	0.0	0.9	0.0	0.1	0.0	0.0	0.0	0.0	0.1
	Decb	0.4	0.0	0.0	0.2	0.9	0.6	0.1	0.0	0.0	0.2	0.8	0.1
	Dsb	0.2	0.0	0.0	0.2	0.0	0.6	0.0	0.0	0.0	0.2	0.8	0.2
User 3	Dsc	0.0	0.4	0.1	0.3	0.2	0.1	0.1	0.2	0.3	0.1	0.3	0.4
	Decb	0.3	0.3	0.0	0.0	0.5	0.7	0.1	0.0	0.0	0.2	0.3	0.2
	Dsb	0.3	0.1	0.1	0.3	0.3	0.8	0.2	0.2	0.3	0.3	0.0	0.2
User 4	Dsc	0.0	0.6	0.0	0.0	0.8	0.1	0.7	0.0	0.0	0.0	0.0	0.5
	Decb	0.8	0.0	0.0	0.3	0.1	0.2	0.1	0.0	0.0	0.0	0.8	0.1
	Dsb	0.8	0.6	0.0	0.3	0.9	0.3	0.8	0.0	0.0	0.0	0.8	0.6
User 5	Dsc	0.1	0.2	0.0	0.0	0.1	0.4	0.1	0.0	0.0	0.0	0.1	0.1
	Decb	0.8	0.7	0.0	0.0	0.9	0.3	0.9	0.0	0.0	0.0	0.4	0.9
	Dsb	0.7	0.9	0.0	0.0	0.8	0.7	0.8	0.0	0.0	0.0	0.3	0.8
User 6	Dsc	1.0	0.4	0.0	0.4	1.0	0.0	1.0	0.3	0.0	0.4	0.8	0.0
	Decb	0.0	0.0	0.0	0.6	0.1	0.3	0.0	0.0	0.4	0.6	0.7	0.0
	Dsb	1.0	0.4	0.0	1.0	0.9	0.3	1.0	0.3	0.4	1.0	0.1	0.0
User 7	Dsc	0.7	0.4	0.0	0.1	0.5	0.2	0.4	0.0	0.0	0.0	0.5	0.1
	Decb	0.1	0.2	0.0	0.1	0.3	0.1	0.1	0.0	0.0	0.2	0.2	0.1
	Dsb	0.6	0.2	0.0	0.2	0.8	0.3	0.3	0.0	0.0	0.2	0.3	0.0
User 8	Dsc	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2
	Decb	0.0	0.1	0.0	0.0	0.0	0.4	0.3	0.4	0.0	0.0	0.0	0.3
	Dsb	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.3	0.0	0.0	0.0	0.5
User 9	Dsc	0.2	0.2	0.0	0.0	0.0	0.6	0.2	0.5	0.0	0.0	0.2	0.3
	Decb	0.5	0.1	0.0	0.0	0.6	0.1	0.4	0.1	0.0	0.0	0.4	0.0
	Dsb	0.7	0.3	0.0	0.0	0.6	0.7	0.6	0.6	0.0	0.0	0.6	0.3
User 10	Dsc	0.2	0.5	0.0	0.0	0.3	0.6	0.3	0.6	0.0	0.0	0.1	0.4
	Decb	0.5	0.1	0.0	0.0	0.3	0.1	0.5	0.0	0.0	0.0	0.4	0.2
	Dsb	0.7	0.6	0.0	0.0	0.6	0.7	0.8	0.6	0.0	0.0	0.5	0.6

Based on the data in Table II and using (2), (3) and (4) for each user the three delta values Dsc, Dcb and Dsb were calculated. All deltas are shown in Table III where these ones that could be used for a successful user pose recognition (i.e. higher or equal to 0.5) are in ***Bold/Italic***.

Based on the data in Table III all three relative “deltas” were also calculated - RDsc, RDcb and RDsb.

For all deltas values the number of each type of absolute “deltas” Dsc, Dcb and Dsb, per each user, only where value is higher or equal to 0.5, were counted and of relative “deltas” RDsc, RDcb and RDsb where the percentage is higher or equal to 50%. The results are shown in Table IV

NUMBER OF “DELTA” HIGHER THAN 0.5/50% PER USER

User	Delta					
	Dsc	Dcb	Dsb	RDsc	RDcb	RDsb
User 1	2	4	7	4	5	8
User 2	1	3	2	3	7	5
User 3	0	2	1	8	8	10
User 4	4	2	6	4	4	7
User 5	0	5	6	4	6	7
User 6	4	3	5	8	5	10
User 7	3	0	2	6	4	7
User 8	0	0	2	2	4	3
User 9	2	2	6	5	6	8
User 10	3	2	8	6	5	8

V. CONCLUSION AND DISCUSSION

For the positive result in the study are counted only the cases with two or more “deltas”. That is so because the mode of the sum of the touched by two fingers sensors on the wearable device bezel from all 300 attempts is 3; average is 3.18. That means that having two of them with differences in probability higher or equal to 0.5 (50% for the relative ones) we will have total difference from 1 or higher value, which will be higher than the difference from other touched sensors (if any) with difference in probability lower than 0.5 (50% for the relative ones).

The data in Table IV shows that for any two given poses (from all three possible poses) it would be possible based on the position of the users’ fingers over touch sensitive bezel of a wearable device (smartwatch) to:

- differentiate between standing and sitting poses (Dsc) with 60% probability
- differentiate between sitting and lying poses (Dcb) with 80% probability
- differentiate between standing and lying poses (Dsb) with 90% probability

The conclusion is that the lying pose could be differentiated with higher enough probability while the sitting and standing poses in more than half of the cases (60%). If we base the pose recognition method on the relative “deltas” we could achieve even highest probability.

The presented method is not related to the leading user hand (with which the user operates with its device) so the

described methodology can be applied also to users who wear the device on their right hand (respectively control the device with their left hand).

VI. FUTURE WORK

There are several further research that could be made in order as the results from this study to be confirmed and the presented methodology to be additionally developed. One of them could be about the methodology - a dedicated software recognizing the user body pose to be developed. The other area of a possible research is to combine data from other device sensors, such as the accelerometer, gathered and recorder for a given period of time before the user interaction and the user pose to be determinate by the two finger touch over the device bezel.

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Lagrange Method Implemented in Modeling and Simulation, Fundamentals of Animation, Creating Models and Motion of a Character

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Abstract—Modeling and simulation field uses different principles and tools for the execution of the models and the production of data for the system. The implementation of a simple simulation code on a PC might look like a simple task, but actually, it gives us more information than we think. For more complex systems are needed more complex simulations, implemented in a multi-computer environment, where the processing units are connected insightfully, in a high-speed network. This implementation requires better knowledge of computer architecture, distributed computing technologies, and the network. In this paper, we have implemented Lagrange method in the simulation part in order to prove its efficiency in the field of modeling and simulation. In addition to that, we have created different models using different shading, materials, lighting, modifiers, particle systems, physics, and constraints. Blender was used as a powerful tool in the creation of those models. A character has been created, adding rigging and making the bone structure while using the armature tool.

Keywords- Lagrange method, modeling, animation, simulation, Blender, Matlab

I. INTRODUCTION

The data informational technologies are used as one phase in the modeling and simulation process in order to output the data in the desired performance, where particular techniques from statistics and probability are implemented in order to improve the result, if unexpected results are displayed, or the ratio of the error is higher than expected. The repeated simulations are required to get simulation process where the data is represented as a way to interface with the model. The systems that are investigated in this phase are complex and large, so the data graphs cannot give a clear visible output of the model behavior. For that purpose, the visualization is used to represent the data and the behavior of the system. The visualization is used to construct 2D and 3D models of the system that is being modeled. With this representation of data is allowed to the user to plot and display visual system time functions for a better understanding of the dynamic behavior of the models represented in the system. The functions implemented in MATLAB give an accurate representation of the models, whether it is a rotation of an object, lighting, scaling or shifting.[1]

II. MODELS AND CHARACTERISTICS

A. Simulation paradigms

Simulation paradigms are of the greatest use for understanding the distribution of the model output. The values used in the system models are randomly selected, so the Monte Carlo simulation is one of the best methods used in the calculation of the output. Probabilities are used within this paradigm.

B. Continuity

The continuous simulation uses system variables as functions over a continuous amount of time. The time here is independent as a variable.

C. Discrete functions

The use of discrete functions allows the user to specify the change of the system only at a distinct point in time.

D. Fidelity

Fidelity is another term that is used for the description of the simulation and how close it is to the reality. High fidelity is used only when the model matches the most of the real world and behaves as a real system. This is not easy to achieve, because the models cannot obtain each of the aspects being represented in the system. The low fidelity is used when the model is not as accurate in the real world definition, and the aspects are not that important for the experiment. Different models can be used for different type of fidelity.

E. Validity

Validity is a term used for representing the accuracy of the model representation in the virtual world. It contains three concepts on which are based (i) *reality* - how real the scene is; (ii) *requirements* - the diverse set of fidelity levels; (iii) *representations* - which aspects of the real-world scene are represented.

F. Resolution

Resolution is known as granularity and is the degree of detail or accountability of the simulation of the real world.

More detail included in the simulation, better perception of the reality.[3]

III. HIGH AND LOW FIDELITY MODELS

With the representation of these models, we can see that the simulation on only one building would require only the components needed for designing the building. The rendering process takes only a little of the time needed to give the rendered output with the highest possible quality. The textures, lighting and modeling principles are implemented in the modeling process, so the building looks quite realistic. But the low fidelity here is obtained from the poor containment of detail. For example, we can see that the building has a lot of windows, like an ordinary building should have, but the reality is not on a high level because there is no reflection from the windows, considering the fact that it is rendered during daylight, the shadows are poor or non-existing at particular points of the building, the roof is not very convincingly modeled as a roof should look like. But as an overall, the model looks like a building and can be used in the modeling process as a part of a scene.



Figure 1. High fidelity model 1

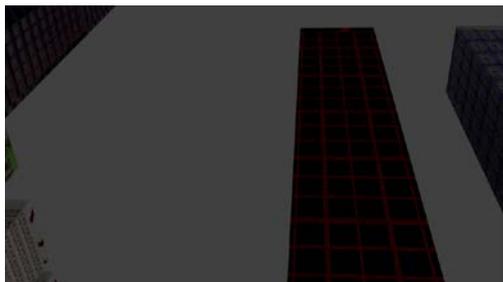


Figure 2. Low fidelity model 1

Understanding the importance of these attributes in the modeling and simulation field, the joint of them can allow the modelers to construct close approximations of the real-world scene. Different types of simulations can be used with the combination of resolution and scale, or scale and fidelity, or resolution and fidelity. More of the resolution can lead to less of the scale and the opposite.[1]

A. Types of Models

There are different types of models used in the modeling and simulation field, which later on can be used for animation

as well. They are common in these fields, so among the most used are:

1) *Physics-Based Models*: this is a model based on a mathematical model where several equations are derived from the basic principles of physics. These models are representations of phenomena, are intangible, which means cannot be touched or physically existing. An example of that is Newton's law for gravity. Here is represented with the rolling of two dice on the ground, while being tossed previously.



Figure 3. Physics based model

2) *Particle System Based Model*: this is a model which is based on the particle systems tool. It is one of the most commonly used tools in Blender, where the objects being modeled are represented. The type of the system can be an emitter or a hair. The seed can increase, but the default value is 0.



Figure 4. Particle system implemented in a model

3) *Data Based Models*: another type of models that are based on the data that describes the aspects of the object/model. The data collection here is essential if we want to make the scene as realistic as possible. Real-world data can be included in the simulation testing process, so we can see the results with varying inputs. Depending on the conditions of the real-world virtual scene that is going to be created, the model is developed with the main aim to achieve the best possible accuracy.

B. Visualization

In this section, we will talk about the different basic characteristics or fundamentals upon which visualization is based and got its definition. In modeling and simulation, the term visualization is often used for the representation of data for visual and analytical simulation. The computer graphics is at the core of this discipline and requires higher and deeper understanding of the fundamentals in CG.

The system of the computer graphics can be viewed as a black box, where the inputs are objects that interact with one another while being put in the box. The output of those

interactions is few 2D images that are displayed on specific output devices, like the LCD - liquid crystal display and the CRT - cathode ray tube. The modern 3D computer graphics systems were based on the model of synthetic camera and different mathematical representations were needed to describe the transformations and representations of the 3D objects, like the lights, parameters of the camera, an interaction between the 3D objects, the type of environment, etc.

Linear algebra can be considered among the most commonly used mathematical tools in computer graphics, which gives the fundamental approach of it. The more modern approach is more optimized in order to render more complex polygons.[1]

C. Shading and Lighting

Shading and Lighting are needed in the modeling and animation process in order to distinguish the different models that have been created. The shading provides more realistic visual effects, while the lighting is the main source of excitation for the human. The color sources of the excitation are needed in the formation of physical images, so the lighting creates electromagnetic wavelengths in a range of 380-750 nm in the spectrum. Due to the physiological structure of the human eye, the visible light band only covers a certain area in a continuous range. The display hardware devices like LCD and CRT can only generate primary colors, so the final result is the linear wavelength with their combination. Color gamut is the display device that generates the range of those colors but is not in a position to represent the visible spectrum. Every display device has a different gamut, representing colors with the color representations of R, G, B, like red, green and blue respectively. [10]

a) *Ambient light*: This light has uniform lighting, meaning that all of the objects that are in the scene receive the same amount of light, regardless of their direction or location in the scene. But, different objects can reflect the light in a different manner and can appear differently. These lights are used to provide lighting to the entire environment and have been scattered a lot of times, so their directions cannot clearly be determined. [10]

b) *Spotlight*: The spotlights have lightning effects in the shape of a cone and are specified by the cutoff angle, direction, and location. Their cone shape is determined by the location of the light and its production is only in a specific area, it is not outside of the cone. The intensity of the light depends on the f parameter that represents the angle between the spotlight and the direction of the vector that connects the location of that light. This type of light is also called a point of light and is often specified by the color and the location. The amount of light that is transmitted and received at a specific point Q depends on the target object. The intensity of the light often decreases and is represented as a decreasing function with an angle f , often computed as $\cos e f$, e being the parameter used for adjusting the tightness of the light. [10]

c) *Directional light*: The directional lights are also called distant lights and are used to light objects that are far on the scene, like the sunlight. It has a constant intensity which is

dependent on the direction and its location is assumed to be in the infinite state, this they don't have a specific location in the virtual world. [10]

1) Flat Shading

Four vectors, reflection, light direction, surface normal and viewer direction are used in the calculation of the color at a specific point. But these points inside a polygon can be easily simplified, recalling that the surface normal is always constant, for all points of the polygon, so if the light is distant and the polygon is in the center of the scene, the direction of the light can be often viewed as a constant. These approximations can also be done for the viewer direction, and we can conclude that all of the points that are placed inside the polygon will have the same color, so the calculation of the lighting can be performed only once when the points are being assigned to that polygon. [10]



Figure 5. Flat shading

In the smooth shading, the calculation of the lighting is based on each of the vertices at the polygon. The color represents a point inside of that polygon, which then is calculated with the interpolation of the vertex colors, with different methods. One type of smooth shading is Gouraud shading, where the vertex is calculated in a normalized range including the neighbor polygons that share that vertex upon which the calculation is based. [10]



Figure 6. Smooth shading

3) Phong Shading

Phong shading is lately found in the latest graphics cards. It interpolates the normal lines of the vertices instead of the colors, all across the polygon. The calculation of the lighting is performed at each of the vertices of the polygon, so it provides more realistic results in the rendering.



Figure 7. Phong shading

software, vertex, edge and a face, where each of them can be accordingly edited and transformed in order to get the wanted polygon, or object. The vertices are the smallest units in the meshes, so all of the information is contained at them.

There is an option of X-mirror where the panel of the mesh options allows the designer to edit the symmetrical vertices on the other side of the mesh. For example when you transform the elements, the edge, vertex or the face, if there is X-mirrored part in the space, the transformation will be accordingly, depending on the symmetry on the X-axis. The vertices must be placed in a perfect manner in order to work with the mirrored geometry in Blender. If the position is not accurate or exact, the vertices will not be correctly mirrored, thus the meshes will distort and the object will look weird. [10]

IV. TEXTURE MAPPING AND DIGITAL IMAGE

As previously mentioned, the vertices are used to specify the information for the meshes, as smallest units that contain the information. If the object has a complex appearance, like for example contains a lot of edges, faces, vertices, colors and geometric details, a lot for polygons will be needed in this case in order to present the object as accurately as possible. Even though today's PCs have high memory capacity and storage, due to the graphics cards, it is impossible to store a large number of objects that are represented by a lot of polygons with high resolution meshes. In this case, we can use the texture mapping technique in order to obtain the maximum visual effect without impacting the geometry of the object or the complexity. The colors of the vertices are matched to the vertices of the locations in the digital images, so that is why they are called texture maps.[5]

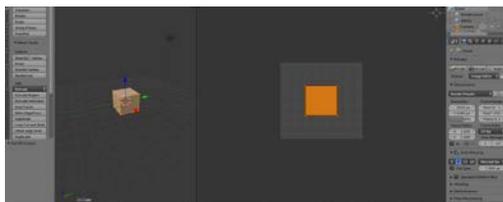


Figure 8. Grid



Figure 9. Textured model

The mapping can improve the appearance of the object, not only its colors. It is similar to the decoration of a room with the use of wallpaper, like instead of painting the wall with a color, you can just put specific wallpaper. The same pattern of the wallpaper will be distributed across the room, so here is the

same way; the same pattern is used in the texturing process. The "wallpapers" that are used here can be defined in 1D, 2D, and 3D spaces. The most of the texture maps use 2D textures and digital images as one of the main modeling methods.

The digital images are 2D images contained arrays of pixels or picture elements. Every pixel contains a tiny square on the devices, so the human eye can barely recognize it while seeing a picture.

Depending on the size of the image, the range of pixels can be different, so if the picture is smaller, the texture mapping can be blurred, if the image is larger, the texture mapping will be sharp and clearly visible. Each of the pixels contains a specific value of intensity for the grayscale images or values for the color images. Only three of the components need to be present in the presentation of color value, red, green and blue. One of the commonly used techniques is the use of 1 byte (8 bits) for the representation of the value of intensity for each of the color components, in the range from 0 to 255, representing different colors and shades of colors.

The texture mapping matches to every vertex of the mesh. Here it is not important the size of the image, because it always looks in the normal way, with the appropriate texture coordinates in the range of [0, 1], u and v representing the horizontal and vertical directions. Every vertex of the mesh has a pair of texture coordinates, like [0.32, 0.45], so the color of the vertex is specified by the location and the texel coordinates in the map.

The coordinates of the textures inside the polygon are determined by the interpolation of the vertices of the polygon. [10]



Figure 10. Model without texture

V. MATLAB

MATLAB is one of the more advanced visualization tools, using high-level computing language, performing numeric computations, data analysis, data visualization and algorithm development. It is used in almost every field in computer science, teaching science, mathematics, and engineering, being optimized for vector, matrix, and array computations. It contains a lot of toolboxes intended for mathematics, statistics, data analysis, control system design, image processing, test and measurement, computational finance, databases, computational biology, neural network applications, optimization, probability and many more.

The desktop environment of MATLAB consists of a lot of tools used in the algorithm development, debugging and running computer programs. It also has powerful visualization properties, like for example, graph and bar plots, scatter plots, line plots, histograms and pie charts. In this project, we have included some examples and applications of these toolboxes, functions, and visualizations, representing and implementing Lagrange method for the plot of 2D objects and their transformations. The object represented below is a surface modeled in MATLAB while using Lagrange interpolation polynomial. There was a set of numbers given for x,y, from where the following numbers were extracted from the formula and used in the creation of surfaces. The straight line that passes through the dots in the surfaces is in the form of multiple polynomials and it connects the edges, while the surface itself has a shape rounded in the centered area for a particular degree.[6]

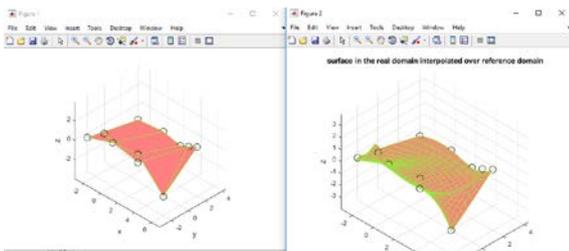


Figure 11. Lagrange method in a surface

VI. BLENDER

Finally, we come to Blender. This is one of the best, free and most powerful software used for modeling and rendering objects and scenes as approximations of the real world. It can be used also to create interactive video games and is mostly used among small studios that are satisfied from its responsive development process. It is a cross-platform application that can be run on Microsoft Windows, Linux and macOS. Compared to the other software, Blender has small memory and its interface contains the use of OpenGL. It is used for any media production, like films, commercials, games, short animations, research projects, applications, etc.

The key features accompanying Blender are the fully integrated 3D content, tool for rendering, video editing, animation, modeling, texturing, compositing, rigging, and many more. It is uniform on almost every major platform and contains Python scripts. The architecture of the 3D objects shows us that it is very efficient and fast tool for modeling. Blender performs a lot of tasks, starting with the basic ones, up to the complex ones. But still, the great artists need to know the human anatomy, lighting, animation principles and composition at an advanced level in order to make masterpieces.

Location, scale, rotation, movements are one of the constraints that are present in the software. There are a lot of constraints that represent limitations to the target objects and often are very useful in the static projects. The rigging is an important section of this software which needs advanced

knowledge in order to give life to the characters and objects and thus make an animation.

Without correct rigging, the object cannot be used for the animation purposes, because the use of bones and armature here is the real target point.[9]

VII. ANIMATION

It is a form of pictorial presentation that has become one of the greatest industries in the world today. It is featured on the technology-based learning environments and includes simulation of motion pictures where the movement of particular objects is being shown. The educational computer animation is representing one of the most elegant tools in the rise of computers with powerful graphics. Here will be discussed the history and early beginnings of computer animation, its principles, and its applications. Also will be presented some animated objects and the methods used for their animation in order to understand better the importance of such tools in our lives.

In the past two decades, the basic and widely known definition for the animation was the one with motion pictures representing moving objects. The three key factors that influenced the beginning of the animation are the motion, the picture, and the simulation. There are different types of animations, starting from the ones that depict the movement of real objects, animations made with computer graphics, cartoons, animations with 3D objects, etc.[3]

A. Squash and Stretch

Squash and Stretch is a technique that gives a definition to the flexibility or inflexibility to a given object, depending on its mass. Different forms of distortions can happen during the action. The squash is a position where the object looks flattened by some external pressure or source or is constricted by the own power. The stretch is a position where the object is shown in the same form, but a little bit or more extended. But an important fact to remember here is, the object will still have the same volume, no matter how much stretched or squashed it is.

The beginner animators often practice this fundamental by drawing a bouncing ball, having a ball, making it fall, bounce from the ground and doing squash and stretch, and then getting back in the normal shape.[3]

B. Timing

The timing is used as a principle in order to describe the size and the weight of the figures, the gap between the character actions and the personality of those characters participating in the animation.

In order to make the idea clear, the timing needs to be accurate, the action to be perfectly anticipated, the feedback of the taken action to be adequate, and to allow the audience to get the needed time and to know what to expect with every second passed. The motion needs to be clear, precise and straightforward, so the audience considers the movements of the characters at least closely accurate and realistic.[3]

C. Anticipation

This is the third principle which is accompanied by the preparation of the action that needs to be taken in the animation, the proper action, the main parts of it and the end of the action. Here the attention of the audience needs to be attracted, to prepare them for the next movement of the character and give them a chance to guess what will happen next before it actually happens. It is used to make a clarification on which action will be taken next. For example, if we have a character who is trying to grab some object, first will extend the hands in a try to grab the object, then it will make some facial expressions to show the audience that is trying to do something with that object, and finally, at the end, it gets that object. Let's take another example: we have a fat man sitting in a chair. He is trying to get up, so the first thing he needs to do is to bend his upper part of the body in the front of the chair, put the arms on the chair's handles, pushes with the hands and then finally gets up.[3]

D. Staging

This principle has its origin from the 2D animation written with a hand. If we want to understand it in a better way, we need to focus on the arrangement of the idea itself. In this principle, the idea has the main focus. In order to make the characters, their facial expressions, movements, and moods more realistic, the animator needs to stage every change in the character's movement. Every action should take one action at the time, so if there are a lot of movements at a same amount of time, the audience will be confused and will not understand the idea precisely. Each action should be staged in the simplest possible way before it goes in the next phase.[3]

E. Follow-Through and Overlapping Action

The follow-through is defined as the end of the action, its termination. The actions cannot come out from nowhere and stop suddenly; they are usually continued even after the movement has been staged. For example, if we have the character to throw a ball, it won't put back the arm in the normal position after the throw has been performed, it will continue moving it forward in order to make the movement more realistic. The parts of the actions need to be synchronized, so the objects and the characters need to get along, have a particular lead and to follow the momentum. For example, if we have a character moving, the hips will be the leading force, while the legs will follow the torso, accompanied with the hands, head and fingers, and also hair, if the character has a long one.[3]

F. Straight Ahead and Pose-to-Pose Action

This is another approach in the animation process where the main difference between these two actions is the level of readiness. The first action straight ahead has its start from nothing and continues during the animation as the idea occurs. The second one, pose-to-pose obtains the certainty that everything is ready, every movement of the character is already known, prepared and drawn, so it is only a matter of connecting the movements one after another.[3]

G. Slow In and Out

The principle slow in and slow out works with the gaps between the drawings in the animation. It describes the slow poses, the extreme poses and the fast poses of the characters. We have heard about this term in mathematics known as second and third order continuity of the motion, so it describes the logic behind this principle. Slow in is for the next pose while slow out is for the previous one.[3]

H. Arcs

The arc defines the visual path of the action, from one place to another. Instead of using just a straight line, the use of arcs is highly recommendable in the creation of animation. It will give the movements less stiff and smoother look. Sometimes the arc can turn into a straight line, for example in the free fall in physics. In the software, this principle is represented with 3D key-frame computer animation systems that can control the timing between the present values.[3]

I. Exaggeration

Exaggeration does not necessarily mean the distortion of the shape of a character or an object. It depends on the animator how will show the facial expressions, form or emotions of the characters. For example, if a character looks happy, it can always look happier. If a character looks sad, it can always look sadder. This is the main idea behind this principle, and often can be misunderstood by the animators.[3]

J. Secondary action

The secondary action comes from the primary action. These actions are important because they give meaning to the motion of the characters and are always inferior to the primary ones. They also give a more realistic appearance to the animation, making it more interesting and more complex. For example, the movements of a character are the main idea; the facial expressions are the secondary actions.[3]

K. Appeal

Magnetism, communication, charm, plainness and pleasing design are included in the appeal principle. It is what makes the audience to want to see. If a character looks charming, eye-catching or interesting, it will draw the attention of the audience faster than any other character that looks complicated, with strange moves or shapes.[3]



Figure 12. Rigging

VIII. RENDERING

This is the process of converting the models into pixels and giving an output as an image or animation. The animation is a

set of images where the objects take a different place in space. When the computer graphics movies are created, every frame of the movie is sent to series of computers in order to be generated into an image. This process is very long and sometimes can even take years to finish. In order to speed up the rendering process, the pictures are usually sent into so-called "Render Farms" which consist of a rendering workload split among computers.[5]



Figure 13. Rendering

IX. Conclusion

As a conclusion we can derive the fact that modeling, simulation and animation is a widely-used field in today's world, representing its significance in many branches. With the presence of different models, people can easily predict certain circumstances, interact, understand and remember information. The simulation helps to simulate different phenomena, actions, movements, objects or characters, providing the chance of interacting with the simulated environment.

The Blender software is used in this project in order to demonstrate particular movements of a character, to design a specific outdoor scene, design different models in order to apply the principles of modeling and animation to them and to render a scene and a few seconds animation. The software contains very useful and powerful tools for modeling and animating. At the very core of this field, the models represent the closest approximations of the real world and reality. After few simulations of the models, there is the analysis which is made in MATLAB in order to draw conclusions about the different representation of 2D models drawn with a code, the use of Lagrange polynomials and integration to test different methods in the modeling and animation process with the plot of surfaces in the example mentioned above. The accent was put on Lagrange polynomials modeling of surfaces with given n points where LAGRANGEPOLY as an option can return x and y coordinates for all points of inflection and extrema points of the polynomial, but this can be used as an option, it is not relevant for the plot of surfaces.[1][2][7][8]

X. FUTURE WORK

As a fact we can obtain for the future work is a well-developed model that can always operate well in the environment and performed simulations. Engaging in this field requires and allows more precise abstraction of the reality, accurate techniques and tools used within, validation by

mathematical equations, proofs and foundations, and methodologies used for the complexity issues. Here are some of the main points of this part of the paper important for the future work in these fields:

- understanding the construction of the scenario where the models will be integrated;
- exploring the possibilities in the operating procedures, policies and other methods, without causing any change in the real or actual system;
- developing an understanding of the operation of the system about the performance and predictions in the environment;
- choosing correctness in the testing;
- diagnosing problems and issues at the early stages of the process;
- identifying the constraints on the information, materials, and processes;
- using an animation in order to visualize the plan of work;
- better training;[5]

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DEVELOPMENT OF A PLC-BASED HYBRID PI CONTROLLER

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Abstract—The present article proposes methodology for hybrid PI controller development, by implementation of micro-PLC. The controller is set as conventional P plus I component, which is synthesized by using the tools of the fuzzy logic. The program is written with FBD (function block diagram), mainly by using reference blocks, generators, and counters. The present research shows that the controller proposed has a variety of tuning capabilities, which allows its implementation for control objects with variable parameters including non-linear.

Keywords- PI controller, fuzzy controller, PLC, FBD

I. INTRODUCTION

Fuzzy control is successfully applied to solve a wide range of problems in various areas where the control objects are nonlinear with inaccurate parameters and are exposed to significant disturbances. The implementation of fuzzy controllers [1-3] is relatively easy when high class PLCs are introduced for which usually are provided functional blocks in order to ease their design and further application. It is however barely valid for low class PLCs, in this case the designer has only fewer varieties of functional blocks. This imposes that the development of the fuzzy controller will be solved mainly by using elementary logical blocks [4-5].

II. EXPLANATION

Specific low-level PLC (SIEMENS microcontroller from the lowest class – “LOGO!”) is used for the provision of the present development [6]. The implementation of the conventional P controller with the chosen PLC is simple as it disposes inbuilt functional block (FB) amplifier [7]. This block initially possesses an option for setting the offset so that the output will deliver the value of the control error. By adding another amplifier block with a variable negative coefficient, it is possible to form the control signal which is formed to represent the proportional control term. By changing the gain of the added amplifier, the P control can be further set to satisfy the required control quality (reference value). P controller is known as relatively fast, however it also introduces static error. The integral component is suitable for implementation to avoid the static error and it is further considered that adding an integral component will solve the

problem. The integration or summation as substituted for discrete systems, however, cannot be easily solved due to lack of inbuilt mathematical functions for low classes PLCs. Therefore, a specific program segment is developed to represent the integral control component on the basis of logical elements i.e. timers, pulse generators and counters. In the present development LOGO! OBA5 controller is used along with additional module - AM2 PT100. The temperature in the control object is being measured by using directly connected PT100 resistor and relay output is controlled through electric heater connected to the PLC.

The program that implements the fuzzy integral component is presented in Fig. 1. It has a variable coefficient as it is expected the control error may have different value for each interval. This nonlinearity in the integration process is expected due to project the nonlinearities specific for the real control objects and allows better tuning for particular object. In the program presented, the analogue signal is delivered by the block AI3 which is corresponding to the first analogue input of the optional module. The next block B006 is an amplifier which is scaling and shifting the signal so that the output delivers the value of the temperature in degrees. For PT100 unit the settings are set automatically. The resulting value is an integer, with the last digit reflecting tenths of degrees. The temperature range for the AM2 PT100 is -50 C° to $+200\text{ C}^\circ$, with accuracy of 0.25 C° . Block B010 is implemented to subtract the reference from the currently measured value or it shows the control error. The block offset parameter serves as a set point, that can be set as desired by the user. The blocks - B001, B002, B008 and B009 are responsible for fuzzyfication of the control error. Technically they are comparators that determine the interval of the error. For example, the marked block B002 is active with 1 at its output when the error is in the range between $+0.1\text{ C}^\circ$ to $+9.5\text{ C}^\circ$. This causes the timer B007, which is an off delay timer, to generate a pulse with duration of 0.12 seconds. This time is obtained as the sum of the delay time in B007 and the pulse duration of the B005 generator. The last block is the main clock generator of the PI controller. It determines at what point the input is read and the output control signal is generated. The duration of the cumulative pulse determines how long it will be allowed to generate block B016. Since it is given a pulse time of 0.1 seconds and a pause of 0.1 seconds, then in the specific situation it will only

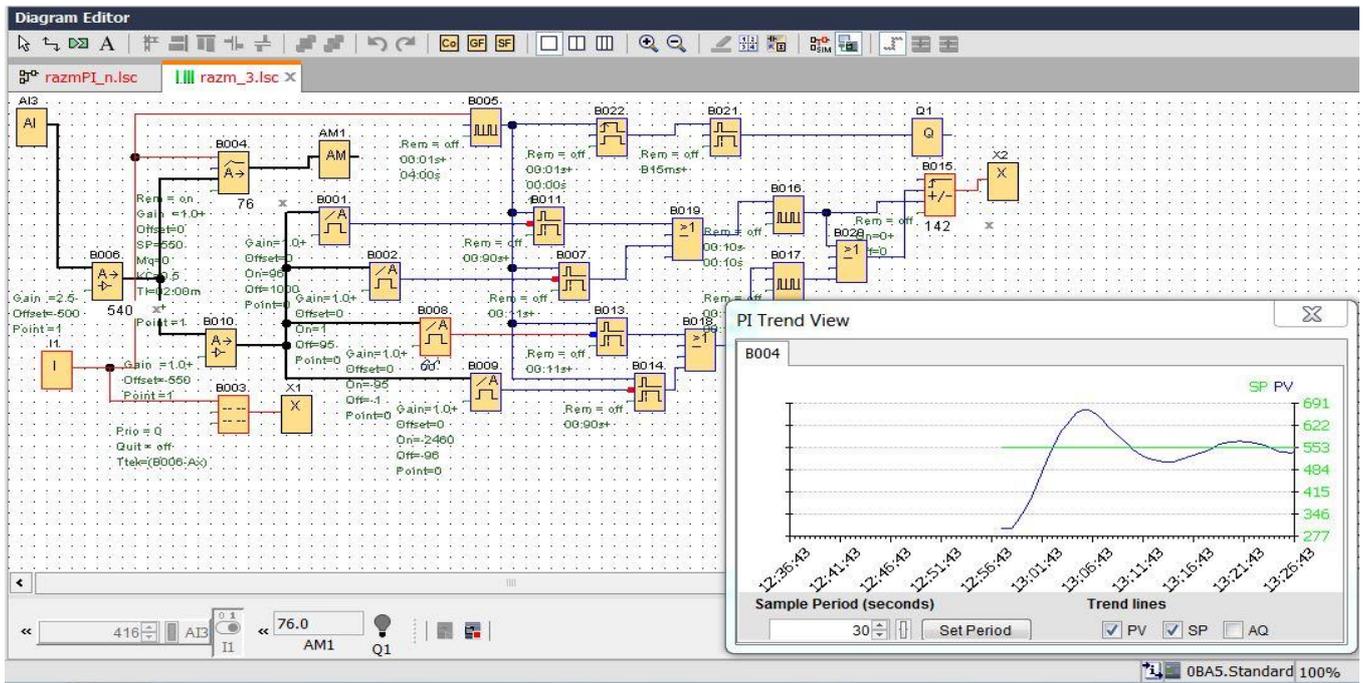


Figure 1. Program of Fuzzy I regulator and graph of process quantity.

generate one pulse. This impulse is subtracted from the value of the counter B015, but if the pulse is from the other generator, it will be added to the current counter value. In this way, the counter performs the function of an adder or a wider integer.

The control itself is produced at each step of the main generator B005, with its pulse duration of 0.01 seconds triggering the off delay of the B021 timer. Its adjustable delay parameter is taken from the current counter value. This changes

the filling of the generated PWM (Pulse Width Modulation), which is proportional to the sum accumulated in the counter. In the particular case shown in Fig. 1, the duration of the generated pulse will be 142 milliseconds within 4 seconds as the controller's basic step.

In Fig.1 is also presented the graph of the temperature (process value) in blue and the reference value 55 °C - Green line. It is obvious that the process is with significant overshoot and further fluctuations, as it is normal once I controller

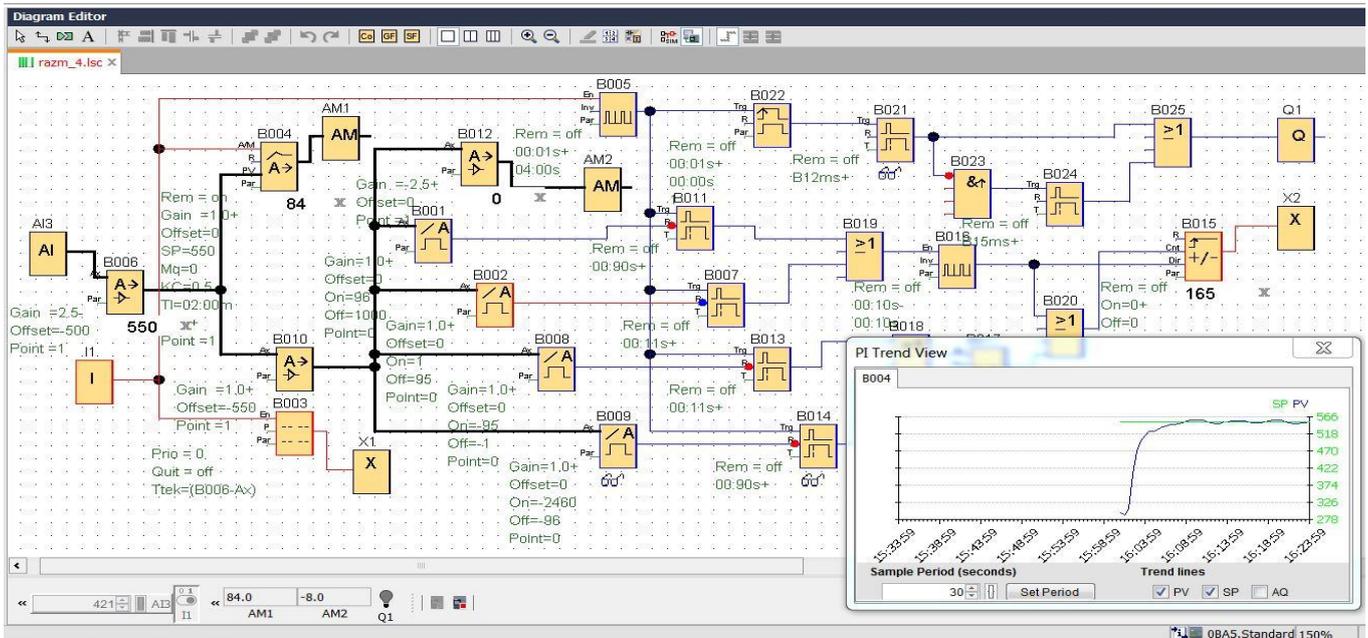


Figure 2. Program of the hybrid PI regulator and graph of the process parameter.

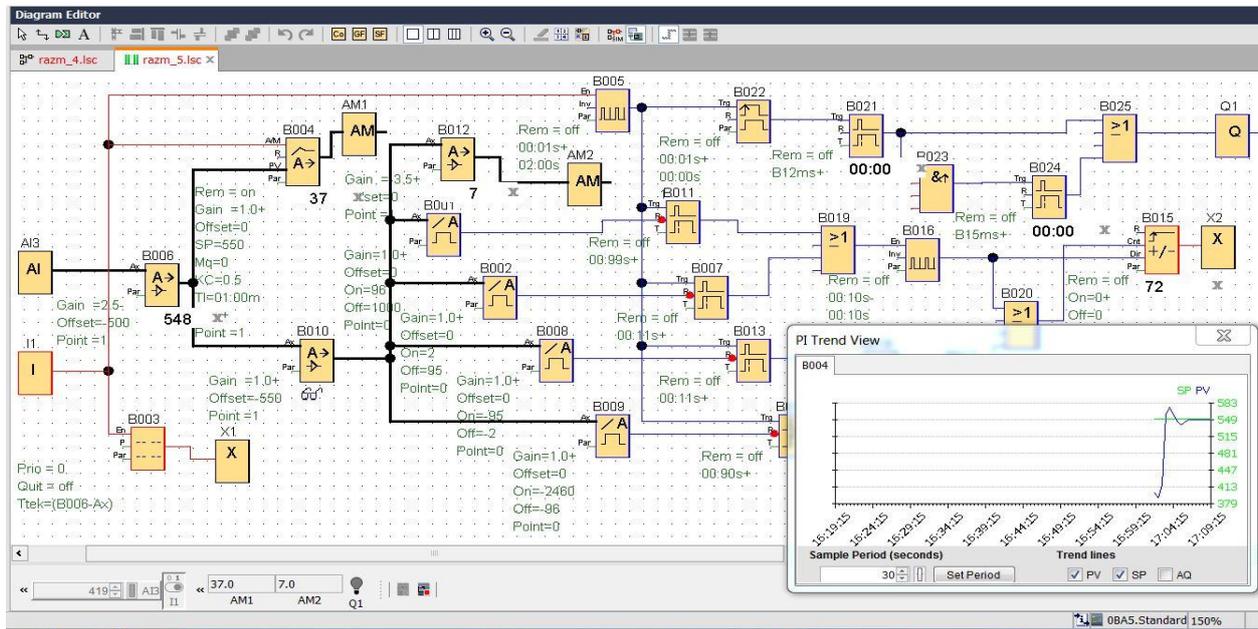


Figure 3. Hybrid PI regulator with increased proportional and integration ratios.

is being implemented.

Both parameters are decisively improved with the introduction of the P component in Fig. 2. The gain (P component) is formed by the amplifier block B012 added and respectively its gain coefficient represents the proportional coefficient of the controller. The two components are summed as times from blocks B021 to B025 and further used to trigger the change of PWM filling at output Q1. The process variable very quickly reaches the reference with no over-shoot, for value 2.5 of the Proportional component and integral time constant of the fuzzy I controller 4 seconds. If only the fuzzy I controller is implemented the process is settled in 20 minutes, however the hybrid PI regulator (shown in Fig. 2) grants that the control variable reaches 52 degrees in 3 minutes and then

slowly (for 5 minutes) reaches the reference. This indicates that the proportional component was predominant by the third minute, but at this point it turned out that the integral component still has not reached the value needed to ensure that reference is met.

Fig. 3 shows the same controller with a proportional component value 3.5 and time of 2 seconds of the PWM, which is also an integration time constant, resulting in 1.4 times increase of the proportional component and another 2 due to the reduction of the PWM time. Or a 2.8 times increase in the proportional component and 4 (2x2) times increase for the integration time constant. As a result, the reference is reached for about 1 minute and is exceeded by 2.5 degrees. In addition, the control process time is significantly reduced - with only one

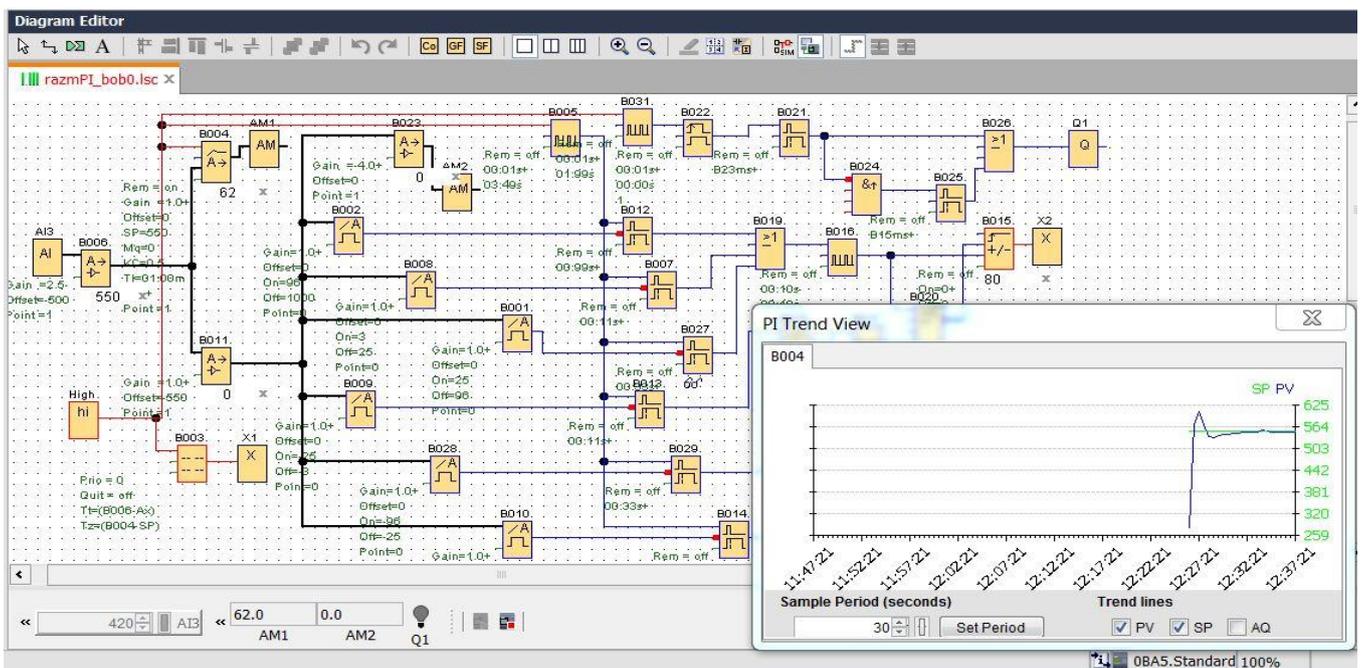


Figure 4. Hybrid PI regulator with two clock generators and more fuzzification intervals.

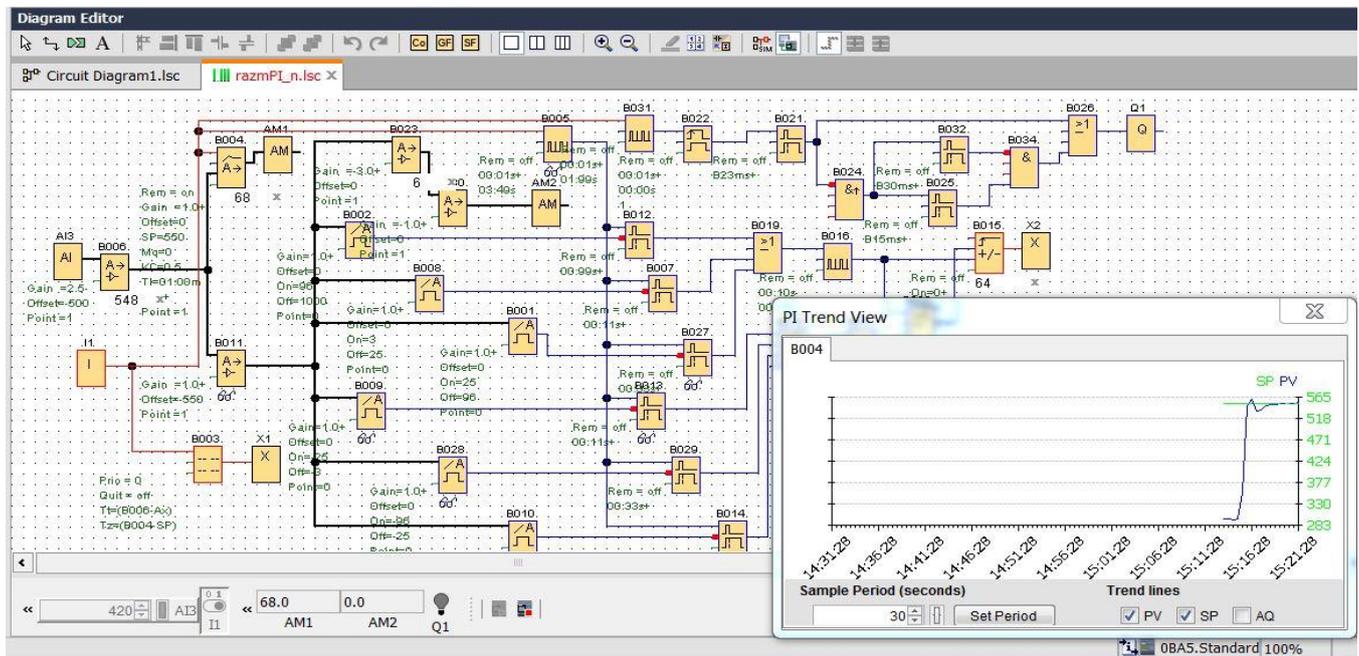


Figure 5. Hybrid PI regulator also taking into account the negative proportional component.

fluctuation of the control variable. These parameters could be further improved by adjusting the PLC parameters.

The controller represented in Fig. 3, however, has some drawbacks. It can be observed that the change in the PWM step changes at the same time the integration time constant value, which does not allow precise settings. In addition, the fuzzyfication intervals are only 5, which gives less options for adjustment of the error intervals.

This is avoided with the implementation of the controller shown in Fig. 4, which uses two separate clock generators for PWM and integration - B005 and B031. Thus the two steps are already independent. In addition, seven intervals are used for the fuzzyfication of the process variable, which is more appropriate to ensure fine tuning of the integral component. The cycle of the PWM on Fig. 4 has remained 2 seconds, but the proportional component and the integration time constant are increased in value. As a result, the time needed for the process variable to reach reference is about 30 seconds, but it exceeds it with 5.6 degrees. Significant overshoot is also presented.

In the presented in Fig. 5 are taken measures to prevent and eliminate the disadvantages of previously proposed hybrid controllers. In this case the proportional component is added only if positive value. The negative values of the proportional component are disregarded. In the latter controller, the control signal is formed by the blocks B032 and B034, which subtract the negative proportional component from the integrated component.

It appears that over-shoot is also improving. In Fig. 5 overshoot is 2.5 degrees and the damping is again significant. All of the above presented simulations are held performed in experimental mode with the same relatively fast temperature control object, for a purposeful comparison.

III. CONCLUSIONS

- It is clear that in steady state the process is still characterized with fluctuating, but it is within the accuracy of measurement. Since the controller is digital, it has the so-called "dead zone" determined by the measurement accuracy, which is quite low for a low-class PLC. Despite that high control accuracy is achieved.
- The parameters of the transition response can be further improved by adjusting the controller parameters, which in the latter proposed controller are independent and can be further adjusted within considerably wide range. This allows its implementation in wide variety of control objects.

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Selecting the Optimal IT Infrastructure of a Data Center

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Abstract - The successful work of any organization in the modern world is dependent on the quality of the Data Center services used for this purpose. In order to meet the quality requirements of the services provided, it is necessary to make an appropriate design and to precisely select its structure and components. This paper demonstrates the use of the author's approach when choosing the optimal IT infrastructure and analyzes its work.

Keywords-data center, reliability, availability, business continuity, disaster recovery

I. INTRODUCTION

Choosing the optimal IT Infrastructure (ITIS) for the data center (DC) needed for the work of each organization is a complex issue. Its complexity is a result of the contradiction that exists between the cost of the required investment and the price the organization wants to pay. The higher quality and the more reliable the IT infrastructure is, the higher its cost. On the other hand, there is no point in investing in IT infrastructure with a lower cost that does not meet the requirements of the organization and its business processes.

The rationale of IT solutions is usually determined by companies that offer IT equipment. Choosing the right solution, however, depends both on the proper understanding of the organization's needs and on the qualifications of the designers. In rare cases the proposed solution is determined by purely commercial interests. The analysis of literary sources [1]–[3] shows that there is no approach developed to help organizations evaluate the proposed solutions. Consequently, the following question arises for organizations that need to implement ITIS: How to find the solution that is optimal for the case?

The approach developed by the author and presented in [4], [5] is a way to solve this problem. This article presents and analyzes the application of this approach for the purposes of a particular project.

II. REQUIREMENTS FOR IT INFRASTRUCTURE QUALITY

The requirements placed on IT infrastructures are different both in number and in character, so each one of them is unique in its composition. Below are the six indicators used to assess the quality of DC used in the author's approach.

A. Brief description of the indicators used in the approach

The first indicator is the Recovery Time Objective (RTO)

and determines the time for recovery of the operation of the ITIS after an incident. RTO is measured in minutes, hours or days, and the lower its value, the higher the price and the quality of the IT infrastructure.

The second indicator is Recovery Point Objective (RPO) and determines the allowed time period for which the data will be lost. The RPO use the same units as RTO. Therefore, each organization would like this amount of time to be as low as possible.

The third indicator is the availability K_{av} of ITIS, which presents the time in which ITIS delivers the services expected of it. It is usually measured in percentages from 0% to 100% of the total system operating time. The higher the percentage, the higher the availability of the system.

The fourth indicator K_{capex} reflects the initial investment (CAPEX) required for the implementation of ITIS, and the fifth K_{opex} – the operating costs (OPEX) for the operation of ITIS. The two metrics can take values from 1 to 6 depending on the amount of money required as described in [5]. The aim of each assignor is to have these values as greater as possible, which means less money is needed.

The sixth indicator K_{impl} reflects the commissioning time of the system. The indicator can take values from 1 to 6 depending on the amount of time for implementation of ITIS as described in [5]. In today's dynamic world, each client would like this time to be as short as possible. On the other hand, the more complex a system, the longer it is.

In the author's approach to select an optimal ITIS, the assignor is required to set the desired values for the above-mentioned indicators and their weighting factors (significance coefficients). The significance coefficients can take values from 1 (low significance) to 3 (high significance). Then the complex geometric indicator for the quality of the desired DC K_{CR} is calculated and compared with the calculated complex indicator K_{jg} of the previously developed reference ITIS (RITIS) (BoP, BoC, BoVPS, RoP, HoP, HoMP) [5], where j is index of the RITIS (see Table I). The range of values of complex geometric indicator is between 0 and 1. Higher value corresponds to a higher quality of ITIS. The outcome of the approach consists of choosing one of the RITIS as optimal for the specific case. This RITIS, the complex indicator of which is greater than the K_{CR} and has the nearest value to it, is selected.

B. The values of assignor’s indicators in relation to DC quality

For the needs of a particular company, it is necessary to make an optimal choice of ITIS. After the risk assessment, analysis of business processes in the company and evaluation of their degree of importance, the assignor defines a task, including values of the single indicators and their weighting factors (WF) as follows: RTO=1 hour, RPO=2 hours, $K_{av}=99,99\%$, $K_{capex}=2$, $K_{opex}=5$, $K_{impl}=2$ and WF as follows: 2, 3, 3, 2, 2, 2.

The set values of the indicators together with the RITIS indicators are filled in in Table I, after which the values of the so-called “Ideal ITIS” are automatically calculated.

TABLE I. VALUES OF SINGLE INDICATORS

WF		2	3	3	2	2	2
Better value of indicator ->		min	min	max	max	max	max
RITIS \ Indicators	j	RTO	RPO	K_{av}	K_{capex}	K_{opex}	K_{impl}
BoP	1	49	24	99,3562	6	4	4
BoC	2	26	24	99,4366	6	3	4
BoVPS	3	24	24	99,4864	6	3	4
RoP	4	57	24	99,7705	5	3	3
HoP	5	221	3	99,9048	2	2	2
HoMP	6	1	1	99,9999	1	1	2
CR		1	2	99,9900	2	5	2
Ideal ITIS		1	1	99,9999	6	5	4

III. APPLYING THE APPROACH

According to the approach for optimal ITIS selection, described in [4], the normalized values of the single indicators d1-d6 and their weighting factors b1-b6 are automatically calculated in Table II.

TABLE II. STANDARTIZED ESTIMATES OF SINGLE INDICATORS

	b1	b2	b3	b4	b5	b6		
	0,14286	0,21429	0,21429	0,14286	0,14286	0,14286		
	d1	d2	d3	d4	d5	d6	K_{jg}	$K_j - K_{CR}$
BoP	0,02041	0,04167	0,99356	1	0,8	1	0,280760	-0,386530
BoC	0,03846	0,04167	0,99437	1	0,6	1	0,295040	-0,372250
BoVPS	0,04167	0,04167	0,99486	1	0,6	1	0,298470	-0,368820
RoP	0,01754	0,04167	0,99771	0,83333	0,6	0,75	0,246780	-0,420510
HoP	0,00452	0,33333	0,99905	0,33333	0,4	0,5	0,248120	-0,419170
HoMP	1	1	1	0,16667	0,2	0,5	0,557150	-0,110140
CR	1	0,5	0,9999	0,33333	1	0,5	0,667290	
							Selected RITIS:	None

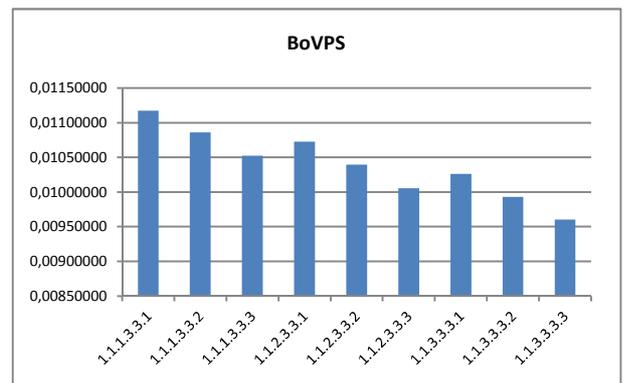
The result is also automatically calculated and recorded in the cell to the right of „Selected RITIS“ in Table II. It accepts one of the values of the set {“BoP”, “BoC”, “BoVPS”, “RoP”, “HoP”, “HoMP”, “None“}. In this case, RITIS is not selected.

After analyzing the calculated values in Table II, it can be seen that the calculated complex geometric indicator of the desired ITIS (CR) has a value of 0.667290, and for all RITIS proposed it is lower. After comparing the values of the single indicators of the desired ITIS with the values of the relevant RITIS indicators, it is found that they are satisfied in the following cases:

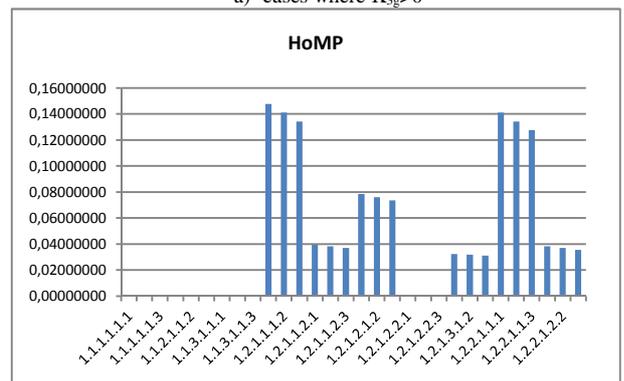
- RTO and RPO – only HoMP;
- K_{av} – only HoMP;
- K_{capex} – only HoP;
- K_{opex} – none;
- K_{impl} – HoP and HoMP.

In the case of an unsatisfactory result, the algorithm for choosing an optimal ITIS provides for an input data correction and iterations to be made. Therefore, in order to solve the task, it is necessary to adjust the values of one or more of the single indicators and / or weighting factors. In order to support the decision-making process, special software tools have been developed to enable digital and graphical representation of the data.

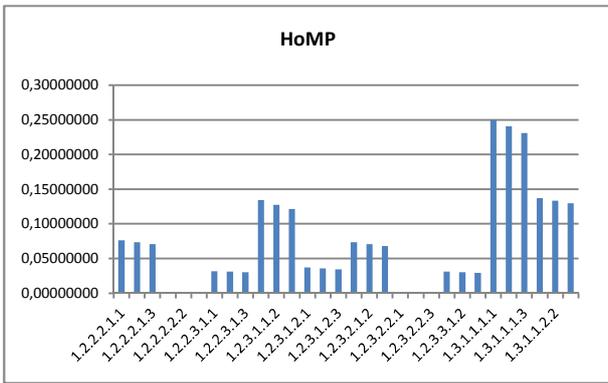
For the set values of the single indicators, an analysis of the K_{jg} dependence on the weighting factors was performed. The K_{jg} values for all 729 combinations of significance ratios were calculated. The results presented in Fig.1 show that the task has a solution (i.e. $K_{jg} \geq K_{CR}$) in 414 cases. In 9 of these the decision was BoVPS Fig.1(a), and in the other 405 – HoMP Fig.1(b-k). By analyzing the BoVPS, HoMP and CR single values shown in Table I, BoVPS can be seen to have significantly lower RTO, RPO, and K_{av} values, whereas HoMP values are better than required, but on the other hand, capital and operating costs are many times higher.



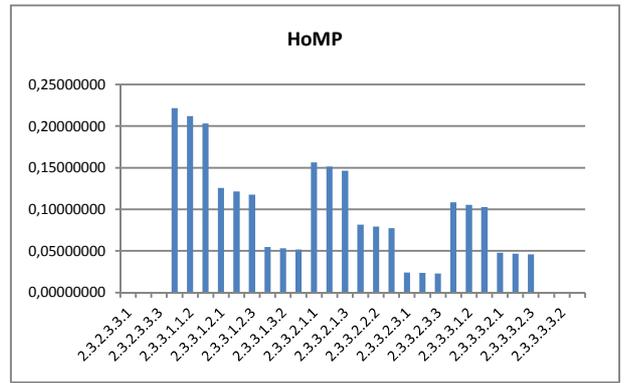
a) cases where $K_{jg} > 0$



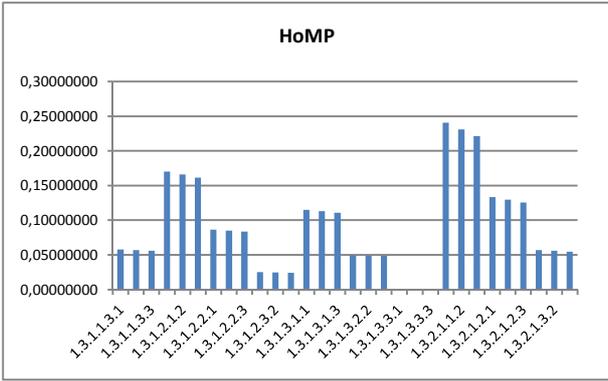
b) the first set of 30 cases where $(K_{jg} - K_{CR}) > 0$



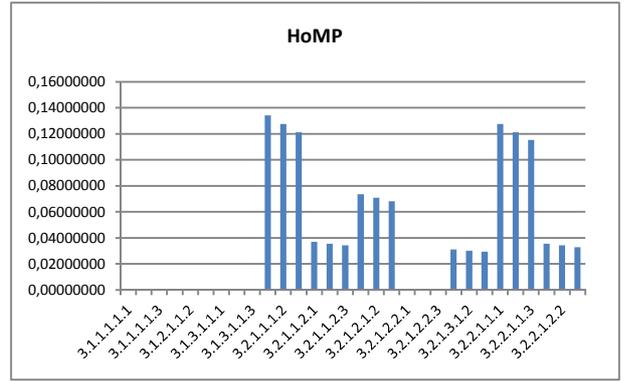
c) the second set of 30 cases where $(K_{6g}-K_{CR})>0$



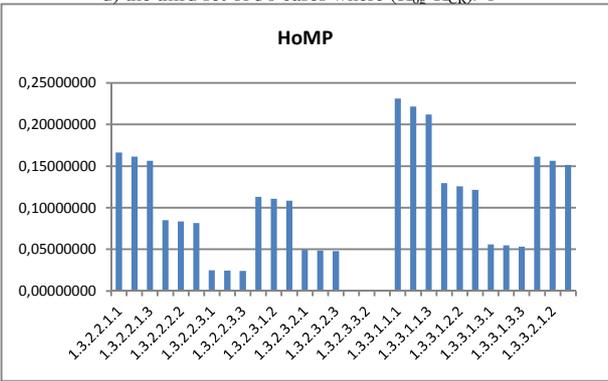
g) the sixth set of 30 cases where $(K_{6g}-K_{CR})>0$



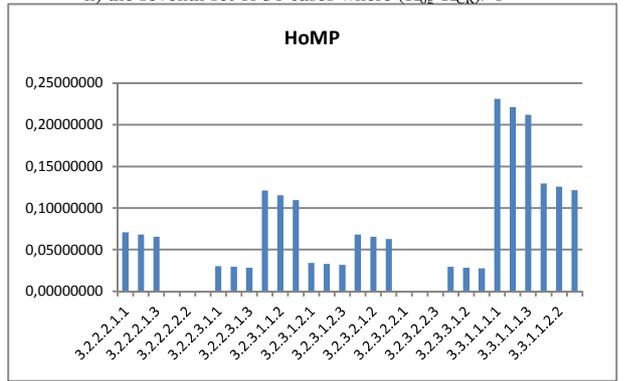
d) the third set of 30 cases where $(K_{6g}-K_{CR})>0$



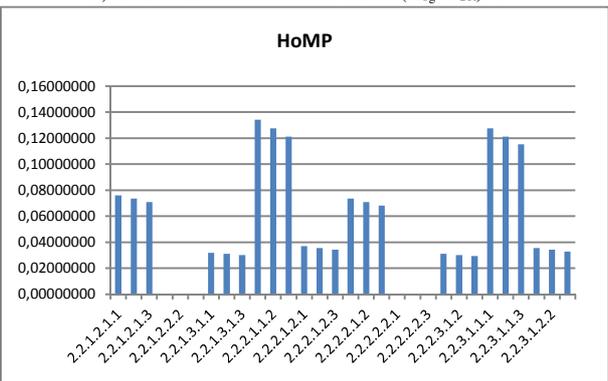
h) the seventh set of 30 cases where $(K_{6g}-K_{CR})>0$



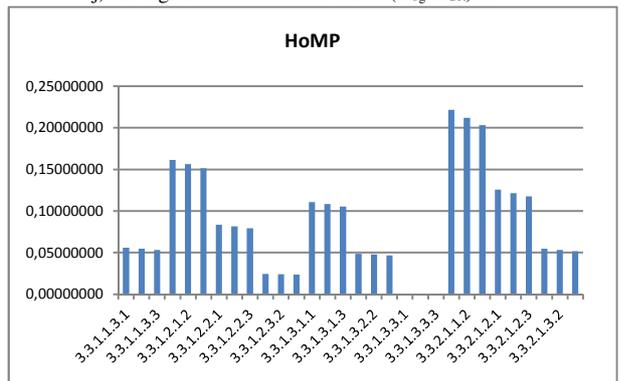
e) the fourths set of 30 cases where $(K_{6g}-K_{CR})>0$



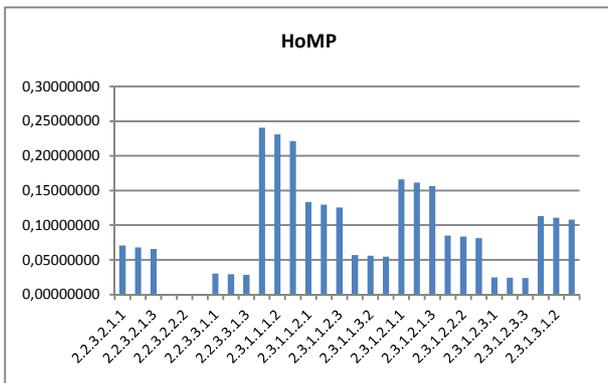
j) the eighth set of 30 cases where $(K_{6g}-K_{CR})>0$



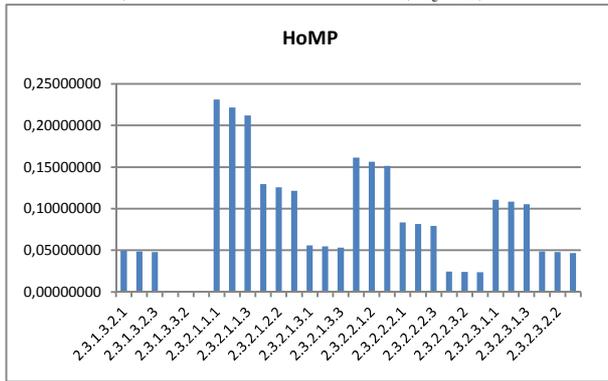
f) the fifths set of 30 cases where $(K_{6g}-K_{CR})>0$



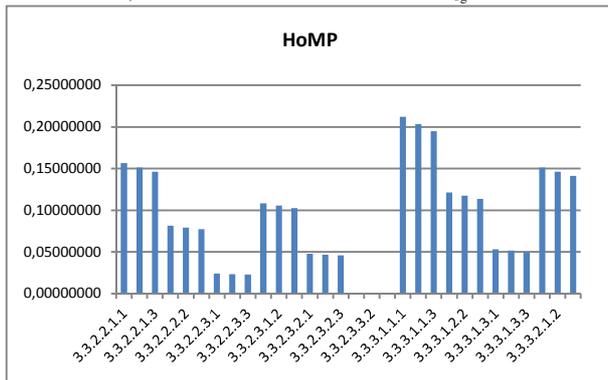
k) the ninth set of 30 cases where $(K_{6g}-K_{CR})>0$



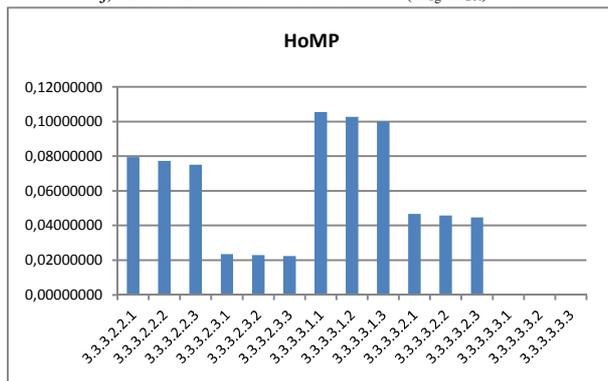
h) the tenth set of 30 cases where $(K_{6g}-K_{CR})>0$



i) the eleventh set of 30 cases where $K_{6g}>0$



j) the twelfth set of 30 cases where $(K_{6g}-K_{CR})>0$



k) the last set of 15 cases where $(K_{6g}-K_{CR})>0$

Fig. 1. Dependency of $(K_{jg}-K_{CR})$ - vertical axis on weighting factors - horizontal axis

After reviewing the graphs in Fig.1, the company's management accepted to make a compromise when it comes to the value of capital and operating costs and to maintain the values of the first three single indicators. The modified values for the single indicators are as follows: $RTO=1$, $RPO=2$, $K_{av}=99.99\%$, $K_{capex}=2$, $K_{opex}=2$, $K_{impl}=2$, and the weighting factors: 2, 3, 3, 1, 2, 2, respectively. The result of the calculations for these inputs is given in Table III.

TABLE III. CALCULATIONS WITH INPUT DATA $\{1, 2, 99.99\%, 2, 2, 2\}$ AND $\{2, 3, 3, 1, 2, 2\}$

	b1	b2	b3	b4	b5	b6		
	0,14286	0,21429	0,21429	0,14286	0,14286	0,14286		
	d1	d2	d3	d4	d5	d6	Kjg	Kj-KCR
BoP	0,02041	0,04167	0,99356	1	0,8	1	0,263520	-0,369170
BoC	0,03846	0,04167	0,99437	1	0,6	1	0,277980	-0,354710
BoVPS	0,04167	0,04167	0,99486	1	0,6	1	0,281460	-0,351230
RoP	0,01754	0,04167	0,99771	0,83333	0,6	0,75	0,232580	-0,400110
HoP	0,00452	0,33333	0,99905	0,33333	0,4	0,5	0,251020	-0,381670
HoMP	1	1	1	0,16667	0,2	0,5	0,632710	0,000020
CR	1	0,5	0,9999	0,33333	0,5	0,5	0,632690	
						Selected RITIS:	HoMP	

After repeating the experiment, the HoMP decision was reached. Table III shows that the calculated K_{CR} of CR is 0.632690 and the HoMP with 0.632710 and none of the other RITIS meets the requirements of the assignor. The comparison of the HoMP and CR values shows that the first exceeds the CR by RPO and K_{av} , coincides with the RTO and K_{impl} class and is lower by one point for the K_{capex} and K_{opex} indicators. Analyzing the result, the firm's management decided to accept it and to invest in the ITIS, which has lower K_{capex} and K_{opex} (i.e. higher price) ratios at the expense of the higher availability of K_{av} and RPO.

IV. CONCLUSIONS

The presented application of the optimal ITIS selection approach to a particular task demonstrates that the difficulty of solving this task can be overcome and reduced to justification and setting values for six indicators. The nature of these indicators is such that any businessman or organization manager can without difficulty identify them without the need for technical knowledge.

The approach is applicable both in the design and analysis of an existing data center.

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Environmental Performance of High Risk Potential Enterprises in Devnya Municipality

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Abstract—Key indicator for environmental management systems' efficiency is environmental performance of organizations. Present research focuses on high risk potential enterprises in Devnya Municipality, in which certified environmental management systems are applied: “Solvay Sodi” JSC, TPP “Deven” JSC and “Devnya cement” JSC. Environmental performance of organizations for a ten-year period (from 2006 to 2015 year). Conducted analyses proves that environmental management systems' implementation at investigated high risk potential enterprises leads to a significant improvement in their environmental performance.

Keywords- *environmental management system, environmental performance, high risk potential*

I. INTRODUCTION

Industrial areas' plurality with a high concentration of enterprises of chemical industry, processing industry and the processing of fuels are carriers of a significant environmental risk. This requires in terms of industrial zones, especially when they involving high risk potential enterprises (HRPE) to take proactive measures to prevent and minimize environmental risks. The set of measures includes organizational-management measures and equilibrium of technical and technological measures. From organizational-management measures with a high potential positive effect on the rational use of natural resources and environmental protection (EP) the implementation of environmental management systems stands out.

Devnya's industrial zone is an important industrial complex, involving enterprises from chemical industry, electrical engineering, limestone mining and processing enterprises, electricity production. Most of the production facilities were built between 1974 and 1977. Taking into account the increasing standards and requirements for EP and ensuring healthy working conditions, for technological capacities renewal and improving the performance of enterprises in terms of environmental performance significant investments are needed [5]. At Devnya Industrial Complex (DIC) includes six HRPE: Devnya Cement JSC, Solvay Sodi JSC, Agropolychim JSC, Deven JSC, SOL Bulgaria EAD, Polimeri JSC. They are the main pollution sources for Devnya Municipality as they exert strong anthropogenic pressure on atmospheric air quality and natural waters quality. Negative impact that exert is significant and indirectly affects the other

environmental components. Generated waste quantitatively as well as qualitatively also are significant and can be ignored.

The legislative requirements and restrictive measures to enterprises regarding environmental protection doesn't provide sufficient efficiency for nature use in many occasions [4]. In this context, HRPE at DIC are geared towards introducing environmental management systems (EMS) through which to fulfill both their environmental policy and their economic efficiency goals. Introduction of environmental management systems in HRPE correlates with sustainable improvement of organizations' environmental performance.

II. METHODOLOGY

The present study focuses on the ecological performance of HRPE in Devnya Municipality, the Northeastern planning region of Bulgaria. For the purposes of present research HRPE is defined as “an enterprise where there are dangerous substances in quantities equal to or in excess of the quantities listed in Annex 3, Part 1, Column 3, or Part 2, Column 3, where applicable, by uses the aggregation rule set out in Note 4 of Schedule 3 to the Environmental Protection Low (EPL) [2, 14].

“Low risk potential enterprise / facility” is an enterprise / a facility where there are dangerous substances in quantities equal to or in excess of the quantities listed in Annex 3, Part 1, Column 2, or Part 2, Column 2, or Annex 3, Part 1, Column 3, or Part 2, Column 3, where applicable, by uses the aggregation rule set out in Note 4 of Schedule 3 to the Environmental Protection Low (EPL).

HRPE in Devnya industrial complex are observed. The industrial enterprises and waste landfills in Devnya Municipality, subject to control and inspection by Regional Inspectorate of the Environment and Waters (RIEW) – Varna are presented in Table I. Those classified as high-risk potential enterprises (HRPE) are presented in Table II. Among these enterprises, Polimeri JSC, Devnya ceased operations in the beginning of 2011.

A specific object of the study is environmental performance of HRPE, in which there are implemented systems for ecological management (certified): Devnya Cement JSC, Solvay Sodi JSC, Agropolychim JSC, Deven JSC [21]. For environmental performance analysis, key indicators are taken

into account regarding the organizations' impact on environment. The air quality at Devnya municipality is most severe affected by the abovementioned HRPE enterprises' manufacturing activity. Thus, emissions of: CO, CO₂, NH₃, NO_x/NO₂, SO_x/SO₂, Fine Particulate Matter<10µm (PM₁₀) are observed by emitting HRPE. [7, 16, 17, 18, 22, 24] Data for ten-year period, from 2006 to 2015, are collected and analyzed. Actual data from the company's own environmental monitoring, data from the Annual Environmental Reports are used in analytical mode. The environmental performance effectiveness is assessed and efficiency of introduced EMS is accordingly determined.

III. RESULTS AND DISCUSSIONS

A. Main feature of HRPEs in DIC

The locations of HRPEs on DIC are shown at Figure 1. The terrain is mainly flat with an average altitude of 16 meters; the prevailing winds are from North and North-West direction. The relative share of windlessness in the year is relatively high. Ground inversions and fogs are typical for DIC [8, 9]. An adverse impact on atmospheric air quality is caused by frequent droughts implying long retention of pollutants [23].

The HRPEs on DIC that are object of present study have different objects of activity. Table III presents HRPEs' production capacity by production plants and installations.

1) Devnya Cement JSC

Italcementi Group (the fifth world cement producer) entered the Bulgarian market in 1998 by purchasing Devnya Cement JSC. Currently, Devnya Cement Group is the largest cement producer in Bulgaria with an annual production capacity of 2.5 million tonnes. Devnya Cement JSC has installations for production of cement clinker and cement. Wet clinker produce method is in use [12].

2) Solvay sodi JSC

Solvay Sodi JSC (part of Solvay Bulgaria EAD) is the largest soda plant in Bulgaria and Europe for synthetic production of calcined soda (calcined soda, soda bicarbonate and calcium chloride) and Solvay's largest European plant with a nominal capacity of 1.5 million tonnes per year [11].

In 1861, Ernest Solvey developed a revolutionary ammonia method for the production of calcined soda. The product is obtained synthetically from limestone and salt and from energy (steam). The main products are Na₂CO₃ - calcined soda (light and heavy) and NaHCO₃ - soda bicarbonate (sodium bicarbonate for food and technical purposes) as an accompanying product. Raw materials are limestone and natural salt solution. Energy carriers are solid fuels - coke and anthracite, steam and electricity. Subsidiary material is ammonia water [11].

TABLE I. INDUSTRIAL ENTERPRISES AND WASTE LANDFILLS IN DEVNYA MUNICIPALITY, SUBJECT TO CONTROL BY RIEW

Company name	Activity	Company name	Activity
Agropolychim JSC	Production of nitrogen fertilizers	Industrial Zone Varna West Ltd.	Hazardous waste dump and storage of own waste in Devnya town
Agropolychim JSC	Non-hazardous waste landfill - for phosphogypsum, Saya dere area, Devnya, landfilling	Kaolin JSC	Installation for sand flushing
Agropolychim JSC	Non-hazardous waste landfill - phosphogypsum, Drenka, Devnya, landfilling	Polymeri JSC	Production of organic and inorganic chemicals
Alifos JSC	Production of monocalcium and dicalcium phosphate	Rosika - 77 Ltd	Rosika - 77 Ltd, producing detergents on Solvay Sodi territory
Bulgarian Sugar Company Ltd	Sugar Factory	Sidi Ltd	Manufacturing and painting of metal constructions
Deven JSC	Production of heating and electric energy	Sol Bulgaria EAD	Factory for production of industrial gases, on territory of Agropolychim JSC
Deven JSC	Non-hazardous waste landfill	Solvay-Sodi JSC	Production of calcined soda
Devina Ltd	Workshop for chalk mines	Sunfleurs Gold Ltd	Transesterification of oils and their transformation into biodiesel, pyrolysis of waste organic raw materials from plant, animal and other origin, containing hydrocarbons and production of synthetic diesel fuel
Devnya Cement JSC	Production of cement clinker	Hexazon Ltd	Hexazon Ltd, Devnya, Saya dere area, Production of household chemistry
Duke Engineering Ltd	Manufacturing and painting of metal constructions	Eskana Invest 96 JSC	Explosives production plant of Karovcha locality

TABLE II. HIGH RISK POTENTIAL ENTERPRISES IN DEVNYA INDUSTRIAL COMPLEX

Company name	Activity	Industry type	Object risk
Agropolychim JSC, Devnya, Industrial Zone	Production of nitrogen fertilizers	chemical	high
Deven JSC, Devnya, Industrial Zone	Production of heating and electric energy	supply of electricity and thermal energy, gaseous fuels and water	high
Devnya Cement JSC, Devnya, Industrial Zone	Production of cement clinker	construction industry	high
Polymeri JSC, Devnya, Industrial Zone. Ceased its activity since the beginning of 2011.	Production of organic and inorganic chemicals	chemical	high
Sol Bulgaria EAD, Sofia	Factory for production of flammable gases	chemical	high
Solvay-Sodi JSC, Devnya, Industrial Zone	Production of calcined soda	chemical	high



Figure 1. Location of HRPE on DIC territory

Legend: 1 - Agropolychim JSC, 2 - Deven JSC, 3 - Devnya Cement JSC, 4 – Polimeri JSC, 5 - Sol Bulgaria EAD, 6 - Solvay sodi JSC

3) *Deven JSC*

The Thermal Power Plant Deven JSC was established in 1965 and since 2000 has been part of Solvay Bulgaria EAD. The main products are electricity, steam and demineralized water. The combustion plant is cogeneration. Combined production is carried out by steam turbines with teams, condensation and counter-pressure through the separate combustion of imported coal, petcoxon, natural gas and fuel oil. About 90% of the energy produced is dedicated to Solvay Sodi. The plant is the only source for powering DIC' plants with heat and power [11].

4) *Agropolychim JSC*

Agropolychim JSC (founded in 1974) produces nitrogen, phosphorus and complex mineral fertilizers, ammonia, acids, salts and compressed gases. The Nitrogen Fertilizer Plant ensures the production of “Stabilized Ammonium Nitrate” and “Liquid Nitrogen Fertilizer”. This includes production of ammonia, nitric acid, stabilized ammonium nitrate (CAE), liquid nitrogen fertilizer (UAN) and tank BABKOK for heat production (to Ammonia installation) with a rated thermal input of 56 MW. The phosphorous fertilizers production installation ensures the production of phosphoric acid, sodium tripolyphosphate (HTP), triple superphosphate (TSP) and complex fertilizers (MAP, DAP and NPK) [10].

Described enterprises with ISO 14001 certified EMS are presented in Table IV.

Devnya cement has an integrated management system that has been certified according to ISO 14001:2004 - EMS since 2004, according to ISO 50001:2011 - Energy management system since 2007, according to ISO 14064:2006 - The carbon footprint since 2011, according to ISO 9001:2008 - Quality management system (ISO 90010) and under OHSAS 18001:2007 - Occupational health and safety management systems fulfills all requirements and it is expected to be certified soon.

For Solvay Sodi and TPP Deven, one of the important common objectives is implementation and certification of a common integrated management system for quality, health, safety and environment. The two enterprises have certificates according to the requirements of ISO 9001:2008 - QMS since 2000, ISO 14001:2004 - EMS and OHSAS 18001:2007 since 2006.

Agropolychim is certified by ISO 14001:2004 - EMS. Meets the requirements of ISO 9001:2008 - QMS and OHSAS 18001:2007, but it's not certified.

The policies developed by the enterprises that make the smooth operation of management systems continuously reviewed and updated to ensure their effectiveness.

TABLE III. HRPEs' PRODUCTION CAPACITY BY PRODUCTION PLANTS AND INSTALLATIONS

HRPE	Product	Production plant / installation	Capacity
Devnya Cement JSC	Cement clinker and cement	Installation for the production of cement clinker - furnace 1-6	furnace № 1 – 24 t/h furnace № 2 – 24 t/h furnace № 3 – 27 t/h furnace № 4 – 27 t/h furnace № 5 – 70 t/h furnace № 6 – 70 t/h
		Installation for the production of cement - four horizontal ball mills 1-4	mill № 1 – 100 t/h mill № 2 – 100 t/h mill № 3 – 100 t/h mill № 4 – 100 t/h
Solvay sodi JSC	Chemical products Calcined soda/ soda ash	light soda	1500 thousand t/y
		heavy soda	1300 thousand t/y
		sodium bicarbonate	30 thousand t/y
Agropolychim JSC	Nitrogen and phosphorus fertilizers	Ammonia 100 %	207 900 t/y
		Nitric acid 100 %	363 000 t/y
		Ammonia water 24 %	64 000 t/y
		Stabilized ammonium nitrate	412 500 t/y
		Liquid nitrogen fertilizer	792 000 t/y
		Phosphoric acid (100 % P ₂ O ₅)	205 000 t/y
		TSP (100 % P ₂ O ₅)	164 000 t/y
Deven JSC	Energy with a rated thermal input of 1 180 MW/ electricity	Fuel system № 1 for the production of superheated steam, burning coal, with steam generators № 2, 3 and 6 and - circulating fluidized bed steam generator - №7	700 MW
		Fuel system № 2, combustion Natural Gas (Sparking Fuel Oil) for the production of superheated steam with Steam Generators № 9	160 MW

TABLE IV. HRPE IN DIC WITH IMPLEMENTED CERTIFIED EMS

Company name	Certified EMS	EMS introduction year
Devnya Cement JSC	ISO 14001:2004	2004
Solvay sodi JSC	ISO 14001:2004	2006
Agropolychim JSC	ISO 14001:2004	n/a
Deven JSC	ISO 14001:2004	2006

B. Ecological performance

Devnya Municipality is an ecological “hot point” in ecological terms. HRPE's emissions are determining for the deteriorated air quality, so HRPEs are the subject of the present study. As well as emissions from domestic solid fuel heating during the winter months and the intensive transport for contribute the deteriorated air quality [1, 19, 20]. In 2015 Devnya Municipality was exempted from the obligation to develop a program for atmospheric air quality (AAQ) improvement, the analysis done to estimate fine particulate levels at 90.4% indicates that the norm is observed [13, 15]. Specific pollutants issued by enterprises: As, Cd, Cr, Cu, Hg, Ni, Pb, Zn and their compounds, anthracene, benzene, naphthalene, polycyclic aromatic hydrocarbons (PAH), chlorine (HCl) and its inorganic compounds, Fluorine (HF) its inorganic compounds in Devnya cement; Fluorine (HF) its inorganic compounds and N₂O in Agropolychim, are not subject of this analysis.

According to the Republic of Bulgaria legislation regarding the environmental monitoring [3], the following indicators are obligatory for the purpose of the atmospheric air quality assessing: CO, CO₂, NH₃, NO_x/NO₂, SO_x/SO₂, Fine particulate matter <10µm (PM₁₀). HRPE in Devnya - subject of the study,

reports emissions of atmospheric pollutants as part of their environmental performance.

Efficiency assessment of the implemented certified EMS is carried out through the enterprises' environmental performance. To determine its performance, quantitative and qualitative measures are required (the indicators listed). In addition, they need to be scrutinized over a long-time period.

Concerning atmospheric air, emissions of CO, CO₂, NH₃, NO_x/NO₂, SO_x/SO₂, Fine particulate matter <10µm (PM₁₀) were analyzed on an annual basis for enterprises that were considered to be major. Ammonia indicator (NH₃) is not applicable to Deven JSC and Devnya cement JSC, and for Solvay Sodi - Fine particulate matter <10µm (PM₁₀). The collected data from enterprises' Annual Reports about environment for the period are presented in Figures 2 - 22 by indicators and enterprises [6]. Threshold value is presented by legislative regulations for each indicator. Thresholds for the observed indicators coincide. For the period 2006 - 2015 the situation in the studied objects is the following:

- “Devnya cement” JSC (Fig. 12 - 6) [12]: Presented data regarding CO, NO_x/NO₂, SO_x/SO₂ and PM₁₀ are obtained by regular measurements. The CO₂ emissions are calculated for the period from 2008 to 2015. For 2006 and 2007 official data regarding CO₂ are not available. Regarding to CO the threshold is not exceeded. However, data analyzing shows that values in

recent years vary so much that suprathreshold values can be expected again, if no more serious measures and actions are taken.

Regarding CO₂, NO_x/NO₂, SO_x/SO₂ emissions as it is presented on Fig. 3, 4 and 5 exceed determined threshold values and vary widely through the period. Relatively lower and deductive values of CO₂, NO_x/NO₂ and SO_x/SO₂ emission for the period from 2008 to 2011 correspond to deducted production during the period. Nevertheless at the same 3-year period PM₁₀ emissions show more than threefold exceedance (188 tons per year in 2006 and 2008) of the limitations granted. After 2008 the levels are deducted and under the limitations from 2009 to 2015 excluding 2012 when more than twofold exceedance (137 tons/year) is recorded. In 2015 the lowest level of PM₁₀ is measured – only 15 t/y.

- “Solvey sodi” JSC (Fig. 7 - 11) [11]: Regarding to main ambient air pollutant CO (threshold = 500 t/y), CO₂ (threshold = 100 000 t/y), NH₃ (threshold = 10 t/y), NO_x/NO₂ (threshold = 100 t/y) shows significant exceedance of granted by IPPC permits, although in different years there are lower and higher measured values. The recorded maximum of 25 591 t/y CO is in 2008. It accounts 51 times the annual limits of all production installations. From 2010 to 2013 the amount of CO reduces to 13 087 t/y or 26-fold exceed of threshold. In the next two years emitted CO increase to around 15 000 t/y. For the observed period CO₂ stays above the limits of 100 000 t/y. Moreover from 2007 to 2009 the trajectory is decreasing from 553 197 t/y in 2007 to 296 439 t/y in 2010, followed by increasing trend to the end of the period. In the last five observed years the average level of CO₂ accounts nearly 500 000 t/y, with maximum of 558 000 t/y in 2014 or more than fivefold exceedance. For the whole analyzed period indicator SO_x/SO₂ with threshold 150 t/y does not exceed the values set in the legislative regulations, but is sustainably increasing. This results in drastic increase and measured value of the 285.080 t/y (about 1.5-fold exceedance) in 2015.

Regarding specific for “Solvey sodi” air pollutant NH₃ recorded data are causing serious concern too. According to IPPC permits the limit is set to 10 tonnes per year. The minimal recorded value NH₃ is 470 t/y in 2009. The extreme of 1 472 t/y is measured in 2014. The overall trend with respect to NH₃ for the analyzed period is increasing.

- “Agropolychim” JSC (Fig. 12 - 17) [10]: For the entire ten-year studied period by the main atmospheric pollutants group, only CO and SO_x/SO₂ are below the thresholds. But they are slowly growing, so thresholds exceeded can be expected soon. The remaining four major pollutants are above the maximum levels, according to the legislative regulations. Theirs reported levels vary greatly, and it is impossible to determine their trend.

- The situation in Deven JSC (Fig. 18 - 22) [11] is almost identical to that in Devnya cement JSC: CO does not exceed the threshold, but the quantities issued vary greatly over the years and there is no concrete trend. CO₂, NO_x/NO₂, SO_x/SO₂ and PM₁₀ very exceeded thresholds according legislative regulations. Only PM₁₀ (38,383 t/y) in 2015 is in norms according to Deven's JSC legislative regulations.

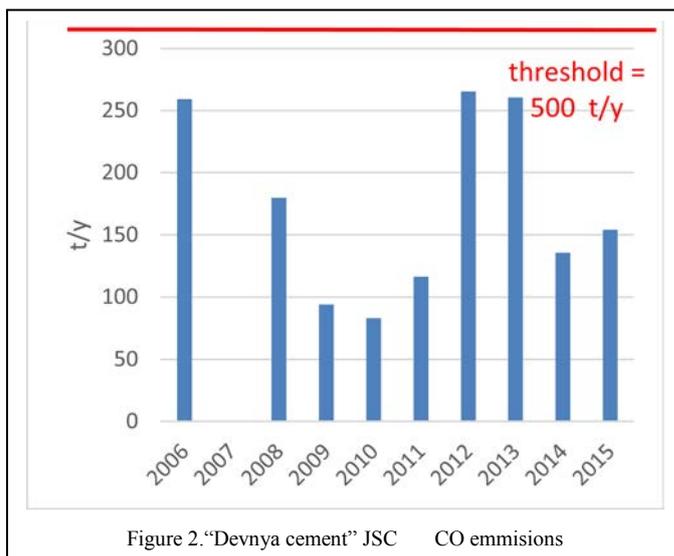


Figure 2. “Devnya cement” JSC CO emissions

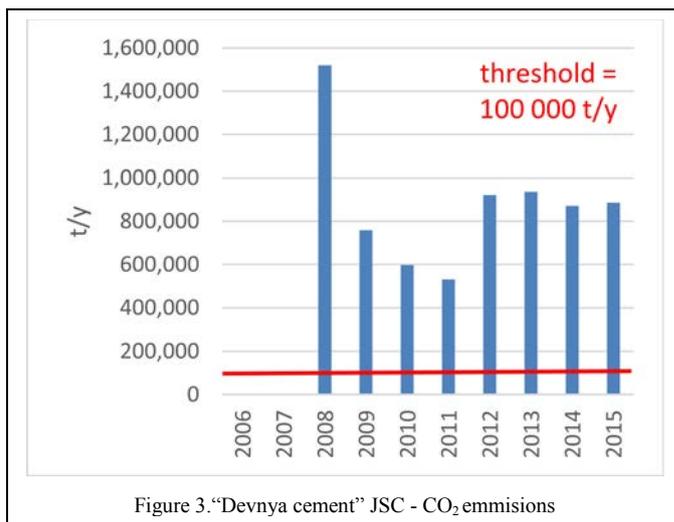


Figure 3. “Devnya cement” JSC - CO₂ emissions

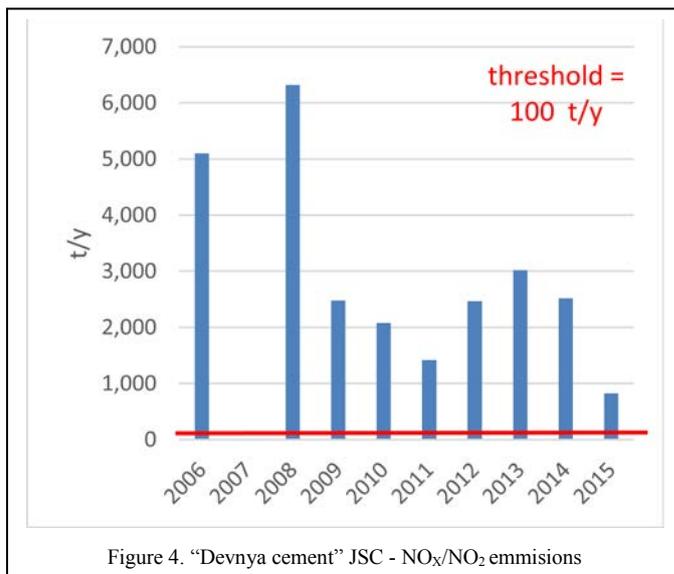
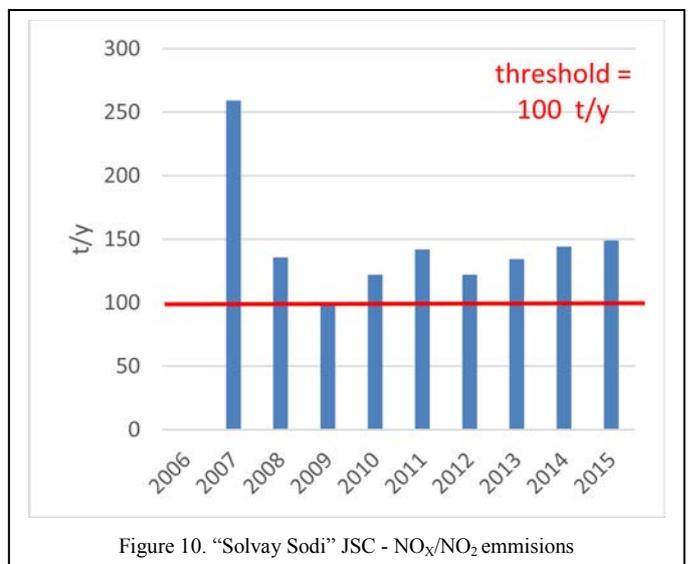
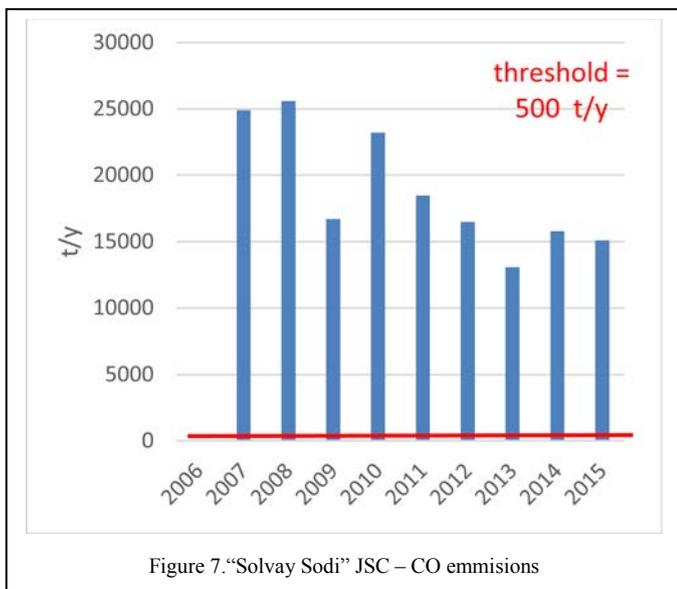
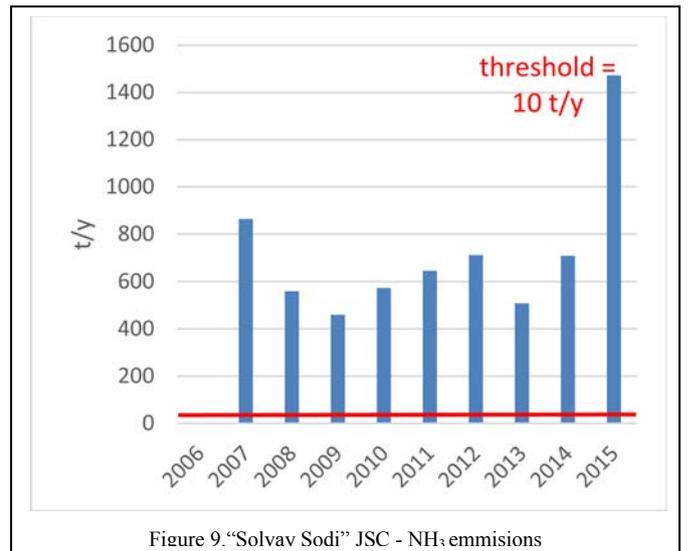
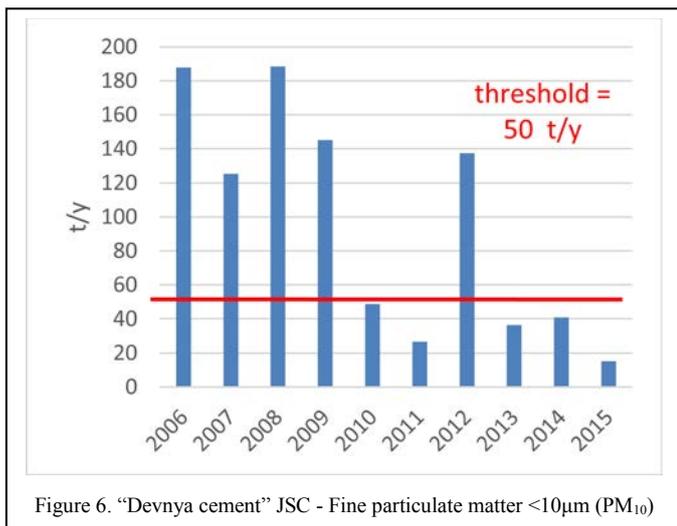
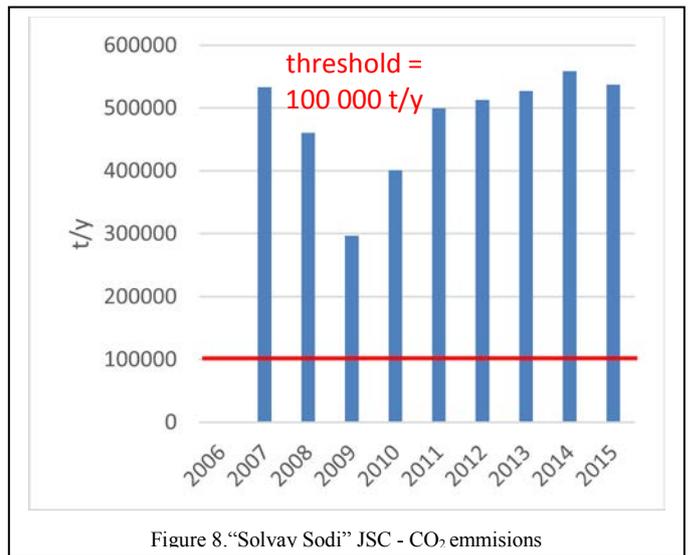
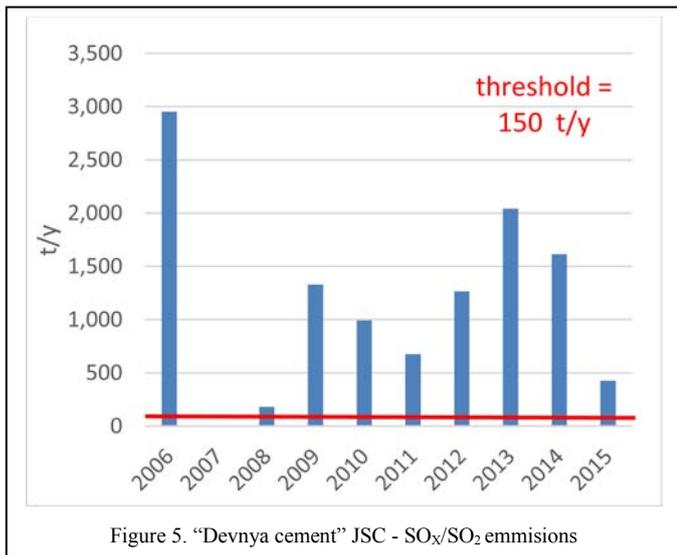


Figure 4. “Devnya cement” JSC - NO_x/NO₂ emissions



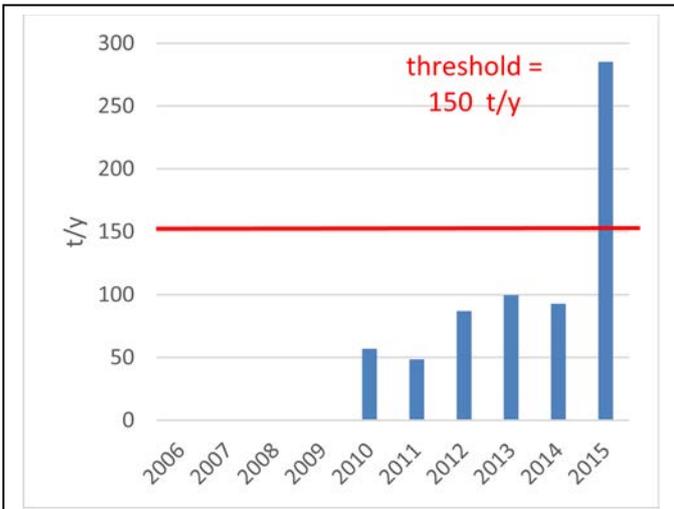


Figure 11. “Solvay Sodi” JSC - SO_x/SO₂ emissions

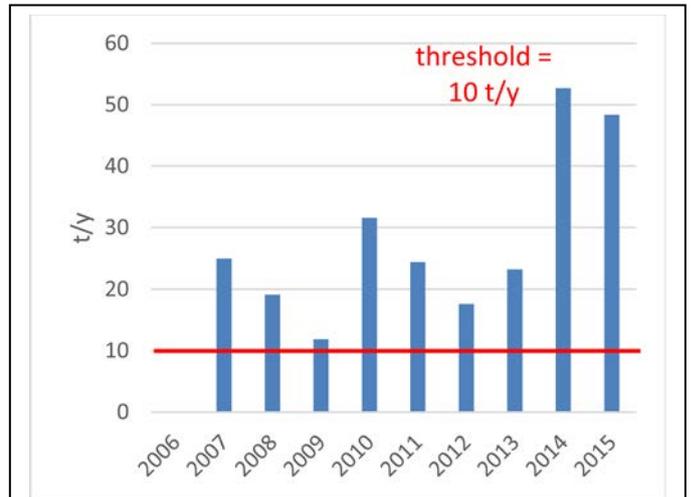


Figure 14. “Agropolychim” JSC - NH₃ emissions

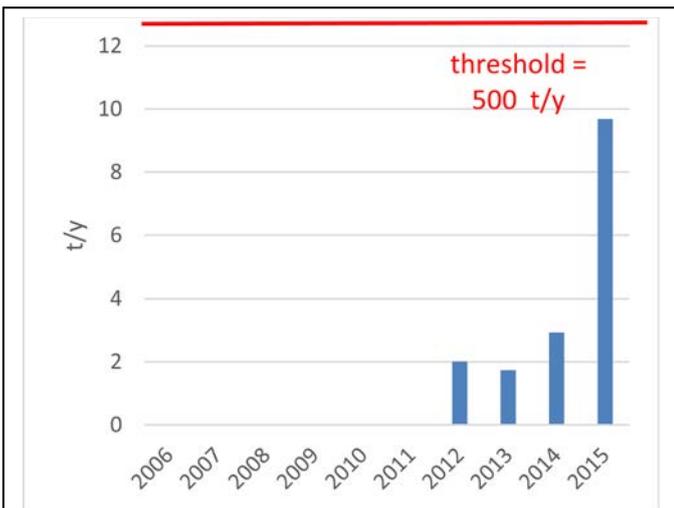


Figure 12. “Agropolychim” JSC – CO emissions

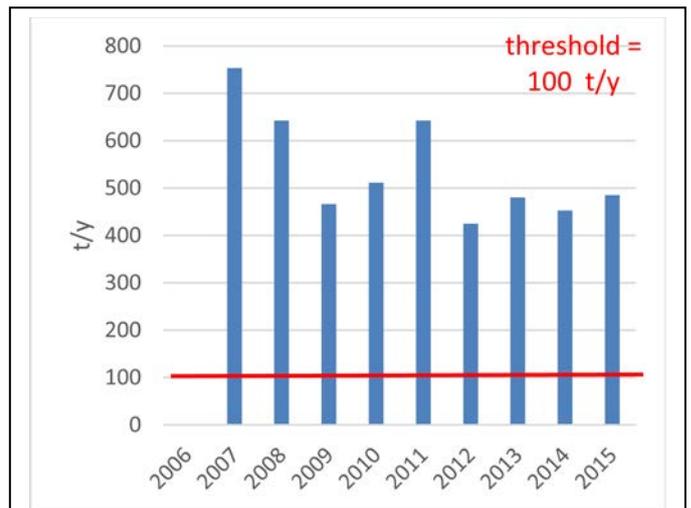


Figure 15. “Agropolychim” JSC - NO_x/NO₂ emissions

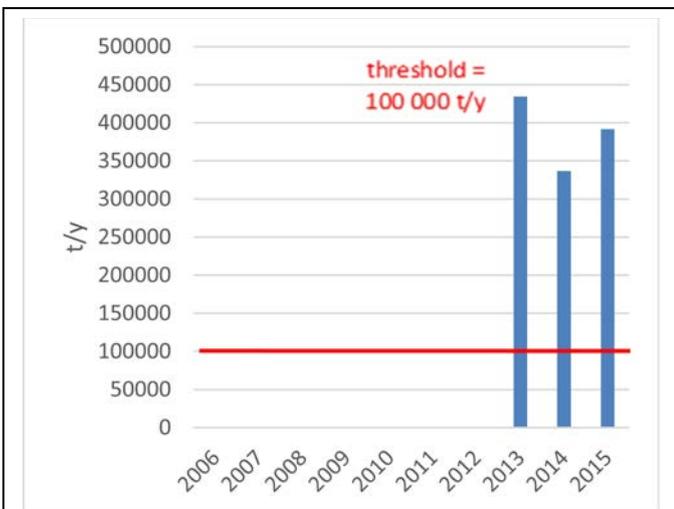


Figure 13. “Agropolychim” JSC - CO₂ emissions

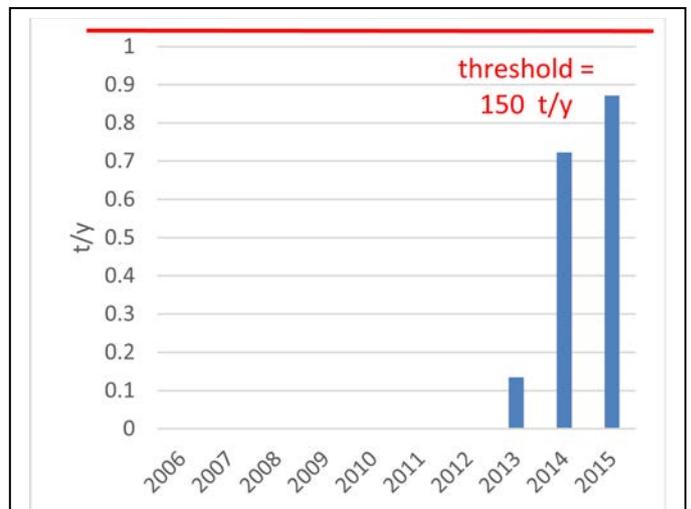


Figure 16. “Agropolychim” JSC - SO_x/SO₂ emissions

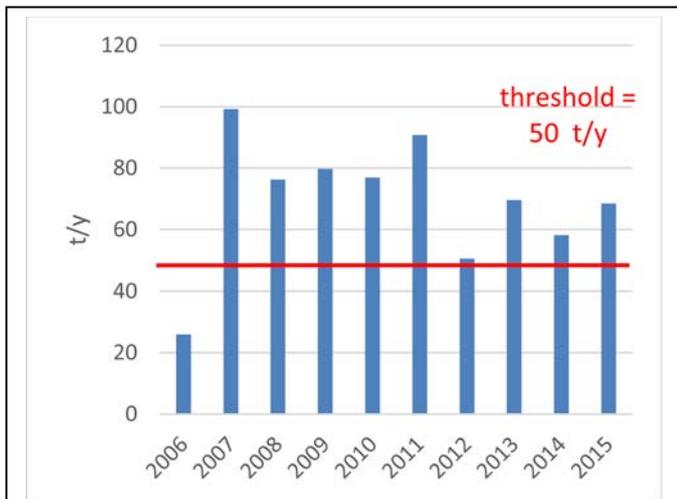


Figure 17. "Agropolychim" JSC - Fine particulate matter <10µm (PM₁₀)

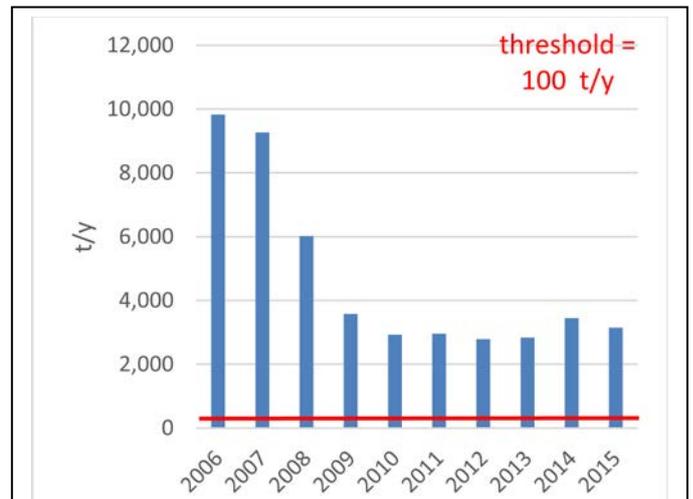


Figure 20. TPP "Deven" JSC - NO_x/NO₂

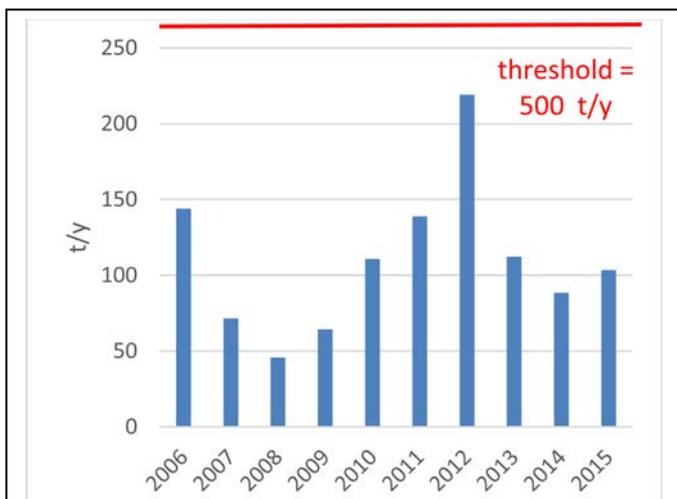


Figure 18. TPP "Deven" JSC - CO emissions

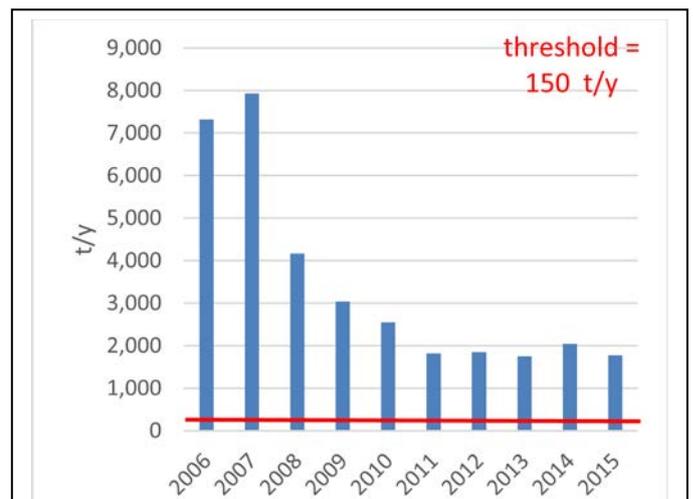


Figure 21. TPP "Deven" JSC - SO_x/SO₂ emissions

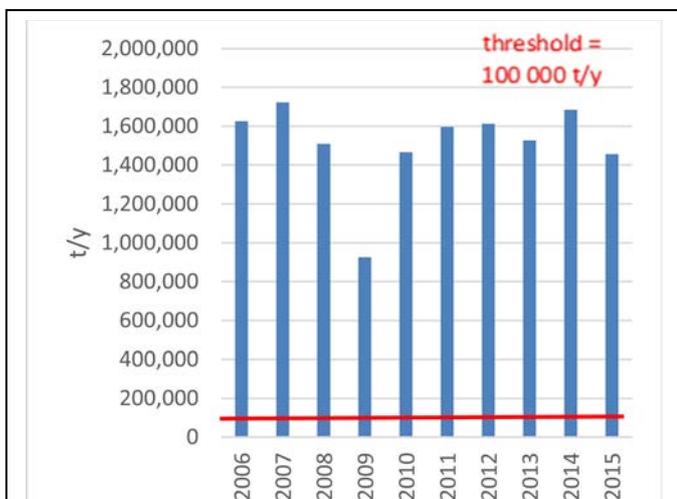


Figure 19. TPP "Deven" JSC - CO₂ emissions

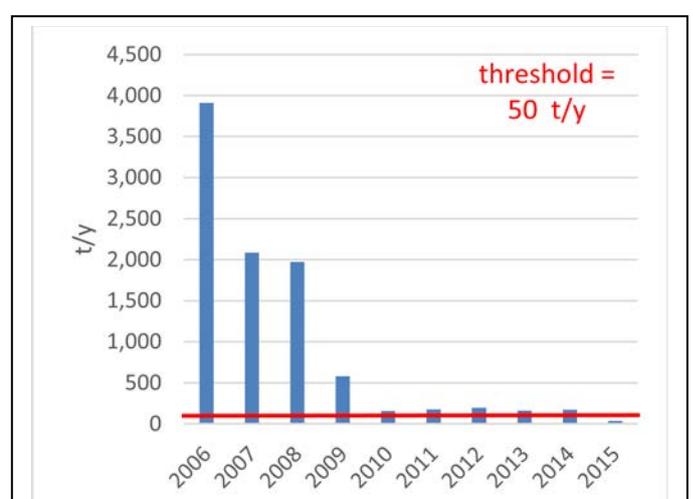


Figure 22. TPP "Deven" JSC - Fine particulate matter <10µm (PM₁₀)

During the analyzed period the HRPEs worked with incomplete loading of production capacities. By 2009, the new circulating fluid bed boiler in Devnya JSC has been put into operation, which significantly reduces the emissions of dust, sulfur dioxide and nitrogen oxides. The Environmental policies of “Devnya Cement” JSC, “Solvay Sodi” JSC, “Agropolychim” JSC, “Deven” JSC have set targets for AAQ improvement insofar as it depends on the particular plant and its exhaust emissions. Specific measures and actions are planned to modernize and/or increase the efficiency of purification facilities.

Periodically, there is a current repair of the electric filters of “Deven” JSC, “Solvay Sodi” JSC and “Devnya cement” JSC; Discontinued of charcoal production in an open way; combustion of natural gas in combustion plants.

IV. CONCLUSIONS

Introduction of ISO 14001 standard to studied HRPEs in Devnya Industrial Complex results in improved environmental performance regarding natural resources management and notably reduction of specific air pollutants. In those particular occasions the RIEW is refraining of further restrictive actions against “Devnya Cement” JSC, “Solvay Sodi” JSC, “Agropolychim” JSC and “Deven” JSC partially because of proven commitments of the HRPEs to environmental protection goals. Implementation of ISO 14001 in addition reassures the society and responsible institution that environmental performance of the organizations is an object of proper management and internal control.

Despite of introduced environmental management systems in the observed HRPEs, the availability of proclaimed environmental policy, the availability of environmental risk management programs and supporting procedures, the environmental performance of HRPEs regarding main air pollutant is unsatisfactorily. All of the abovepresented HRPEs systemically allow excess of IPPC limits regarding main air pollutants, including CO, CO₂, SO_x, NO_x.

The need of further actions to reduce the main air pollutants and thus to improve air quality is obvious.

Introduction on environmental management systems to large scale industrial enterprises creates preconditions for greening the economy, but gives no guarantees for it.

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Integrated Environmental Management System in High Risk Potential Enterprises

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Abstract—In today's globalizing society, achieving and maintaining the balance between economic efficiency and environmental responsibility is a primary task. Paper presents an analytical overview of environmental management systems. A comparative analysis between the most frequently used environmental management systems in manufacturing enterprises is carried out. The analysis of high risk potential enterprises' experience in environmental management systems' implementation shows that there is an objective need to optimize the analyzing procedures and data interpreting of organizations' environmental performance.

Keywords—environmental management system, manufacturing enterprises, high risk potential.

I. INTRODUCTION

The ecological problems of the present are continuously exacerbated by the increase of the anthropogenic pressures and processes such as intensive industrial development, urbanization, increased energy consumption and others. At the same time, global environmental issues such as climate change, the quantitative and qualitative reduction of fresh water, the degradation of natural habitats and the reduced ecosystems ability to provide ecosystem services require urgent action. A change in production and consumption patterns is indispensable. The introduction of environmental management systems (EMS) of different types in an attempt to minimize negative environmental effects on one hand and to obtain a competitive advantage on other hand is among the measures with a notably positive socio-ecological effect.

The ecosystem approach has many names, widely regarded as synonymous with the ecosystem-based approach or ecosystem-based management. Different guidelines are developed and they offering a wide range of new management mechanisms and tools to facilitate the ecosystem approach implementation [16, 17, 18].

The growing guidance documents number, which describe similar or interrelated concepts can be confusing and make the ecosystem approach difficult to apply in practice. Current management systems and political results are fragmented and complex, lacking transparency, and often reactive rather than proactive. Several major obstacles are identified, including the lack of common visions and goals, appropriate governance frameworks, the need for systems perspective and the

confusing set of terminology. In order to apply the ecosystem approach, the ecosystem science theory must be coherent with the practical management of ecosystems [16, 17, 18].

The Ecosystem-Based Management System (EBMS) is a standardized process for applying the ecosystem approach principles. It ensures inclusion of key components such as participation, planning and decision making. Promotes accountability and quality assurance to achieve management goals that follow sustainable development principles and are based on ecosystem services [16, 17, 18].

Standards, guidelines and quality assurance systems are widely used in industry and many areas of governance to ensure quality and accountability. EBMS is a quality assurance, adaptive management tool that introduces into practice the ecosystem approach by normalizing a common set of tools and introducing a common language that is particularly useful for practice and capacity building [16, 17, 18]. It combines the classical environmental and risk management system theory with the ecosystem approach principles in order to a formal systematic structure be develop for adaptive management of public goods.

II. METHODOLOGY

Current study focuses on the implementation of Integrated Environmental Management System (IEMS) in enterprises with high risk potential (HRPEs) as a strategic tool for achievement and maintenance of balance between economic efficiency and environmental protection. An analytical review of the existing and applied EMSs are carried out with special attention being paid to the applied environmental management systems in HRPEs. The environmental management systems introduced and implemented in HRPEs in industrial complex of Devnya are studied. Different voluntary EMSs are compared to their structural and functional organization, environmental risk management correlation, system implementation and maintenance requirements, and key elements in the organizations' environmental performance that are strongly affected by the such systems implementation. For the purposes of this study, the HRPEs Devnya cement JSC, Solvay Sodi JSC, Agropolychim JSC, TPP Deven JSC, all located in Devnya Industrial Complex (DIC) in Northeastern Bulgaria are considered. Actual data on their environmental performance is used.

III. RESULTS AND DISCUSSION

A. INTEGRATED ENVIRONMENTAL MANAGEMENT SYSTEMS

In order for an EMS to fulfill its main objectives, including the effective use of natural resources, improving the enterprises' environmental performance, improving the predictability of economical and socio-ecological performance, it should be incorporated into the enterprises' overall management.

Generally acceptable and approved by the European Environment Agency is EBMS as a management system, based on the ecosystem principle. Thus, achievement of good environmental status has priority. The EBMS is structured as a three-pillar model, recognizing and following the Deming

cycle in its functioning. The structural and functional organization of EBMS is presented in Fig. 1 [16, 17, 18].

Before introduction and implementing of EBMS the initial assessment of economic, social and ecological environment is required. It allows organizations to create clear contextual vision for their own development, including regarding the interaction with the environment and nature in particular.

The first pillar is the information pillar and provides information infrastructure, channels for disseminating information, databases, metadata, etc.

A participatory pillar involves universal (general) participation.

The Ecosystem Based Management System (EBMS)

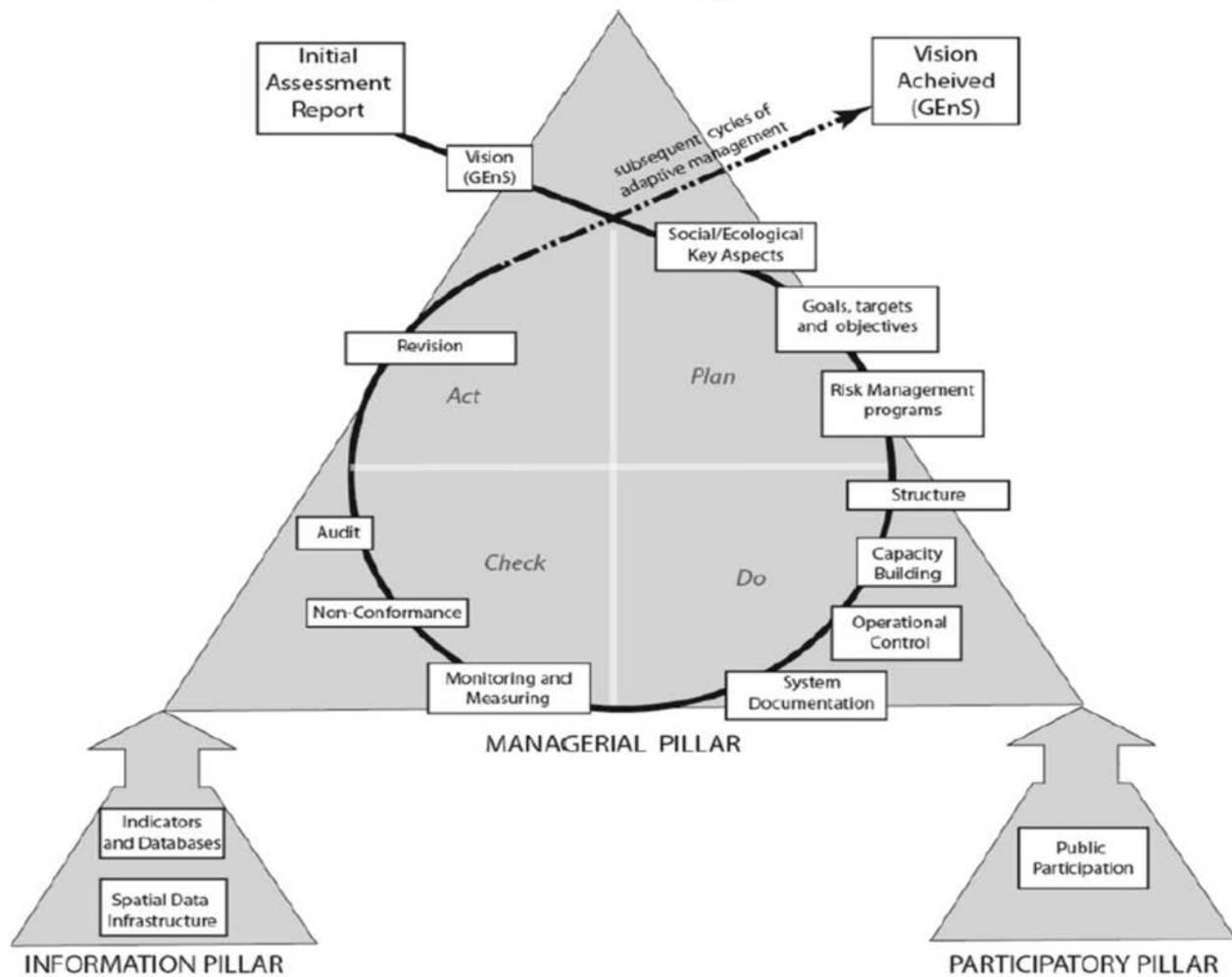


Figure 1. The structural and functional EBMS organization (source EEA)

The EBMS Managerial Pillar facilitates: “planning” phase when main issues are identified, objectives are set up and risk management programs and plans are established; the operational phase when the general structure of the system is organized and incorporated in every level of the organization, capacity is build and operational control is enforced; the

“check” phase when monitoring and audits take place and “act” phase when the process is reviewed by the higher management. That’s how the EBMS facilitates “Plan-Do-Check-Act” cycle, known also as “Deming cycle”.

Planning encompasses the determination of social-ecological aspects, national and international requirements and risk assessment, which contains the following elements: risk management plan and risk management programs (collaborative agreements, concerted actions, best management practice, regulatory policy alignment). "Implementation and operation" contains the risk treatment in 4 steps: structure and responsibilities, capacity building, communication and EBMS documentation; operational control and emergency preparedness and response. "Checking and corrective measures" are represented by monitoring and auditing. It contains monitoring, unplanned events and conflict resolution, EBMS record and EBMS audits [16, 17, 18].

The sequencing of the processes for the introduction and operation of the system are presented in Fig. 1. in the cycle, starting from the initial assessment through the organization's vision, through identifying and analyzing the key socio-ecology aspects of the organization's activities, through targets setting, planning, control, auditing, and review by management. This process is iterative with a cyclical character. In the ecosystem-based management system, the iterative steps follow the framework of the International Organization for Standardization for Environmental and Risk Management - ISO 14001 and ISO 31000. The risk management inclusion follows modern best practices for managing environmental decision-making. Using an environmental management system is a well-established tool for achieving environmental goals [16, 17, 18].

Globally there are a large EMS number that can be certified or not [12]. Although each EMS itself represents an important step towards better environmental performance, committed organizations often reach the boundaries of these systems and are aware of the need for a new, more demanding and ambitious EMS - for example, ISO 14001 EMAS.

One of the objectives of EU environmental policy is to encourage all types of organizations to use environmental management systems and to reduce their environmental impact. Environmental management systems are one of the possible tools by which companies and other organizations can improve their environmental performance while saving energy and other resources. The EU encourages organizations to participate in the Eco Management and Audit Scheme (EMAS).

EMAS and ISO 14001 are the two most widely recognized and enforced environmental management systems applicable to private companies and public institutions.

EMAS is fully compliant with ISO 14001, but goes further in its requirements to improve productivity, employee engagement, legality and communication with stakeholders. In this way, the number of organizations with registered EMAS and ISO 14001 environmental management system in the EU Member States is a useful measure to assess whether private companies and public institutions are increasingly involved in environmental management.

The most accentuated on the environment's welfare are: ISO 14001 - EMS; ISO 14031 - Environmental Management - Assessing Environmental Performance. Instructions; EMAS - Environmental Management and Audit Scheme.

According to data from the European Environment Agency: registered EMAS organizations in and outside Europe are 3865 and ISO 14001 are 80938; registered EMAS organizations in Bulgaria are 9 and the ISO 14001 is 565 [14].

Below is a brief description of ISO 14001 and EMAS.

1) *ISO 14000, ISO 14001 –EMS*

ISO 14001 for EMS is the most widely distributed voluntary EMS for which certification is performed and is most recognizable. The ISO 14000 series was introduced in 1996. It includes 22 standards, including [1, 2]:

- EMS (ISO 14001, ISO 14004 and ISO / TR 14061);
- Environmental Audit Guidelines - Audit Programs, Reviews and Ratings (ISO 14015);
- Eco labels (ISO 14020 and ISO 14021);
- Environmental efficiency assessment (ISO 14031 and ISO / TR 14 032);
- Environmental management by Life Cycle Assessment (ISO 14040, ISO 14041, ISO 14042, ISO 14043, ISO / TR 14047, ISO / TS 14048 and ISO / TR 14049).

ISO 14001 was first released in 1996, updated in 2004, and the new version released in 2015.

ISO 14001: 2015 requires: environmental management to be more visible within the organization's strategic framework; greater management engagement; the implementation of proactive initiatives for environmental protection (EP) from disability and degradation, such as sustainable use of resources and mitigation of climate change; lifecycle focus to ensure that the environmental aspects of development are reviewed for the rest of their lives; adding a communication strategy targeted at stakeholders [1, 2].

Allows easier integration into other MS, thanks to the same structure, terms and definitions.

Improving efficiency of resource using and controlling the environmental impact are equally important issues in this standard. It requires organizations to commit to compliance with the applicable environmental legislation. The implementation of specific environmental management strategies is only required when organizations commit to comply with the law, with continual improvement and prevention of pollution. The main standard focus is the identification and assessment of environmental aspects. ISO does not define a "commitment", but it is expected that an organization is able to demonstrate to its partners and other stakeholders that the engagement is actually being implemented. This is a necessary condition for achieving ISO EMS certification [1, 2, 15, 19]. ISO 14001 sets out EMS requirements that can be integrated with other management requirements to help organizations achieve their economic and environmental goals.

The stages of development and implementation of MS up to the acquisition of a certificate under the different standards are: Status review; Development of the MS documents;

Implementation; Functioning; Certification and acquisition of certificate.

MS have a common structure containing the following processes: document development and control; training of employees; risk assessment; internal audit of IMS elements; leadership review of the entire IMS; corrective actions.

The ISO 14001 standard follows the model in Fig. 2 and is conditionally divided into 5 component sections.

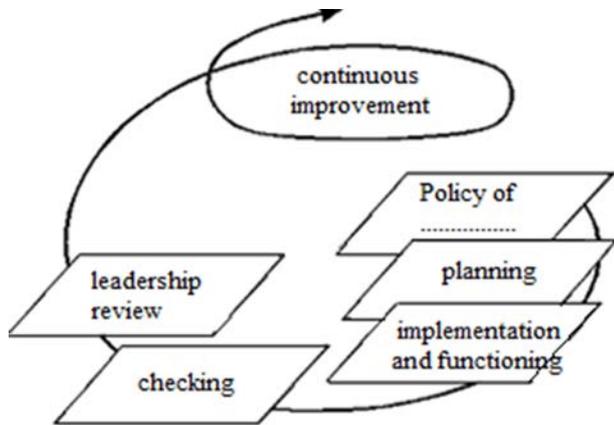


Figure 2. ISO continuous improvement cycle (source ISO)

ISO 14001 sets out the criteria for setting up an Environmental Policy and environmental objectives, taking into account the environmental impact and compliance with the applicable environmental legislation. The standard applies only to those environmental aspects that the organization can control and on which it can influence. There are no ecological criteria in place in the standard itself. What is required is actually the implementation of ISO 14001, which is the subject of continuous improvement [1, 2].

Environmental Policy: The most important policy requirement is the senior management support. The policy sets the beginning of the validation of the EMS principles. It is the policy that sets environmental objectives and tasks, allocates responsibilities and establishes the milestones in the EMS development, on the basis of which the MS should be evaluated. Senior management is responsible for initiating environmental policy and providing resources and guidance for others who may be in charge of developing a final policy [1, 2].

When developing environmental policy, the primary objective is to keep the policy as simple as possible. It is intended as a guideline, and how the objectives are met is dealt with in detail in the environmental programs. However, the policy should not be too general.

ISO standards for environmental management are common and are therefore generally valid.

The ISO 14001 standard is the only in ISO 14000 that is auditable through the conformity assessment process and is the only one in the series on which the organization can be certified. An ISO 14001 certification does not automatically mean that an organization is “eco-friendly” than another. It shows that there is an approach to controlling environmental

aspects and impacts, and that continuous improvement is the overall goal of this organization. Whether the organization is truly “eco-friendly” should be shown and proved individually by providing the necessary information to stakeholders [1, 2].

The introduction of ISO 14001 should not be an end in itself, but the potential and actual benefits and resources needed to implement and maintain it should be analyzed.

Among the EMS benefits are [1, 2]: - improvement of environmental performance and compliance; - conservation of resources; - increasing efficiency; - improving employees' spirit; - compliance with the law, improvement of the opinion of the public, regulators, creditors, investors, official authorities, insurance companies, stakeholders; - awareness of the environmental problems and responsibilities of employees; - reduction of debts; - competitive advantages; - fewer incidents.

In order to improve environmental management, an organization should focus not only on what is happening but also on why something is happening. Over time, systematic identification and correction of system failures leads to better environmental and overall organized work.

The benefits for certified organizations are [1, 2, 15, 19]: Enhancing the trust of partners and external stakeholders; an opportunity for the organization to manage its environmental problems, leading to better environmental performance; minimizing the risk of environmental incidents and reducing their impact; raising employees' environmental awareness, changing their thinking and habits, and transferring good "green" practices outside of the organization; efficient control of resource consumption, leading to cost savings; identifying all applicable requirements for the organization; effective implementation completely eliminates the risk of sanctions by control bodies; awareness of potential savings and reduction of energy and raw materials consumption; reduction of waste disposal costs; lower fees related to the use of natural resources; lower insurance premiums from risk mitigation; improving management of the organization; reduce the harmful impact on the environment; a structured way of communicating; regular internal audits and third party audits to quickly identify weaknesses; avoiding lawsuits (eg in terms of environmental damage, accidents); prevents incalculable risks with respect to the environment; timely implementation of environmental protection measures.

HRPEs in DIC with certified ISO 14001 EMS have Devnya cement JSC, Solvay Sodi JSC, Agropolychim JSC and Deven JSC.

2) EMAS

The EMAS scheme was introduced under Regulation (EC) № 761/2001 of the European Parliament and of the Council of 19 March 2001. Revised and adopted by Regulation (EC) № 1221/2009 (also known as EMAS III) and directly applicable in all Member States.

Any public or private organization can implement EMAS. Thanks to EMAS III, the scheme is also available to non-EU organizations or European companies operating in non-EU countries.

EMAS can be introduced into one, several or all sites belonging to private or public organizations in any sector of activity. The smallest unit that can be registered is an object.

The EMAS purpose is to promote the continuous improvement of organizations' environmental performance by introducing and implementing an environmental management system, assessing the performance of such a system, providing information on environmental performance, open dialogue with the public and other stakeholders, as well as active employee involvement [9, 10].

EMAS was established in 1993 and has evolved over time. The EMAS Regulation provides the legal basis for the scheme. The overall objective is to harmonize implementation in all Member States and create a common legislative framework.

EMAS is a voluntary instrument at the disposal of any organization operating in any sector of the economy within or outside the European Union that wants to: take environmental and economic responsibility; to improve its environmental performance; to disclose its environmental performance to the public and to stakeholders as a whole. Organizations registered under EMAS must: to demonstrate compliance with environmental legislation; to undertake to continuously improve their environmental performance; to show that they maintain an open dialogue with all stakeholders; to involve employees in improving the organization's environmental performance; to publish and update an EMAS-certified environmental statement for public disclosure of information. Additional requirements: Organizations must undertake an environmental review (including identification of all direct and indirect environmental aspects); to be registered with a competent authority after a successful verification of their organization. Once registered, organizations are entitled to use the EMAS logo. The EMAS logo can be used as a marketing or sales tool to promote the organization's excellent environmental performance [9, 10].

General procedure for EMAS introduction is presented in Fig. 3. [9, 10].

(1) First step is an environmental review- an initial analysis of all its activities, conducted in order to identify relevant direct and indirect environmental aspects and applicable environmental legislation.

(2) Introduction of an EMS in accordance with the requirements of EN ISO 14001.

(3) The system has to be checked by conducting internal audits and review by the management.

(4) The organization prepares an EMAS environmental statement.

(5) The environmental review and environmental management system shall be verified and the declaration certified by an accredited or licensed EMAS verifier.

(6) Once the organization is verified, it applies for registration to the Competent Authority. The European Commission is developing "sectoral reference documents" for a number of priority sectors, in consultation with Member States and other stakeholders. Each document includes the

following elements: best environmental management practice; environmental performance indicators for the specific sectors concerned; where appropriate, benchmarks of excellence and rating systems that determine the level of environmental performance achieved. Where sectoral reference documents exist for their specific sector, organizations registered under EMAS are required to comply with them on two levels: when developing and implementing their environmental management system for environmental audits; when preparing the environmental statement. Participation in EMAS is a long-term process. Whenever an organization reviews its environmental performance and plans improvements, it should refer to specific topics in the sectoral reference documents (if any) in order to decide in what sequence it will address the individual issues.

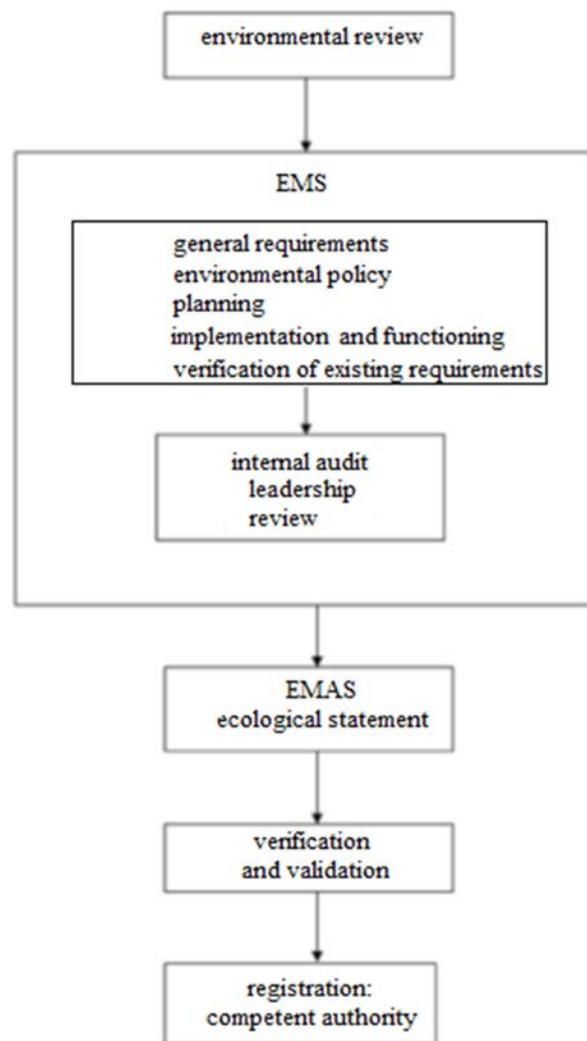


Figure 3. A common scheme for EMAS introduction [9, 10]

EMAS environmental statement [9, 10]:

"Environmental statement" means full information to the public and other stakeholders on the following characteristics of an organization: structure and activities; environmental policy and environmental management system; environmental

aspects and impacts; environmental program, objectives and tasks; environmental performance and compliance with applicable environmental legal obligations.” The statement is one of the unique features of EMAS compared to other EMS. As regards the public, it reaffirms the organization's commitment to environmental protection. It is a good opportunity for the organization to disclose what it does to improve the environment. EMAS lays down some minimum requirements for the declaration, but the organization can decide how much it wishes to go into details, as well as structure and layout, and the content should be clear, reliable, trustworthy and true. The organization decides whether it wishes to include its environmental statement in its annual report or in other reports, for example on corporate social responsibility.

The environmental statement can be used to report organizational performance data on marketing, supply chain and procurement activities. The organization may use information from the certified declaration to market its EMAS logo activities, assess suppliers based on EMAS requirements, and give preference to EMAS registered suppliers.

EMAS is considered to be one of the most reliable and most sustainable EMS on the market, adding several elements in addition to the requirements of the international standard for environmental management systems EN ISO 14001. It is characterized by: the stricter requirements for measuring and evaluating environmental performance in relation to the objectives and tasks set, and continually improving these environmental outcomes; compliance with environmental legislation, which is ensured through State oversight; active participation of employees; the main environmental indicators that create comparability on a multi-annual basis within an organization and between organizations; the provision of information to the general public through the validated environmental statement; registration by a public authority following an inspection by an accredited or licensed environmental verifier [9, 10].

EMAS benefits the participating organizations in the scheme [9, 10]: improved environmental and financial performance: high-quality environmental management; resource efficiency and lower costs; improved risk management and capabilities: guaranteeing full compliance with regulatory requirements of environmental legislation; reduced risk of fines in relation to environmental legislation; regulatory relief; access to incentives related to deregulation; enhanced trust, reputation and transparency: independently-certified environmental information; using the EMAS logo as a marketing tool; better business opportunities in markets where environmental production processes matter; better relations with customers, the local and the wider public, and with regulators; greater empowerment and motivation of employees: better workplace environment; greater engagement of employees; better ability to build a team.

Taken together, these elements lead to three distinctive features of EMAS: performance - trust - transparency.

None of the organizations in Devnya Industrial Complex is registered under EMAS.

The benchmarking of the most environmentally-friendly environmental management systems in manufacturing plants shows that EMAS and ISO 14001 have a common goal of ensuring good environmental management. However, they are perceived as competitive. The European Commission recognizes that ISO 14001 can be a stepping stone to EMAS. Indeed, the requirements of EN ISO 14001 for environmental management systems are an integral part of EMAS III. ISO 14001 and EMAS are based on the same conditions.

EMAS additional requirements [9, 10]:

- Initial Environmental Review: EMAS requires an initial environmental review to identify the environmental aspects of an organization. However, when an organization already has an ISO 14001 certified EMS, it does not need to carry out an official environmental review when it goes to EMAS;

- Authorization issued by a public authority to comply with legal requirements: The organization registered under EMAS must demonstrate full compliance with environmental legislation;

- Commitment to continuous improvement of environmental performance: An organization wishing to register under EMAS must commit to continuously improving its environmental performance. Environmental performance is assessed by an environmental verifier;

- Employee participation and openness to the public: an EMAS registered organization has to demonstrate an open dialogue with employees and stakeholders, including stakeholders, local authorities and suppliers;

- Verified Environmental Statement: The organization has to provide a public statement about its environmental performance. The environmental statement shall state the results achieved in relation to the environmental objectives set, as well as the future steps to be taken to continuously improve the environmental performance of the organization.

The main difference between ISO 14001 and EMAS is limited to the organization's obligation to publish a statement about the environmental aspects that it has defined.

The cost of introducing these EMSs is lower than the savings. Positive impacts are: energy and resource savings, less negative incidents, improved stakeholder relationships, more market opportunities, organizations can encourage their suppliers to introduce EMS as part of their own GA policy, can facilitate internal procedures between businesses for both parties may allow the organization to have regulatory relief.

B. INTEGRATED ENVIRONMENTAL MANAGEMENT SYSTEMS IN HRPEs IN DEVNYA INDUSTRIAL COMPLEX, BULGARIA

In Bulgaria, Devnya municipality is among the municipalities with the highest concentration of enterprises in the country. DIC shows a high concentration of large scale industrial plants, most of them belonging to the chemical industries. HRPEs in DIC are: “Devnya cement” JSC, “Solvay Sodi” JSC, “Agropolychim” JSC, “Polimeri” JSC, “SOL Bulgaria” Ltd and TPP “Deven” JSC.

The HRPEs, which have certified EMSs, are “Devnya cement”, “Solvay Sodi”, “Agropolychim” and “Deven”.

“SOL Bulgaria” Ltd - Devnya (develops its activity on the territory of Agropolychim JSC) declare fulfillment of the requirements of the ISO 14001 standard, but its system is still not certified. “Polimeri” JSC ceased activity from the beginning of 2011, but to date the control bodies still struggle with the damage done to the sites of the enterprise and the environment [3, 4].

Devnya cement has an integrated management system, including quality management, environmental management and energy efficiency management. The incorporated environmental management system of the organization is introduced in 2004 and is certified under ISO 14001:2004. The energy management is added as a certified system in 2007. Currently maintained certification is under ISO 50001:2011. The overall management system is further developed by certification in accordance with ISO 14064:2006 (The carbon footprint) in 2011. Devnya cement follows the quality managerial pattern respecting ISO 9001:2008 under which is certified too. Last, but not list the organization incorporate the OHSAS 18001:2007 standard (Occupational health and safety management systems) and is in a preparatory stage of initial certification process [7].

Devnya cement demonstrates commitment to ideas of environmental and social responsibility and manages its environmental performance.

For Solvay Sodi and TPP Deven, one of the important common objectives is implementation and certification of a common integrated management system for quality, health, safety and environment. The two enterprises have certificates according to the requirements of ISO 9001:2008 - QMS since 2000, ISO 14001:2004 - EMS and OHSAS 18001:2007 since 2006 [6].

Agropolychim is certified under ISO 14001:2004 - EMS. The company declares that meets the requirements of ISO 9001:2008 - QMS and OHSAS 18001:2007, but it isn't certified yet [5].

The policies developed by the above enterprises ensure preconditions for smooth operation of management systems, continuously reviewed and updated to ensure their effectiveness. Within the scope of EMS of the studied HRPEs their environmental performance is monitored and controlled internally and externally.

Thus the companies benefit from deduction of energy losses, energy costs, improved resource management and markedly improved public image. Trustful relationships with responsible institutions, e.g. RIEW, confirm the above stated. Furthermore the RIEW is refraining of the most restrictive actions against “Devnya cement”, “Solvay Sodi”, “Agropolychim” and “Deven” despite the fact that on annual basis (from 2007 to 2015) these HRPEs reported two- to fivefold exceedances of the permitted limits of main air pollutants' emissions CO₂, NO_x/NO₂, SO_x/SO₂ and PM₁₀ [5, 6, 7]. Regarding air pollutants Devnya cement exceed strongly defined IPPC threshold limits on: CO₂, NO_x/NO₂, SO_x/SO₂.

[7]. Solay sodi reports drastic exceedance of granted by IPPC limitations on the same parameters as well as on NH₃ [6]. Agropolychim's environmental performance is marked by constant (from 2007 to 2015) exceedance of annual thresholds on CO₂, NH₃, NO_x/NO₂, Fine particulate matter <10µm (PM₁₀) [5]. Thermal power plant Deven emits excessively CO₂, NO_x/NO₂, SO_x/SO₂ and PM₁₀ [6].

Of course, the fact that these HRPEs are large scale investors for the region can't be ignored.

IV. CONCLUSIONS

Despite of some differences in introduction phases and certification requirements all observed EMSs share common principals, objectives and features. The EMS does not guarantee environmental performance improvement in short term, but creates prerequisites for minimizing the negative effects of the organization's activities and products on the environment.

The most recognizable EMSs on a global scale are ISO 14001 and EMAS. The comparison between them shows that they are very similar, based on common foundation and both can be assigned as variation of EBMS. EMAS brings some additional requirements to organization, e.g. publishing and verification of an environmental statement. At the same time both systems, ISO 14001 and EMAS provide commensurate benefits to organizations.

The benefits for certified organizations under ISO 14001 and EMAS conclude in improved environmental and financial performance based on efficient use of natural resources, proactive environmental risk management, increased predictability of results and obtained overall positive image. In addition the companies benefit indirectly by using improved environmental performance as a marketing tool to attract potential clients.

In Bulgaria ISO 14001 is well recognized, despite of EMAS. One particular reason is that International Organization for Standardization is globally well known, issued over 570 different standards, and many ISO standards are adopted in Bulgaria. More than 580 organizations in private and public sector are certified under ISO 14001 in Bulgaria alone. The number of EMAS certified organizations is our country is minor.

In Devnya industrial complex 4 of total of 6 HRPEs implement EMSs: “Devnya cement”, “Solvay Sodi”, TPP “Deven” and “Agropolychim”. All of them are certified under ISO 14001.

The environmental management systems, providing no specific eco limitations, allow companies to achieve and maintain a balance between economic priorities, environmental responsibility and environmental protection.

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Employment of the Smart Contracts in the Practicing of the Franchising Business Model

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Abstract—Smart contracts which are based on the blockchain technology are not only a research interest of the Information and Communication (IC) sciences. Frequently, the interest for the smart contracts is accompanied by exploring their application dimension. The potential for use of smart contracts has been identifying in some business areas like insurance sector and in the so-called share economy. The main research challenge of this paper is to recognize the opportunities for application of smart contracts in the implementation of franchising business model. Through analysis of the main attributes of practicing the franchising business model, the paper will identify and suggest on the employment of the smart contracts as an added value in the process of employment and increase of the franchising business model efficiency.

Keywords-smart contracts, blockchain, application, franchising business model

I. INTRODUCTION

The ICT development has a profound effect and influence on today's economy. Particularly, many business processes have been dramatically transforming and changing by the development of ICT technology. The blockchain as a technological advance is expecting to have wide-reaching implications and cause transformation of many business activities and models, industries and the entire economy. The blockchain technology provides a potential to automate transactional activities and business processes. The World economic forum (WEF) counts the blockchain technology as one of the ICT megatrends shaping today's society. The WEF's recent report predicts that by 2025, 10% of the global GDP will be stored on blockchains or blockchain related technology [1]. The blockchain technology has a variety of applications, among them are the distributing computing platforms used for running smart contracts.

Smart contracts are computer programs that facilitate and enforce the implementation of an agreement. They can secure and enhance the performance of the economic activities. Increasingly, smart contract as blockchain-based technology offers solutions in the financial sector such as securities trading, foreign exchange and insurance. Also, there are countless other interesting applications like the land registry, health, education, sharing economy and energy [2]. They can have limitless application. Therefore, the purpose of this article is to explore the opportunities for the application of the blockchain and smart contracts in the implementation of the

franchising business model. Franchising is a growing model of doing business domestically and internationally. Franchising is a contractual model of entering the market. It is a business format in which a company - franchisor grants to other company the right to do business in a prescribed manner over a certain period in a specified place in return for royalties or the payment of other fees [3].

Since franchising business model as a contractual model emphasizes the necessity for trust as a central point for the success of franchising relationship, the smart contracts can be an effective tool in the securing the accomplishment of the contracted conditions. Since the operation of the franchising business model relates to the execution of transaction activities, the employment of smart contracts can reduce the number of transaction costs associated, since it cuts out any intermediaries involved. Frequently, the issues connected with the protected rights like those covered in the franchising business model, are very difficult to be controlled, so the smart contracts as a blockchain technology can make visible and reliable the process of their exercising. Since the franchising business model records emerging application in almost any area of production of goods and services, it can ensure a widespread employment of the smart contracts in an economy.

Exploring through the smart contracts as a blockchain technology and the mode of operation of the franchising business model, in this paper, we are trying to identify and outline the issues of the employment of the smart contracts. As an outcome of the paper will be suggested models of deployment of the blockchain technology in the exercising of the franchising business model.

II. FRANCHISING

Franchising is according to some authors old as human history [4], [5]. Many compare Roman Empire with franchising system where Roman Senate was franchisor and governors of different conquered countries were franchisees. Their task was to maximize income and after covering their cost to send profit to the Roman treasury (profit). First modern franchising concept was Singer Sewing Center from 1858 which was soon followed by General Motors, Coca-Cola, etc. Revolution in franchising happened when Ray Kroc developed McDonald's franchising system and started business format franchising. Since then franchising has become a means of business expansion and growth, nationally as well as internationally, and a prevalent growth strategy in the business world [6].

Boroian and Boroian [7] defined that franchising occurs when a company (franchisor) licenses its brand and way of doing business to another company (franchisee) which agrees to work in accordance with the franchising contract. Other authors defined franchising based on different emphasis. (Table I)

TABLE I. DEFINITIONS OF FRANCHISING

Author	Emphasis
Emmerson (1980) [8]	the legal relationship between the contractual parties
Spinelli et al. (2004) [9]	trade and/or service mark
Mlikotin-Tomić (2000) [10]	on franchise agreement and intellectual property package

Franchising is used when companies want to expand their business in a geographical sense but don't want to depend on their own [11]. It represents privilege which is given to entrepreneur which allows the recipient to do certain activities. Franchising brings advantages and disadvantages for both included parties – franchisee and franchisor. A proven business model which can guarantee recognition on the market [12] and training that can compensate franchisees' potential lack of experience and knowledge [13] are probably the biggest franchising advantage. Lower failure risk and franchisor development program benefits are among other advantages of franchising [14]. With franchise business model franchisor has a lower capital requirement and can achieve faster growth rate which enables economy of scale with franchisees providing three significant resources: money, managers and time [12]. A potential disadvantage for franchisors can be profit since franchisors want higher income through royalties while franchisees want to maximize their profit by keeping expenses controlled [14]. On the other side, franchisees have significant advantages from being part of franchising system such as lower failure risk, help in location selection, standard products and/or services are presented within the recognized business system [12]. It is important to state that there is a disadvantage for being franchisee and the major one is excessive franchisors' control [15]. Other researchers [16] state overdependence on the system and potential influence of factor on which franchisees can't influence.

In relation to other organizational forms, franchising differs in three significant characteristics: (1) geographic dispersal of organization units; (2) replication across units; and (3) joint ownership [17]. There are similar organizational forms, but it is very rare that any other form has these three characteristics. Franchising in relation to the other growth models needs a smaller number of employees and secures very driven managers which manage franchised sites [18].

Franchising is present in several different types and forms, but two most known types are product distribution franchising (or product and trade name franchising) and business format franchising [5]. In the first, the franchisee has right to use franchisor's trade name or product but without supporting relationship from the franchisor. With this type of franchising, the franchisee is operating autonomously but has benefits from marketing activities of the franchise system. This type of

franchising is most common in gas stations, car dealerships, and soft drinks bottling companies. The second type is most advanced franchising model and it gives to franchisees the whole package including business system. This type is mutually beneficial for both included parties – franchisor and franchisees and it is present in fast food and services sectors. The third type of franchising is so-called conversion franchising and it is mainly used in hotel and real-estate sector. When deciding to start franchise system potential franchisor need to decide if he will use single-unit franchising, multi-unit franchising, development area franchising and in case it is expanding internationally master franchising.

The importance of franchising is seen in its influence on the world economy. According to the Schwarzer [19] franchising accrues 1,6 trillion USD turnover representing 2,3% of global GDP, involves more than 2,2 million companies with more than 19 million people employed. The economic output of franchising of an average 4% represents a significant portion of national GDP. Franchising is becoming the fastest growing form of business in the global economic system [17]. Companies today use franchising business model for international expansion. From adaptation possibilities of franchising business model to new business trend and use for international expansion, it is possible to conclude that franchising will play important role in the future.

Today, franchising business model is adapting to the new business trends, new business concepts, new business techniques, and technologies. Today we are witnesses of franchise systems which are completely based online, and which don't need buildings and offices because their entire business is run online. Thus, franchisors have to look to the coming future and accept the newest technology which can be used in their franchising systems. They need to be prepared to make investments in technology so that their systems will develop in future as well [20]. One of these new technologies includes smart-contract and blockchains.

III. OVERVIEW OF THE SMART CONTRACTS AS A BLOCK CHAIN TECHNOLOGY

The development of the blockchain technology as a new ICT value is perceived as a platform for launching new values applied in the business and transactional systems. The blockchain creates new potentials and opportunities for exchange of values and resources in the digital economy. It automates business interactions among numerous partners and results to digital interaction.

The blockchain is a distributed, shared, encrypted database that serves as an irreversible and incorruptible public repository of information [21]. It is a chronological database of transactions organized and recorded into smaller datasets known as blocks. The applications of block chain technology are extremely broad and affect any area comprised of many different participants, where values or funds are exchanged, and a guarantee of the data is essential [22]. Blockchain can be used to make online secure transactions, authenticated by the collaboration of the participants allowing them to verify and audit transactions [23]. Against the first generation of blockchain systems designed to provide only cryptocurrencies,

the latest systems can also function as distributed computing platforms [24]. These types of distributed and trustworthy platforms enable the implementation of smart contracts which can automatically execute or enforce their contractual terms [25].

The smart contracts are at the core of the blockchain technology. Smart contracts are computer programs executed by the nodes (parties) and implementing self-enforced contracts. Smart contracts as a blockchain technology allow parties to transact securely without a centrally trusted intermediary and avoiding high legal and transactional costs. As software, the smart contracts translate real contracts or expressions of will into code. The main issue of smart contracts is their digital execution. Firstly, defined by Szabo [26], smart contracts are embodied set of promises in the digital form, including protocols within which the parties perform their promises. Fairfield defines smart contracts as automated programs that transfer digital assets within the blockchain upon certain triggering conditions hence representing a new and interesting form of organizing the contractual activity [27].

Smart contracts replace the conventional contracts by having the ability to self-executing and self-enforcement [28]. As self-governing contracts, they simplify and automate lengthy and inefficient transactions and processes. It is the result of the predetermined terms and conditions recorded in the code. The explicit information provided in the code reduces the errors and misinterpretation of the terms and conditions, as a crucial property of smart contracts [29]. Smart contracts do not require human interpretation or intervention, their settlement is done entirely by running a computer program [30], thus the outcomes are validated instantaneously without the mediation of the third party.

Smart contracts are described as programs that can receive inputs, execute code and then provide an output. Accordingly, a smart contract is an event-driven program, with the state, which runs on a replicated shared ledger and which can take custody of assets on that ledger [31].

Currently, several platforms operate as support of the smart contracts, but Ethereum is the head language creating decentralized smart contract system. The application of Ethereum protocols could be identified into three categories of contracts, those that involved: financial application, semi-financial and non-financial application [32]. Some research analyses [33] consider the interpretation and programming opportunities of smart contracts on various blockchain platforms. Likewise, the decentralized cryptocurrencies, which guarantee authenticity but not privacy, the recent blockchain models of cryptography create privacy-preserving smart contract [34]. On that base, it is made a differentiation between “public blockchains” that could be readable and writable by everyone and “private blockchains” which could be written only by organization members or contractual parties. The public blockchains are useful when no central entity is available to verify a transaction and it is followed by full decentralization. Private blockchains provide some benefits to the parties. Primarily, they increase the privacy as access permission could be provided only to selected nodes or parties.

The limited permission results to reduced risk of attacks since nodes that validate the transactions are already known [35].

The smart contracts carry the possibility of disrupting industries, business processes and business models. They innovate and contribute processes of gathering the information, bargaining, entering and upholding the contracts. They contribute to the reduction of the transaction costs as a significant portion of the total costs; enhance and strength the trust between the contracting parties; guarantee the fulfillment of deadlines and contracting terms. Smart contracts entirely remove the reliance on sellers’ reputation, thus the acquiring of customers depends on the entrants’ quality. Consequently, the economy becomes more efficient since smart contracts improve consumer surplus and welfare [36].

Smart contracts as a blockchain technology lead to higher contractibility and enforceability of contingent contract that expedite the exchange of money, property, shares, service or anything of value in an algorithmically automated and conflict free-way [36]. Blockchain technology offers a way of recording transactions or any digital interaction in a way that is designed to be secure, transparent, highly resistant to outages, auditable and efficient [37]. Due to the automate rule-based monetary transfer and contingent enforcement, smart contracts show growing application in a variety of transactions and business models. As potential areas of employment are recognized: financial transactions such as insurance and financial derivatives; digital economy and e-commerce; human resource management; education; health and public sector. Thus, in the theory and practice are developed several models and prototypes of deployment of smart contracts. Cong and Zhiguo [36] have developed a simple model of smart contracts refers to “successful delivery” of services or goods as a contingent for money transfer. In intellectual property, smart contracts are used to certify the proof of the existence of protected rights [38]. The insurance sector is considered as one of the areas where the use of smart contracts and block chain technology could positively affect different processes i.e. from customer acquisition and management to frauds prevention. Self-executed smart contracts in insurance lead to automatically arising from payout because of the clearly defined preconditions determined in the code. Also, other interesting applications of smart contracts are recognized in the cargo shipping and real estate. Since cargo shipping involves several intermediaries that handle papers and payment, smart contracts employment contributes to the improvement, making more efficient the handling process and reducing the costs. In the real estate sector, smart contracts can be used to keep an overview of all leases and permanent monitoring and verifying the payment received [39].

In the following, the attention of the research interest of the paper is specifically devoted to the employment of the block chain technology – smart contracts in the conducting the franchising business model, as a growing model of doing business domestically and internationally. Franchising as a business model enables the entrepreneurs to join a famous franchise chain of a brand name, successful business system and practices and know how to start up a new business or to continue their current business. Therefore, smart contracts are

recognized as a useful tool which could improve any phase and process in the application and execution of the franchising system.

IV. MODELING THE SMART CONTRACTS IN THE FRANCHISING SYSTEM

Smart contracts as software programs translate the real contracts or expression of will into code. The “if-then” relations of smart contracts are embedded into the blockchain and self-execute if certain conditions are met. Since the application of the smart contracts is examined and confirmed in many industries, the issue of analysis of this part of the paper is the possibility of exercising of smart contracts in the franchising business model. The franchise business model can be applied to almost all kinds of sales of products and services which open possibility for wide spread usage of the smart contracts.

Franchising business model as a legal relationship between the contractual parties, franchisor and franchisee, can involve a range of issues, including the right to sale, usage of intellectual property like the trademark, know-how and the employment of business practices, for monetary compensation. The fulfilment of the contractual provisions, deadlines, and payments between the franchisor and franchisee could be upheld automatically and more efficiently by employing the smart contracts.

We present the functionality of the smart contracts in the franchising business model in the case of the private and public blockchain. In the private smart contract model (Model 1) exists two parties, franchisor as a provider of franchise and franchisee as a recipient of the franchise. They operate the franchising business model within a smart contract consisted of coded inputs recorded in the blocks of the blockchain. Through exercising the franchise, the parties execute the inputs and if the conditions of the contract are met then the output is realized automatically.

Model 1: Private smart contract in franchising system

Parties: Franchisor (F_{sor}) and Franchisee (F_{see}) are the nodes.

Inputs: Transactions as inputs are coded in the smart contracts and recorded in the blocks

Protocol: The nodes execute the private inputs of the smart contracts

Output: If the conditions of the contract are met - then the results are realized automatically

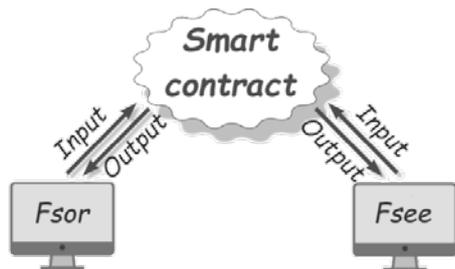


Figure 1. Model for private smart contract in franchising system: Authors’ creation

Against the private smart contract, the public smart contract entails the franchisor and a number of franchisees who present the nodes in the blockchain network (Model 2). In this case, it is established franchise relationship between all the nodes in the network. Transactions which are happened among the nodes are visible to all parties, which increase the usefulness and transparency of this model, especially in the master franchise.

Model 2: Public smart contract in franchising system

Parties: Franchisor (F_{sor}) and a number of franchisees (Fee₁, Fee₂, Fee₃,, Fee_n) are the nodes. Each node is connected to all other nodes

Inputs: Activities and transactions as inputs are coded in the smart contracts and recorded in the blocks

Protocol: The nodes execute and distribute the inputs across the network

Output: If the conditions of the contract are met - then the results are realized automatically

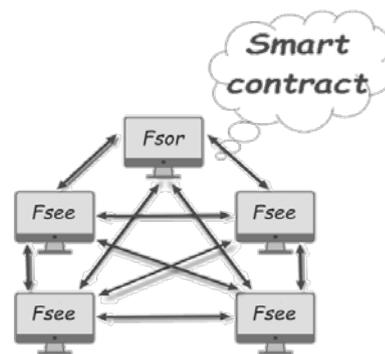


Figure 2. Model for public smart contract in franchising system: Authors’ creation

The infrastructure of the smart contracts suggested in the previous models enables automated and efficient fulfillment of the provisions detailed and coded in the contract. Their role is particularly important in diminishing the issues recognized as disadvantages to the parties in the franchising business model. Smart contracts enhance the reliability referring to the deadlines and the amount of the payment of the franchising fees. They protect franchisors from the eventual lag of payment and enable to control the process if the fee is contracted as a percent of the sold products and services. They can also prevent the franchisees to be oversized with various fees and payment which are not specified in the contract.

The potential lack of the franchise business model is also the issue of protection of the intellectual property. Since the franchisor transfers the rights to use intellectual property (trademark, patents, and copyrights) to the recipient of the franchise, the smart contract can certify the proof of existence and authorship of the intellectual property.

Smart contracts can enable the franchisor to have higher control over the exercising of granted rights to the franchisee. As opposed to traditional contracts, where parties can decide whether to fulfill their obligations, the smart contract cannot be

breached. Once the contracting parties have agreed to be bound by a clause, the smart contract’s code immutably binds them to that clause without leaving them the possibility of a breach [40].

Particularly the issue of control is more challenging in the case of the master franchise. It is a kind of franchise where the franchisor gives the franchisee the right to negotiate and sale a franchise to the other potential recipients-franchisees which make harder the controlling process. So, the employment of the smart contracts can make the whole process to be visible to all parties who are involved in the master franchise model. At the same time, the public character of the smart contracts contributes to the higher transparency of the conditions and terms to all nodes (parties) in the franchising system, without putting someone in more or less privilege position.

V. BLOCKCHAIN AND FRANCHISING

The modern technology used in franchising is constantly developing. The blockchain is increasing its presence in the security industry and thus there is no reason why franchising and blockchain technology can be used together. Blockchain technology can change the mode current franchising systems work in several different ways. According to Naranga [41], blockchain can make following changes in franchising systems:

- Manage financial transactions within your franchise with a higher level of digital security
- Improve the security of the overall flow for Candidate Qualification Forms (CQF) and Franchise Disclosure Documents (FDD).
- When sending CQF’s to potential franchisees, the data collected within this process will be protected by a higher level of security. The information collected here allows the franchisor to understand if the individual(s) meet basic requirements for location ownership.
- Similarly, when FDD’s are sent to potential franchisees, the anticipated signature retrieval process is better protected and upon receipt, the new franchisee may begin the onboarding process.
- This creates an area where data can be shared between systems and become interoperable, the concept of interoperability becomes reality.
- All data is decentralized yet secure for franchisee and franchisor profiles, this makes accessibility easier for the end user.

Previous characteristics can help franchisors and franchisees in securing their data and to help franchisors in selecting the best possible franchisees for their system. This also increases the flow of the forms franchisor uses and the flow of the information toward potential franchisees.

Although the connection between smart contracts, blockchain and franchising are still new it can provide franchisors to shape new characteristics and efficiencies into their franchise networks and to influence the market with new compelling ways. Blockchain can offer open and transparent

access to distributed data chain and prevent potential tempering of data and information and with that increase trustworthiness. The blockchain technology and platform is not limited only to information but it can be used for exchange and store the value securely [42]. Programs are existing which can be of assistance to franchisors to manage their fee systems by streamlining the collection of franchisees’ fees and to increase accountability, thus eliminating the need for intermediates. Currently, there are several franchise systems already running or being prepared for the launch which are using blockchain technology (Table II)

TABLE II. FRANCHISING EXAMPLES

Franchise	Sector
Coin teleraph	Digital currency news
NewsBTC	Digital currency news
Coingia	Bitcoin exchange
MegaBigpower	Cryptocurrency mining business
Restart energy	Electric energy blockchain franchise
Bitcoin & blockchain center franchise	Different services in the crypto market
Steemit	VR franchise on blockchain basis
THEBIToff	Cryptocurrency exchange
Aspire ATM	Bitcoin ATM franchise
FunFair	Online Casinos
Ox	Decentralized Exchange with Off Chain Order Books
KIBO	First decentralized lottery franchise
Happy Tax	Cryptocurrency specialty tax practice franchise

Table II shows different fields of blockchain application where we can find franchise systems. Most of the franchise systems are directly connected to the cryptocurrencies because blockchain and smart contracts are originally connected to this field. Other examples use blockchain technology as a base for further development of their businesses. Another possible application of blockchain technology in franchising can be in the hospitality industry and within its supply chain. In such application, blockchain can maintain transparency and allows visibility of the supplies status. In this way, the franchisee can make better procurement plan and optimize supplies shelf life [43]. Simultaneously blockchain can establish supplies attribution which can be used for increasing customers trust. This can be achieved by purchasing material from ethical companies and by proving this to buyers. Blockchain can give thorough perceptibility of the times and procurement quality. This can be used for supply chain optimization, cost benefits and consequently profits for franchisor and franchisees.

Use of blockchain technology in franchising started a discussion about legal regulation and acceptance of cryptocurrency as a way of payment or as a loyalty program in different franchise systems. For instance, Burger King in Russia created own crypto-currency named WooperCoin [44] and Hooters [45] followed their steps. Abel et. al. [46] stated

that blockchain technology and crypto-currencies need to be more developed to be accepted more in franchising. According to them, franchisors are finding hard to overcome the current gap in technology and maybe don't want to devote time or other resources to understand it and to set processes of implementing blockchain technology in their systems. With more use of smart contracts in franchising, they will become part of the franchise agreement, so the legal regulation will need to be developed as well. Franchise agreements will need to develop as the use of new technology become more apparent. As technology improves so blockchain technology will become a part of everyday life in the franchise sector and the jurisprudence around its use will increase [46].

VI. CONCLUSION

The blockchain technology basically could offer access to an innovative and more efficient way of governing and managing the social and business processes. The blockchain is receiving growing attention from research community and industry where it is considered as a breakthrough technology. Smart contract as a blockchain technology represents a new value in the exercising the existing business models like the franchising model.

The main objective of the paper was to suggest the possibility and opportunity for employment of the smart contracts as a blockchain technology in the increasing the efficiency of the franchising business model. To focus on the impact of the smart contracts on the franchising system we have modeled the general features and structure of the private and public smart contracts. The purpose of the models is to make visible the process of employment the smart contracts in the franchising system and suggesting on the key features of the content.

Within the paper, we considered the changes that smart contract can bring to the franchising system. They can be identified in the direction of managing and enhancing control over financial transactions within the model; increasing control over the process of exercising the activities and transactions determined by the contract. Basically, the smart contracts can create more efficient, more reliable and more transparent franchising system. In the paper, we examined how actually the smart contracts and the blockchain technology can reshape the franchising system and indirectly reshape a range of industries and businesses that have implemented the franchising system. Smart contracts can deliver indirectly higher value to all these industries. Smart contracts can shift the franchising system into a more innovative, higher trustworthy and less expensive level. The achievement of a wider employment and benefits of the smart contracts in franchising system is depending on the future development of the blockchain technology as a joint challenge of the IC technology, legislation, and economics.

Based on this paper findings we are proposing further research to see:

- How the smart contracts and blockchain technology can help franchising business model in practice.
- Development of the current franchising systems based on smart contracts and blockchain technology.

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Information-Technological Decisions in Engineering of Company Management Processes

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Abstract - In the following paper is discussed the necessity of new information-technological solutions in engineering the processes of company management in a dynamic environment. The interest shown to Business Process Reengineering (BPR) is not accidental. It is motivated not only by technological but only by economical premises. Characteristic feature of traditional reengineering is that it is directed exclusively to the inner company's processes and is being accomplished within the organizational borders of the establishment. But it is already exhausted and the look must be focused on its improvement in the form of a new, more refined kind – called X-engineering. Basic information-technological solutions, used within the borders of X-engineering are the Enterprise Resource Planning systems (ERP systems). Their base is integration of all data and processes into a combined, unified platform with database for all processes.

Keywords-ERP systems, company management, reengineering, X-engineering, business processes

I. INTRODUCTION

In the world of constant change there is a need for means and methods, with the help of which the activity of the organizations becomes more effective and competitive. The engineering of company management processes is undoubtedly a powerful means used to achieve these goals. That is why the interest in it will grow in the near future. It is related to designing and realization of solutions concerning the information and technological relations between the structural units of the business system. According to, this is a process that unifies the analysis of the existing system of management processes (diagnostics or reverse engineering) and the design of new management processes (straight engineering) [3].

The general scheme of engineering of the organizational structure of management can be described in the way presented in Table 1, which illustrates the content of the analysis in the field of straight and reverse engineering.

TABLE I. GENERAL SCHEME OF MANAGEMENT PROCESS ENGINEERING

Diagnostics (Reverse Engineering)		Information source	Projecting (Straight Engineering)	
Direction of the analysis	Content		Tendency	Content
1. Identification and analysis of the management processes team	Identification of: -management processes team and their borders -clients -general, structural and logical relations.	Organizational and other documentation, observations, interviews, inquiring, analysis results of the organizational structure of management.	1. Management process modeling	Determination of the team, content and technological relations between management processes, their quantitative and qualitative indexes.
2. Analysis of technological relations between the processes	Modeling and analysis of management processes		2. Modeling of the information system of management	Projecting of the management information structure, team and the kind of the management documents, routes of information spaces.
3. Analysis of the information relations between the processes	Analysis and structuring of the information, circulating in the company, determination of the information spaces.			

II. BUSINESS PROCESS REENGINEERING

Business Process Reengineering (BRP) represents creating/projecting of new business processes, dramatically increasing the efficacy of a business establishment activity [8]. It is based on the general methodology for process management. In this sense, BRP has similar features with some of the methods for improving of the processes or/and the quality. Unlike refinement, reengineering is connected with a

cardinal change of processes rather than their gradually improvement.

According to the reengineering founder Michael Hammer, there are four tendencies that distinguish the economic processes specificity.

First, he considers that they focus on the results and not on its end. The effectiveness of whichever establishment is identified by the obtained results – material, moral, etc. This means that even if the work is organized in the best possible way, if the desirable aims are not achieved, it makes no sense[4].

Second, a new corporate culture is needed, as result of which fundamental matter is given to the client. With business globalization, the organizational culture change may be fatal for high-technological establishments. Therefore, it is imperative to apply modifications (e.g. reengineering), which can be accomplished in a short-term interval and through small projects. In this way is changed not the organizational culture but the critical processes. The hierarchical structures and bureaucracy are eliminated by multi-functional inner teams and delegation of decision-making rights.

Third, the process thinking requires horizontal principal of business management activity. It leads to maximization of usefulness, which means it creates additional value for the client. This method of approach can be realized when the hierarchical structures are substituted by process-orientated teams, working for the common aim, which is the user.

Fourth, business processes are premise for realization of corporate aims. According to Hammer, this activity stems from well-designed ways of working. The organization and the management of the business processes is an activity that is connected to the challenges facing modern organizations. The latter is necessary to determine the key processes and eliminate the ones that are not adding value. Of course, overcoming of traditional thinking about business management activity requires the organizations to adapt quickly to the market developments and concentrate totally on “processes, results and clients”. Otherwise, the part of the traditional functioning organizations that would not be able to survive in the conditions of the dynamic business environment is not small.

Until the reengineering conception appears, business organizations functioned based on traditional approaches, methods and techniques. In most of them is accepted the idea that the industrial manufacture is an action, which is fragmented into components. In the contemporary economic conditions are needed new rules for organization and management of corporate processes. Many of the old-fashioned ways for organization and management of the economic activity no longer correspond to the organizational aims. Usually they serve only for process improvement but not for their radical alteration. This necessitates vanguard conception to be introduced, which is due to provide for drastic changes in the team and the structure of economic processes. Reengineering unites the economic operations in one complete process, and the essence of this doctrine is at the heart of one of the ways of realizing the new industrial revolution.

M. Hammer defines reengineering as fundamental reconsideration and radical redesigning of economic processes in order to obtain dramatic alterations in the critical performance of the organizations – cost, quality, time and customer service" and defines four concepts - fundamentalism , radicality, drasticity (increase in performance through a one-time but large leap) and processability [4].

The reengineering is a fundamental concept of a radical change in economic processes. Its features are as follows:

- reengineering is a concept that should be associated not with the improvement of economic processes but with their radical alteration;

- reengineering ignores the principle of subdividing the operations in order to unite them in one complete process.

- reengineering requires fundamental reconsideration of business, through transition from functional structures to process teams, creative potential, modeling and automation of the processes;

- reengineering imposes avant-garde method of approach for economic activity realization. It is suitable with the new tendencies in economy and specificity of the high-technological establishments.

III. BUSINESS PROCESS REENGINEERING METHODOLOGY

Business process reengineering methodology should be perceived as avant-garde management tool. It can be used for adaption of our high-tech enterprises to the global alterations in the business environment. It aims to provide concrete solutions for:

- Determination of expert team and the level of importance of economic processes during realization of the establishment's purposes;
- Determination of the significant business processes;
- Determination of the degree of adequacy of the significant business processes and organizational departments, part of the current economic situation;
- Determination of the possibilities for engineering of selected economic processes;
- Defining the scope of the reengineering performed;
- Redesign of the selected business processes and the interactions between them;
- Simulation of the designed economic processes;
- Appropriate changes in the control subsystem when business processes reengineering;
- Planning and as effective as possible accomplishment of the reengineering alterations;
- Analysis of the results when reengineering and outlining of future possibilities for rational alteration of the economic processes.

IV.X – ENGINEERING

There is currently a new wave of interest in the reengineering of business processes in that its principles and methods that are relevant to system engineering as a whole can be applied to the development of inter-company relations, the effectiveness of interfaces between several independent actors in a collaborative activity. Reengineering is not obliged to be limited to the walls of an office or enterprise, but it must also affect processes running between the company and its users, suppliers and partners. This new, more-refined look of reengineering is called "X-Engineering" [10]. "X" means the crossing of the company's borders. As equivalent Bulgarian-language versions can be used "extra engineering" (from Latin Extra-external), "ex-engineering", "hiks-engineering" or just "X-engineering". The main driving force of all the transformations is the modern information technologies, which enables the company to adapt quickly according to the changes and the dynamics of the external environment.

The dynamics of the environment, in which the companies function, determines also the necessity of new means and incomes of the management engineering. The customer orientation becomes more and more obvious, and the competition gets a new look - the race is not between individual companies, but between whole chains of manufacturers and suppliers. The integration of processes is now critically important. Interest in business process management (BPM) and the means for business process managing is not accidental. It is motivated not only by technological but also by economical premises. A new stage in the development of the Reengineering methodology is the so-called Reengineering of External Processes (X-Engineering). Among the modern engineering methods of management, "General Methodology of X-Engineering" is distinguished. Every initiative for X-engineering should start with answers to the three key issues:

- How the company is supposed to alter?
- What benefits should be expected from the alterations.
- Who should the company increase the level of integration of activity and cooperation with?

Having exact-formulated answers to the questions asked, what is necessary is that the activity of initiated alterations from the position of "The Three P" be considered.

Process - it includes methods and technologies for interacting with external counterparties such as consumers, suppliers, distributors, shareholders and other stakeholders. To ensure business success in the future, the company must identify the ways and means for such a change in external processes that would lead to the most cost-effective quotations. The company must constantly assess these processes from the client's point of view.

Proposition - is a formulation of the composition of the production and services (and the conditions for acquiring them) that are as close as possible to the customer's needs. The company needs to know the expectations, values, problems,

needs and behavior of its client. Only this will allow to formulate the most interesting and profitable offer to the client.

Participation - is an extension of cooperation between different independent business subjects based on the creation of common, integrated processes. The company has to look for and find partners whose cooperation will lead to truly mutually beneficial results. The management of the company should determine how the activity can be improved by integrating the processes with one or the other company, and how to organize these processes.

The famous scientist J. Champy [10] initiates the fourth P in the organization of the X-engineering, which is:

Place - This aspect embodies the future, target positioning of the company. It is sufficiently traditional in terms of both organizational-management engineering and strategic management. The only difference within X-engineering is that target positioning implies its accomplishment not only by the company itself but also by all its partners. To this extent, the company should go to business only with other business partners, and that is why this aimed position should be, if not common to all, at least coherent and not controversial.

X-engineering uses information technology systems to achieve a significant improvement in business integration processes of the different companies and to create effective integrated processes between the company, consumers, suppliers, competitors and partners. Basic information-technological decisions used within X-engineering are the ERP-systems.

V. ENTERPRISE RECOURSE PLANNING

ERP-systems appeared in the mid-1970s and were successfully adapted to changes in the architecture of information-calculating systems. These systems aggregate information of all enterprise functions and operations, track spates of materials, orders, and finished production between the borders of all processes. One of the factors for the popularity of ERP-systems is that they can be used to make more effective purchase and delivery solutions based on request spate control, starting with their formulation and ending with the delivery of the finished product.

Although the functionality of these systems has long surpassed their abbreviation, it can still be used for a simple check. Which means that the company needs at least one of the following: *Enterprise, Resource, Planning*. Let's look at them one by one:

- *Enterprise* is used in the sense of a large enterprise corporation. This often means a holding company or a large company where many people and activities have to be combined.

- *Resource* - when the company's resources become so numerous that their thinking is difficult, it needs an ERP system.

- *Planning* - The ERP system becomes vital when planning and performance control processes become so difficult that they need to be placed in an information system that monitors, guides, and alerts when it fails. At this point, the availability of

a initiated and well-functioning system can allow the company to continue growing without any resentments. In spite of the increased number of orders, the larger number of people to control, and the greater variety of external factors that influence, the ERP system allows the company to continue to execute on time and quality customer orders. The system allows for easy planning of resource constraints (commodity, human, monetary, etc.) in a wide variety of activities and enables constant control of everything that happens.

VI. PUNCTIONAL MODULES OF THE ERP SYSTEM

There is no single opinion in the literature on what are the core modules of an ERP system [13], but most authors, as well as observations on practice, show that they are limited to the following “Fig. 1”:



Figure 1. Functional Modules of the ERP System

A. *SCM /Supply Chain Management/* The system is a network of links with different distributors that allows the company to receive supplies of materials on time and in the necessary quantity to transform them into production materials, transform into intermediate and end products and delivered to consumers . The systems are equally suitable for both manufacturing and service companies.

B. *FRM /Financial Resource Management/* The financial modules of ERP systems reflect the financial and accounting dimensions of the company's business. They should integrate financial and accounting activities with cash and budget management activities, as well as with the preparation of reports and analyzes. The integration of financial modules with other modules in the ERP system allows many of its operations to be set up automatically.

C. *HRM /Human Recourse Management* include many functions performed by the organization's leadership and responsible professionals, whose goal is to increase employee efficiency through economic, informational and governance interactions. The Human Resource Management module in an ERP system includes all aspects of staff management when performing tasks within the organization.

D. *CRM /Customer Relationship Management/* have critical significance to customers satisfaction in a long-term plan

because they create values for them and besides they increase the incomes and profits of the company. The more CRM applications integrate into the company's management system, the greater these values become. This creates an environment that allows us to study and satisfy the needs and desires of our clients. As a result, there is greater customer loyalty and a steady increase in company earnings and profits.

E. *MRP /Manufacturing Resources Planning* is a methodology for managing manufacturing enterprises, planning production capacities and material needs. The subsystem is intended for medium and long-term production planning and the need for resources, as well as an analysis of the facts in the implementation of the production plans.

VII. STANDART METODOLOGY FOR INTRODUKTION. OF AN ERP – SYSTEM. STAGES:

Stage 1- Business Survey - is the initial stage from which the introduction of the ERP-system starts. The most important thing is to conduct a detailed study of the company analyzed, as well as the entire subject area, and provide all the necessary information for the next stages. In general, the planning of the entire introduction project is in progress, for this purpose the business environment and the analyzed company's specifics have to be examined, the customer's desires and necessities are also being examined. The main participants and managers of the project are identified. A schedule is being prepared and key users are selected to identify the core business processes in the system. Another important point is to educate end-users so that the implementer and the client can speak one language with respect to the system.

Stage 2 – Analysis is the second major step in the introduction process. It aims at a detailed research and in-depth analysis of the existing business processes and their impact on the end result of the introduction. A detailed work schedule should be prepared and the scope of the project properly determined. The latter sets the framework for the whole introduction. It specifies what will introduce and describe in detail the introduction results. There is also a need for further developments to the system. A more detailed plan for important events during the introduction period, a communication plan for meetings and information exchange between the participators in the implementation team and customer, a project change management procedure, and a testing plan are being prepared.

Stage 3 - Design and Introduction - builds on what has been achieved from the analysis stage on, and one of its goals is to produce complete design documentation on the introduced ERP system. Specific settings are made for the needs of the particular company. The database starts filling with specific nomenclatures and being set according to the particular needs. An elaboration of the projects for its design, an elaboration of the additional functionality of ERP system and one of development of the scenarios for the main cases testing are done. They are used to test the system and must be approved by the client. Settings are made by the introducers, which customers are testing and then return information. Detailed user guides are also made.

Stage 4 - ERP system installation - its main task is the designed and realized ERP system to be installed in accordance with the plan and to become a fully operational software application. Here we need to complete the end-to-end system readiness, planning and conducting end-user training, productivity testing and user acceptance. Once the results of these tasks have been achieved, we can go further to installing and resetting of ERP system as a step leading to realization of full system acceptance. Attention should be paid to controlling changes in the environment and to accomplishment of the planned at the previous stage migration data. Once these tasks have been accomplished, we can move on to the actual use of the finished system.

Stage 5 - Use of the ERP system in real-world conditions, maintenance and development - aims to ensure that the system is finally introduced and delivered to the client and to move to its real-life operation. Fundamental attention should be paid to the completion of project activities, planning the use of the system under real conditions, creating conditions for project support and review of the results achieved. All this creates prerequisites for managing development and change.

VIII. ENTERPRICEONE®

EnterpriseOne is a full-fledged ERP solution that includes complete modules for united communications and call center, CRM (Customer Relationship Management), BI (Business Intelligence) and is fully optimized for mobile devices and touchscreen interface. The presence of an Application Programming Interface (API) allows EnterpriseOne to create additional functionalities and services easily. [12]

ERP.BG (ARP Bulgaria Ltd.) is a Bulgarian developer of business management systems with over 19 years of experience. Since its establishment, the company has set as its main aim to increase the competitiveness of its customers through the capabilities of the software technologies - a goal which determines the direction of development of ERP.BG to this day.

Working in the cloud. EnterpriseOne® is available as the SaaS (Software as a Service) model, which is introduced much faster and easier, and guarantees a higher level of security and reliability than traditional on-premise versions. The "cloud" model of work provides consumers with 24-hour access to the company's information resources seven days a week, and furthermore from each spot connected to the Internet. Another important advantage is the cost savings for a server, server operating system, database, network infrastructure, and administration.

Unified version. The SaaS offering model guarantees our customers that they will always work with the latest version of the ERP solution. The same EnterpriseOne® version is used by the smallest to the largest clients, with the differences in the editions being based only on "scalability".

Openness to external applications (APIs). EnterpriseOne® is one of the first ERP systems with its own Application Development Interface (API). The ERP system can be connected to a various applications which complement the basic solution. Connected systems run in real time with

EnterpriseOne® on a single database server, storing all of the data in the ERP system.

EnterpriseOne® is a unified, integrated software solution for the entire company and in this sense is not organized as a simple set of separate modules. However, to make the solution as clear as possible and what the results of its introduction and use are, it is divided into basic functional subsystems and applications as well as in different departments in a manufacturing, commercial or distribution company:

CRM (Customer Relationship Management) subsystem - designed to provide better customer service and the need for in-depth control and improved efficiency in the company's marketing and marketing department. With EnterpriseOne® CRM, there is a better look at the business and marketing department, optimizing task allocation, tracking the development of marketing campaigns, and making informed decisions based on the financial results of these departments.

Subsystem Manufacturing - brings together several important benefits. It contains powerful tools for material planning and monitoring the load of production capacities. The subsystem allows each produced product to designate technologies and to facilitate the management of multi-step production.

Logistics Subsystem - Manages the movement of commodity-material values, connects and coordinates various logistics activities - customer service, forecasting demand, inventory management, order processing, transportation, warehousing, location, etc. It makes it easier to get the necessary products and materials in time.

The Finance subsystem - fully complies with the requirements of a modern, well-structured finance department, combining the tracking of incoming and outgoing cash flows. With this subsystem, it is easy to manage multiple companies in a single basis, including multi-business operational reports. It includes mandatory statutory requirements and information required by management.

Project Management Subsystem - information on stock availability, delivery and delivery times, payment deadlines and delays, resource load schedule, project risks, and discussion of their overheads are available.

Business Intelligence Module is a powerful tool for extracting, analyzing and presenting company data in a handy graphic format.

IX. CONCLUSION

The dynamics of the environment in which companies operate also determines the need for new means and ways of approach to management engineering. Customer orientation becomes more and more obvious, and competition is redefining - the race is not between individual establishments, but between whole chains of manufacturers and suppliers. The integration of processes already has critical importance. The interest shown in the Business Process Reengineering - BPR methodology is not accidental. It is motivated not only by technological but also by purely economic prerequisites. The characteristic feature of "traditional" reengineering is that it is

directed exclusively towards the internal processes of the company and takes place within the organizational boundaries of the enterprise. Notwithstanding the fact that some companies have been able to achieve substantial outgoes recution, increase profits and turnover, increase quality and productivity, accelerate response to market changes, and improve customer service, but the comparison of the enormous amount of energy, money, and effort that are invested in traditional business process reengineering projects should be acknowledged that it does not justify the hopes the companies' management relies on. Thus, in spite of the attempts of the founders of this tendency: "give it a second life", we should agree with some researchers and admit that the business process reengineering is already exhausted and the look must be focused to reengineering the external processes or the so-called X-Engineering [1].

Modern information technologies are practically one of the main subsystems of each enterprise and a basic unit within complex organizational reconstructions. The Internet and related technologies are currently being successfully used to overcome the communication barriers between the company and its external partners, suppliers, sub-contractors, customers and other stakeholders, transferring authority to lower levels of governance, and improving management and production processes. Major IT solutions used in X-engineering are ERP systems [2]. Their use in managing the organization has the following advantages:

- complex reconsideration and re-evaluation of company organization, policy and practice;
- awareness of the interrelation of the actions of all employees, real co-operative creation and optimization of all working processes - industrial, commercial, management;
- improving the quality of arbitrary management decisions as a consequence of abrupt improvement in the awareness of their decision making and the reliability of the data used;
- rapid and adequate response to changes in market, technology and financial conditions;
- a strong reduction to the elimination of the negative consequences of delays, overstocking, deficits, deviations from standards, lack of trend reporting, etc;

- improving collection of receivables and return on investment;
- reducing the prime cost of products;
- improving the resources using efficiency, assets and staff;
- professional growth of staff by redirecting from routine to creative activity - analyzes, prognosis, decision making;
- full control of all processes in the enterprise.

Transformation of organizations from chaotic into perfect presupposes adequate cultural attitudes, empathy and active project focus on all system levels (organization - team - individual). Naturally, there is no universal formula and simple solutions. Achieving the maximum potential of the human factor is a major challenge in governance in the new millennium. The basic principles and models explored in the article are the means by which high management will meet these requirements. None of this is obligatory. It all depends on the choice. There is no law that says the chaotic organization must be transformed into a sustainable or perfect one. This is a voluntary choice. A survival question.

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Development of Wind Energy Projects in Bulgaria - Challenges and Opportunities

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Abstract: The demand of clean energy is increasing rapidly in the last two decades. The wind energy is the fastest growing sub-sector in Bulgaria. Present paper highlights the development trends regarding wind energy production and consumption in Bulgaria. Main challenges and legislation gaps, as well as opportunities respecting wind energy sector are tackled.

Keywords: wind energy projects, gross final energy consumption, grid, environmental impact

I. INTRODUCTION

Renewable energy sources (RES) are alternatives to fossil fuels and contribute to reduction of greenhouse gas emission, diversifying energy supply and reducing dependence on fossil fuels. Rapid growth of RES sector in EU came as a response to climate change mitigation policy measures on one hand and energy safety and security policy on the other hand.

Following "The White Paper", European Union accepted that at least 20% of the EU energy consumption must come from RES by 2020. By transposing "Directive 2009/28 EC of the promotion of the use of energy sources [1], EU Member States shall submit targets known as EU 20/20/20 or: 20 % gross final energy consumption produced by renewable energy; 20% reduction of the CO₂ from their levels of 1990; 20 % grow in energy efficiency. The Directive specifies national renewable energy targets for each EU Member States, taking into account its starting point and overall potential for renewables. For Bulgaria the target is deducted regarding gross final energy consumption produced by RES to 16% by 2020 instead of 20%. Introduction stimulating investments in renewable energy policy the EU and Bulgaria in particular tackles energy safety and security issue as well as contributes to climate change mitigation and environmental protection.

II. METHODOLOGY

The subject of present research is the development of wind energy projects and market in Bulgaria. The opportunities for further development of wind energy projects in the context of European realities and Bulgarian experience are identified and analyzed. Actual data for the production of energy by wind energy projects, installed capacity from 2011 to 2017 are used in order to assess qualitatively the potential growth. The analytic work is performed based on statistical data from National progress reports and EUROSTAT data regarding energy RES

production and consumption (percentage of gross final energy consumption).

Contextual indicators as preferential prices for wind energy by full load working hours are used for assessment. The technical appliance and the availability of the grid infrastructure are taken into account.

III. RESULTS AND DISCUSSIONS

The main ideas that stood behind the Directive 2009/28 EC can be broken down to the followings [1]:

- certainty for investors and to encourage continuous development of technologies which generate energy from all types of renewable sources;
- guarantee the proper functioning of national support schemes and cooperation mechanisms;
- energy prices reflecting external costs of energy production and consumption, including, as appropriate, environmental, social and healthcare costs;
- renewable energy plants should be objective, transparent, non-discriminatory and proportionate when applying the rules to specific projects
- priority access and guaranteed access for electricity

The Bulgarian Parliament brought in force that set of legislative articles transposing "The Directive" in a Law for Renewable Energy (LRE) [3] adopted and in force from 03.05.2011[3]. It counts of nearly six months of delay with respect to adopted obligation to transpose the Directive in the national legislation till 5-th of December 2010 [4].

With this act Bulgaria defines the overall legislative framework for further development of RES sector, growing RES market and supporting energy efficiency insuring legal opportunities for priority development of renewable technologies.

Bulgarian governance declared support to RES development but in fact the State creates obstacles for further enlargement of RES field. According to National Report on progress in the promotion and use of energy from RES, 2017 [17] and corresponding EUROSTAT data the share of RES for

Bulgaria in gross final energy consumption reaches 18.8% in 2015 when the 2020 target is 16% [4].

According to the last EU progress report from 1-st of February 2017, 10 countries, including Bulgaria exceed their 2020 targets till the end of 2014 [15]. Among them Hungary,

Reduction of the preferential prices from 97.66€ per MW/h in 2011 up to 48.86€ per MW/h in 2014, which accounts nearly 50 % price decrease [8,9]. Moreover at the same period of time the production and construction costs for wind energy projects, the land price, the maintenance, the health and social care insurance which altogether form the price per installed MW

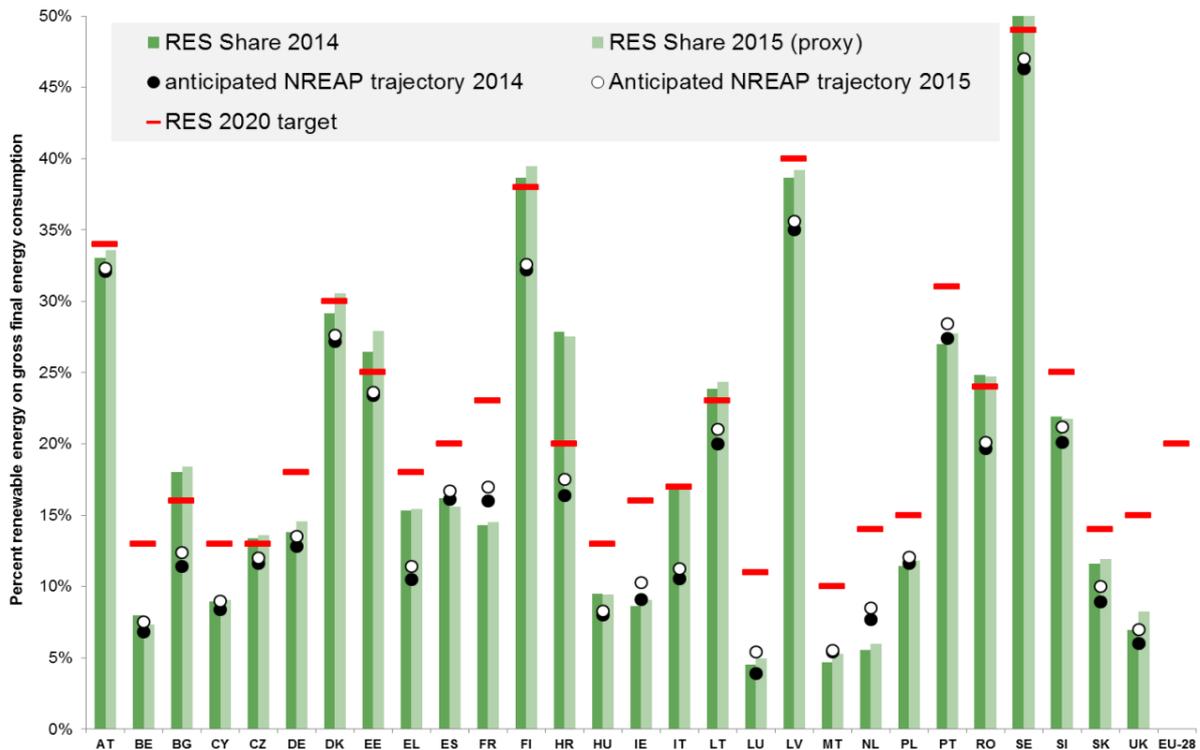


Figure 1. Member States current progress towards 2013/2014 and 2015/2016 indicative RED targets. (source: Öko-Institut, EUROSTAT)

Bulgaria and Estonia stand out the 2020 trajectory.

After reporting the exceeded minimal targets respecting RES share in energy consumption Bulgaria changes the real market conditions for new and approved RES producers (solar and wind energy projects) on large scale.

Starting at 2013, the legislative framework is multiply changed and thus harms the stability and development perspectives of the RES sector as a whole. The following actions of Bulgarian national institutions evidence the abovementioned:

Annually accepted “0” (zero) available capacity for grid connection via decision of the State committee for energy and water regulation in 2012, 2013, 2014, 2015 [5,6,7].

Accepting no decisions for available capacity for grid connection, at all, from the committee of energy and water regulation after 2015 which is in a contrary with art. 6, point 3 from the LRE, under which such must be accepted and published on the web-page on the committee [12,13,14]

wind generator are stable with rising up trends. From economical point of view it altogether draws uncertain future for projects’ refundability.

For 2013 and 2014 the SCEWR didn’t accept preferential prices for project with capacity of more than 1 MW which makes impossible production of more than 2250 full load working hours [10,11]. The economic effect which investors aim to deduct the costs per installed capacity investing on a large scale is absolutely unachievable.

After 2015 the state committee for energy and water regulation even didn’t accept and published, on their web page which is obligatory under art.6 of the LRE, decisions for accepting preferential prices [12,13,14]. With taking no decision for preferential prices, the SCEWR gets in a contrary with the declared promotion of RES in Bulgaria from 2015 till now. Thus, the Committee harms the principle of transparency of decision making process and its obligation to provide exact and up to date information regarding all decisions. It reflects on the investment intend in the RES field.

Starting from 2012 the big scale projects e.g wind farms, are neglected. As it is shown on Table 1, from 2015 to 2017 there is no accepted preferential prices either for capacity

which can work under 2250 full load hours neither for those over 2250 full load hours.

TABLE I. PREFERENTIAL PRICES FOR ENERGY PRODUCED BY WIND PROJECTS IN BULGARIA [EURO]

Year	Preferential price per MW/h for production up to 2250 full load working hours	Preferential price per MW/h for production over 2250 full load working hours
2011	97.66 €	88.46 €
2012	76.20 €	68.01 €
2013	75.70 €	-
2014	48.86 €	-
2015	-	-
2016	-	-
2017	-	-

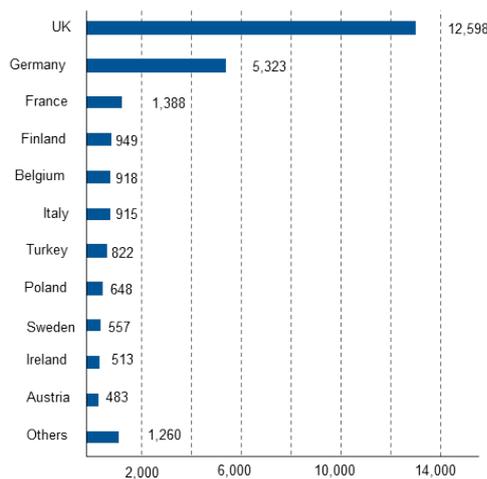


Figure 2. Investment in the wind energy sector in EU (28) for 2015, [€Millions] (source: EWEA)

Clear disproportion between declared priorities and fulfilled actions exists. The following statistical findings are eloquent visible [16].

In the bar graph on Fig.2 for the new investment in wind energy capacity in EU Member States in 2015 (EWEA), Bulgaria does not appear at all [16], because of both accepted “0” capacity and preferential prices. At the same time if focused on new installed capacity in EU (28) in 2015, Germany leads with more than 6000 MW followed by Poland, France and the UK with around 1000 MW each. The group of Sweden and Netherland installed between 500-600 MW. Only the countries with limited inland on shore wind capacity had reached between 1 and 11 MW. Despite of favorable conditions for wind energy projects development, Bulgaria is not presented because of the installed capacity for 2015 is equal to zero.

In Bulgaria we are witnessing a dangerous conflict between declared policy and achieved results once more. The EU regulation for RES stands for sustainable development of the sector and encourages the Member States to promote energy

efficiency, energy production and consumption of energy from RES origins. It is proven in all EU legislative documents in the field, including the Directive 2009/28 EC. The Directive obligates Member States to “... introduce measures effectively designed to ensure that the share of energy from renewable sources **equals or exceeds** that shown in the indicative trajectory”.

The framework allow to the Bulgarian State to transfer renewable energy over its target to countries which geographical potential or other reasons, do not allow them to reach their targets. Thus the exact country which receives the RES energy will not have to pay penalty for not reaching their target. Over more the price which the end consumer will have to pay in Bulgaria will be reduced and positive social effect can be reached. Unfortunately this opportunity is not used in



Figure 3. Theoretical potential of wind energy in Bulgaria [17]

Bulgaria till now, no matter that Bulgaria itself has relatively high wind potential. Theoretical potential of wind energy in Bulgaria is presented of Fig.3

For wind energy projects development the areas of interest are those with 5 to 7 m/s and more than 7 m/s or estimated territory of 1 430km².

Up to 3400 MW present the wind energy capacity in Bulgaria [17], when just 700MW are already installed till the end of 2016, noting that for the last 2 years there is no grow in the wind energy installed capacity [15].

The availability of grid network and supporting infrastructure in many occasions is a key factor for wind energy investments. Bulgaria is favored by its location and well developed electricity grid, mainly constructed in the 70’s and 80’s years of 20-th century. This is the period of time when Bulgaria is the main energy exporter among the Balkan countries. In the last decade significant investments were made in order to rehabilitate the existing electricity grid and introduce smart grids more widely. On Fig.4 is presented the actual grid connection covering in Bulgaria by the Global Energy Network Institute [18]. The connected nuclear power plant, thermal power stations as well as hydropower plants, photovoltaic and the major wind energy projects are presented. An issue of specific interest is not only the presence and spatial



Figure 4. Electricity grid connection covering map of Bulgaria (source: GENI)

coverage of the grid network, but the technical capacity for grid connection. Despite the fact that potential availability for grid connectivity of wind energy projects of different scale exist, available capacity is not normatively approved.

Another challenge appears during the process of choosing of proper wind farm location [19]. Land use conflicts persist due to spatial overlap between the natural habitats location, places with high ornithological importance, wet zones, and natural protected areas on one hand and suitable location for wind energy projects on the other hand. This might be a precondition for conflict between the RES industry and the environmental protection goals. Thus, it requires environmental risk prevention and mitigation measurements to be taken into account in the very early stage of wind energy project's realization [19].

IV. CONCLUSION

The presented above findings leads to the conclusion that there is a gap between declared policy for promotion of renewable energy and its factual fulfilment. The implemented measures till 2013 correspond well to the main idea to introduce RES in the energy mix of the country, supporting wind energy investments and producers. As a result significant growth in wind energy installed capacity and produced energy is on hand.

Starting from 2013 Bulgaria makes “U turn” by acting against wind energy promotion. Led from the above described facts and their roots we conclude that the main challenge that confronts wind energy development is the lack of political will for “greening” the energetic. Without neglecting the key environmental, technical and economic aspects imposed as obstacles in front of large scale wind energy projects, most of the issues can be overcome tackling the gap between declarative and implemented measures in the field of RES.

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Innovative Information and Communication Technologies - a Precondition for a Higher Competitiveness of the Organization

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Abstract—(Achieving and maintaining strategic competitive advantages is a prerequisite for the organization's higher competitiveness. In the conditions of highly competitive and open markets, maintaining a systemic advantage over others in business is an extremely difficult task, and this is the capacity of the leaders in the respective sector.

Of particular interest in theory and especially in practice is the question of achieving strategic superiority. There are many points of view on how to achieve a competitive advantage and hence a lasting superiority over other organizations in the business. Diversity stems from the fact that these advantages should be consistent and reflect the main factors determining the strategic positioning of the organization and its programming in the appropriate perspective. Innovation and the degree of integration of digital technologies into production processes are becoming increasingly important for the competitiveness of enterprises.

Keywords - information and communication technologies, competitiveness, industrial revolution, business environment

I. INTRODUCTION

Globalization in the modern world covers all areas of life, economics and modern technology, politics and culture. The innovative development of information and communication technologies (ICT) provides an opportunity to maintain the competitiveness of companies in local, regional and global markets. In modern production, the development and deployment of innovative technologies is associated with certain risks. The competitiveness of companies on world markets can only be ensured through the continuous introduction of innovative technologies. Over the last few decades, information systems (IS) have led to a dramatic increase in the productivity of large and small businesses. They enable organizations to innovate, thus gaining advantages over other players in their market.

The company's innovation strategy leads to competitive recovery, expansion and consolidation of market positions. Striving to win the battle with competitors, companies are looking for new business optimization solutions, smart information technology deployments, and reduced likelihood of making faulty management decisions with adverse consequences.

The purpose of this study is to analyze the impact of ICT on the achievement and maintenance of strategic competitive advantages and to show how they become a prerequisite for increasing the competitiveness of the organization in the conditions of highly competitive and open markets. In the long run, it is directed at improving the competitiveness of the Bulgarian business on the basis of existing theoretical researches, worldwide experience and good and successful practices.

II. IMPACT OF ICT TO ACHIEVE COMPETITIVE ADVANTAGE

The Information revolution changes the modern economy. The dramatic reduction in the cost of receiving, processing and transmitting information changes the way of life and work. This is the Fourth industrial revolution for the world:

- First - mechanized production systems - end of the 18th century (1784); Henry Cort;
- Second - mass production, division of labor - end of the 19th century (1870); Henry Ford;
- Third - automation, electronics and IT, device intelligence (mid-1970s, 1969);
- Fourth - machine-machine communication, machine-man, system intelligence, networking, Internet in production processes, online support and individualization of mass products, factories of the future, self-organization of production complexes.

Dominant technologies in the Fourth Industrial Revolution are:

- Mechatronics;
- Informatics;
- Electronics;
- Robotics;
- Sensors.

Industry digitization or ICT integration in industry is increasingly becoming an instrument of efficiency but the

effect of digitization is like a horizontal technology that enhances the competitiveness of all industries.

The modern business environment is very dynamic. Organizations today must confront new markets, new competition and increasing customer expectations. This causes manufacturers to set new targets:

- Lower overall costs throughout the supply chain;
- Shortening delivery times;
- Reduction in stocks to a minimum;
- Increase in product range;
- Improving product quality;
- Ensuring more reliable deliveries and better customer service;
- Maintaining a balance between demand, supply and production.

Organizations must constantly change their business processes and procedures to respond adequately to the requirements, expectations and needs of customers and competitors.

Business Process Management (BPM) can be defined as a systematic approach to improving business processes in the organization (including their design, deployment, control, analysis and optimization) that combines management methods and IT tools techniques.

IT has a strong impact on the way that organizations use to design, execute, and support their business processes. Using BPM, organizations can gain competitive advantage by means of using the opportunities that ICT give. Using Business Process Reengineering (BPR), organizations can significantly improve their performance and enhance, the quality of their products and services. The integration of IT with business processes is one of the ways in which IS can bring to the organization a lasting competitive advantage,

Collaboration between IT experts and business users in this area is geared towards developing applications that provide effective integration of people, information, and other resources that are under the umbrella of organizational processes being organized to support the achievement of top goals.

Dynamic changes in the market environment force companies to re-organize their business continuously to deliver better-quality products and services faster and at an affordable price.

A survey by the IT Governance Institute in 2008 [1] found that the top 10 key IT business goals in industry sectors are:

- Improving the orientation and service of the clients;
- Ensuring compliance with external laws and regulations;
- Establishment of continuity and accessibility of services;

- Management of business-related risks;
- Offering of competitive products and services;
- Improving and maintaining the functionality of business processes;
- Ensuring a good return on business investment;
- Acquiring, developing and maintaining qualified and motivated people;
- Creating flexibility in response to changing business requirements;
- Getting reliable and useful information for making strategic decisions.

IT encompasses information that companies create and use, and related technologies that process information.

ITs change the way companies operate. This concerns the whole process through which companies create their products. In addition, the product itself is being restructured: the whole package of physical goods, services and information companies are provided to create value for their buyers.

An important concept that highlights the role of IT in competition is the "value chain". This concept divides the company's activities into technologically and economically separate activities that it carries out to develop its business. The value the company creates is measured by the amount that buyers are willing to pay for a product or service. Business is profitable if its value exceeds the cost of doing valuable business. In order to gain a competitive advantage over its competitors, the company must either perform these activities at a lower cost or execute them in a way that leads to differentiation and more value. [2]

The main activities are those involved in the physical creation of the product, its marketing and delivery to buyers, as well as its maintenance and after-sales service. Supporting activities provide inputs and infrastructure that enable the implementation of core activities. Each activity uses purchased material resources, human resources, and a combination of technologies. Business infrastructure, including features such as general management, legal work, and accounting, maintains the entire chain. In each of these categories one company performs a number of separate activities depending on the particular business.

The value of the business chain is a system of interdependent and related activities. Links exist when the way an activity takes place affects the cost or effectiveness of other activities. Links in performing various activities often need to be optimized. This optimization may require compromises. For example, more expensive product design and more expensive raw materials can reduce the cost of after-sale services. The company must resolve these compromises, in line with its strategy, to achieve a competitive advantage.

Links also require coordination of activities. Good coordination makes it possible to deliver on time without the need for expensive inventory. Careful management of links is often a powerful source of competitive advantage because of

difficulties experienced by rivals in perceiving them and by allowing compromises in organizational lines.

Links not only link value activities within a company but also create interdependencies between its value chain and those of its suppliers and channels. The company can create a competitive advantage by optimizing or coordinating these connections from outside. Deliveries on site by the vendor can have the same effect. But savings opportunities through coordination with suppliers and channels far outweigh logistics and order processing. Company, suppliers, and channels can benefit from this through better recognition and use of such links.

A competitive cost advantage or differentiation is a function of the company's value chain. The value of a company reflects the collective cost of doing all its valuable activities to competitors. Each value activity has cost reasons that identify potential cost sources. Similarly, a company's ability to differentiate reflects the contribution of each value activity to meeting the buyer's needs. Many of a company's activities - not just its physical product or service - contribute to differentiation. The buyer in turn depends not only on the impact of the company's product on the buyer but also on other company-related activities such as after-sales warranty and post-warranty services.

In seeking a competitive advantage, companies often differ in terms of the competitive scope or scope of their business. The competitive range has four key dimensions:

- Segment coverage;
- Vertical range (degree of vertical integration);
- Geographical scope;
- Scope of the industry (or the scope of the related industries in which the company competes).

Competitive range is a powerful means of creating a competitive advantage. The broad scope can allow the company to use relationships between value chains serving different industries, geographic areas or related industries. Competition at national or global level with a coordinated strategy can bring competitive advantage to local or local competitors. Through the use of a wide vertical range, a company can take advantage of the potential benefits of doing more business internally than by outsourcing.

By choosing a narrow range, on the other hand, a company may be able to adjust the value chain to a particular target segment to achieve a lower price or differentiation. The competitive advantage of narrow range comes from customizing the value chain to best serve specific varieties of products, buyers, or geographic regions. If the target segment has unusual needs, large-scale competitors will not serve it well.

III. INFLUENCE OF INFORMATION TECHNOLOGIES ON THE VALUE CHAIN

IT penetrates the value chain at every point, transforming the way activities are performed by value and the nature of the links between them. It also affects the competitive scope and

restructures the way the products meet the needs of the buyers. These key effects explain why IT has gained strategic importance and is different from the many other technologies that businesses use.

Each value activity has both a physical and an informational component. The physical component includes all the physical tasks required to perform the activity. The data-processing component covers the steps necessary to capture, manipulate and channel the data required to perform the activity.

Every valuable activity creates and uses information of some kind. Logistics, for example, uses information such as scheduled promises, shipping rates and production plans to ensure timely and cost-effective delivery. Service activity uses service request information to schedule calls and order parts and generate information about product failures that a company can use to review product design and manufacturing methods.

This broader view of Supply Chain Management (SCM) is illustrated in Fig. 1, which describes a simplified supply chain network structure, the information and product flows, and the key supply chain management processes penetrating functional silos within the company as well as corporate silos across the supply chain. Thus, business processes become supply chain processes linked across internal and external company boundaries. [11]

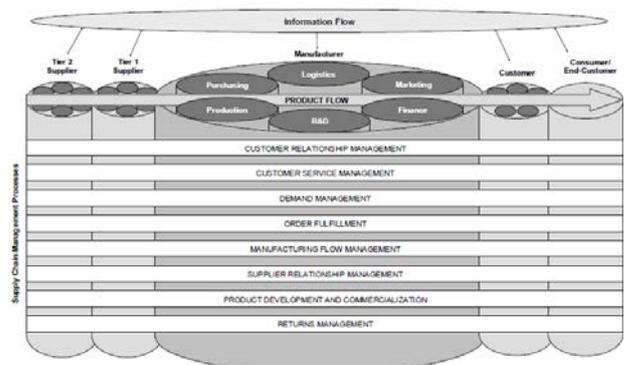


Figure 1. Supply Chain Management : Integrating and Managing Business Processes Across the Supply Chain [11]

The physical and IT components of an activity can be simple or quite complex. Different activities require a different combination of the two components.

For most of the industrial history, technological progress essentially affects the physical component of what companies do. During the Industrial Revolution, companies achieved a competitive advantage by replacing machines with human labor. The processing of information at that time is mostly the result of human effort.

Now the pace of technological change is turning. Information technology is advancing faster than physical

processing technology. The cost of storing information, manipulation and transmission is rapidly falling, and the limits of what is possible in the processing of the information are expanded. The cost of computer power compared to the cost of manual data processing is at least 8,000 times cheaper than the price 30 years ago.

The Information Revolution affects all categories of value activity by allowing computer-assisted design in technological development to include automation. The new technology replaces machines with the human effort in processing information. Paper books and thumb's rules have yielded to computers.

Initially, companies use IT primarily for accounting and records. In these applications, computers automated repetitive office functions such as order processing. Today IT is distributed throughout the value chain and performs optimization and control functions as well as more valued executive functions.

IT generates more data as the company carries out its activities and allows the collection or capture of information that previously did not exist. Such technology enables a more comprehensive analysis and use of advanced data. The number of variables a company can analyze or control has grown dramatically, etc.

IT also transforms the physical component of processing activities. Computer controlled machines are faster, more accurate and more flexible in production than older, manually operated machines.

IT influences not only the way in which individual activities are carried out but also through new information flows significantly improves the company's ability to use the links between activities inside and outside the company. The technology creates new connections between activities and companies can now coordinate their actions more closely with those of their buyers and suppliers.

Finally, the new technology has a strong effect on the competitive scope. ISs allow companies to coordinate activities in remote geographic locations. IT also creates many new relationships between businesses, expanding the scope of the industries in which a company must compete to achieve a competitive advantage.

So widespread is the impact of IT faced by managers with a difficult problem: too much information. This issue creates new IT applications to store and analyze floods with information accessible to executives.[10]

IV. INFLUENCE OF INFORMATION TECHNOLOGIES ON PRODUCTS

Most products have a physical and information component. The buyer must not only get the product, but also know how to use it. This means that the product includes information about its features and how it should be used and maintained.

Historically, the physical component of the product is more important than its information component. The new technology

makes it possible to provide much more information along with the physical product.

ITs improve product performance and make it easier to increase the content of the product. Electronic control of the car, for example, becomes more and more visible in the displays on the dashboard, talking boards, diagnostic messages and the like.

Computer aided design (CAD) is used to design and develop products that can be end-user goods or intermediates used in other products. CAD is widely used in the design of tools and machines used in component manufacturing. CAD is also used to design buildings from small residential buildings (houses) to the largest commercial and industrial buildings (hospitals and enterprises).

CAD is used everywhere in all engineering processes from conceptual designs and plans, through detailed engineering and component analysis to definition of production methods.

Areas of use:

- Architecture;
- Industrial Design;
- Engineering;
- Garden Design;
- Construction;
- Mechanics;
- Automotive;
- Cosmonaut;
- Consumer goods;
- Machine building;
- Shipbuilding;
- Electronics and Electrical Engineering;
- Planning of production processes;
- Digital design;
- Software applications;
- Sewing and Textile Industry.

Computer-aided manufacturing (CAM) is the use to control machine tools and related ones in the manufacturing of workpieces CAM may also refer to the use of a computer to assist in all operations of a manufacturing plant, including planning, management, transportation and storage. Its primary purpose is to create a faster production process and components and tooling with more precise dimensions and material consistency, which in some cases, uses only the required amount of raw material minimizing waste and simultaneously reducing energy.

A higher form of application of IT is the integrated CAD/CAM systems. Over the last few decades, CAD/CAM systems have a very high level of application primarily on the

basis of the development of computing, applied mathematics, and IT. Their use in the design of products and the accompanying technological processes led to improved product quality, shorten deadlines from idea to product realization, flexibility to market changes and requirements of the consumers. (Fig. 2)

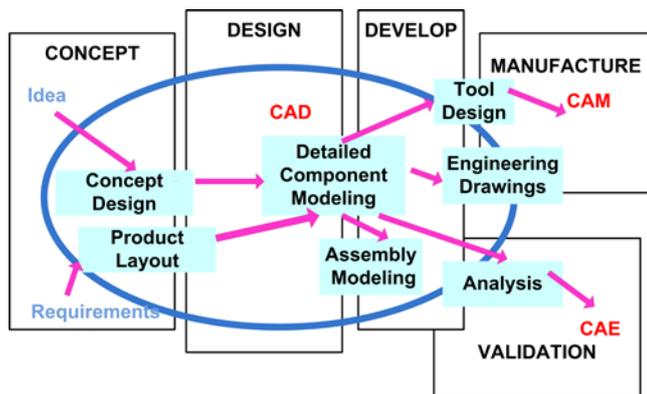


Figure 2. Computer-aided processes.

There is an undeniable tendency to expand the content of the products. This component, coupled with changes in value chains for companies, highlights the increasingly strategic role of IT.

Although there is an obvious tendency for information intensiveness in companies and products, the role and importance of technology differs in every industry.

The banking and public industries have high information technology in both product and process. The oil refining industry has a high degree of utilization of information in the refining process but relatively low information content in the product dimension.

Due to the decreasing costs and the increasing capacity of the new technology, many industries are moving towards higher information content both in the product and in the process. Technologies will continue to improve quickly. The price of hardware will continue to fall and managers will continue to apply technology even at lower levels of the company. The cost of software development, which is now a key constraint, will drop as more packages become available that will be easily adapted to the circumstances of customers. The IT applications that companies use today are just the beginning.

IT not only transforms products and processes but also changes the nature of the competition itself.

A) *Changing the essence of competition*

ITs change the rules of competition: [12]

- Advances in IT change the industrial structure.
- IT is an increasingly important lever that companies can use to create a competitive edge. The search for a competitive advantage by the company through IT is often spread to reflect the structure of the industry as

competitors imitate the strategic innovation of the leader.

- The information revolution is generating a whole new business.

These three effects are critical to understanding the impact of IT on an industry and to formulating effective strategic responses.

B) *Changing the structure of the industry*

The structure of an industry is formed by five competitive forces [4] (Fig. 3):

- the power of buyers;
- the power of suppliers;
- the threat of new entrants;
- the threat of substitute products]
- rivalry between existing competitors.

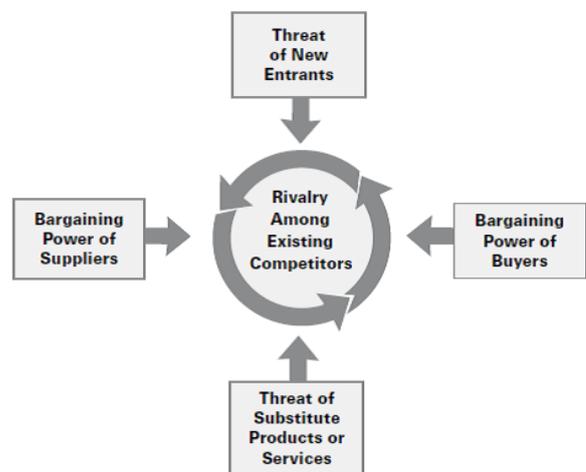


Figure 3. The Five Forces that shape Industry Competition.[4]

The influence of the five forces varies across industries, and to varying degrees determines their profitability. The influence of each of the five forces may also change, improving or reducing the attractiveness of the industry. [3] [4]

C) *Determinants of the attractiveness of the industry*

IT can change each of the five competitive forces and, hence, the attractiveness of the industry. Technology thaws the structure of many industries, creating need and opportunity for change: [5]

- IT increases buyers' power in industries that are assembled for purchased components. Automated Material Accounts and Suppliers Quotation Files make it easy for buyers to assess material sources and decision-making or receivables.

- IT requiring large investments in sophisticated software products have set barriers to entry. For example, banks competing in cash flow management services for corporate clients need sophisticated software to provide customers with online account information. These banks may also need to invest in improved computer hardware and other facilities.
- Flexible computer-designed and manufacturing systems have affected the substitution threat in many industries by making it faster, easier and cheaper to incorporate improved features into products.
- Automating order processing and customer billing has increased rivalry in many distributors. The new technology raises fixed costs while moving people. As a result, distributors often have to fight harder to increase volume.

Industries such as airlines, financial services, distributors and information providers have felt these effects so far [5].

D) Structure of Information Technology and Industry

IT has a particularly strong impact on the negotiation of the relationship between suppliers and buyers as they affect the links between companies and their suppliers, distribution channels and buyers. In some cases, the boundaries of the industries themselves have changed. [6]

The systems that connect buyers and suppliers are growing and improving.

ITs change the relationship between scale, automation and flexibility. Large-scale production is no longer essential to achieving automation. As a result, barriers to entry into a number of industries are declining.

At the same time, automation no longer necessarily leads to flexibility. Automation and flexibility are at the same time, and this changes the pattern of rivalry between competitors.

Increasing flexibility coupled with decreasing product design costs leads to increased personalization and niche market niche opportunities. Computer design not only reduces the cost of designing new products, but also significantly reduces the cost of modifying or adding features to existing products. Costs of adapting products to market segments are declining, affecting the pattern of rivalry between industries and companies.

ITs have made a number of professional service sectors less attractive by reducing personal interactions and making the service more of a commodity. Managers should carefully observe the structural effects of the new technology in order to realize their benefits or to be prepared for the consequences of the new technology. Automating millions of jobs can lead to mass unemployment, a rise in inequality and a drop in wages. Occupations such as accountant or real estate agent may completely disappear. Some predictions indicate that in 30 years the number of robots will grow from 57 million today to 9.4 billion.

V. CREATION OF COMPETITIVE ADVANTAGE

In each company, IT has a powerful impact on a competitive advantage, regardless of price or differentiation. Technology affects value-related activities, allowing companies to gain competitive advantage by using changes in the competitive range.

A) Reducing costs

IT can change company costs in every part of the value chain. [7]

The historical impact of technology on costs is limited to activities where the recurrent processing of information plays a major role. However, these limits no longer exist. Even activities such as assembly, which mainly involve physical processing, now have great data processing capabilities.

B) Improving differentiation

The impact of ITs on differentiation strategies is dramatic. The role of the company and its product in the value chain of the buyer is the key factor for differentiation. The new IT makes it possible to personalize the products [7].

By combining more information with the physical package of products sold to the buyer, the new technology affects the ability of the company to differentiate.

C) Changing the Competitive Scope.

IT can change the relationship between competitive scope and competitive advantage. The technology enhances the company's ability to coordinate its activities at regional, national and global level. It can unlock the power of a wider geographic scope to create a competitive edge.

The Information Revolution creates relationships between previous separate industries. The merger of computer and telecommunication technologies is an important example. This convergence has a profound impact on the structure of the two industries.

Broad-line companies are increasingly able to segment their offerings.

As IT becomes more widespread, the possibilities of using a new competitive range will only increase. However, the benefits of expanding the scope can only be accrued when IT distributed throughout the organization can communicate [7], [8].

D) Emergence of new enterprises

The Information Revolution gave birth to completely new industries. [12]

- Their emergence is technologically feasible.
- IT can create new businesses by creating derivative demand for new products.
- ITs create new business in the old.

VI. ROLE OF INFORMATION SYSTEMS IN THE MANAGEMENT OF ORGANIZATIONS IN THE 21ST CENTURY

A very effective application of ICT is the Management Information System (MIS). These systems are used to manage and analyze operations and solve business problems.

MIS focuses on the use of ICT in management of organizations. In the 21st century, almost all organizations use ICT to manage effectively their operations, help managers to make better decisions, optimize and automate basic business processes, improve market positions, increase employee efficiency, reduce operating costs and potential risks. This becomes a precondition for achieving a competitive advantage and facilitating the seamless internal and external communication with employees, customers, partners and other stakeholders.

MIS is usually built up of modules covering different functional areas. The content and structure of modules depends on the type of enterprise and the type of organizational structure used. In most manufacturing plants, there are modules covering the main functional areas of management. (Fig. 4)

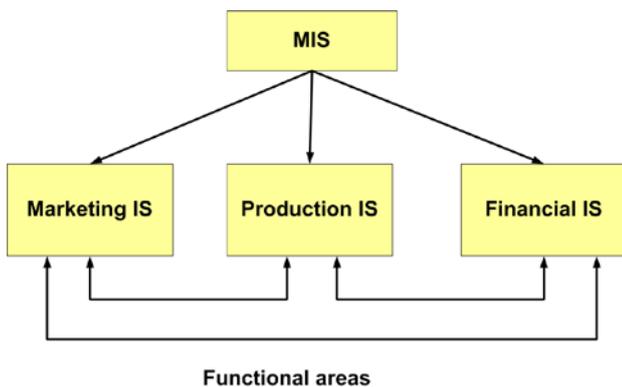


Figure 4. Management Information Systems.

The availability of information generated from the external environment in which the organization operates and its appropriate transformation and distribution to all functional sections and departments is vital to gain competitive advantage over other competitors. (Fig. 5)

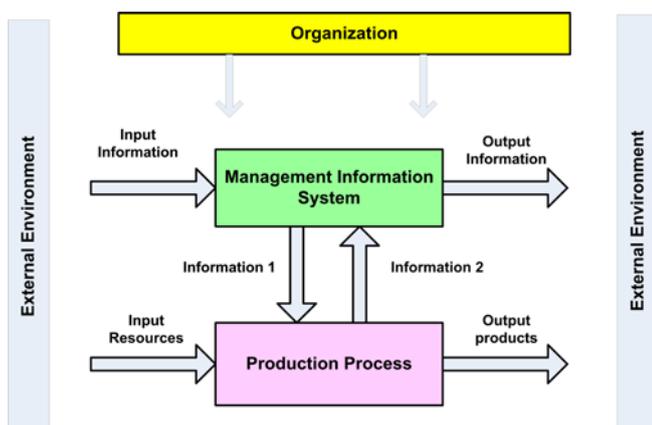


Figure 5. The role of Management Information Systems in organization.

Today the main focus of companies is to remain competitive globally, using the capabilities of modern IT and ICT. Companies can use ICT to deliver products and services with the highest quality at affordable prices and top quality services to customers and help companies to enter new markets through e-commerce.

In order to remain competitive, companies invest in modern information systems such as Enterprise Resource Planning (ERP) software that integrates the various business areas and provides consistent real-time data for rapid decision-making. ERP systems help companies manage their operations seamlessly around the world.

Companies remove the inaccuracy of paper tracking through the deployment of ERP systems. Instead of stand-alone computer systems, ERP uses a unified program that connects various functional departments such as finance, HR, manufacturing, warehouse, planning, purchasing, inventory, sales and marketing. Although each department may have its own set of software modules, the software is interconnected so that the information can be shared across the organization.

Good practices around the world show that the positive impact of ERP systems is increasing if the organization has a certified and functioning Quality Management System (QMS). Most often, this is an ISO 9001 certified QMS. It is also possible to be integrated systems as Customer Relationship Management (CRM), Business Intelligence (BI), Environmental Management System (EMS), Occupational Health and Safety Management System etc.

VII. CONCLUSION

Many companies start to participate in the global market as it provides a chance for greater revenue and greater business prospects.

Challenges vary depending on the size of the business. For smaller businesses, control operations and storing information are less complex. With the growth of business, especially those that intersect with global relations, ISs are used to accurately manage operations without increasing the number of employees.

As companies try to reduce costs, improve productivity, employers look for ERP systems to help them grow and stay competitive globally. ISs increase business productivity.

It is important for ICT to be aligned with the business plan and to be involved in defining its direction.

ICTs must be at the heart of strategic and operational management, and thus the leading role of IT managers must have the ability to influence the vision and strategy of the corporation in order to ensure the maintenance of the operational efficiency of the business.

It is not possible to achieve long-term business success without using the benefits of IT in this digital age. Companies need to bear a reasonable price to achieve this success because using an innovative approach to business strategy, hiring highly qualified IT professionals and making the right decisions at the right time is a prerequisite for business success.

As IT solutions continue to increase the productivity, efficiency and effectiveness of business operations and communications, business will continue to rely on the success of IT.

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Smart Sustainable Development and Labor Migration in Europe, Eurasia and Balkan Region

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Abstract — The Europe and Eurasia region is well known as part of changes and migrations on global level. This paper discusses about the relationship between labor migration and poverty in EU, Eurasia and Balkan region, during a period of rapidly growing inequalities in well-developed and transition countries. This is placed against the on-going debates on changes in the patterns of employment and job creation, during the period of economic liberalization in transition countries, under the Smart Sustainable Development and Inclusive Growth policies, and also under the impact of the global financial crisis. The focus is on the migration patterns of different social groups in EU, Eurasia region in comprising with Macedonia and Belarus, analyses whether economic growth signifies a route out of poverty, and the specific policies that exist and should be improved and recommended. The paper states the Big Data helps with analysis of migration for policy developments and decisions related to saving or reducing migrants' level, developing a new policy and requirements on legal migration. This is directly relevant for policy and the Smart Sustainable Development and Inclusive Growth model and an inter-disciplinary approach to the study of migration.

Keywords - Sustainable Development, Inclusive Growth, Smart Development, Big data, global drivers, labor, migration, poverty

I. INTRODUCTION

More people are on the move now than ever before. The overwhelming majority of migrants leave their countries of origin voluntarily, in search of better economic, social and educational opportunities and a better environment. At the end of 2015, there were estimated to be over 244 million international migrants, representing an increase of 77 million, or 41% compared with the year 2000. However, the world is also witnessing the highest level of forced displacement in decades due to insecurity and conflicts. At the end of 2015, there were estimated to be over 21 million refugees and 3 million asylum seekers worldwide. [11]

Globalization has made the free flow of goods and ideas an integral part of modern life. The world has benefited greatly from the accelerated exchange of products, services, news, music, research and much more. Human mobility, on the other hand, remains the unfinished business of globalization. Migration policy and cooperation frameworks struggle to

address the push-pull forces of migration and the cascading effects that migration has on communities of origin and destination.

In the 2030 Agenda for Sustainable Development, the needs of refugees, internally displaced persons and migrants are explicitly recognized. The Agenda recognizes the positive contribution of refugees and migrants for inclusive growth and sustainable development, for which good health is a prerequisite. Member States have made a commitment to work towards its full implementation, have pledged that no one will be left behind and wish to see the Sustainable Development Goals and their targets met for all nations and peoples and for all segments of society. Member States and partners will help to address multiple economic, social and environmental determinants of the well-being of refugees and migrants. On 19 September 2016, the United Nations General Assembly adopted the New York Declaration for Refugees and Migrants, setting out commitments to enhance the protection of both refugees and migrants. Its two annexes pave the way for the development of the global compact on refugees and the global compact for safe, orderly and regular migration in 2018. [13]

II. DEVELOPMENT AND MIGRATION

What is development? A multidimensional process connected by which a more balanced distribution of wealth / prosperity, and better opportunities for a viable future (poverty reduction), and for reduction of insecurity are achieved.

Consequences: increases individual opportunities to migrate, but brings about that fewer people will want to or need to migrate.

Migrants are “(a) persons - outside the territory of the state of which they are nationals or citizens, are not subject to its legal protection and are in the territory of another State. Individuals migrate where they can best maximize their earning potential, or respecting models of cost-benefit analysis, he also emphasizes the role of social networks in the process of decision making where to relocate.

The 2030 Agenda for Sustainable Development recognizes for the first time the contribution of migration to sustainable development. Migration is a cross-cutting issue, 11 out of 17 Sustainable Development Goals (SDGs) contain targets and indicators that are relevant to migration or mobility. Migration

is relevant to all three pillars of sustainable development—economic, social and environmental.

There are the positive consequences of the migration for development like: transfer of skills and knowledge, social / political influence of migrants and so on. And the negative consequences of the migration for development are: brain drain as losing highly skilled human capital, social aspect of disruption of family life, sensitivity of the economy in way of economic fluctuations, inflationary effects and increasing of local inequalities etc.

The number of immigrants from developing countries living in richer, more developed countries has increased substantially during the last decades. At the same time, the quality of institutions in developing countries has also improved. The data thus suggest a close positive correlation between average emigration rates and institutional quality. Recent empirical literature investigates whether international migration can be an important factor for institutional development. Overall, the findings indicate that emigration to institutionally developed countries induces a positive effect on home-country institutions.

Inclusive, smart sustainable growth in developing countries is one of the key elements to achieve poverty reduction and migration problems resolving.

While billions stand to gain from migration—including migrants and their families, local communities, businesses and national economies—migration can also create new vulnerabilities and inequalities if poorly managed. Releasing the development potential of migration and minimizing its negative impacts require comprehensive, well-managed migration policies. Cooperation between countries of origin and destination is needed to ensure orderly mobility with full respect of the human rights of all migrants. Comprehensive approaches also require cooperation to be multidisciplinary: migration and development communities need to work together and include other related policy areas, including those affecting human rights, humanitarian issues, education, health, employment and the environment. Furthermore, the involvement of non-State actors is essential—first and foremost migrants themselves, including diaspora groups and transnational networks, but also local and international NGOs, the business and finance sectors, academia and local communities.

It is opinion exists that the only way to reduce migration to wealthy countries is to stimulate development in poor countries. But this is a myth. As a rule, social and economic development in poor countries leads to more migration.

According with Hein de Haas research development increases people's capabilities and aspirations to migrate. International migration is often a costly and risky business. Many people in poor countries do not have enough money and other resources to emigrate. When societies become wealthier,

more people will be able to emigrate. And more people will have qualifications and education which allows them to get visas. Education and access to modern media such as satellite television and Internet initially leads to more migration. If people go to school and universities, they increase their life aspirations, become more aware of opportunities elsewhere.

Emigration goes down once countries move into high development categories.

What can force people not to emigrate? Answers: if the home country becomes high development country or easier way is to restrict land rights. For example, France was one of the countries in old Europe to grant land rights to all heirs, not just the oldest kid in the family. As the result: when families were growing, kids were moving to cities, faced unemployment and poverty, but all of them were able to come back to the countryside, have an own piece of land, and feed themselves from it. We are observing similar situation in Ethiopia today. There, individuals lose rights to own the land if they do not work on it for more than three years. As Ethiopians know that migration is a risky and may not necessarily turn out right, they prefer staying at home and keeping their land, rather than taking this risk and finding themselves without anything. This is why we cannot see that a lot of Ethiopians abroad, even from richer areas of Ethiopia.

For countries who want to improve levels of development, developed infrastructure, high quality of an institution, capital market performance, direct investments, protection of investments, entrepreneurship and democracy development and an adequate supply of jobs are the foundation of sustained prosperity and economic and social inclusion. Access to decent jobs for all is the key to helping people pull themselves out of poverty, reducing income inequalities and achieving social cohesion and one of the ways of migration problem solving.

The need to consider migration to as an intrinsic - and in this sense inevitable - part of human development rather than a problem to be solved.

III. COMPARING MIGRATION IN MACEDONIA AND BELARUS

Migration in The Republic of Macedonia sometimes has a greater swing and sometimes smaller, but however that is continuous process that lasts for decades backwards.

Here we will make an analysis of the trend of migration for the last ten years in The Republic of Macedonia starting from 2007 to 2016. We put the accent on international migration, especially on the emigrated citizens of The Republic of Macedonia. According to the data of the State Statistical Office of The Republic of Macedonia the trend of emigration of the Macedonian citizens was variable. Starting from 2007 with 224 emigrated citizens until 2012 the number of emigrated Macedonian citizens was increasing and has the highest number of 1330, and after that this number has started to decrease until 440 people in 2016 (Table 1). [2]

TABLE I. INTERNATIONAL MIGRATION FLOWS OF THE POPULATION IN THE REPUBLIC OF MACEDONIA

<i>International migration</i>	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Immigrants	2181	1609	1857	2715	3211	3787	3991	4208	5358	4743
Citizens of The Republic of Macedonia	366	219	259	303	349	396	490	265	259	283

<i>International migration</i>	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Foreigners with temporary stay	861	557	1000	1356	1747	2072	1941	2273	3617	2481
Foreigners with extended stay	954	833	598	1056	1115	1319	1560	1670	1482	1979
Emigrants	240	751	792	1007	1290	1415	1041	839	1016	630
<i>Citizens of The Republic of Macedonia</i>	224	740	769	923	1143	1330	945	740	767	440
Foreigners with temporary stay	16	11	23	84	147	85	96	99	249	190
Net migration	1941	858	1065	1708	1921	2372	2950	3369	4342	4113

Using this formal information of the State Statistical Office seems that just 8021 people have left the country and move in other countries in the world, but the formal information given by World Bank give the figure of around 600.000 people that have left The Republic of Macedonia and moved somewhere in Europe, USA or Australia. According to that data, The Republic of Macedonia in 2013 is on 25-th place in the world where the number of emigrated citizens is 30.2% of the population. This frightening data motivate us to make an analysis about the reasons and characteristics of the emigrated people. [4]

In the study of U.S. News & World Report, Sweden is named the best country for migration. Belarus was on the 70th position out of 80.

Analyzing the migration exchange of Belarus with the near abroad, it should be noted that along with the influx of migrants from the Russian Federation, the migrant potential of Belarus is also formed by migrants from Kyrgyzstan, Tajikistan, Turkmenistan and other CIS countries. Poland, like other European countries, like Russia, is ready to compete for the Belarusian "brains" and "hands". As far as the far abroad countries, the leaders in attracting Belarusian citizens are the USA, Israel, Germany.

TABLE II. INFORMATION ON THE NUMBER OF MIGRANT WORKERS WHO ENTERED THE REPUBLIC OF BELARUS FROM THE MEMBER STATES OF THE EURASIAN ECONOMIC UNION, PERS.

<i>Country of civil accessories</i>	2014	2015	2016	2017
The Republic of Armenia	387	383	372	400
The Republic of Kazakhstan	1034	653	385	313
The Republic of Kyrgyzstan	48	72	50	57
The Russian Federation	4546	2209	2140	2453
Total	5580	3317	2947	3223

The population of Belarus is replenished at the expense of the countries of the Middle East (Iraq, Iran, Afghanistan, Syria, etc.) and South-East Asia (Vietnam, China, India, etc.). Analyzing the qualitative composition of those people that are arriving in Belarus, first of all, more people are in working age than they are driving in. At the same time, in the migration

flows of the CIS and EEA countries, low-skilled workers are the predominant social group of the population, and the analysis also showed that among the arriving majority - persons of senior working age, and more highly qualified personnel leave the country than enter.

Therefore, even such a migration increase cannot extinguish the demographic decline of the population of the republic and ensure its further increase. Moreover, a high proportion of persons of pre-retirement and retirement age among those who have come to the republic for permanent residence accelerate the aging process of the population, worsening its age structure. The proportion of migrant workers of working age is only 1.2% higher than the proportion of the able-bodied population in Belarus. In this regard, migrants are not able to significantly increase the number of employed population in the national economy.

TABLE III. NUMBER OF MIGRATION FLOWS OF THE CITIZENS OF THE REPUBLIC OF BELARUS

<i>Year</i>	<i>Number of people who left Belarus</i>	<i>Number of people who entered in Belarus</i>
2008	9268	9231
2009	7643	9637
2010	6866	10312
2011	7610	12421
2012	8712	18040
2013	7792	19435
2014	9219	24941
2015	9855	28349
2016	13098	21038
2017	15087	18961

Important analysis is the division of the emigrated citizens according to the gender and age. Comparing the number of males and females citizens during the period of ten years it can be noticed that always prevails the number of mails. And also by the analysis of the age of emigrated people during the last decade prevailed people from 30-64 years and after them people from 15-29 years (Table 4). That means that all people that are going abroad are working capable. They are the active population in the country compared with the category of children from 0 to 14 years and the retirees with more than 65 years.

TABLE IV. EMIGRATED CITIZENS OF THE REPUBLIC OF MACEDONIA ABROAD BY GENDER AND AGE

<i>Year</i>	<i>Gender</i>			<i>Age</i>			
	<i>Total</i>	<i>males</i>	<i>females</i>	<i>Age 0-14</i>	<i>Age 15-29</i>	<i>Age 30-64</i>	<i>Age 65 and over</i>
2007	224	130	94	34	81	95	14
2008	740	414	326	84	271	385	27
2009	769	425	344	79	215	430	45
2010	923	540	383	68	247	545	63
2011	1143	608	463	68	213	771	91
2012	1330	708	622	37	204	912	177
2013	945	522	423	31	189	586	139
2014	740	436	304	30	173	415	122
2015	767	427	340	43	219	393	112
2016	440	225	215	30	140	219	51

From Belarus emigrated in recent years, men of working age 30-64 years, which is shown in Table 5.

TABLE V. EMIGRATED CITIZENS OF THE REPUBLIC OF BELARUS ABROAD BY GENDER AND AGE

<i>Year</i>	<i>Gender</i>			<i>Age</i>			
	<i>Total</i>	<i>males</i>	<i>females</i>	<i>Age 0-14</i>	<i>Age 15-29</i>	<i>Age 30-64</i>	<i>Age 65 and over</i>
2007	9479	4821	4655	869	3219	4912	479
2008	9268	4286	4982	973	3227	4334	734
2009	7643	4256	3387	1003	2959	3156	525
2010	6866	3745	3121	860	2505	2919	582
2011	7610	3801	3809	946	2569	3453	642
2012	8712	4949	3763	924	2573	4419	796
2013	7792	4431	3361	835	2565	3770	622
2014	9219	5425	3794	877	3340	4372	630
2015	9855	5439	4416	1069	3274	4912	600
2016	13098	7464	5632	1606	4214	6549	729

Because most of the emigrated people from The Republic of Macedonia are active or working-able, very important is the analysis from aspect of the reasons for moving away (Table 6). Most commonly listed reasons are family reasons and employment, but most of the people moved without response.

Sometime the reasons for going in other countries may be education or marriage, but they are listed in a smaller number of cases.

TABLE VI. EMIGRATED CITIZENS OF THE REPUBLIC OF MACEDONIA ABROAD BY REASONS FOR MOVING AWAY

<i>Year</i>	<i>Total</i>	<i>Reason for moving away</i>						<i>without response</i>	<i>unknown</i>
		<i>employment</i>	<i>marriage</i>	<i>family reason</i>	<i>education</i>	<i>all</i>			
2007	224	46	9	123	2	44	44	16	
2008	740	174	73	372	13	108	104	4	
2009	769	184	88	338	35	124	124	0	

Year	Reason for moving away							
	Total	employment	marriage	family reason	education	all	without response	unknown
2010	923	192	77	300	30	324	318	6
2011	1143	314	119	497	26	187	185	2
2012	1330	247	101	614	32	336	336	0
2013	945	127	65	383	19	351	342	9
2014	740	85	42	292	14	307	306	1
2015	767	83	54	263	18	349	346	3
2016	440	43	36	78	6	277	275	2

With this age and qualification structure of external migration processes, the country faces the problem of shortage of qualified personnel in certain professions and specialties, the professional and qualitative and territorial imbalance of labor supply and demand in the labor market is increasing. As for the ethnic structure of citizens arriving in Belarus, as analysis has shown, about 60% of them fall on three nationalities -

Russians, Ukrainians and Belarusians. It can be assumed that in the near future the number of Ukrainians will increase due to the events in Ukraine, as well as the number of Turkmens, which has been steadily increasing in recent years.

Belarusian citizens emigrate mainly for family reasons and in search of more paid work (Table 7).

TABLE VII. EMIGRATED CITIZENS OF THE REPUBLIC OF BELARUS ABROAD BY REASONS FOR MOVING AWAY

Year	Reason for moving away							
	Total	employment	marriage	family reason	education	all	without response	unknown
2007	9479	870	598	1765	541	3412	1921	372
2008	9268	754	462	1756	553	2657	2595	491
2009	7643	842	542	1498	521	1874	1945	421
2010	6866	678	732	1291	345	1835	1403	582
2011	7610	705	316	1723	532	1846	1927	561
2012	8712	801	639	1985	772	2513	1603	399
2013	7792	756	644	1879	242	2043	1934	294
2014	9219	929	943	1876	321	2319	2456	375

Having on mind the bad economic situation in The Republic of Macedonia, the process of transition that lasts too long and the coefficient of poverty it is normally people to move abroad looking for better living conditions. Speaking at risk of poverty rate, calculated in percent we can compare this number of The Republic of Macedonia with the number in EU (28) for 2014 and 2015 given by the Eurostat web site. The Republic of Macedonia has 22.1 % at risk of poverty rate in 2014 and 21.5 % in 2015. Compared with this data EU (28) has 17.2 % at risk of poverty rate in 2014 and 17.3 % in 2015. This comparison gives us results that The Republic of Macedonia has 4.9 % in 2014 or 4.2 % in 2015 higher risk of poverty rate than the EU (28) which significantly reflects on the living standard and quality of life of the citizens of the country. This is maybe the most important and reasonable reason for moving away. [3]

To see the income distribution in the country which is very close to poverty rate in that country we will use as measurement the Gini coefficient.

The Gini coefficient (sometimes expressed as a Gini ratio or Gini index) is a measure of statistical dispersion intended to represent the income or wealth distribution of a nation's residents, and is the most commonly used measure of inequality. Calculating this index is measured the inequality among values of a frequency distribution (for example, levels of income). Value of zero expresses perfect equality, where all values are the same (for example, where everyone has the same income) and value of 1 (or 100%) expresses maximal inequality among values (e.g., for a large number of people, where only one person has all the income or consumption, and all others have none). In other cases, where the results for Gini index, is the value above 50 is considered as high inequality;

value of 30 or above is considered as medium and value lower than 30 is considered as low inequality. From analysis of the Gini index according to the World Bank data base for each country separately we have the Table 8 where is made a comparison between The Republic of Macedonia and Belarus for Gini index in period from 2010 to 2015. Here The Republic of Macedonia has higher value for Gini index than in Table 4 and its value in 2010 was 42.8 which has decreased and in 2015 it was 35.6. This values for Gini index still put The Republic of Macedonia in the group of countries with medium inequality. Compared with Belarus where the Gini index in 2010 was 28.6 and decreased to 26.7 in 2015 which put this country in the group of low inequality. The world Gini index in 2015 was 0.65 or 65 from 100 which mean that in the world is high inequality in the distribution of the income. [14]

TABLE VIII. GINI INDEX FOR THE REPUBLIC OF MACEDONIA AND BELARUS

<i>Gini index in %</i>	<i>2010</i>	<i>2011</i>	<i>2012</i>	<i>2013</i>	<i>2014</i>	<i>2015</i>
Macedonia	42.8	40.2	40.1	38.5	36.9	35.6
Belarus	28.6	27.1	26.5	26.6	27.2	26.7

The current migration situation calls for the intensification of migration policy measures. An important step in this direction has already been taken. The Concept of the National Program of Demographic Security of the Republic of Belarus for 2016-2020 has been developed and approved. It developed measures on migration policy. In spite of all this, the migration situation in the Republic of Belarus remains stable, controlled, controlled and has no significant impact on the social, social, political and criminal situation in the country. In the Republic of Belarus, a national asylum system has been established, based on the internationally recognized concept of asylum. In particular, the government bodies responsible for managing forced migration have been identified, the necessary legislative framework has been developed and adopted, corresponding to the current trends in the development of international legal protection for asylum-seekers, and the necessary infrastructure has been created to receive forced migrants.

IV. USING BIG DATA AND GEO-LOCATED SOCIAL MEDIA (TWITTER) DATA TO INFER MIGRATION TRENDS

It was generally concurred that policymakers and society require much better data on migration and development. The absence of real migration information frequently prompts public misperceptions about the size of migration and its effect. Poor official statistics on migrants’ movement settles on it troublesome for chiefs around the globe to create effective strategies. The absence of relocation information also makes it harder to contend for the inclusion of migration.

Big Data might help to improve our understanding of migration trends around the world.

The term “Big Data” refers to the trend of the advancement of technologies that have opened the doors to a new approach to understanding and decision-making, which is used to describe huge amounts of data. Before analyzing big data, it is

imperative to know the myriad sources of the data to make well-informed decisions.

Big Data usually refers to the vast amount of data generated by the use of digital devices and web-based tools and platforms.

Big Data may enhance our comprehension of people relocation all over the world over. Big data can be useful for: track post disaster displacement utilizing call detail records; distinguish modalities and determinants of mobile money payments through different sorts of mobile phone information; evaluate and anticipate migration flows and rates through the Internet protocol (IP); locations of website logins and sent messages; analysis migration trends and look at examples of internal and international migration utilizing geo-located online networking information; and examinations transnational networks and diaspora groups or migration related open talk through web-based social networking content.

The primary sources are: streaming data that usually covers the web data used by IT, social media data that is extracted from social media interaction, and publicly available data. Social media can be used as early warning signals for commodity price volatility or spikes in unemployment or emigration rates in some countries, and there are plans to set up a network of “Pulse Labs” aimed at establishing public-private partnerships to harness the potential of Big Data in development program planning and monitoring. Dialog of the potential uses of Big Data to fill migration data gaps is still in its earliest stages.

The quantity of migration studies drawing on Big Data is still generally restricted yet but quickly expanding. Some examples are shown below.

CDR information can be utilized to track forced displacement or infer internal migration designs and for making of early warning systems for forced migration and population removals; migration anticipating; examining internal and temporary/circular migration patterns. CDRs are digital records consequently created and gathered by mobile network administrators each time a cell phone call is made.

Apart from call records, existing research shows that other kinds of mobile phone data can also be collected, analyzed and used in several ways money like money transfers and purchases.

The next examples are using IP addresses of website logins and e-mail sending and geo-located social media (Twitter) data possible to estimate international migration trends.

So the usage of Big Data has significant challenges. There is also serious privacy, ethical and human rights issues related to use of data inadvertently generated by users of mobile devices and web-based websites. The availability of a potentially very large sample does not ensure that the data will be representative, because information only refers to ICT users – a self-selected sample of the whole population. The possibility of “selection bias” inherent in the use of ICT-generated data in migration research undermines the external validity of migration studies – although the normally large quantity of samples makes them more likely to be accurate. As a consequence, policies can be informed by restricted evidence and non-representative data.

In particular cases, for example, in the examination of data accumulated from social media, the inconceivability of confirming the honesty of the data gave by users can also threaten the validity of empirical studies. At last, infrastructural challenges in information sharing, administration and security require more work and communication between analysts and policymakers.

Nevertheless the potential of Big Data for the study of different migration types is particularly significant, given that traditional data collection tools, for example, government censuses and household surveys don't typically capture such patterns.

V. CONCLUSION

Migration was the issue of the year in 2017 and it will likely remain important in 2018.

The Republic of Macedonia has continuous process of migration and now a day this increasingly trend of emigration of Macedonian citizens from the country can occur a big problem in the future. According to the data of the State Statistical Office there are only 8021 people that have emigrated in some European countries, USA, Canada or Australia, but the real situation is different and this number is higher and it is around 600.000 people, according to World Bank.

Analyses confirm that most of the emigrants are male and the age limit for emigration is 15-64 years, where most of them are young people, active e working capable. Most commonly listed reasons for moving are family reasons and employment, and sometime education and marriage. But the most reasonable reason for moving away is the highest percent of the risk of poverty rate, compared with EU (28) which reflects on the living standard and quality of life of the citizens in the country. Mostly, emigrated citizens have finished primary and secondary school, but very often they have university's diploma or master's degree. In that context we can see that they are good qualified people, with knowledge and skills. From aspect of their occupation that they have, they are: craft and related trades workers, service workers and shop and market sales workers, people with elementary occupations, professionals, technicians and associate professionals, clerks and etc.

The population of Belarus is replenished at the expense of the countries of the Middle East (Iraq, Iran, Afghanistan, Syria, etc.) and South-East Asia (Vietnam, China, India, etc.). Analyzing the qualitative composition of those people that are arriving in Belarus, first of all, more people are in working age than they are driving in. At the same time, in the migration flows of the CIS and EEA countries, low-skilled workers are the predominant social group of the population, and the analysis also showed that among the arriving majority - persons of senior working age, and more highly qualified personnel leave the country than enter.

Well-known broad-based multidisciplinary partnerships should be established at the local, national, bilateral, regional

and global levels with the aim of addressing the following policy priorities like a Mainstreaming migration into development, creating regulatory environments to enhance the impact of migrants' privately-funded contributions to development, ensuring respect for and protection of the human rights of all migrants, addressing often negative public perceptions of migrants and migration, promoting evidence-based policymaking on migration and its linkages with development, considering incorporate migration as a key element in a possible new Global Partnership for Development goal, targets for relevant specific development goals, particularly poverty alleviation, disaster risk reduction and access to quality education, health and decent work.

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Regression Analysis of Experimental Data for the Soil Electrical Parameters considering Humidity and Frequency

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Abstract—The paper presents results from unplanned factor analysis of experimental data for the electrical characteristics of soils with different humidity, determined at different frequencies. Equations for determining of the soil resistivity and dielectric permittivity depending on their value at 50Hz, different humidity and density of the soil for frequencies from 100kHz to 1MHz have been obtained as a result from a two-variable regression analysis. Verification of the results authenticity and a graphical comparison between the experimental and computing results have been performed.

Keywords – electrical parameters of soil, soil resistivity, dielectric permittivity, regression analysis

VI. INTRODUCTION

Soil resistivity ρ and dielectric permittivity ϵ_r directly affect on the parameters of lightning protection and grounding systems for computer modelling of the processes in them at direct lightning strokes. Their frequency dependency is necessary to be considered [1].

Results from conducted experimental studies for determining the soil resistivity and dielectric permittivity of a certain site for building an electricity object are presented in [1]. The influence of the soil humidity and density is also evaluated. The studies are conducted with a Precision Impedance Analyzers 6500B Series [2]. These results are used as a basis for creating a simulation model of a grounding system for study of the processes in the soil when flowing the lightning impulse current [3].

The paper presents results from unplanned factor analysis of experimental studies of the electrical characteristics of soils with different humidity, determined at different frequencies, conducted by the authors [1]. A programme developed in the Technical University – Varna has been used for statistical processing of the experimental data – a two-variable regression analysis [4]. Equations for determining of the soil resistivity and dielectric permittivity depending on their values at 50Hz, different humidity and density of the soil for frequencies from 100kHz to 1MHz have been obtained. Verification of the results authenticity between the experimental and computing results have been performed.

VII. DESCRIPTION OF THE EXPERIMENTAL METHODS [1]

A. Method for measurement of the soil moisture content - gravimetric method [5].

One of the most commonly used direct method for measurement of the moisture in a certain substance is the gravimetric method. This method is very accurate and it is used in standardization, but it is prolonged (if infrared rays are used the duration is shortened by 60 minutes). In the method for determination of the material moisture the following formula is used [5, 6, 7]:

$$\omega = \frac{m - m_0}{m}, [\%] \quad (1)$$

Where:

m – weight of the wet material;
 m_0 – weight of the dry material;
 $m - m_0$ – weight of the water.

The weight m of a small part of the moist material is measured. Afterwards, it is put in a dryer at a temperature of about 120°C for 1÷2 hours. Next, the sample is put in a desiccator for 1 hour in order to be achieved thermal equilibrium, and the weight of the dried material is measured. The moisture is calculated by (1). For better accuracy, the weight is measured by electronic scales.

B. Method for determination of the soil relative permittivity [5, 6].

The most used method is the dielectric method. Under the influence of an electric field the dielectric is polarized. Its dielectric permittivity can be determined by measurement of the change of the capacitance of a flat-plate air capacitor (C_0) when placing the dielectric (soil) between its electrodes (C) [5]:

$$\epsilon_r = f(C, C_0), \quad (2)$$

where C depends on the frequency of the electromagnetic field.

VIII. EXPERIMENTAL STUDIES [1]

Experimental studies for determining the soil resistivity and the soil dielectric permittivity for wet and dry soils, as well as for loose and pressed soils at frequencies 50Hz and in the range from 100kHz to 1000kHz have been performed. The measurements were performed in laboratory conditions at a temperature 20°C.



Figure 1. Precision Impedance Analyzers 6500B Series

The measurement of the electrical characteristics R , C , C_0 for each sample having different moisture content is performed by the Precision Impedance Analyzers 6500B Series, Fig. 1. By this device the values of the resistance and the capacitance can be directly determined and indirectly, using equations, the soil resistivity and the relative permittivity can be calculated. The device can measure the following parameters: capacitance C ; inductance L ; resistance R ; reactance X ; conductance G ; dielectric loss tangent $tg \delta$; quality factor Q , impedance Z ; admittance Y ; phase angle θ . The total frequency range is from 20Hz up to 5MHz. The speed of measurement for the used frequency from 100 kHz to 1000 kHz is from 60 ms to 250 ms (in the Meter Mode) and from 60 ms to 190 ms (in the Analysis Mode). The measurement accuracy is up to 0,05%, and the dielectric loss tangent has accuracy up to 0,0005%.

For each sample the analyzer allows rapid and accurate measurements of a certain number of values of R , C , C_0 , Z and D at different frequencies.

The samples are placed in a suitable sensor (Fig. 2), which is a flat-plate capacitor with circular copper plates with a diameter of 37,78 mm and distance between them 49,2 mm (other sensors with different dimensions could be used). The surrounding surface is made from plexiglass, because of its great resistance. On the top of the sensor there is a spring so that the sample is under a constant mechanical pressure. This provides a minimum presence of air in the examined soil.



Figure 2. Measurement sensor

The analyzer measures the volume resistance R_v of the soil sample and the soil resistivity can be calculated:

$$\rho = \frac{R_v \cdot S}{h}, \Omega \cdot m \tag{3}$$

where R_v – volume resistance of the soil sample, Ω ; S – area of the electrode, m^2 ; h – thickness of the soil sample, m .

The soil resistivity can be calculated also after measurement of the parameters C and $tg \delta$ and using the following equations [2, 5]:

$$tg \delta = \omega C R_v, \tag{4}$$

where $tg \delta$ - dielectric loss tangent; $\omega = 2\pi f$.

$$R_v = \frac{tg \delta}{2\pi f C}, \tag{5}$$

In Tables I, II and III are given the results for ρ and ϵ_r .

TABLE IX. SOIL RESISTIVITY OF WET LOOSE SOIL [1]

$\rho_{50 Hz} [\Omega \cdot m]$ / $f, [kHz]$	50	93	200	270	500
100	42	58	42	143	323
200	40,6	26,3	24,4	80	207
300	39,7	23,8	35	49	135
400	39	25	40	31	121
500	38,3	24	26	29	75,3
600	37,7	22,4	21	26,4	68
700	37,14	21,8	18,7	26,3	39
800	36,6	21,5	29	26,2	55
900	36	21,1	45,7	26,1	49
1000	35,5	20,7	42,7	26	48,6

TABLE X. SOIL RESISTIVITY OF WET PRESSED SOIL [1]

$\rho_{50 Hz} [\Omega \cdot m]$ / $f, [kHz]$	50	100	110	120	160
100	28,13	56	60,4	87,2	122,9
200	13,54	44,5	56,8	85,2	100,3
300	13,38	39,2	54,5	75,8	114,1
400	13,34	43,4	51	74	110,5
500	13,26	43,3	50	74,18	95,1
600	13,14	43,2	46	72,68	89,1
700	13,01	43,2	39,4	71,54	86,3
800	12,98	50,3	36,2	71	84,5
900	12,79	46,6	30	62,56	80,7
1000	12,56	47,3	27,7	35,6	65,8

TABLE XI. DIELECTRIC PERMITTIVITY OF DRY SOIL [1]

$\epsilon_r (50 Hz)$ / $f, [kHz]$	10	45	60	135
100	6,07	13	13	102
200	2,6	20	19	147
300	5,6	9	4,3	147,6
400	0,75	15,4	22,6	15,47
500	1,07	6	10,7	16,41
600	1,9	12,7	9,17	16
700	2,3	4,35	11,5	16,33
800	2,5	4,0	20	24
900	4,4	1,77	11,1	9,5
1000	3,9	2,26	1	12,2

IX. REGRESSION ANALYSIS OF THE EXPERIMENTAL RESULTS

The authors have developed the research by processing the experimental results for the electric characteristics of soils with different humidity measured at different frequencies in an unplanned factor experiment, presented in [1]. Two-variable regression analysis is applied for obtaining equations for determining the soil resistivity and dielectric permittivity depending on their value at 50Hz, the humidity and density of the soil, as well as for frequencies from 100kHz to 1MHz.

The obtained equations with two variables (x_1 – frequency f , kHz, x_2 – the soil resistivity at 50Hz ρ_{50Hz}) are as follows:

- For soil resistivity of wet loose soil

$$y = 87,138575 - 0,15732186x_1 - 0,7209673x_2 + 4,1893 \cdot 10^{-4} x_1^2 + 0,00652561x_2^2 - 3 \cdot 10^{-7} x_1^3 - 1,334 \cdot 10^{-5} x_2^3 + 1 \cdot 10^{-8} x_1^4 - 0,00123078x_1x_2 - 1,26 \cdot 10^{-6} x_1^2x_2 - 1,29 \cdot 10^{-6} x_1x_2^2 \quad (6)$$

- For soil resistivity of wet pressed soil

$$y = -1635,354 - 0,44786885x_1 + 78,454936x_2 + 2,6433 \cdot 10^{-4} x_1^2 - 1,2845263x_2^2 - 1,2 \cdot 10^{-7} x_1^3 + 8,87543 \cdot 10^{-3} x_2^3 - 2,177 \cdot 10^{-5} x_1^4 + 0,01102365x_1x_2 - 5,8 \cdot 10^{-7} x_1^2x_2 - 1,1191 \cdot 10^{-4} x_1x_2^2 + 3,5 \cdot 10^{-7} x_1^2x_2^2 \quad (7)$$

- For dielectric permittivity of dry soil

$$y = 70,723735 + 0,01611329x_1 + 22,824079x_2 + 9,533 \cdot 10^{-5} x_1^2 - 0,87670151x_2^2 - 2 \cdot 10^{-8} x_1^3 + 11,30732 \cdot 10^{-3} x_2^3 - 4,388 \cdot 10^{-5} x_1^4 - 4,8861 \cdot 10^{-4} x_1x_2 - 2,86 \cdot 10^{-6} x_1^2x_2 + 4,18 \cdot 10^{-5} x_1x_2^2 + 3 \cdot 10^{-8} x_1^2x_2^2 - 4,3 \cdot 10^{-7} x_1x_2^3 \quad (8)$$

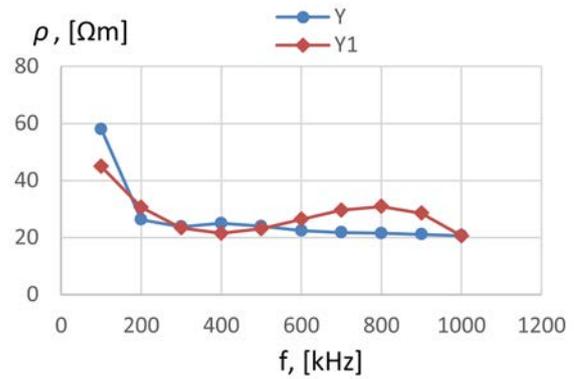
An analysis of the regression dependencies (6) and (7) is made on the significance of the members involved and the possibility of their simplification for the purpose of their practical use.

As a result, the following dependencies can be proposed that lead to error not greater than 1,8 %.

$$y = 87,14 - 0,16x_1 - 0,72x_2 + 4,2 \cdot 10^{-4} x_1^2 + 0,007x_2^2 - 1,33 \cdot 10^{-5} x_2^3 - 0,0012x_1x_2 + 1,26 \cdot 10^{-6} x_1^2x_2 - 1,29 \cdot 10^{-6} x_1x_2^2 \quad (9)$$

$$y = -1635,35 - 0,448x_1 + 78,455x_2 + 2,6433 \cdot 10^{-4} x_1^2 - 1,285x_2^2 + 8,875 \cdot 10^{-3} x_2^3 - 2,177 \cdot 10^{-5} x_1^4 + 0,011x_1x_2 - 1,12 \cdot 10^{-4} x_1x_2^2 + 3,5 \cdot 10^{-7} x_1^2x_2^2 \quad (10)$$

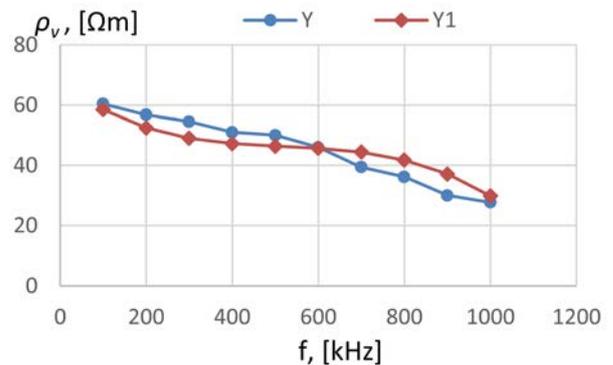
Comparative graphical analysis between the experimental results and the computing results by the regression equations (6), (7) and (8) is presented in Fig.3÷5.



$f, [kHz]$	$Y, [\Omega.m]$	$Y1, [\Omega.m]$
100	58	44,91
200	26,3	30,59
300	23,8	23,38
400	25	21,49
500	24	23,09
600	22,4	26,41
700	21,8	29,61
800	21,5	30,92
900	21,1	28,52
1000	20,7	20,61

At $\rho_{(50Hz)} = 93 \Omega \cdot m = const$

Figure 3. Comparative graphical analysis of the frequency dependency of the soil resistivity for wet loose soil between the experimental results Y and computing results from the regression equations Y1.

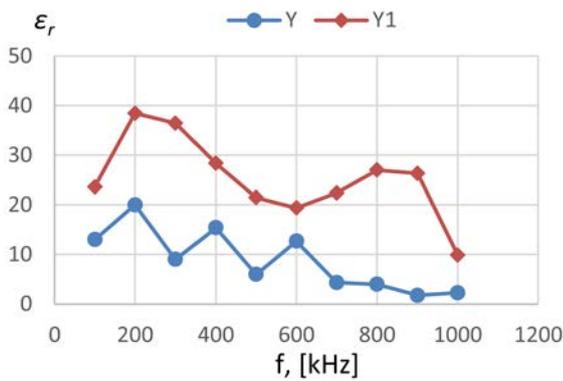


$f, [kHz]$	$Y, [\Omega.m]$	$Y1, [\Omega.m]$
100	60,4	58,51
200	56,8	52,48
300	54,5	49,01
400	51	47,26
500	50	46,42
600	46	45,72
700	39,4	44,42
800	36,2	41,78
900	30	37,14
1000	27,7	29,82

At $\rho_{(50Hz)} = 100 \Omega \cdot m = const$

computing results from the regression equations Y1.

Figure 4. Comparative graphical analysis of the frequency dependency of the soil resistivity of wet pressed soil between the experimental results Y and computing results from the regression equations Y1.



f, [kHz]	Y	Y1
100	13	23,62
200	20	38,46
300	9	36,45
400	15,4	28,37
500	6	21,45
600	12,7	19,41
700	4,35	22,39
800	4,0	27,00
900	1,77	26,33
1000	2,26	9,89

At $\epsilon_r(50\text{Hz}) = 45 = \text{const}$

Figure 5. Comparative graphical analysis of the frequency dependency of the soil dielectric permittivity of dry soil between the experimental results Y and computing results from the regression equations Y1.

X. CONCLUSIONS

1. The experimental results have shown that the great variety of the values of ρ and ϵ_r necessarily determines the need for preliminary sampling before commencing the design of a grounding system and subsequently using the regression

equations proposed in the paper to find their values at any frequency.

2. The obtained regression equations for determining ρ and ϵ_r from the frequency and their values at 50Hz are suitable for sizing of grounding systems considering the impulse processes in the soil under the impact of lightning impulse current.

3. The regression equations are useful for obtaining estimates of ρ and ϵ_r only for the area of Varna from where the soil samples are taken. The authors work on compiling tabular data for different regions of Bulgaria.

4. The paper provides an approach for obtaining data for ρ and ϵ_r where a precise analysis of the soil processes at lightning impulses impact is needed.

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Determination of dangerous lightning current levels for power substations 220kV

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Abstract— Lightning strike on an overhead power line cause overvoltages that spread in it, as waves. This waves can be dangerous for the equipment in electrical substations. The study of incoming waves is extremely important in the proper sizing and coordination of insulation in the electrical substations. This paper present results from model study of incoming waves due to lightning and determination of dangerous lightning current levels for power substation 220kV.

Keywords- lightning overvoltages, lightning current, overhead line, power substation

I. INTRODUCTION

Lightning is a unique phenomenon in nature. In its operation, a large amount of energy can be generated, which can be extremely destructive. Due to the direct and indirect impact of lightning on the overhead lines, overvoltages are produced which can be significantly higher than the so-called insulation level of the equipment in the power system. Electrical power substations 220 kV with overhead power lines are protected from atmospheric overvoltages with metal-oxide surge arresters (MOSA). They must be selected so that electrical and mechanical characteristics comply with the conditions under which they are operated.

The aim of the report is to investigate the atmospheric overvoltage levels and to determine the dangerous amplitudes of the lightning current for substations with a voltage level of 220kV through a simulation model. Simulation model of a real 220kV substation was developed in MATLAB Simulink to model a direct lightning strike by phase conductor at any 220kV air line connected to the substation under study. We have seen cases of so-called, a "cut" wave with parameters ranging from 10kA to 100kA and different distances to the point of impact. Surge voltage measurements are made at the inlet of the power line to the substation.

II. MODEL DESCRIPTION

The investigated model is electrical air insulated outdoor power substation 220kV. It is connected by double bus bar with single breaker scheme with 3 overhead transmission lines, 3 autotransformers, 2 measurement joints and 1 tie breaker. For the equivalent scheme of the substation every element is given with their capacitance [1]. Conductors in the substation are given by distributed parameters line with real distances calculated for dominant transient frequency [2]. The frequency is given by:

$$f = \frac{1}{4\tau_0} \quad (1)$$

Where: $\tau_0 = l/c$, l is the distance from 1st tower to the substation and c is velocity of the light in the free space.

The model of the lightning current is presented with double exponential function [3] given by:

$$I(t) = \frac{I_{max}}{\eta} * (e^{-\frac{t}{\tau_1}} - e^{-\frac{t}{\tau_2}}) \quad (2)$$

Where: I_{max} - peak of the current, η - correction factor, τ_1, τ_2 - time constants for determination current rise time and decay time.

The equivalent scheme of the substation with capacitances and distributed parameter lines is shown on figure 1.

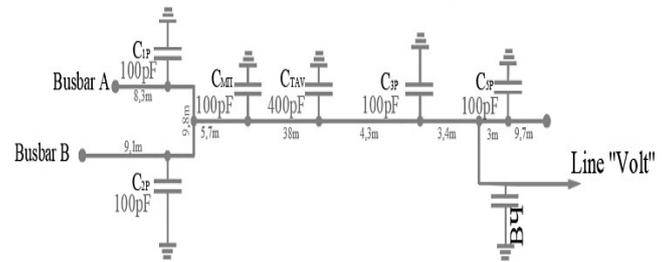


Figure 1. Single line equivalent scheme

The model of lightning current is presented by current source with double exponential form and lightning impedance path. It is modeled with Matlab Simulink. Lightning model in Matlab Simulink is shown on figure 2.

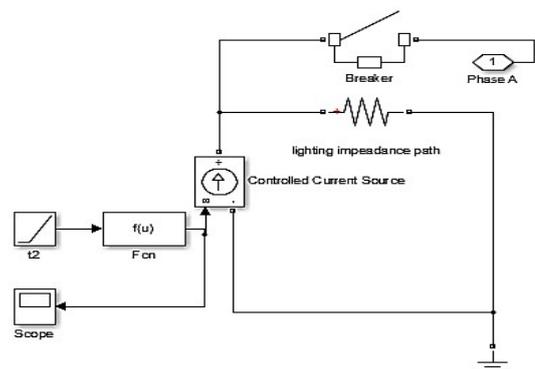


Figure 2 Lightning current model

Block t_2 is for setting the start time for the lightning. The double exponential form of the lightning is presented by function block (Fcn). The conversion of the signal to a current signal is done by controlled current source block from Matlab Simulink library. Lightning impedance path is presented by resistance block with 1000Ω [4]. The breaker is synchronized with the start time of the lightning.

The equivalent scheme of the substation is implemented in Matlab Simulink. One fider of the model is shown on figure 3.

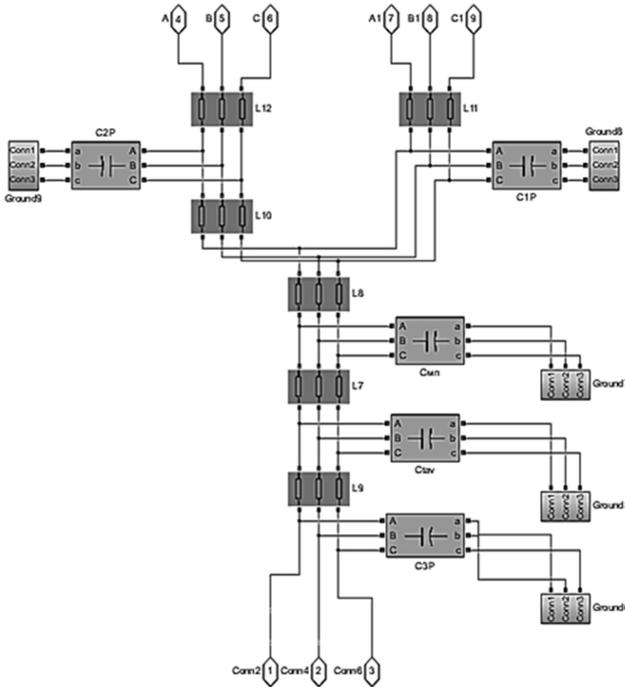


Figure 3 Model equivalent scheme

Where the block with L are distributed parameter line with the real distances between the equipment and block C present the capacitances of the equipment in the substation. The power source is presented by power-frequency voltage source and resistor in series for the system of 220kV [2].

III. VARIANT STUDIES

Research on the overvoltages due to lightning strokes on phase conductor "A" of overhead line "Volt"

There are variant studies of the lightning strokes on line "Volt" for several distances. The distance for the point of impact is 50m, 100m, 200m and 500m away from substation entrance. The values for the amplitude of the lightning current are 10kA, 15kA, 20kA, 30kA, 50kA, 80kA and 100kA with $1/10\mu s$ for of the wave. Overvoltages waves incoming to the substation are measured on the substation entrance by voltmeters on each phase. The results are grouped for each distance and compared to the BIL of the system 220kV. By comparing of the results are determined current levels that cause dangerous overvoltages for the equipment in this case.

IV. SIMULATION RESULTS

The simulation result from the model study are shown on figures 4,5,6 and 7. They present the measured overvoltages at substation entrance due to lightning current compared with the BIL of the system.

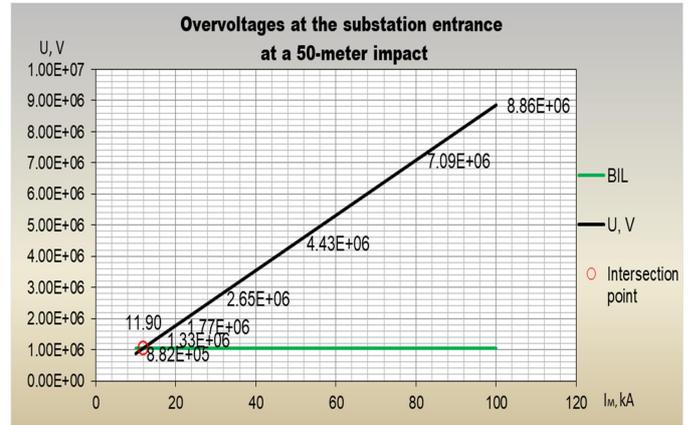


Figure 4 Voltages at substation entrance for 50m away stroke

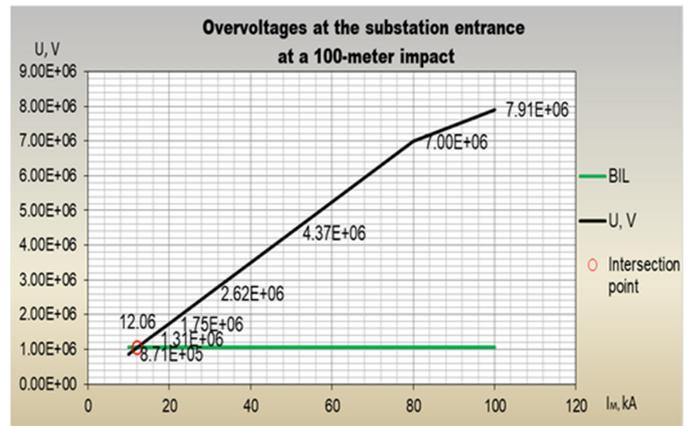


Figure 5 Voltages at substation entrance for 100m away stroke

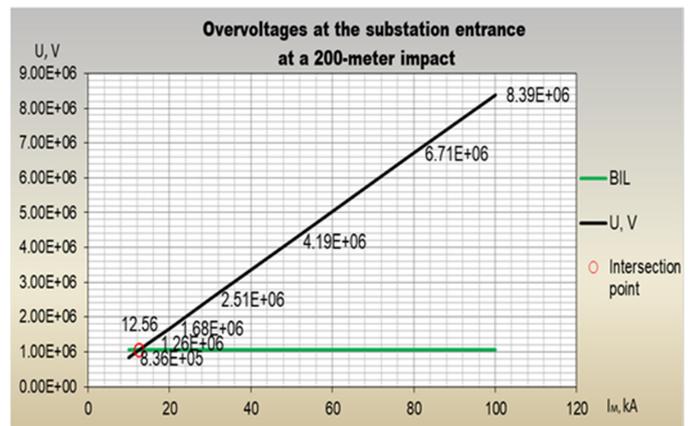


Figure 6 Voltages at substation entrance for 200m away stroke

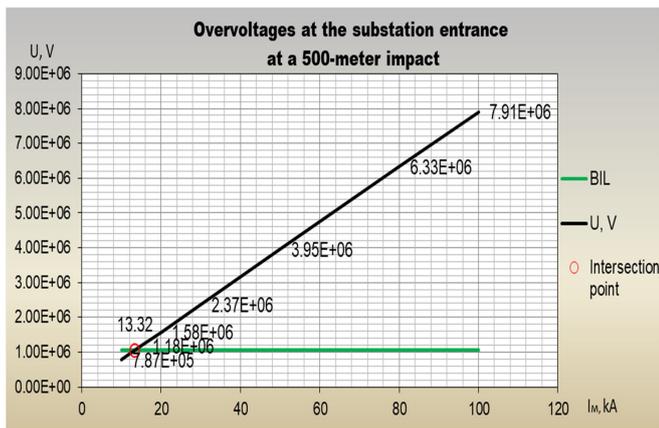


Figure 7 Voltages at substation entrance for 500m away stroke

V. CONCLUSIONS

Following the results it can be seen that lightning current cause overvoltages that are dangerous for the equipment. In the each case of the model study is defined exactly the dangerous

lighting current level by intersection point of the curves. This can be useful for precise insulation coordination and future development of researches.

The developed model can be used for wave processes in power substations.

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Application of wavelet functions in signal approximation

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Abstract Wavelet functions are widely used in many mathematical and engineering fields. This paper discusses the capabilities of wavelet functions for approximation of different determinate signals. The purpose is to evaluate a set of wavelet functions for approximation of signals. M-functions in the Matlab programming environment are created. Haar, Coiflets, Symlets, Daubechies, biorthogonal and discrete Meyer wavelets are used. The efficiency of approximation is assessed. A comparative analysis of the used wavelet functions in terms of relative error of approximation and norm error of approximation using discrete wavelet transform is presented.

Keywords- approximation, Matlab functions, relative error, wavelets

I. INTRODUCTION

A special type of signals - wavelets (elementary waves) are actively used in the modern theory and practice. They demonstrate their efficiency especially in performing spectral analysis, approximation, filtration and compression of one-dimensional and two-dimensional signals.

Wavelets, in turn, are some of the latest tools for decomposing functions or continuous time signals on frequency elements and the study of each frequency element with a resolution corresponding to its scale. They are basically considered to be an alternative to the Fourier transformation, and in this case the wavelet analysis has important advantages that arise from the wavelet function properties.

This paper discusses the approximation of signals using wavelets in the Matlab environment. Both built-in functionality from the Wavelet Toolbox [2] and external algorithms and functions are used.

II. FEATURES OF THE WAVELET FUNCTIONS

Wavelets are mathematical functions that are used to decompose analog signals on frequency elements and later to analyze them with the corresponding resolution according to their scale [1, 7, 8, 10, 14]. The process of representing a function through elementary waves is called a wavelet transformation.

Wavelets are determined by the wavelet function $\psi(t)$, also called *mother* wavelet, and the scaling function $\phi(t)$, also called *paternal* wavelet. The resulting waves are translated copies of the parent wavelet $\psi(t)$, which in turn is scaled by

coefficients a and shifts to a coefficient b . Thus, the following dependencies are obtained.

$$CWT(f; a, b) = \int_{-\infty}^{\infty} f(t) a^{\frac{1}{2}} \bar{\psi}(a^{-1}(t - b)) dt \quad (1)$$

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}} \psi\left(\frac{t-b}{a}\right) \quad a, b \in R, a \neq 0 \quad (2)$$

The elementary waves are orthogonal, semi-orthogonal and biorthogonal. The wavelet function can be symmetrical or asymmetrical, with a compact domain and missing one, having a different degree of smoothness.

There are different wavelet families that have proven to be particularly useful in signal processing. Some of them are:

- Haar wavelet;
- Daubechies wavelet;
- Symlet wavelet;
- Coiflet wavelet;
- Biorthogonal wavelet;
- Morlet wavelet;
- Mexican hat;
- Meyer wavelet;
- Complex wavelet.

III. WAVELET APPROXIMATION

Wavelet transformation is widely used in several areas, including the signal approximation [3, 4, 5, 6, 9, 11, 12, 13, 14, 15, 16]. To approximate a given signal, function $[ya, E, N] = \text{approxsig}(y)$ has been developed in the Matlab environment. It accepts as the input argument the original (experimental) signal y and returns the approximated signal ya , along with the relative error E and the norm error N . They are calculated by the following formulas

$$E = \sqrt{\frac{\sum_{i=1}^n (y - ya)^2}{\sum_{i=1}^n (y)^2}} \quad (3)$$

$$N = \text{norm}(y - ya) \quad (4)$$

where:

E – relative error of approximation;

N – norm error of approximation;

y – original (experimental) signal;

ya – approximated signal.

To approximate a signal, it is necessary to proceed through the following steps:

Step 1. Load a signal that will be approximated.

Step 2. Select a wavelet to work with and select a wavelet order (if needed).

Step 3. Convert the wavelet into word.

Step 4. Decomposition of the signal of approximating and detailing coefficients through the selected wavelet.

Step 5. Reverse conversion using Matlab function `idwt` and derived coefficients.

Step 6. Draw the original and approximated signals.

Step 7. Calculation of the approximation errors.

The block diagram of the described algorithm is shown on the following figure.

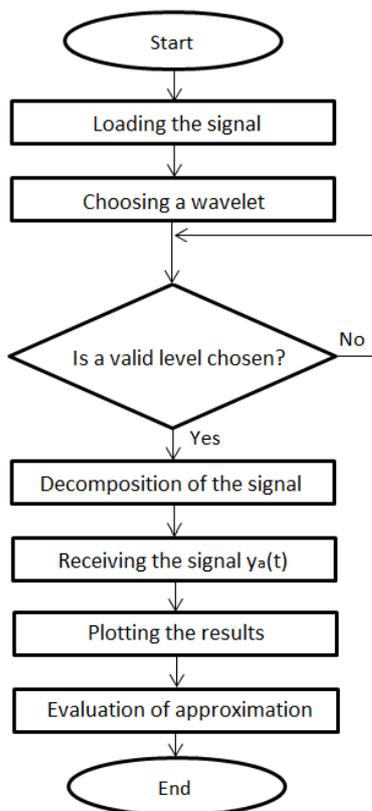


Fig. 1. Block diagram of the algorithm

IV. EXPERIMENTAL RESEARCH

To test the functionality of the developed Matlab function, several experiments were carried out to approximate signals with different wavelet functions. This paper presents only a part of the implemented research in which approximation of the type signals - exponential signal, double aperiodic signal and oscillation signal was performed.

A. Approximation of Exponential Signal

TABLE I. APPROXIMATION ERRORS OF EXPONENTIAL SIGNAL

Wavelet	E [%]	N
Haar (haar)	1.5155e-14	1.2837e-15
Symlets (sym4)	2.9617e-13	2.5087e-14
Daubechies (db5)	5.6392e-12	4.7766e-13
DMeyer (dmey)	6.1441e-5	5.2044e-6

The original signal is shown in Fig. 2.

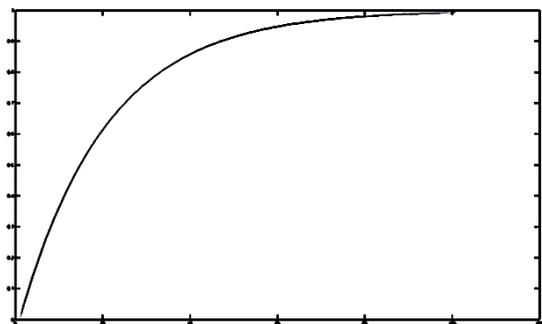


Fig. 2. Original exponential signal

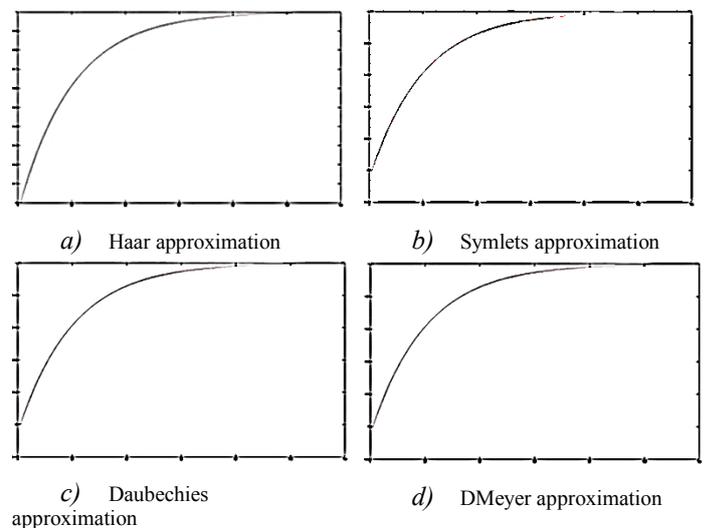


Fig. 3. Original and approximated exponential signals

Figs. 3a, 3b, 3c and 3d show respectively the results obtained after approaching with Haar, Symlet, Daubechies and

DMeyer wavelets. They are compared with the original signal. The original signal is shown in blue and the approximated signal is red. Due to the small approximation error both curves coincide. From the carried-out studies and the results of Table I, can be concluded that the smallest errors are obtained by using Haar wavelets.

B. Approximation of Double Aperiodic Signal

TABLE II. APPROXIMATION ERRORS OF DOUBLE APERIODIC SIGNAL

Wavelet	E [%]	N
Haar (haar)	1.5917e-14	5.2154e-15
BiorSplines (bior3.5)	2.0596e-14	6.7485e-15
Daubechies (db12)	1.3731e-13	4.4992e-14
DMeyer (dmey)	7.7499e-5	2.5394e-5

The original signal is shown in Figure 4. Figures 5a - 5d show respectively the results obtained after approaching with Haar, BiorSplines, Daubechies and DMeyer wavelets.

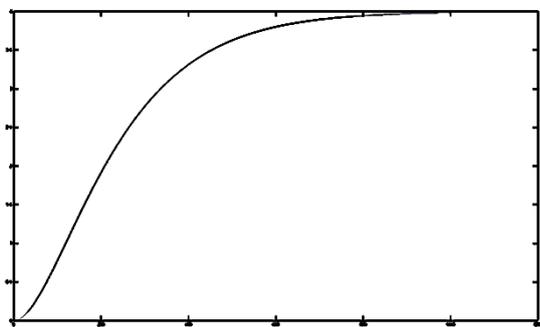


Fig. 4. Original double aperiodic signal

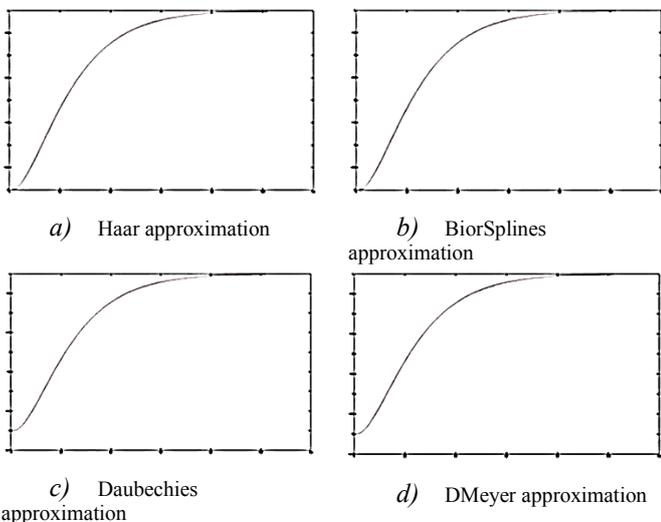


Fig. 5. Original and approximated double aperiodic signals

As can be seen from Table II, the smallest errors are obtained by approximation using Haar wavelets.

C. Approximation of Oscillating Signal

TABLE III. APPROXIMATION ERRORS OF OSCILLATING SIGNAL

Wavelet	E [%]	N
Haar (haar)	1.7003e-14	1.8494e-14
Coiflets (coif3)	3.2566e-13	3.5422e-13
RevBiorSplines (rbio6.8)	3.3276e-13	3.6194e-13
DMeyer (dmey)	5.3453e-5	5.8142e-5

The original signal is shown in Fig.6. Figures 7a-7d show respectively the approximated signals using haar, coif3, rbio6.8 and dmey wavelets.

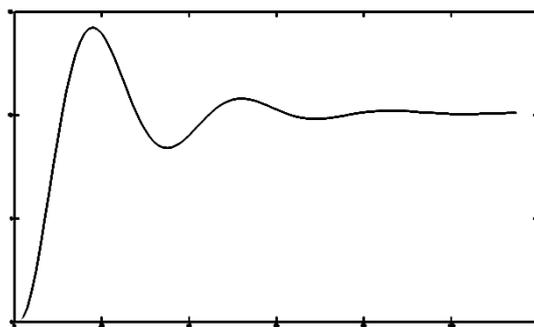


Fig. 6. Original oscillating signal

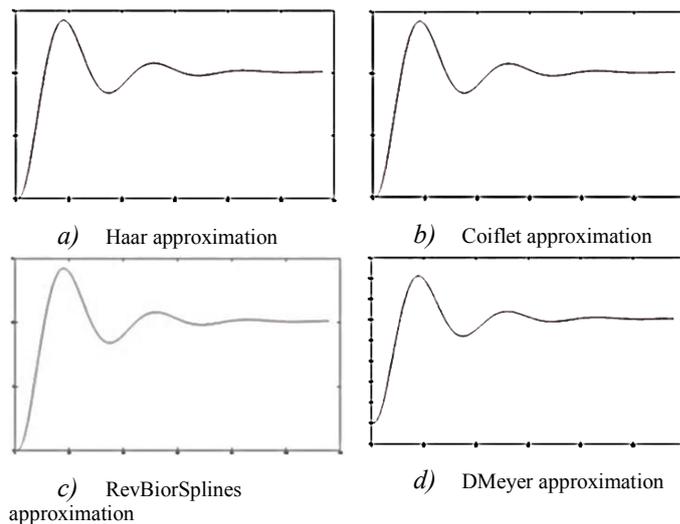


Fig. 7. Original and approximated oscillating signals

Again, the smallest errors are obtained by approximation using Haar wavelets.

V. CONCLUSION

From the research done, it can be concluded that wavelet functions show eminent results in signal approximation. The best results for all three types of test signals are obtained using the Haar wavelets. Greatest errors are obtained for approximation using discrete Meyer wavelets, but the difference in accuracy is insignificant.

The results of the comparative analysis can be used for selecting of proper wavelets for similar signals approximation.

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Compression of images using wavelet functions

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Abstract Recently, wavelet functions are widely used in a number of areas such as mathematics, physics, astronomy, medicine, and of course engineering. This article discusses the decomposition and compression of two-dimensional signals using wavelet functions. The efficiency of the performed wavelet compression is evaluated and analyzed.

Keywords- *compression, decomposition of functions, Matlab, wavelet functions*

I. INTRODUCTION

Wavelets [1, 3, 14] are one of the latest tools for decomposing functions or continuous time signals on frequency elements and studying each frequency element with a resolution corresponding to its scale. These features are widely used in several areas [4, 5, 8, 10, 11, 12]. One possible application of elementary waves is compression of data [9, 13].

Data compression is mainly concerned with the issue of information redundancy. In the terms of computer systems, information redundancy is defined as a constraint that makes us use more bits than is necessary for the presentation of a message. If the redundant information can be removed, the size of the message will be reduced.

Data compression methods can be classified by different attributes. Depending on the result obtained by decompression, the methods are: lossy and lossless. Depending on the type of compression are: Sequence coding, Static (probability) methods, Dictionary methods, Wavelet methods, Fractal methods and Adaptive compression.

Wave methods are used to compress sound, graphics and video images. The input sequence is described using a set of waves (wavelet functions) based on some of its characteristics. A very high compression rate is achieved, at the expense of an inability to achieve 100% accurate decompression. However, in decompression, a result is obtained that is sufficiently close to the original, which is permissible for such files.

This paper deals the processes of image decomposition and compression. A program is created in the MATLAB environment, which is a built-in user interface with built-in protection against incorrect data so that the program is easy and convenient for application even by not so familiar users.

II. IMAGE COMPRESSION USING WAVELET FUNCTION

Compression using elementary waves is a kind of image compression that is suitable for images. Using wavelet transformations, wavelet compression methods are suitable for

representing transient processes. This means that the transient elements of the signal can be represented by a smaller amount of information than if another transformation is used. Wavelet transformation can provide the frequency of the signals and the time associated with these frequencies, which makes it very convenient for application in numerous areas. For example, processing analysis acceleration signals, troubleshooting, designing low-power pacemakers, and large-scale wireless communications.

Before the compression process itself, a wavelet transformation is required. This is associated with creating as many coefficients as there are pixels in the image (i.e. there is no compression yet, as this is only a transformation). These coefficients, in turn, can be more easily compressed, as the information is statistically concentrated in only a few coefficients. This principle is called transformation encoding.

This paper considers a wave compression of images using the MATLAB programming environment. For this purpose, a m-file has been developed, in which the user can choose an image from the Matlab Wavelet Toolbox [2].

Criteria for determining compression performance are: retained energy [%], number/percentage of zeros, and image size after compression. The first two criteria mentioned above can be calculated using the following formulas

$$RE = \frac{nc^2}{no^2} * 100 \quad (1)$$

$$NZ = \frac{nn}{bc} * 100 \quad (2)$$

where:

RE – retained energy;

nc - vector-norm (compressed signal, 2);

no - vector-norm (original signal, 2);

NZ – number of zeros in percentage;

nn – number of zeros of the current decomposition;

bc – number of coefficients;

To compress a signal, it is necessary to proceed through the following steps:

Step 1. Start of the program;

Step 2. Open a menu that gives the user a choice of several pre-selected images embedded in MATLAB;

- Step 3.** Load the image selected by the user;
- Step 4.** Open a menu that allows the user to choose from a few pre-selected wavelet functions;
- Step 5.** Checking whether the user selected by the user needs a line selection, if not, the next step is skipped;
- Step 6.** Opens a menu that gives the user a choice between the possible rows of waves;
- Step 7.** Opens a menu allowing the user to choose between the possible levels of decomposition;
- Step 8.** Switching to image decomposition with user-selected wavelet and decomposition level;
- Step 9.** Compressing the image;
- Step 10.** Displaying the original and compressed image for visual comparison;
- Step 11.** Output of compression results - percentage of retained energy and percentage of zeros;
- Step 12.** End of program

III. EXPERIMENTAL RESULTS

To test the functionality of the developed program, several experiments were performed to decompose and compress signals with various wavelet functions. The classes of individual wavelets through which the various compressions are performed are: Haar wavelets; Daubechies wavelets; Symlets wavelets; Coiflets wavelets; Biorthogonal wavelets; Reverse biorthogonal wavelets and discrete Meyer wavelets.

A. Research of the impact of the decomposition level on different types of images and wavelets

TABLE I. IMAGE CATHERINE

Wavelet	Level of decomposition	RE [%]	NZ [%]	Size [KB]
rbio1.3	4	99.86	89.66	46.9
coif4	5	99.99	85.00	47.1
haar	1	99.98	70.20	49.5
db45	8	99.81	53.80	49.6

From the carried-out tests and the results from Table I it can be concluded that the best compression is obtained in the rbio1.3 wavelet and the decomposition level 4, and the worst - at db45 and decomposition level 8.

Figures 1 and 2 show the original image as well as the results obtained after compression with wavelets rbio1.3 and db45.

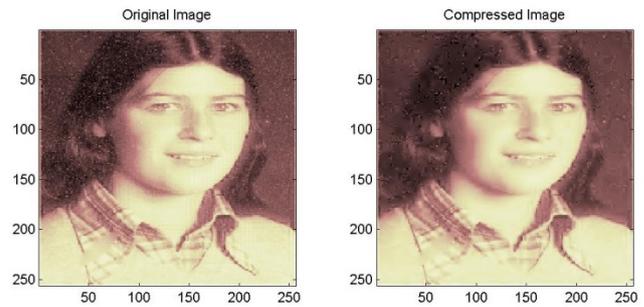


Fig. 1. Original image and the result obtained after compression with rbio1.3

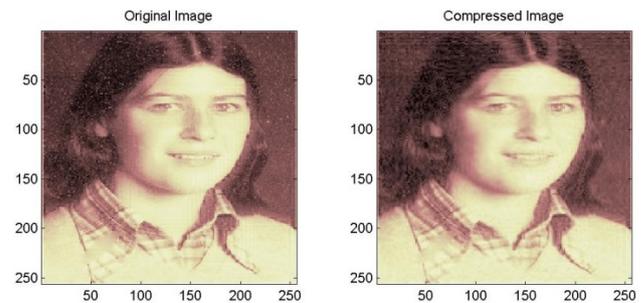


Fig. 2. Original image and the result obtained after compression with db45

TABLE II. IMAGE JELLYFISH

Wavelet	Level of decomposition	RE [%]	NZ [%]	Size [KB]
bior4.4	3	99.9999	78.0012	62.4
sym13	3	99.9972	73.4163	63
rbio1.5	1	99.9986	66.4359	63.4
db45	8	99.9679	44.8659	63.4

From the results obtained in Table II it can be concluded that the best compression is obtained at the bior4.4 wavelets and the decomposition level 3, and the worst - at db45 and the decomposition level 8. Figures 3 and 4 show the original image as well as the results obtained after compression with bior4.4 and db45 wavelets.

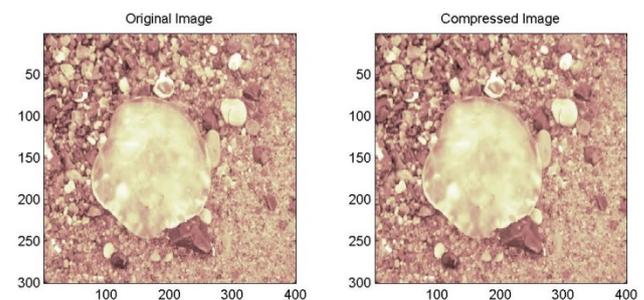


Fig. 3. Original image and the result obtained after compression with bior4.4

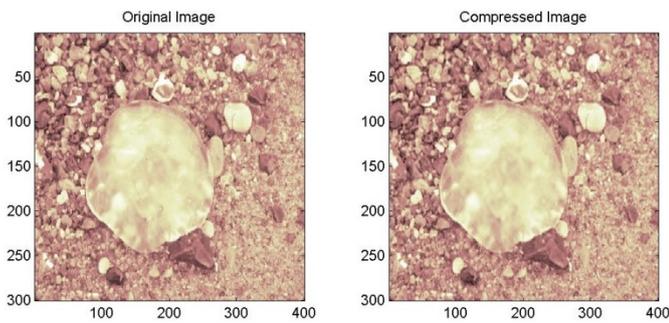


Fig. 4. Original image and the result obtained after compression with db45

TABLE III. IMAGE PORCHE

Wavelet	Level of decomposition	RE [%]	NZ [%]	Size [KB]
rbio1.3	4	99.9902	92.2278	48.8
haar	3	99.9811	90.5888	49.3
sym21	6	99.9965	85.5574	49.7
db44	8	99.9683	67.8036	50.8

According to the results of Table III it can be concluded that the best compression is obtained in the rbio1.3 wavelet and decomposition level 4, and the worst - at db44 and decomposition level 8.

Figures 5 and 6 show the original image as well as the results obtained after compression with wavelets rbio1.3 and db44.

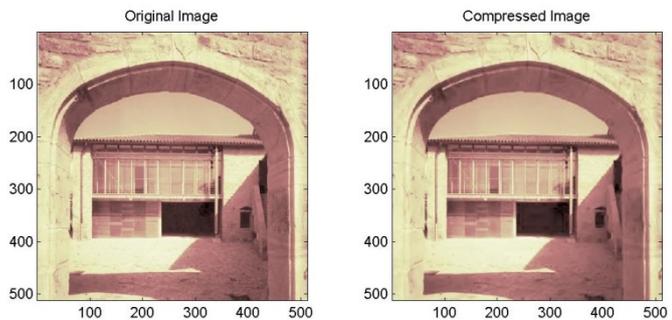


Fig. 5. Original image and the result obtained after compression with rbio1.3

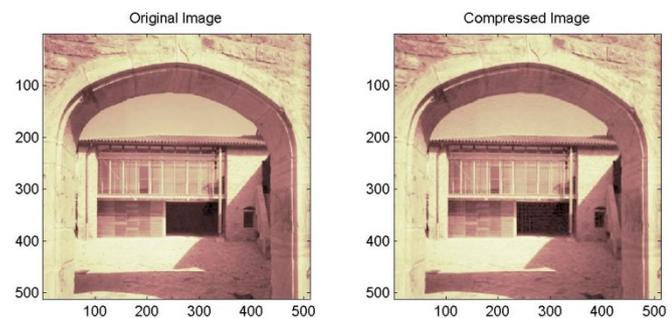


Fig. 6. Original image and the result obtained after compression with db44

It can be concluded from the tests that high or very low decomposition does not produce good compression. Because of this, it is recommended to use decomposition level 3 or 4.

B. Comparing different images with the same wavelet functions

TABLE IV. IMAGE BELMONT

Wavelet	Level of decomposition	RE [%]	NZ [%]	Size [KB]
haar	4	99.9928	75.2005	59.7
db4	4	99.999	75.6444	59.6
coif4	4	99.995	74.4398	59.5
sym4	4	99.9877	76.1249	59.6
bior2.6	4	99.9993	75.0594	59.1
rbio2.6	4	99.9986	73.2596	61
dmey	4	99.9972	64.422	60

Table IV shows that the best compression is obtained using bior2.6, and the worst - using rbio2.6.

Figures 7 and 8 show the original image as well as the results obtained after compression with bior2.6 and rbio2.6

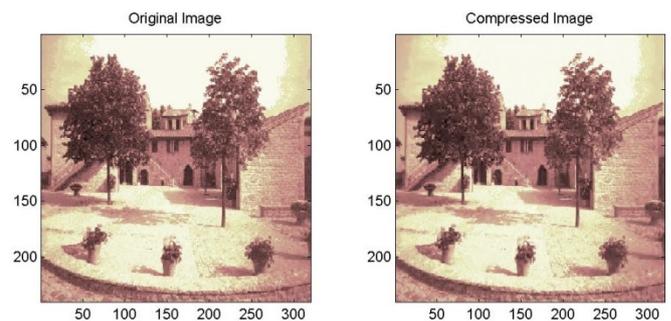


Fig. 7. Original image and the result obtained after compression with bior2.6

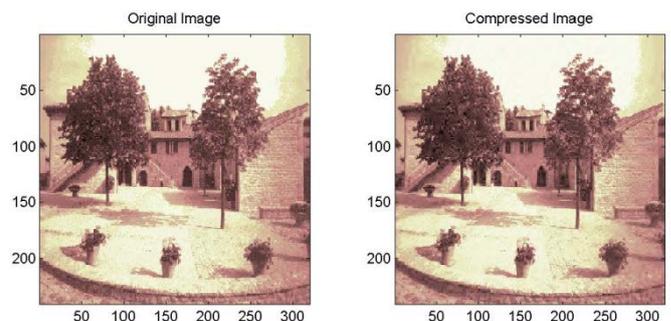


Fig. 8. Original image and the result obtained after compression with rbio2.6

TABLE V. IMAGE BUST

Wavelet	Level of decomposition	RE [%]	NZ [%]	Size [KB]
haar	4	99.9829	84.0195	50.1
db4	4	99.9877	87.3823	49.3
coif4	4	99.9606	86.1762	49.2
sym4	4	99.9905	87.0533	49.2
bior2.6	4	99.9889	85.7572	49.2
rbio2.6	4	99.9466	86.2245	50.3
dmey	4	99.9753	72.0197	49.5

From the results given in Table 5, the best compression is obtained at sym4 wavelets (because there is a higher percentage of retained energy) and the worst – using rbio2.6 wavelets.

Figures 9 and 10 show the original image as well as the results obtained after compression with sym4 and rbio2.6 wavelets.

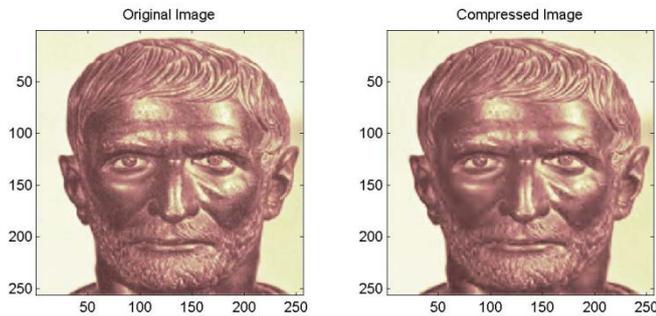


Fig. 9. Original image and the result obtained after compression with sym4

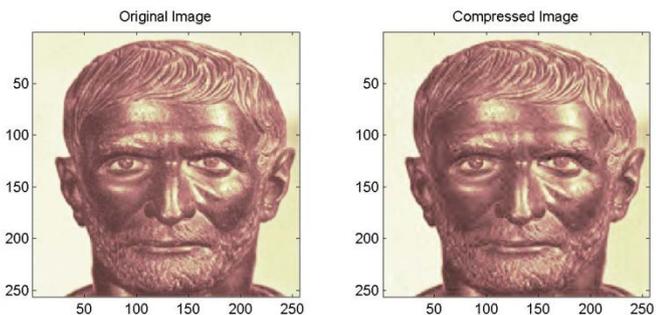


Fig. 10. Original image and the result obtained after compression with rbio2.6

When compressing two different images with the same wavelets in the same order of decomposition, it can be concluded that the best compression is obtained using sym4 wavelets and bior2.6 wavelets. The worst compression is obtained using rbio2.6 wavelets.

IV. CONCLUSION

In this work, a m-file was developed in a Matlab environment, where compression with different wavelet functions of different images was performed. The file is designed to make it easier for the users and eliminate the likelihood of making mistakes.

Using the m-file, a comparative analysis was also made between different classes of wavelets. From the results obtained, it can be concluded that at the same level of

decomposition in different images the best results show sym4 and bior2.6 wavelets, and the worst - rbio2.6 wavelets.

However, it can generally be said that wavelet compression produces very good results in image compression.

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The Use of the Intensity-Curvature Functional as K-Space Filter: Applications in Magnetic Resonance Imaging of the Human Brain

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Abstract— This paper investigates the feasibility of use of the intensity-curvature functional (ICF), high pass filters, and gradient images as k-space filters. The main signal processing technique used is the inverse Fourier transformation and the data is Magnetic Resonance Imaging (MRI) of the human brain. Data were fitted with the bivariate linear and the bivariate cubic Lagrange model functions. The key question that this work addresses is how to emphasize and highlight details in two-dimensional MRI through k-space filtering. The techniques adopted are two. The first one uses the ICF to filter in k-space: high pass filtered and gradient images; and it is termed ONE. The second one uses the k-space of the high pass filters and the k-space of the gradient images to filter the MRI, and it is termed TWO. The study shows that predominantly the technique termed TWO is more effective than the technique termed ONE. The ICF is suggested to be a novel k-space filter.

Keywords- k-space, intensity-curvature functional, magnetic resonance imaging, high pass filter, gradient.

I. INTRODUCTION

Recent research had reported on the use of the intensity-curvature term (ICT) after interpolation of the bivariate cubic Lagrange model function with the aim of highlighting human brain vessels identified with Magnetic Resonance Imaging (MRI) [1]. The intensity-curvature functional (ICF) of three model functions had been demonstrated to be able to be high pass filters and so the intensity-curvature based high pass filters have been introduced [2]. This research consist of a compendium report aimed to investigate the properties of the ICF as k-space filter and to study the properties of other filters which are used both as image space and k-space filters. The image space filters are: the traditional high pass filter (HPF), the gradient calculated along the X direction of the image (GRADX), the gradient calculated along the Y direction of the image (GRADY), and the particle swarm optimization [3] based high pass filter (PSOHPF). For the purpose of the study, two inverse Fourier transformation procedures are here devised. One makes use of the k-space of the ICF and subtracts the aforementioned k-space from the real and imaginary parts of the k-space of the other filters: HPF, GRADX, GRADY, PSOHPF. This technique is here called as ONE. The ICF of the

technique termed ONE makes use of the bivariate linear model function fitted to the MRI data. The second inverse transformation procedure used here, subtracts from the k-space of the MRI image, the k-space of the ICT of the bivariate cubic Lagrange model function [4], the k-space of the ICF, and the k-space of the other filters: HPF, GRADX, GRADY, PSOHPF. Except for the calculation of the ICT, the technique termed TWO also makes use of the bivariate linear model function fitted to the MRI data. In essence what is sought by this research is explained as follows. 1. To investigate which techniques among ONE (see Fig. 1) and TWO (see Fig. 2) is most effective to the purpose of changing the properties of the image space high pass filters and the image space gradients. The change is the suitability of the filters and gradients to emphasize and highlight human brain vessels imaged with MRI. 2. Within the most effective technique, it is investigated as to which one is the most useful k-space filter. The effectiveness of the technique is evaluated on the basis of its capability to emphasize the vessels imaged with MRI. Whereas, the usefulness of the k-space filter is ruled on its aptitude to highlight the vessels. To study the two techniques and to visualize the results of the inverse Fourier transformation procedures, a preliminary analysis had been conducted also using MRI data that does not show vasculature.

II. THEORY

The theoretical background used in this work consists of the Fourier transformations, direct and inverse, and the intensity-curvature concept. While the former is reported here for convenience of the reader, the latter is reported elsewhere [1, 2]. The Fourier direct and inverse transformations are postulated in (1) and (2) respectively.

$$f(\xi) = \int_{-\infty}^{\infty} f(z) e^{-2\pi i \xi z} dz \quad (1)$$

$$f(z) = \int_{-\infty}^{\infty} f(\xi) e^{2\pi i z \xi} d\xi \quad (2)$$

Where $\sqrt{-i} = 1$, and in the two-dimensional case, the phase is $\xi = 2.0 \pi x y / (N_x \cdot N_y)$; $z = (x, y)$.

Let the real and imaginary numbers be defined as (3) and (4), and their magnitude as (5).

$$R_c(\xi) = \cos(\xi) + \sin(\xi) \quad (3)$$

$$I_m(\xi) = -\sin(\xi) + \cos(\xi) \quad (4)$$

$$M_{ag} = \sqrt{[R_c^2 + I_m^2]} \quad (5)$$

In the discrete case for a finite number of samples, let the k-space be defined as (6) and (7), where $k = 1, 2, \dots, (N_x \cdot N_y)$.

$$(F_k, R_c(\xi)) = \sum_{i=0}^{(N_x \cdot N_y)} [f_i(z) \cdot R_c(\xi)], \text{ with } i=1 \dots (N_x \cdot N_y) \quad (6)$$

$$(F_k, I_m(\xi)) = -\sum_{i=0}^{(N_x \cdot N_y)} [f_i(z) \cdot I_m(\xi)], \text{ with } i=1 \dots (N_x \cdot N_y) \quad (7)$$

After the inverse Fourier transformation, let the image space be defined as (8) and (9), where $s, i = 1, 2, \dots, (N_x \cdot N_y)$.

$$(F_s, R_c(z)) = \sum_{i=0}^{(N_x \cdot N_y)} [(F_i, R_c(\xi)) \cdot \cos(\xi) + (F_i, I_m(\xi)) \cdot \sin(\xi)] \quad (8)$$

$$(F_s, I_m(z)) = \sum_{i=0}^{(N_x \cdot N_y)} [-(F_i, R_c(\xi)) \cdot \sin(\xi) + (F_i, I_m(\xi)) \cdot \cos(\xi)] \quad (9)$$

III. METHODS AND RESULTS

A. The Inverse Fourier Transformation Procedure (ONE)

The flowchart of the first technique (ONE) is presented in Fig. 1. The ICF, HPF, GRADX, GRADY and PSOHPF images were Fourier transformed so to obtain the real and imaginary parts of the k-space and their k-space magnitude (see Fig. 3 in (p), (g), (h), (i) and (j)). The inverse Fourier transformation procedure that uses the ICF as k-space filter, comprises of the following steps. 1. The real part of the k-space of the ICF was subtracted from the real part of the k-space of the images (HPF, GRADX, GRADY and PSOHPF). 2. The imaginary part of the k-space of the ICF was subtracted from the imaginary part of the k-space of the images (HPF, GRADX, GRADY and PSOHPF). 3. The resulting differences (in the real and imaginary parts) were inverse Fourier transformed so to obtain the image space back again, and the images are presented in Fig. 3 in (l), (m), (n) and (o). In Fig. 3, (in addition to the steps illustrated in Fig. 1) the image space obtained at step 3 was Fourier transformed again so to calculate the k-space magnitude, which is presented in (q), (r), (s) and (t). Visual inspection focused on the comparison between: the images in (b), (c), (d) and (e) and the images in (l), (m), (n) and (o); shows the effect of the k-space filtering (see Fig. 3). These results were obtained using Magnetic Resonance Imaging OASIS data [5-10].

B. The Inverse Fourier Transformation Procedure (TWO)

The flowchart of the first technique (TWO) is presented in Fig. 2. The inverse Fourier transformation procedure that uses: (i) the k-space of the high pass filters (HPF, PSOHPF); (ii) the k-space of the gradient images (GRADX and GRADY); and (iii) the k-space of the intensity-curvature functional (ICF); in order to filter the MRI was structured on the basis of the following steps. 1. The real part of the k-space of the HPF,

GRADX, GRADY, PSOHPF and ICF, was subtracted from the real part of the k-space of the MRI image, so to obtain five real k-spaces. 2. The imaginary part of the k-space of the HPF, GRADX, GRADY, PSOHPF and ICF was subtracted from the imaginary part of the k-space of the MRI image, so to obtain five imaginary k-spaces. 3. The resulting differences (in the real and imaginary parts) were inverse Fourier transformed so to obtain the image space back again, and the images are presented in Fig. 4 in (a), (b), (c), (d) and (e). In Fig. 4, (in addition to the steps illustrated in Fig. 2) the image space obtained at step 3 was Fourier transformed again so to calculate the k-space magnitude, which is shown in (f), (g), (h), (i) and (j). These results were obtained using Magnetic Resonance Imaging OASIS data [5-10].

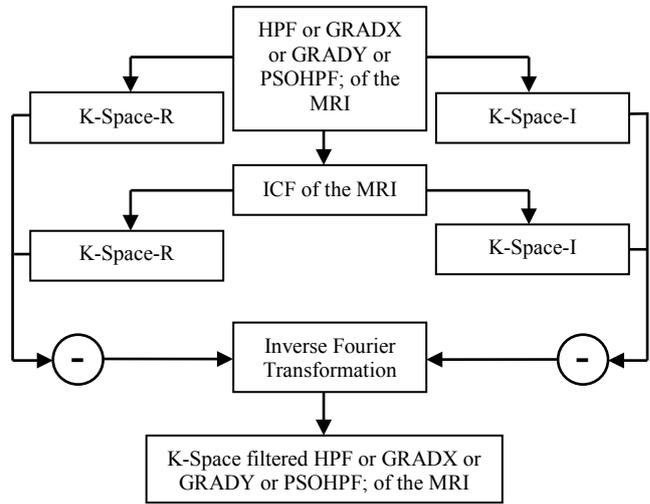


Figure 1. The flowchart of the technique termed ONE.

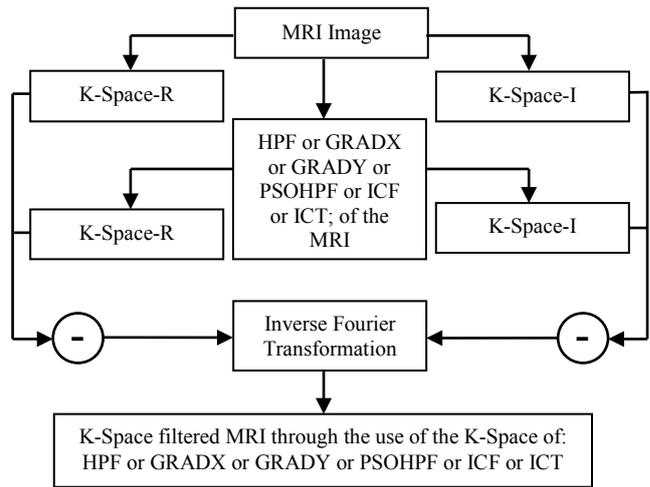


Figure 2. The flowchart of the technique termed TWO.

C. Vessel Emphasis and Highlight in MRI

In Figs. 5, 6 and 7, the departing MRI is presented in (a). The purpose of Figs. 5 and 6 is plural. 1. The pictures are presented with the aim of comparing the image space filters and gradients with the images resulting from the two inverse

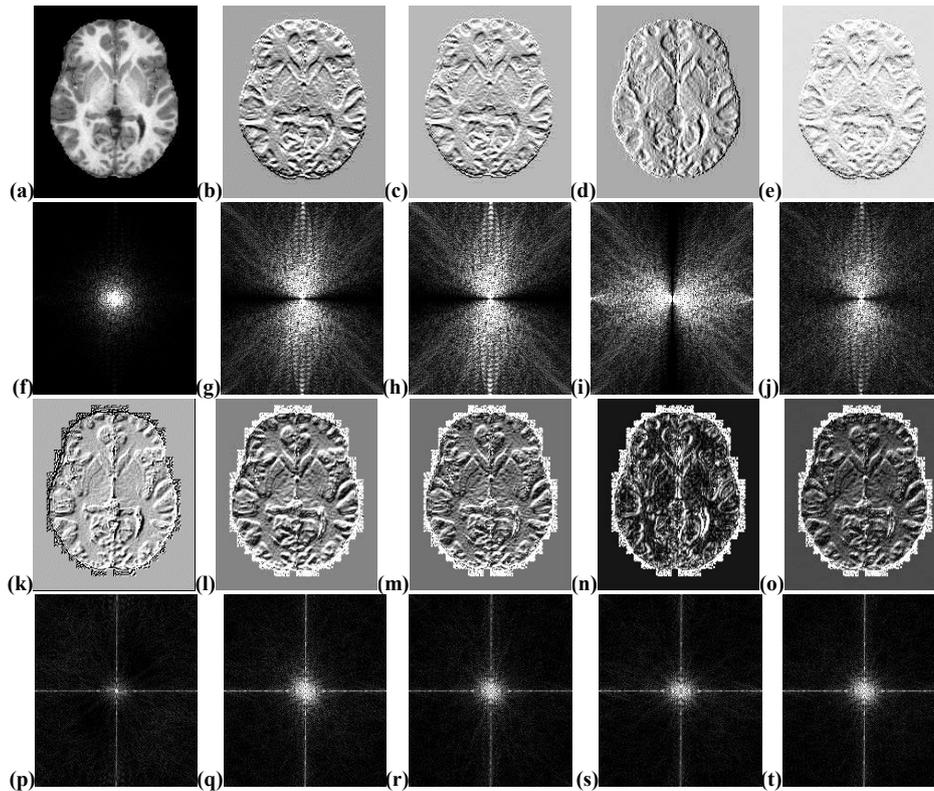


Figure 3. Inverse Fourier transformation technique termed ONE. (a) MRI image. (b), (c), (d), (e): The HPF image; the GRADX image; the GRADY image and the PSOHPF image, respectively. The k-space magnitude in (f), (g), (h), (i), (j) is calculated from: the MRI image, the HPF image; the GRADX image; the GRADY image and the PSOHPF image, respectively. (k) The ICF image. (l), (m), (n), (o): Images result of the inverse Fourier transformation of the difference between the k-space of the filtered images (b), (c), (d), (e) and the k-space of the intensity-curvature functional, respectively. The k-space magnitude in (p), (q), (r), (s), (t) is calculated from: (k), (l), (m), (n), (o), respectively. Note that the k-space magnitude is not the same as the difference between: the k-space of a filtered image and the k-space of the intensity-curvature functional.

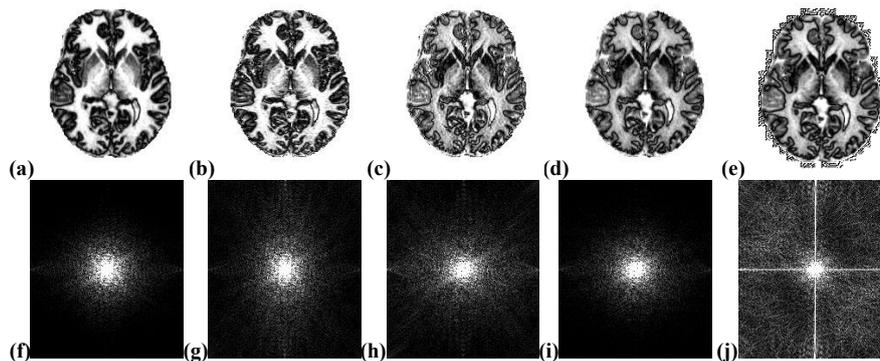


Figure 4. Inverse Fourier transformation technique termed TWO. The picture shows the signal reconstruction of the MRI seen in Fig. 3a after the inverse Fourier transformation has been applied to the k-space differences between the MRI and the: HPF (a); the GRADX (b); the GRADY (c); the PSOHPF (d); and the ICF (e). The picture also shows the k-space of (a), (b), (c), (d) and (e); in (f), (g), (h), (i) and (j) respectively.

Fourier transformation procedures. 2. The second aim is to determine which one between the two inverse Fourier transformation procedures is most capable to emphasize human brain vessels. Emphasis on human brain vessels is attained when the vessels (bright regions of the images), are surrounded by a dark contour after the inverse transformation procedures.

3. The third objective of the two figures is to indicate which one among the k-space filters is most effective to show the vessels surrounded by a dark contour after the inverse transformation procedure and also with increased image intensity (highlight). In Fig. 5, the comparison between: HPF (b), GRADX (c), GRADY (d), PSOHPF (e); and the images resulting from the inverse Fourier transformation procedure

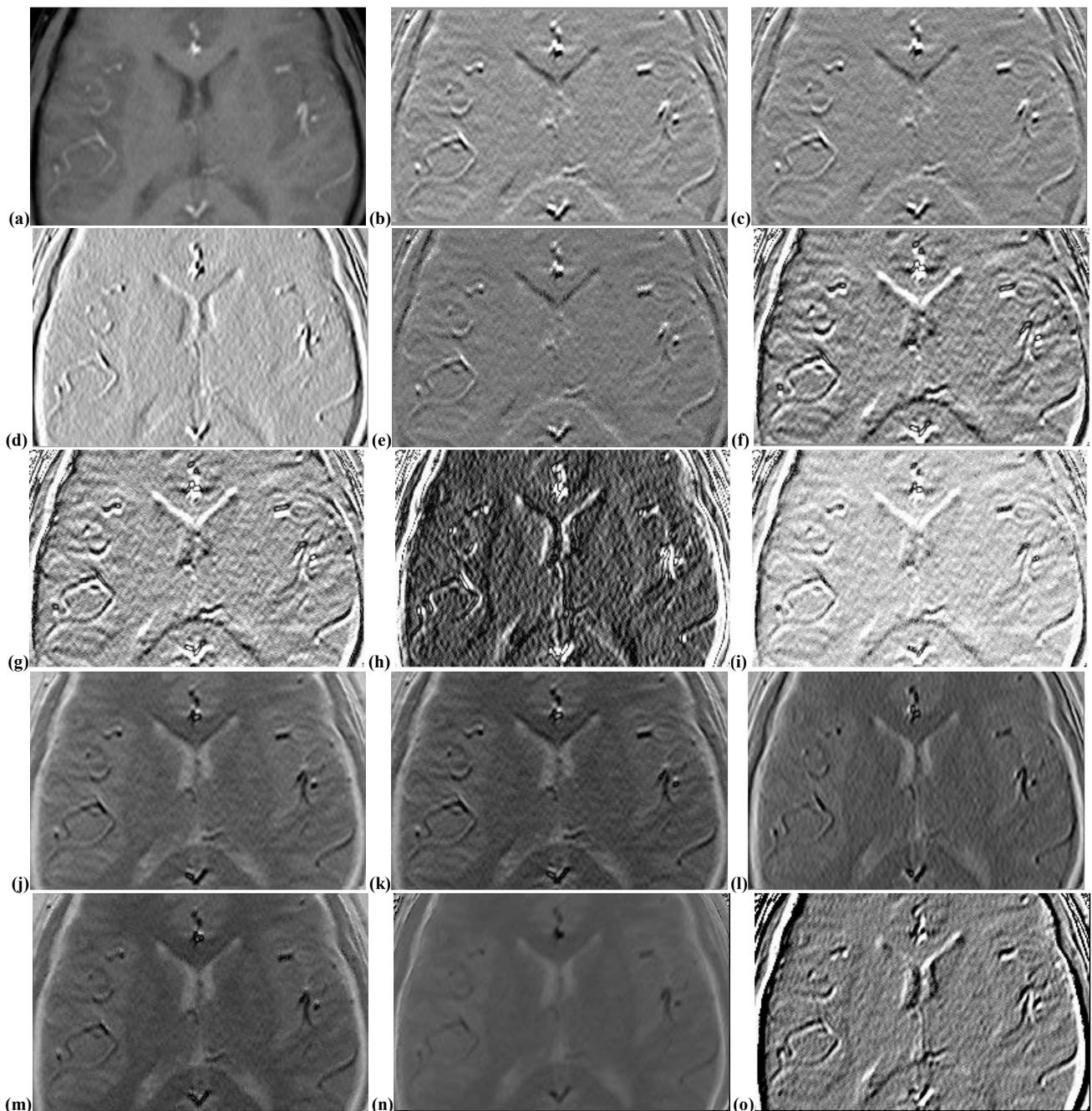


Figure 5. MRI in (a). The images in (b), (c), (d) and (e) show the HPF, the GRADX, the GRADY and the PSOHPF, respectively. The images in (f), (g), (h) and (i) show the signal reconstruction using the Fourier transformation procedure (ONE) applied subtracting the k-space of the ICF from the k-space of HPF, GRADX, GRADY and PSOHPF. The images presented in (j), (k), (l), (m) and (n) show the signal reconstruction using the inverse Fourier transformation procedure (TWO) applied using the difference between the k-space of the image in (a) and the k-space of the: HPF, GRADX, GRADY, PSOHPF and ICF. The ICF is displayed in (o).

termed ONE shows that k-space filtering is apt to emphasize the vessels (see the bright regions surrounded by the dark contour in (f), (g), (h) and (i)). Dissimilarly, the images calculated through the inverse transformation procedure termed TWO (see (j), (k), (l), (m) and (n)) do emphasize the vessels but not as much as the procedure termed ONE does. The ICF of the bivariate linear model function is presented in (o). In Fig. 5, the results indicate that, within the context of the

inverse Fourier transformation termed ONE, the HPF and the GRADX can be improved by k-space filtering using the ICF as the k-space filter (compare (b), (c) versus (f), (g)). Fig. 6 extends on the findings seen in Fig. 5. And, in the specifics, it is observable that both of the two inverse transformation procedures are capable to emphasize and highlight the vessels. Indeed, in Fig. 6, the image space filters and gradients: HPF,

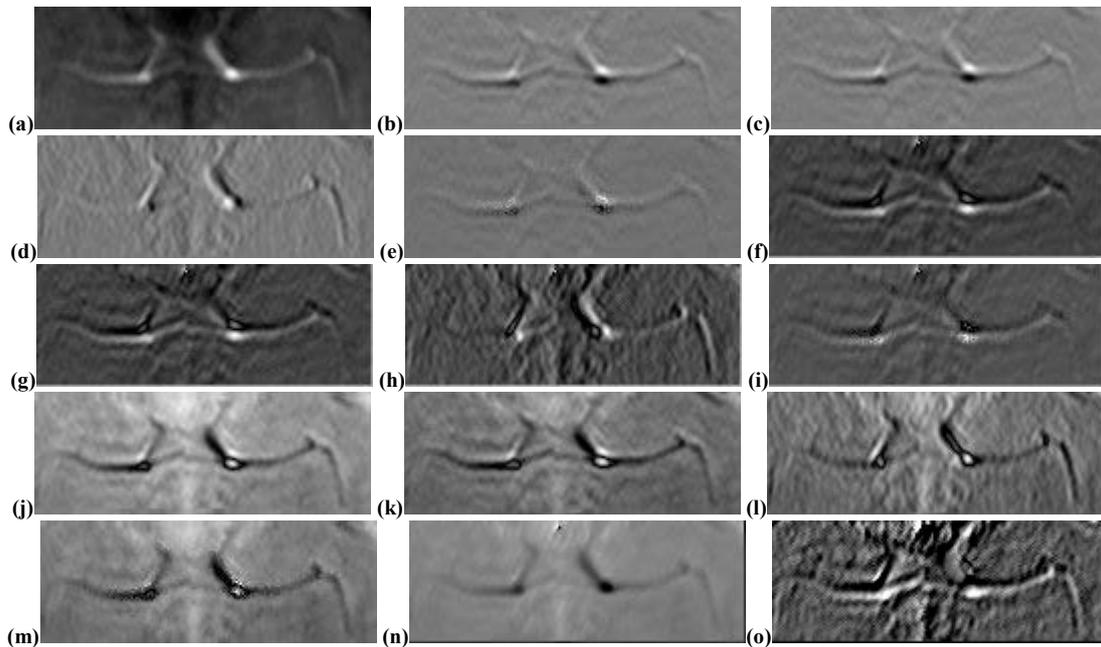


Figure 6. MRI with vessels in (a). The image space filters and gradients: HPF (b), GRADX (c), GRADY (d), PSOHPF (e). The results of the inverse Fourier transformation procedure termed ONE applied subtracting the k-space of the ICF from the k-space of HPF, GRADX, GRADY and PSOHPF, are presented in (f), (g), (h) and (i) respectively. The results of the inverse Fourier transformation procedure termed TWO applied using the difference between the k-space of the image in (a) and the k-space of the: HPF, GRADX, GRADY, PSOHPF and ICF; are presented in (j), (k), (l), (m) and (n), respectively. The ICF is shown in (o).

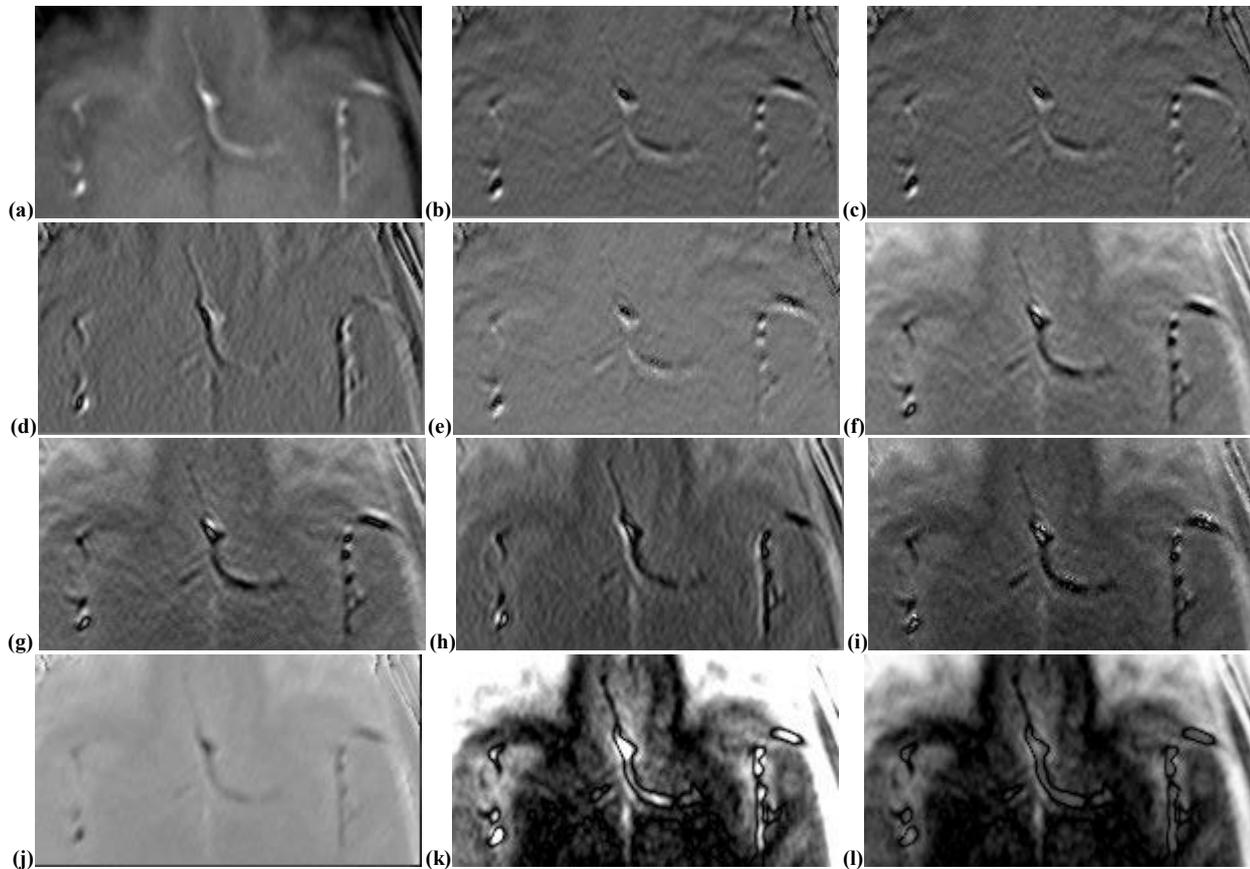


Figure 7. MRI with vessels in (a). The results of the inverse Fourier transformation procedure termed ONE applied subtracting the k-space of the ICF from the k-space of HPF, GRADX, GRADY and PSOHPF, are presented in (b), (c), (d) and (e) respectively. The results of the inverse Fourier transformation procedure termed TWO applied using the difference between the k-space of the image in (a) and the k-space of the: HPF, GRADX, GRADY, PSOHPF and ICF; are presented in (f), (g), (h), (i) and (j), respectively. Images in (k) and (l) present the result of signal reconstruction using as k-space filter the intensity-curvature term (ICT) of the bivariate cubic Lagrange polynomial model function. Note the vessels highlight. The k-space of the ICTs was subtracted from the k-space of the MRI shown in (a). The effect of the contrast brightness enhancement that the ICT is object to (prior to the inverse Fourier transformation procedure), is tested versus no enhancement (compare (k), no enhancement; versus (l), enhancement).

GRADX, and PSOHPPF show the vessels after k-space filtering (compare (b), (c) and (d) versus (f), (g) and (h), respectively). The vessels are also well emphasized and highlighted in (j), (k) and (l), and these images were obtained using the inverse transformation procedure termed TWO. Again, in Fig. 6, the most effective vessel outward show is provided in (h) and (l) and in both of the cases the GRADY is processed: through the ICF as k-space filter (see (h)), and through the GRADY as k-space filter of the MRI shown in (a) (see (l)). Finally, Fig. 7 presents another comparison between the two techniques ONE and TWO showing the result of the signal reconstruction after the inverse Fourier transformation. The ICF based k-space filtering (technique termed ONE) calculated the images in (b), (c), (d), and (e), which are the filtered HPF, GRADX, GRADY and PSOHPPF, respectively. The k-space filtering of the MRI in (a) through the k-space of HPF, GRADX, GRADY, PSOHPPF and ICF (technique termed TWO), calculated the images displayed in (f), (g), (h), (i) and (j), respectively. It is noteworthy to recall the capability of the ICT to emphasize and highlight the human brain vessels (see (k) and (l)) more than any other k-space filter. The aforementioned capability is nevertheless visible also in absence of ICT contrast enhancement prior to the inverse Fourier transformation (see (k)). The ICT is the most effective k-space filter.

IV. DISCUSSION

Magnetic Resonance Imaging of the human brain benefits nowadays of the flexibility offered by the various pulse sequences that are in use and under development with the aim of imaging specific brain structures such as vessels [11, 12]. Rapid progress in MRI imaging techniques has brought to the attention of the MRI modality called Susceptibility Weighted Imaging (SWI) [13]. One of the main advantages of SWI is the use of the phase images collected at the same time of the MRI acquisition, which, however, for long time were discarded regardless of their importance. Current research in MRI now makes use of the phase because it provides with a viable option to visualize vessels, detect micro-vascularity, image micro-bleedings and identify susceptibility changes in tumor tissues in the human brain [14]. The phase is also an indicator of reliable estimates of iron content in the human brain [15, 16]. Additionally, iron detection in the human brain can be pursued with quantitative susceptibility mapping (QSM) which may provide with the estimation of age-related iron changes [17]. Moreover, in recent times the use of ultra-high magnetic fields for MRI studies and diagnostics have improved the detection of the human brain functional activity such as the blood oxygenation level-dependent (BOLD) contrast, the measurement of cerebral blood volume (CBV), and oxygenation changes [18]. Signal processing techniques devoted to vessels imaging in MRI have evolved on the basis of well-established methods like minimum intensity projection (mIP), and maximum intensity projection (MIP) and they currently provide comprehensive vasculature images which are particularly informative because of their use in conjunction with Magnetic Resonance Angiography (MRA) [11]. Within

the aforementioned realm of scientific advances, this work brings to the attention that MRI imaged vessels in the human brain can be studied with a very simple MRI acquisition technique which is commonly discarded because it is wrongly presumed as useless. The MRI technique is the localizer. In addition to the simple MRI recording, this work bases its root foundation in signal processing techniques that use the intensity-curvature concept [1, 2], so to replace the image intensity with the conjoint information content of the image intensity and the sum of second order partial derivatives of the model function fitted to the MRI data. The concept had made it possible to measure the intensity-curvature functional (ICF), and intensity-curvature term after interpolation (ICT) [1, 2, 4]. The model functions used in this research are: (i) the bivariate linear and (ii) the bivariate cubic Lagrange [4]. The signal processing technique adopted to investigate the potential of the intensity-curvature concept is the inverse Fourier transformation, which is a powerful technique and in recent times had been used also for human brain segmentation [19]. Data presented in Figs. 5 through 7 were selected from three subjects' MRI scanning. The major findings of this piece of research are four, and two of them are related to changing the filtering properties of image space high pass filters and gradients: HPF, GRADX, GRADY, PSOHPPF. The change consists in the aptitude of the techniques to emphasize human brain vessels imaged with MRI, and in the aptitude of the k-space filters to highlight the vessels. 1. To the extent of the aforementioned change, the comparison between the results obtained with *the inverse Fourier transformation procedures* indicates the technique termed TWO to be more effective to emphasize the vessels than the technique termed ONE is (see Figs. 6 and 7). These results were obtained using the bivariate linear model function fitted to the MRI data. The vessels are emphasized similarly to what was originally achieved in [1] through the ICT of the bivariate cubic Lagrange polynomial model function. 2. The inverse Fourier transformation procedure termed TWO, used with the ICT of the Lagrange function, provides with vessels highlight (see Fig. 7 in (k) and (l)). This is an additional confirmation to the findings reported earlier in [1]. 3. The intensity-curvature functional of the bivariate linear model function is suggested to be a *k-space filter* able to emphasize the vessels (see Figs. 5 and 6). This is a novelty and it adds up to the properties of the ICF reported in [2] making it possible to distinguish the ICF as a k-space filter. 4. The ICT is the most effective k-space filter because it can emphasize and highlight the human brain vessels in MRI.

V. CONCLUSION

The significance of this work is to emphasize human brain vessels imaged with MRI through k-space filtering. Under this perspective, the intensity-curvature functional (ICF) of the bivariate linear model function is a suitable k-space filter, and the inverse Fourier transformation procedure termed TWO is more effective than the technique termed ONE. The technique which is capable to highlight the vessels remains though the inverse Fourier transformation of the difference between the k-space of the MRI and the k-space of the intensity-curvature

term (ICT) of the bivariate cubic Lagrange model function. This aspect reinforces on the findings reported earlier in [1], about the suitability of the intensity-curvature term to be used as k-space filter.

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Transient and Numerical Models of Three-Phase Induction Motor

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Abstract— The two different mathematical models of three-phase induction motor are derived in order to estimate the motor dynamic behavior during acceleration in different operating modes. The first model is derived from a set of differential equations applied and solved in Simulink. The second model and its set of differential equations are solved using numerical methods in Matlab. The analytical calculation, the experiment, the Finite Element Method (FEM) and the motor model in PSIM software verify the results of both motor transient models. The FEM motor model allows calculation of the magnetic flux density distribution in the motor's cross-section and in the air gap. Additionally, the torque is calculated in the FEM model for different operating speeds and its value is compared with the previously obtained results from the transient models.

Keywords- Induction motor, dynamic models, transient characteristics, FEM model.

I. INTRODUCTION

The three-phase induction motors are among the most widespread induction motors in industrial applications. Since Tesla's invention of the polyphase induction motor and his experimental proof that induction motors can be made with a high degree of efficiency, the three-phase induction motor has become an irreplaceable part in the system of electricity utilization [1]. Its application is significantly improved with the use of power converters and digital controllers allowing motor operation in variable speed applications and complex control systems [2]-[4]. The assessment of motor coupling with the load and its transient behavior during acceleration, as well as during steady-state operation is one of the most important engineering tasks. Various simulation transient models of single and three-phase induction motors can be observed in the literature [5]-[8]. In addition, transient behavior of the motor is modeled and analyzed in cases when the motor is coupled with a soft starter [9]-[10]. Usually, these models are based on one general transformation, which eliminates all time-varying inductances in the electrical machine by referring the stator and rotor variables to a frame of reference, which may rotate at any angular velocity or remain stationary. All known transformations may be obtained by simply assigning the appropriate speed of rotation to this so-called arbitrary reference frame. In this paper, two different transient models of the motor, allowing evaluation of motor dynamic behavior during acceleration, are derived. The first one is defined with a set of five differential equations, modeled and solved in

Simulink. This model is referred to as the simulation model (SM). The second one and its set of differential equations is solved by using numerical methods in Matlab, and this model is referred to as the numerical model (NM). The motor speed and electromagnetic torque as time dependent variables are obtained from both transient motor models. The obtained results are related to various operating modes such as the no load or rated load. The verification of the obtained results from both motor transient models is done by comparison with the results from the motor analytical model, experiments, the FEM model of the motor and motor model in PSIM software. The motor model in PSIM software allows direct comparison of transient characteristics of speed, current and torque from SM and NM with the transient characteristics obtained from the PSIM software. The FEM model of the motor is derived in order to have a clear overview of the magnetic flux distribution in the motor cross-section, as well as in the motor air gap. It allows assessment of the machine core saturation due to the high flux density. The core saturation has a significant influence on the motor's proper operation due to increased losses and motor overheating. Furthermore, as an output from the FEM model, the motor torque is calculated at various operating modes. The obtained values of torque from the FEM models are compared with the obtained torque from the adequate transient characteristics in order to verify the accuracy of the transient models. This paper presents an analysis of the three-phase squirrel cage motor with rated data: output power 2.2 kW, rated speed 1410 rpm, supply voltage 380/220 V in Y/ Δ winding connection and rated current of 8.7/5.5 A.

II. TRANSIENT MOTOR MODELS

A. Simulation Model-Methodology

The first step in mathematical modeling of the transient motor model in Simulink is to transform the supply voltages from the three-phase system (a, b, c) into the synchronously rotating d, q system. The transformation equations are:

$$U_{ds} = -\frac{1}{\sqrt{3}}(U_b - U_c)\cos\theta + U_a \sin\theta \quad (1)$$

$$U_{qs} = \frac{1}{\sqrt{3}}(U_b - U_c)\sin\theta + U_a \cos\theta \quad (2)$$

Where $\omega = \frac{d\theta}{dt}$ i.e. angular displacement $\theta = \int_0^t \omega dt$. The voltages U_a , U_b and U_c are the three-phase supply voltages at 220 V, 50 Hz. The variable ω is associated to the frequency of the supply voltage of the motor. In case of symmetrical three-phase supply voltage $\omega=314$ rad/s. The voltage equations of the stator and rotor circuits are:

$$U_{qs} = R_s i_{qs} + \omega \psi_{ds} + \frac{d\psi_{qs}}{dt} \quad (3)$$

$$U_{ds} = R_s i_{ds} - \omega \psi_{qs} + \frac{d\psi_{ds}}{dt} \quad (4)$$

$$0 = R_r i_{qr} + (\omega - \omega_r) \psi_{dr} + \frac{d\psi_{qr}}{dt} \quad (5)$$

$$0 = R_r i_{dr} - (\omega - \omega_r) \psi_{qr} + \frac{d\psi_{dr}}{dt} \quad (6)$$

In (5) and (6) the transformed rotor voltages U_{qr} and U_{dr} are considered to be equal to zero, since the rotor winding is of the squirrel cage type, and consequently it is short circuited. In the above equations, ω_r is the rotor angular velocity and ω is the arbitrary angular speed, which depends on the frequency of the voltage supply. The flux linkages of the stator and rotor circuits are defined as:

$$\psi_{qs} = L_s i_{qs} + L_{sr} i_{qr} \quad (7)$$

$$\psi_{ds} = L_s i_{ds} + L_{sr} i_{dr} \quad (8)$$

$$\psi_{qr} = L_r i_{qr} + L_{sr} i_{qs} \quad (9)$$

$$\psi_{dr} = L_r i_{dr} + L_{sr} i_{ds} \quad (10)$$

All variables related to the stator have the subscript “s”, and those related to the rotor have the subscript “r”. R_s and R_r are the stator and rotor resistances, L_s and L_r are the stator and rotor inductances, and L_{sr} is the mutual inductance between the stator and rotor winding. By expressing the stator currents i_{qs} and i_{ds} from (7) and (8) and their replacement into (9) and (10), the following equations are obtained:

$$\psi_{qr} = L_r i_{qr} + L_{sr} \left(\frac{\psi_{qs}}{L_s} - \frac{L_{sr}}{L_s} i_{qr} \right) \quad (11)$$

$$\psi_{dr} = L_r i_{dr} + L_{sr} \left(\frac{\psi_{ds}}{L_s} - \frac{L_{sr}}{L_s} i_{dr} \right) \quad (12)$$

By replacing (11) and (12) into (5) and (6) and integrating over time:

$$i_{qr} = \frac{L_s R_r}{L_{sr}^2 - L_s L_r} \int_0^t i_{qr} dt - \omega \int_0^t i_{dr} dt + \frac{L_{sr} \omega}{L_{sr}^2 - L_s L_r} \int_0^t \psi_{ds} dt + \int_0^t \omega_r i_{dr} dt - \frac{L_{sr}}{L_{sr}^2 - L_s L_r} \int_0^t \omega_r \psi_{ds} dt + \frac{L_{sr}}{L_{sr}^2 - L_s L_r} \psi_{qs} \quad (13)$$

$$i_{dr} = \frac{L_s R_r}{L_{sr}^2 - L_s L_r} \int_0^t i_{dr} dt + \omega \int_0^t i_{qr} dt - \frac{L_{sr} \omega}{L_{sr}^2 - L_s L_r} \int_0^t \psi_{qs} dt - \int_0^t \omega_r i_{qr} dt + \frac{L_{sr}}{L_{sr}^2 - L_s L_r} \int_0^t \omega_r \psi_{qs} dt + \frac{L_{sr}}{L_{sr}^2 - L_s L_r} \psi_{ds} \quad (14)$$

The flux linkages ψ_{ds} and ψ_{qs} can be expressed from the transformed voltages U_{ds} and U_{qs} . By replacing the currents i_{qs} and i_{ds} from the equations (7) and (8) in (3) and (4), rearranging the equations per flux linkages and their integration over time, the following equations are obtained:

$$\psi_{qs} = \int_0^t U_{qs} dt - \frac{R_s}{L_s} \int_0^t \psi_{qs} dt + \frac{L_{sr} R_s}{L_s} \int_0^t i_{qr} dt - \omega \int_0^t \psi_{ds} dt \quad (15)$$

$$\psi_{ds} = \int_0^t U_{ds} dt - \frac{R_s}{L_s} \int_0^t \psi_{ds} dt + \frac{L_{sr} R_s}{L_s} \int_0^t i_{dr} dt + \omega \int_0^t \psi_{qs} dt \quad (16)$$

The equations (1), (2), (13), (14), (15) and (16) together with the equation, which defines the rotor speed, constitute the motor transient model. The equation of the rotor speed is:

$$\omega_r = \frac{6L_{sr}}{JL_s} \int_0^t \psi_{qs} i_{dr} dt - \frac{6L_{sr}}{JL_s} \int_0^t \psi_{ds} i_{qr} dt - \frac{2}{J} \int_0^t M_s dt \quad (17)$$

M_s [Nm]-is the load torque and J [kgm²] is the moment of inertia of the motor. The rotor currents and flux linkages are expressed with integral equations instead of differential, as Simulink has more stability in convergence of the solution when equations are expressed in integral form. The electromagnetic torque is found from:

$$M_{em} = \left(\frac{3}{2} \right) \left(\frac{P}{2} \right) L_{sr} \left(\frac{\psi_{qs}}{L_s} i_{dr} - \frac{\psi_{ds}}{L_s} i_{qr} \right) \quad (18)$$

P is the number of poles of the motor. The presented equations (1), (2), (13), (14), (15), (16), (17) and (18) are solved in Simulink for Matlab. As an output, the electromagnetic torque- M_{em} and rotor speed- ω_r as time dependent variables are obtained from the simulation model for different operating regimes: no-load, and rated load of 14 Nm. Beside this, the transient characteristics of the stator current are available as an output from this simulation model. The stator currents are obtained from the inverse transformation from the d,q system into the three-phase a, b, c system.

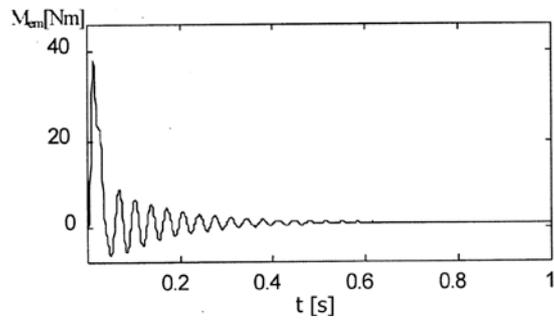
$$i_a = i_{qs} \cos \theta + i_{ds} \sin \theta \quad (19)$$

$$i_b = \left(-\frac{1}{2}i_{qs} - \frac{\sqrt{3}}{2}i_{ds} \right) \cos\theta + \left(\frac{\sqrt{3}}{2}i_{qs} - \frac{1}{2}i_{ds} \right) \sin\theta \quad (20)$$

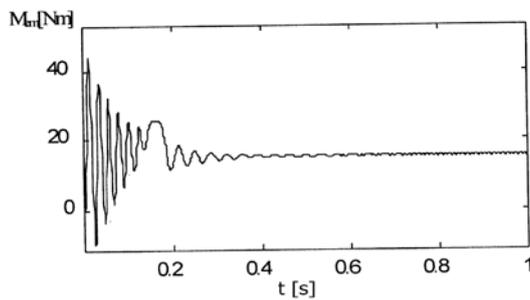
$$i_c = \left(-\frac{1}{2}i_{qs} + \frac{\sqrt{3}}{2}i_{ds} \right) \cos\theta - \left(\frac{\sqrt{3}}{2}i_{qs} + \frac{1}{2}i_{ds} \right) \sin\theta \quad (21)$$

B. Simulation Model-Results

The transient characteristics of speed and torque at no load and rated load are presented in Figs. 1 and 2, respectively. Fig. 3 presents the transient characteristics of the stator current for no load and rated load.

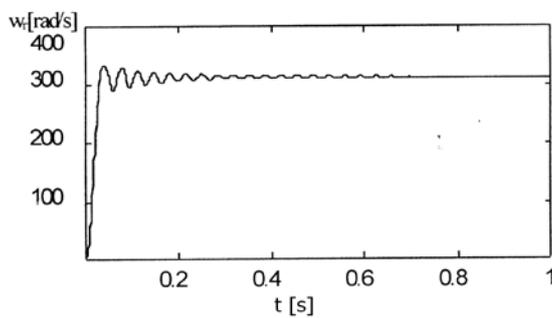


(a) no-load

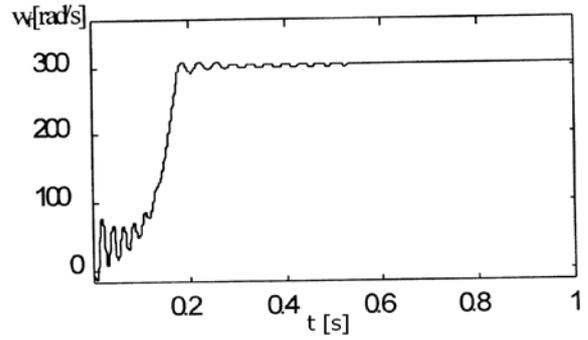


(b) rated load

Figure 6. Transient characteristics of torque

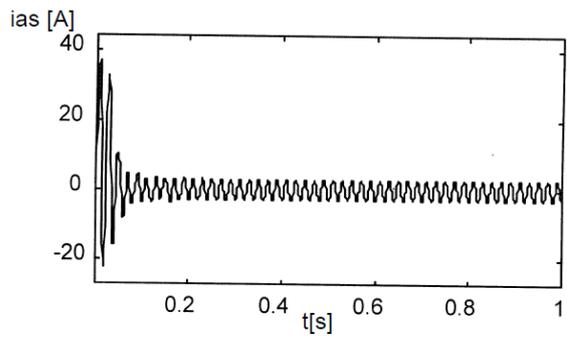


(a) no-load

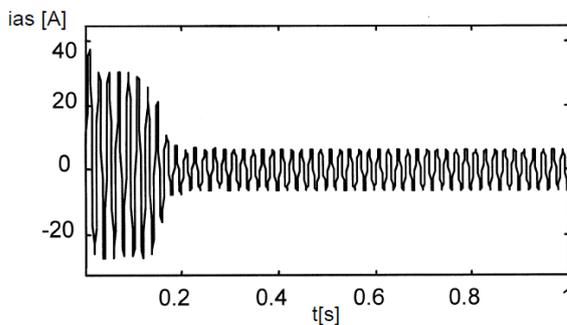


(b) rated load

Figure 7. Transient characteristics of speed



(a) no-load



(b) rated load

Figure 8. Transient characteristics of current

C. Numerical Model-Methodology

The motor numerical model consists of a set of five differential equations in which the time-dependent variables (flux linkages and speed) are transformed in the stationary reference frame or α, β reference frame. The differential equations are:

$$\frac{d\psi_{s\alpha}}{dt} = \sqrt{2}U_{nf} \cos \omega t - a_1\psi_{s\alpha} + a_2\psi_{r\alpha} \quad (22)$$

$$\frac{d\psi_{s\beta}}{dt} = \sqrt{2}U_{nf} \sin \omega t - a_1\psi_{s\beta} + a_2\psi_{r\beta} \quad (23)$$

$$\frac{d\psi_{r\alpha}}{dt} = a_3\psi_{s\alpha} - a_4\psi_{r\alpha} - \omega_r\psi_{r\beta} \quad (24)$$

$$\frac{d\psi_{r\beta}}{dt} = a_3\psi_{s\beta} - a_4\psi_{r\beta} + \omega_r\psi_{r\alpha} \quad (25)$$

$$\frac{d\omega_r}{dt} = P(M_{em} - M_s) / J \quad (26)$$

$$M_{em} = a_5(\psi_{s\beta}\psi_{r\alpha} - \psi_{r\beta}\psi_{s\alpha}) \quad (27)$$

$$a_1 = \frac{R_s L_r}{L_s L_r - L_{sr}^2} \quad a_2 = \frac{R_s L_{sr}}{L_s L_r - L_{sr}^2} \quad a_3 = \frac{R_r L_s}{L_s L_r - L_{sr}^2} \quad (28)$$

$$a_4 = \frac{R_r L_{sr}}{L_s L_r - L_{sr}^2} \quad a_5 = \frac{P L_{sr}}{L_s L_r - L_{sr}^2} \quad (29)$$

The equations (22)-(27) are solved in Matlab with the Runge Kutta solver, giving as an output the transient characteristics of torque and speed.

D. Numerical Model-Results

The electromagnetic torque and motor speed, as time dependent variables, are obtained from the motor numerical models. The transient characteristics of speed and torque for various operating modes are presented in Figs. 4 and 5 respectively.

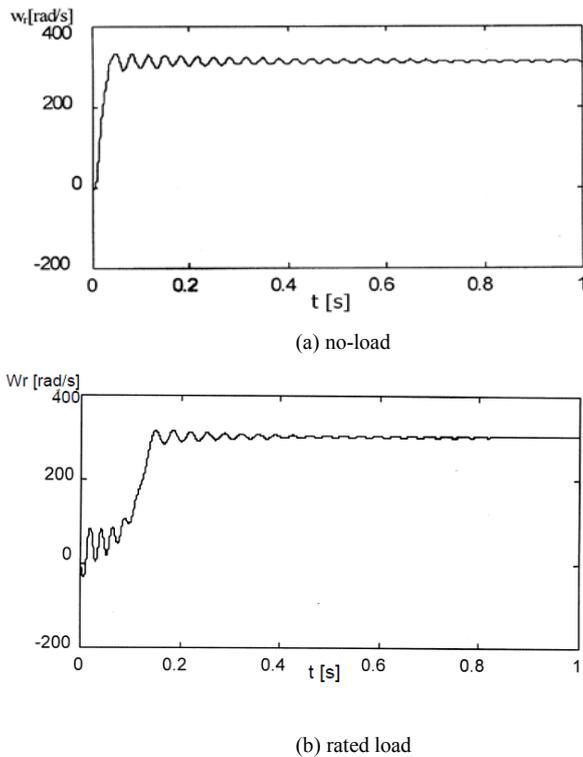
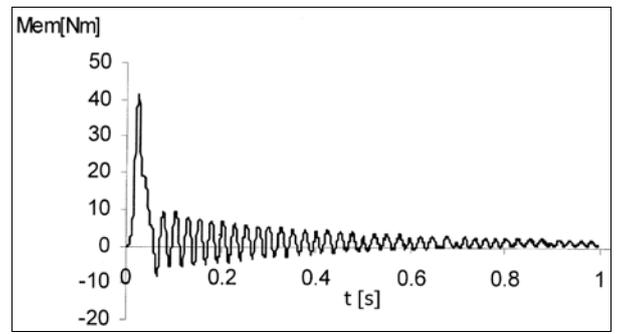
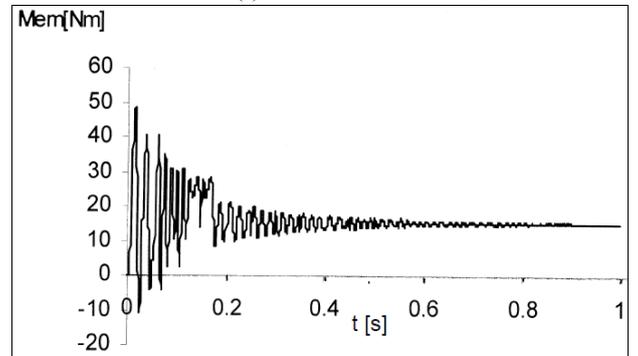


Figure 9. Transient characteristics of speed



(a) no-load



(b) rated load

Figure 10. Transient characteristics of torque

III. FEM MODEL

The Finite Element Method belongs to the numerical techniques often used for calculating various electromagnetic quantities. Over the last years, it has proven to be a reliable tool in designing machines as well as in terms of the magnetic flux density calculation in the entire cross-section of the analyzed machine allowing points of magnetic core with high flux density to be detected [11]-[14]. The knowledge of the magnetic flux density distribution in the machine cross-section gives the possibility of redesigning or optimizing the machine design, which leads to more efficient electrical machines with decreased losses and electricity consumption [15]-[17]. The flux density \mathbf{B} is calculated from the magnetic vector potential \mathbf{A} . In order Maxwell equations to be solved, the complete machine cross-section is divided in numerous elements forming the mesh of finite elements (Fig. 6).

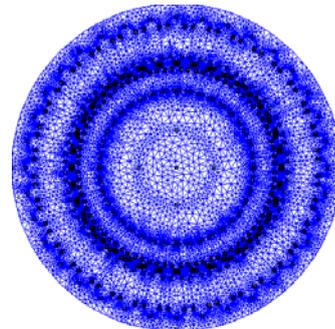


Figure 11. Mesh of finite elements

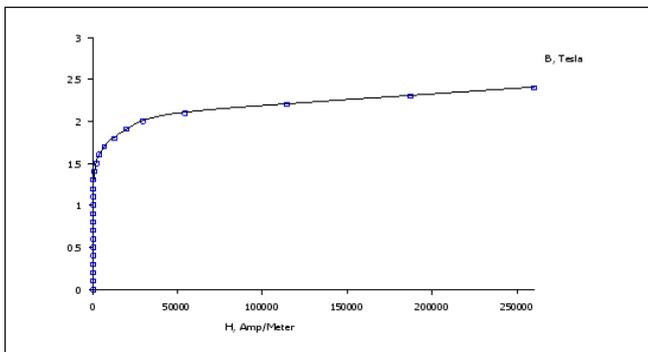
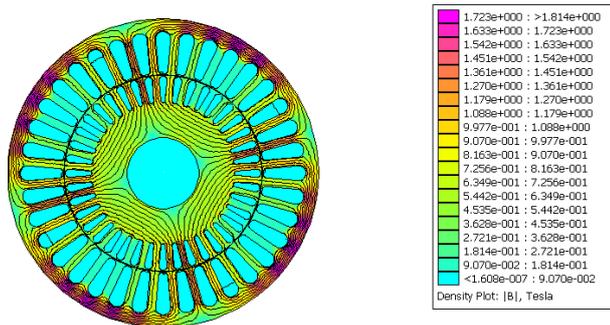
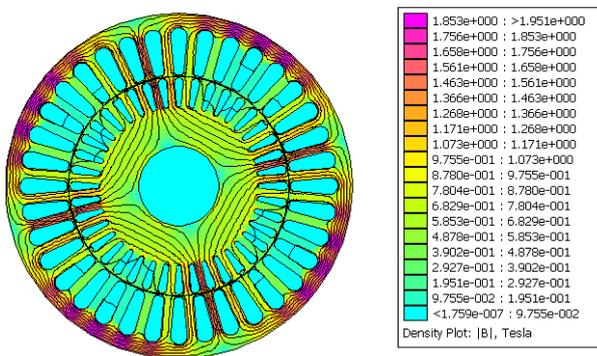


Figure 12. Characteristic of magnetization of iron core

The FEM model of the motor is derived for a time-harmonic analysis, i.e. the power supply of the stator winding with 50 Hz and currents in the rotor winding are freely induced due to the altering electromagnetic field from the stator winding. Fig. 8 presents the flux density distribution at a machine cross-section for no load and rated load. Fig. 9 presents the flux density distribution in the air gap of the motor for no load and rated load.



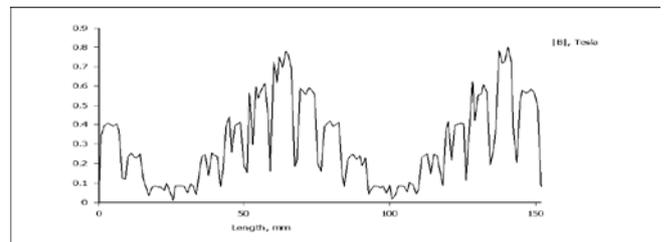
(a) no-load



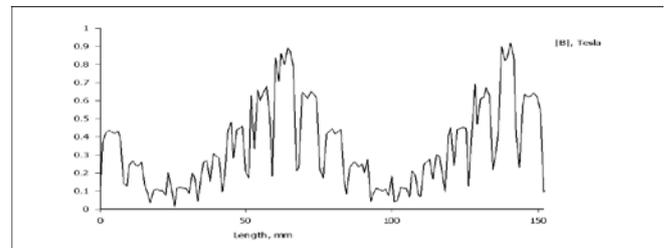
(b) rated load

Figure 13. Flux density distribution in machine cross-section

From the results presented in Fig. 8, the magnetic flux density distribution is within the limits of core saturation (Fig. 7). The air gap flux density in the induction motor is within the recommended values for this type of machine i.e. for $2p=4$ (p is the number of pair of poles), the recommended value of air gap flux density is $0.65\div 0.78$ T [18].



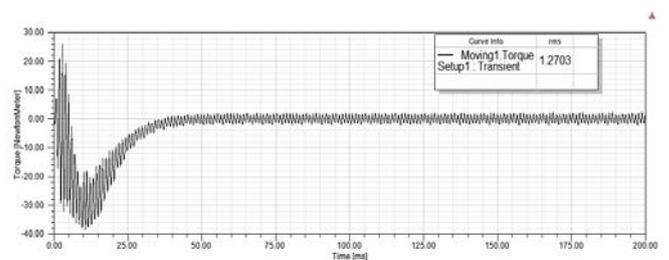
(a) no-load



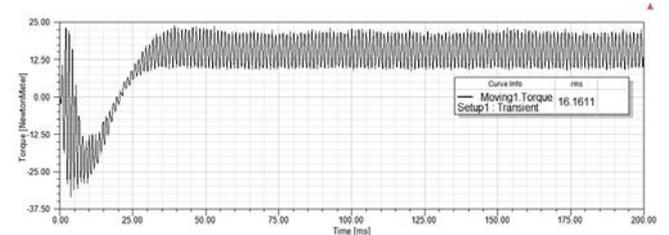
(b) rated load

Figure 14. Flux density distribution in motor air gap

The FEM discretization of the domain of the analyzed object produces a set of matrix differential equations. They are solved with the time decomposition method (TDM). The domain is decomposed along the time axis and all time steps are solved simultaneously instead of solving them time step by time step. The nonlinear matrix equations are linearized for each of the nonlinear iterations. As an output from the FEM model the value of torque for different operating modes- no load and rated load is obtained.



(a) no-load



(b) rated load

Figure 15. Torque from the FEM model

Here, it must be noted that the results of the electromagnetic torque presented in Fig. 10 are obtained for one constant speed i.e. rated speed of 1362 rpm or no-load speed of 1499 rpm

within the whole time range 0÷200 ms (Fig.11). Therefore, the characteristics presented in Fig. 10 do not represent the transient characteristics of torque during motor acceleration from zero speed up to the rated or no-load speed. By using the TDM, the results presented in Fig. 10 are the calculated values of motor torque from the FEM motor model at one constant speed (rated or no-load speed) and they are used for verification of the results of the torque from the simulation and numerical model of the motor.

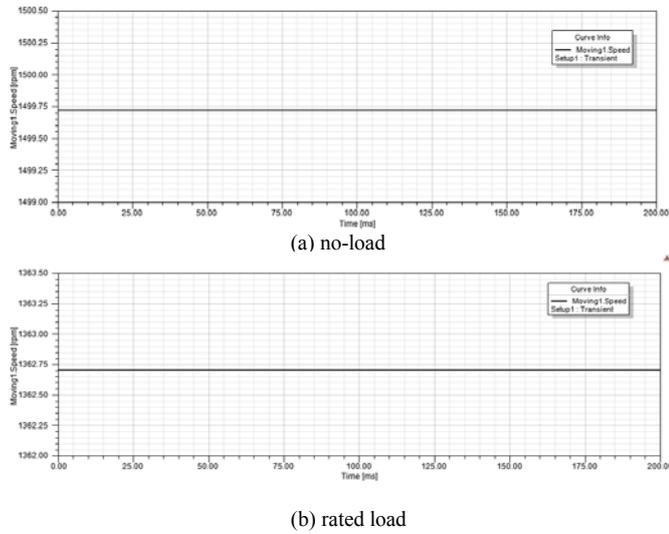


Figure 16. Speed in the FEM model

IV. PSIM MODEL

Different engineering software packages are available for the simulation of transient operating regimes of the electrical machines. In order to verify the results obtained from the SM and NM, the same motor is simulated in PSIM software for no load and rated load operation. The obtained results of current, speed and torque for no-load and rated load operation presented in Figs. 12 and 13 correspondingly.

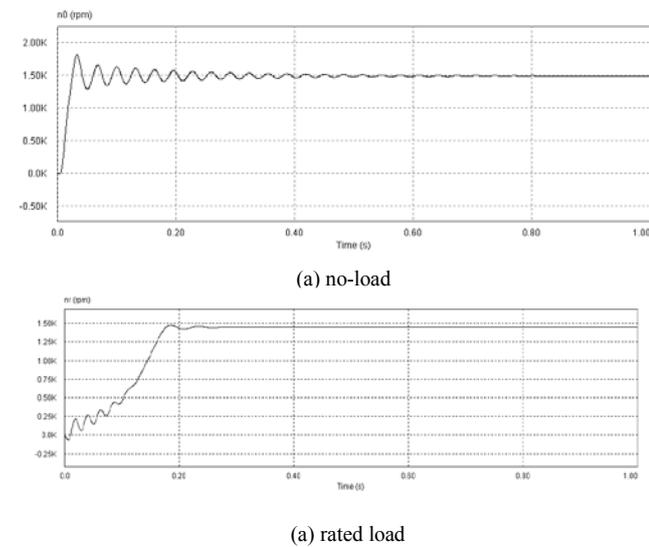
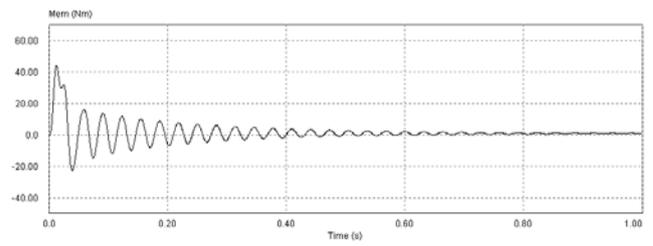
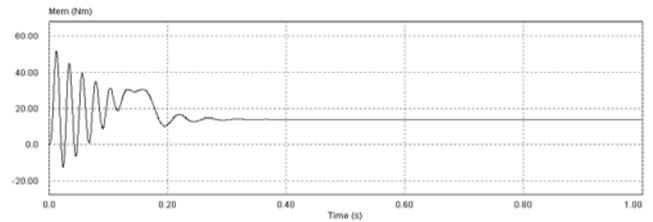


Figure 17. Transient characteristic of speed

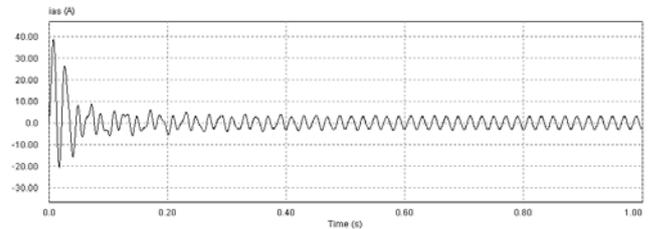


(a) no-load

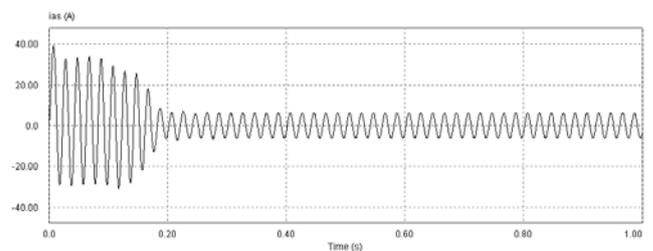


(b) rated load

Figure 18. Transient characteristic of torque



(a) no-load



(a) rated load

Figure 19. Transient characteristic of current

V. DISCUSSION OF THE RESULTS

The results obtained from the SM, NM, the FEM and PSIM motor model are compared and verified with the results from the analytical calculation and the experiment. The methodology of the analytical calculation of the electromagnetic torque and the experiment are explained and a comparison of the results from all the models is presented.

A. Analytical Calculation

The electromagnetic torque of the motor is calculated from the T-equivalent circuit of the squirrel cage motor (Fig. 15).

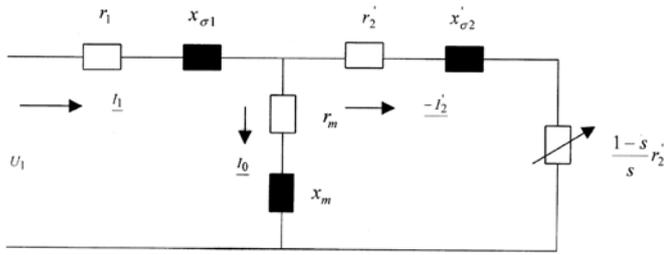


Figure 20. T-equivalent circuit

The stator current can be calculated from:

$$I_1 = \frac{U_1}{Z_e} \quad (30)$$

The equivalent impedance is calculated from:

$$Z_e = (r_1 + jx_{\sigma 1}) + \frac{jx_m \left(\frac{r_2'}{s} + jx_{\sigma 2}' \right)}{jx_m + \frac{r_2'}{s} + jx_{\sigma 2}'} \quad (31)$$

Where r_1 and $x_{\sigma 1}$ are the stator winding resistance and reactance, x_m is the mutual reactance between the stator and rotor winding, and r_2' and $x_{\sigma 2}'$ is the rotor winding resistance and reactance, referred to the stator side. s is the slip calculated from:

$$s = (n_1 - n)/n_1 \quad (32)$$

where n_1 is the synchronous speed and n is the rotor speed. The power factor is calculated from:

$$\varphi = \arctg[\text{Im}(Z_e)/\text{Re}(Z_e)] \quad (33)$$

The motor input power is:

$$P_1 = \sqrt{3}U_1 I_1 \cos \varphi \quad (34)$$

The electromagnetic power in the air gap is found from:

$$P_{em} = P_1 - P_{Fe} - P_{cu1} \quad (35)$$

P_{Fe} are the iron losses. The copper losses are calculated from:

$$P_{cu1} = 3r_1 I_1^2 \quad (36)$$

The electromagnetic torque is found from:

$$M_{em} = 9.55 P_{em} / n_1 \quad (37)$$

Fig. 16 presents the electromagnetic torque for different motor slips in accordance with the analytical calculation. Furthermore, the complete set of motor characteristics (stator current I_1 , efficiency factor η , power factor- $\cos\varphi$, motor slip- s , input and output power P_1 and P_2 , rotor speed- n , and motor output torque M) are calculated and presented in Table I.

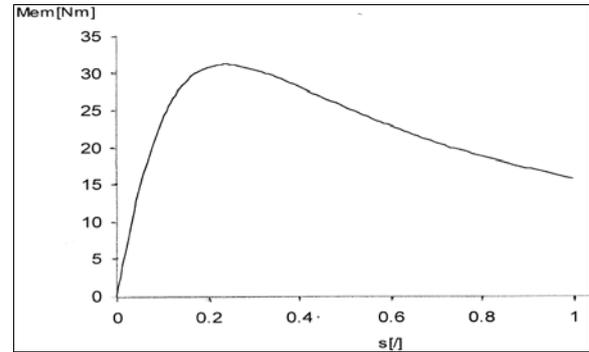


Figure 21. Electromagnetic torque at various motor slips

TABLE VI. MOTOR CHARACT. FROM THE ANALYT. CALCULATION

I_1 (A)	η (%)	$\cos\varphi$	s (%)	P_1 (W)	n (rpm)	M (Nm)	P_2 (W)
2.17	0.128	0.1194	0.0006	171.32	1499.1	0.21	22
2.22	0.590	0.2547	0.0043	372.62	1493.5	1.48	220
2.32	0.732	0.3918	0.0086	600.87	1487.1	2.9	440
2.49	0.791	0.5078	0.0129	834.26	1480.5	4.34	660
2.71	0.82	0.6008	0.0175	1073.1	1473.7	5.79	880
2.97	0.835	0.6728	0.0223	1317.9	1466.6	7.25	1100
3.27	0.841	0.7274	0.0273	1569.3	1459.1	8.73	1320
3.60	0.843	0.7684	0.0325	1827.7	1451.3	10.23	1540
3.97	0.841	0.7989	0.0380	2094.1	1442.9	11.74	1760
4.37	0.836	0.8217	0.0439	2369.4	1434.2	13.28	1980
4.8	0.829	0.8384	0.0502	2654.8	1424.7	14.85	2200

Two typical operating regimes of the machine no load and rated load are highlighted in Table I. The current of 2.22 A represents the no-load operating regime and the current of 4.37 A is obtained for rated load operation.

B. Experiment

The three-phase squirrel cage motor was tested in the faculty laboratory at no load and for the rated load operation. During the no-load test, the motor is accelerated almost to the synchronous speed and the motor input power P_0 , as well as the no-load current I_0 and power factor $\cos\varphi_0$ are measured. The measurements are done for several supply voltages. The measurement for 220 V is presented in Table II, as this measurement actually represents the no-load operation of the motor. The loading of the motor up to the rated operating point is done with a mechanical break and two dynamometers. The motor is gradually loaded up to the rated current. Voltage is kept at 220 V. The output power P_2 is calculated from:

$$P_2 = P_1 - (P_k + P_{Fe,md}) \quad (38)$$

where P_k are short circuit losses (measured from the short circuit experiment). P_1 is the motor input power from the

network. $P_{Fe,md}$ are iron and mechanical losses due to friction. They are calculated from the no-load experiment:

$$P_{Fe,md} = P_0 - 3r_1 I_0^2 \tag{39}$$

The output torque on the rotor shaft is:

$$M = 9.55 \cdot (P_2/n) \tag{40}$$

The results from the experiments (no load and rated load) are presented in Table II.

TABLE VII. DATA FROM EXPERIMENT

rated load							
U (V)	I (A)	P_k (W)	$P_{Fe,md}$ (W)	P_1 (W)	P_2 (W)	M_n (Nm)	n_n (rpm)
220	4.9	417	147.99	2510	1945.01	13.17	1410
no-load							
U_0 (V)	I_0 (A)	P_0 (W)	$P_{Fe,md}$ (W)	M_o (Nm)	n_o (rpm)		
220	2.37	196	147.99	1.25	1495		

C. Comparison of Results and Discussion

Fig. 1 presents the transient characteristic of torque for no load and rated load in the simulation model. For no-load operation, after the torque transients are suppressed, the torque reaches the no-load torque of 1.3 Nm. For the rated load after the motor acceleration has finished, the torque reaches the steady state value of 15.4 Nm. In Fig. 2, the motor accelerates at no load very quickly for less than 0.1 s, and reaches the steady-state speed of 1498 rpm or 313 rad/s. As for the rated load acceleration, acceleration lasts longer, approximately 0.2 s and then the motor reaches the steady state operation of 1433 rpm or 300 rad/s. Fig. 3 presents the transient characteristic of the stator current in the simulation model for no-load and rated load operation. At no load, the motor accelerates with a starting current, multiple times the rated current, and reaches the steady-state no-load current of 2 A (rms value). At rated load, after the motor starting has finished, the current reaches the steady state value of rated current of 4.3 A (rms value).

The motor behavior in the numerical model is similar to the simulation model. In Fig. 4, the motor at no-load operating mode accelerates up to 313 rad/s and at rated load up to 300 rad/s or 1433 rpm. The acceleration time in both cases, at no load and rated load, is similar to the acceleration time of the motor in the simulation model. Fig. 5 presents the transient characteristic of torque for no load and rated load. At no load, after the acceleration has finished, the motor reaches the no-load torque of 2.5 Nm, although, in the numerical model, the torque transients are more emphasized. At rated load, the steady state value of rated torque is 16.6 Nm. The comparison of the results from both motor models - the simulation and the numerical is done on the basis of the obtained values of the torque and speed of the motor after the transients are suppressed and the motor reaches the stable value of speed or torque.

The FEM model of the motor provides the characteristics of torque at no load and rated load (Fig. 9) for one constant speed

within the simulated time interval i.e. the no load or rated speed. At no load, the output torque is 1.27 Nm and the rated torque is 16.1 Nm. Since the presented characteristics of torque from the FEM model (Fig.10) are simulated for one constant speed within the whole time interval (Fig. 11), they do not represent the transient characteristics of torque at motor acceleration from zero to the no-load or the rated speed. They are used for the verification of the obtained values of the torque from the transient characteristics in the simulation and numerical models, after all transients are suppressed. Also, the FEM model is a useful tool in estimation of magnetic core saturation. In accordance with the obtained results of the magnetic flux density (Fig. 8), the flux density is within the limit of core saturation (Fig. 7) and within the recommended values of flux density in the air gap of the four pole induction machine (Fig. 9). Further more FEM model of the motor includes the nonlinearity of magnetic core saturation since this was not taken into consideration in the simulation and the numerical motor model.

Motor is modeled in PSIM software in order transient characteristics of torque, speed and current from simulation and numerical model to be verified. Comparison of results from Figs 2, 4 and 12 verifies the similarity of the transient characteristics of speed from all three models (simulation, numerical and PSIM) with respect to the time of acceleration as well as the final steady state value of speed at no load and rated load. Similar behavior is observed from the comparison of characteristics of torque (Figs. 1, 5 and 13) as well as from the comparison of characteristics of current (Figs. 3 and 14). More detailed comparison of the obtained results is presented in Table IV.

In both transient models, the same motor parameters from the motor nameplate are used, and they are presented in Table III. In Table III, the rated torque and the no-load torque are calculated from (40) by replacing the adequate rated power and rated speed, i.e. no-load losses and no-load speed.

TABLE VIII. MOTOR DATA FROM THE NAMEPLATE /PRODUCER

Parameter	Value
nominal power- P_n	2.2 kW
number of poles p	$2p=4$
nominal voltage Δ/Y	220/380 V
nominal current Δ/Y	8.7/5 A
power factor- $\cos\phi$	0.81
nominal speed- n_n	1410 rpm
rated torque M_n	14,9 Nm
no-load losses P_0	170 W
no-load torque M_0	1,085 Nm

The verification of all the theoretical models (the numerical, the simulation, the FEM and the PSIM) is done with analytical calculations and measurements. Where available, all results are compared with the data obtained from the motor producer [19]. This comparison is presented in Table IV. In Table IV, subscript “0” denotes no-load operation and “n” denotes rated-load operation. In addition, it should be noted that the speed in Table IV is in rpm, derived from the speed in rad/s in Figs. 2 and 4. The rms values of currents are presented in Table IV. The results from the FEM model are read out

within the last time interval of twenty five milliseconds in Fig. 10, after the torque characteristics and the calculation of torque in the FEM model has reached the relatively stable value.

TABLE IX. COMPARISON OF RESULTS

	SM	NM	FEM	PSIM	Anal cal.	Exp.	Prod.
I_0 (A)	2	/	/	2.1	2.2	2.37	2.4
I_n (A)	4.3	/	/	4.6	4.4	4.9	5
M_0 (Nm)	1.3	2.5	1.2	1.5	1.48	1.25	1.1
M_n (Nm)	15.4	16.6	16.1	14.5	13.3	13.2	14.9
n_0 (rpm)	1498	1498	1499	1499	1493	1495	1495
n_n (rpm)	1430	1433	1362	1440	1434	1410	1410

From the comparison of the results presented in Table IV it is evident that there is some difference in the torque from the simulation, numerical and the FEM model in comparison with the torque obtained from the analytical calculation, experiment and producer data. In the case of the experiment and producer data, the torque presented in Table IV is a torque on the motor shaft, which differs from the electromagnetic torque in the air gap, calculated by SN, NM and FEM due to friction and certain stray losses, which decrease the output torque in comparison with the air gap torque. The analytical calculation does not take into account time varying inductances, which can cause some differences in the results.

VI. CONCLUSION

The estimation of the operation of the induction motor at various operating modes is an important engineering task. Often, simulation models are used for the evaluation of various dynamic regimes of the motor operation. They provide useful information in terms of motor coupling with the load and motor behavior during start up and steady state operation. The paper presents two different transient models of squirrel cage motor derived from the two sets of differential equations, which are solved in Simulink and in Matlab. As an output from both models, the transient characteristics of speed and torque for various operating modes are obtained. The motor is modeled in the FEM and PSIM software as well. The FEM model allows the magnetic flux density distribution to be calculated, as well as the torque characteristics for one constant speed corresponding to the motor operating regime. All three models from Simulink, Matlab and FEM are verified by analytical calculation, experiment, PSIM results and available data from the motor producer. The comparison of the results verifies the derived transient models of the motor as sufficiently accurate. The derived models are universal and can be applied on any asynchronous motor, by simple replacement of the adequate motor parameters and load type. However, the nonlinearity of the magnetic core saturation in modeling of both dynamic models was not taken into consideration. This opens a new perspective of further modification and extension of the derived models. In addition, motor optimization is another field of possible extension of motor models, subject to author's further research.

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Integrated Machining Process Modelling and Research System

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Abstract This paper presents own developed research system for modeling of the metal machining process. The research system integrates measuring sensors and systems, computer interfacing devices, software and investigation methodologies in order to develop machining process models. Our own developed hardware and software solutions are part of the applied strategy for full control over the research measuring chain. The resulting machining empirical models are accompanied with uncertainty parameters in order to fit the criteria of application in Smart Machining Systems (SMS) and new manufacturing optimization techniques.

Keywords integration, modelling, machining, uncertainty, smart systems.

I. INTRODUCTION

The fight for better quality products and lower production cost never stops in the production industry. If we make an outlook of what is now on the workshop floors, we can see that even with state-of-the-art computer numerical control (CNC) machine tools equipped with the newest control elements, the process of making new products is long and based on many trials and errors. On the other hand, from the market perspective, the demand for new products grows by an exponential trend. Another important characteristic of the market is the growth of the variety of products that are expected to support the developing technology in all fields. In the field of machining, the development of a system to catch up with the production demands refers to the development of smart machining systems (SMS), which are featured to be capable of self-monitoring and optimizing of the operations, self-assessing their own work, self-learning and improving performance over time [1]. The smart machining systems are intended to be aware of what they produce and how well. In the work of Dashayes [1], the SMS components are presented. We can see that the main input in SMS is from the conceptual process plan (CPP) which is directly correlated to the life cycle engineering (LCE). From the point of view of the machining processes, the dynamic process optimization (DPO) uses machining models (MM) to build and achieve the objectives within the design given frames like the dimensional and geometrical tolerances, the surface integrity and quality. The SMS is expected to optimize the machining process before and during its realization. The machining process uses MMs which are approximations and always contain certain amount of uncertainty. This uncertainty will cause machining errors, and

the process monitor and control (PMC) will return the process to the desired conditions. The SMS is envisioned to recognize the limitations of certain MMs, or methods in general by knowing their uncertainty, and eventually to make the right selection between them. The main elements in this concept are the optimization tools and the MMs. The MMs are based on large knowledge bases and they should be correlated. It is unlikely that this concept can be achieved without interoperability and cooperation between the research institutions and the manufacturing industry. However, there is new information highways between the products, manufacturing industry and the research institutions enabled by the new age of the Industrial Internet of Things (IIoT). The IIoT can be considered like the infrastructure for the smart manufacturing which is under development by the automation suppliers in the last two decades and it will drive the evolution of the industry. The final goal is to make the integrated systems to "talk" between themselves and to deliver meaningful and intelligent results by using the scientific knowledge.

The work in this paper is mainly focused on a comprehensive approach in generating knowledge base in the part of experimental models of the machining process. As we

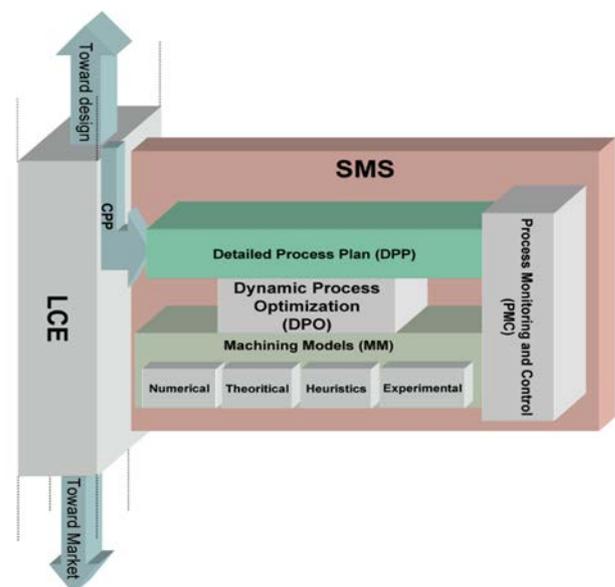


Figure 1. SMS components [1]

mentioned, these mathematical models are approximations and their quality is very important in order to be used in the SMS concept, and other similar concepts. The quality of the experimental models is an issue by itself, which is often neglected due to its complexity. The quality of the experimental models can be described by the uncertainty parameter of the model. The uncertainty parameter of the generated experimental models is based on the propagation of the uncertainties of the single measurements upon which the model is fitted. A lack of such comprehensive approaches is evident in the papers published in this field. This also leads to differences in the results between laboratories. However, the new trends have already determined that new researches and new experimental models should be accompanied by the uncertainty parameter, as recommended in [2-6]. Now, if we go deeply in the analysis of the experimental research of the machining processes and the experimental modeling, we come to the point that this is also a wide system. The experimental research system, in order to provide models as described, should integrate many components. The main components in this chain are the methodology, the measuring system, the hardware and the software solutions, and the machining process itself. Our *directions* into the design of these components, and their subcomponents that we adopted, in order to follow the SMS concept are:

- open platform of hardware and software
- good metrological practice
- all measurements are accompanied by an uncertainty parameter
- interoperability between laboratories and experts

These elements are in function of the investigation (measuring) and the reproducing (modeling) of the machining process or the physical phenomena of interest. Furthermore, we describe the integration and the features of the elements of such developed research system on the Faculty of Mechanical Engineering in Skopje in cooperation with the Wrocław University of Technology from Poland [7].

II. RESEARCH SYSTEM

On Fig. 2, the path of identification and modeling of the cutting forces is presented, as well as the average temperature in the machining by turning. These physical quantities are representative of the set of physical quantities that can be the object of research, and other can be the tool wear, the residual stresses, 3D temperature, etc. In order to present a certain approach in the design and application of the components, we can break the description of the research system down in:

- Identification methodology
- Measuring and computer interfacing components
- Software
- Calibration
- Modeling and representation

Herein, we will present only a brief summary of the main features of the research system in order to fit within the paper size given criteria, and we will stress some features which are of significant importance.

A. Identification methodology

After selecting the phenomena of interest and research, the question arises of what the most appropriate measuring instrument to apply is. Here, balance should be achieved between the available technology, methods and the given concept by the SMS.

For the measuring of the cutting forces, and by following the adopted directions in the previous section, we modernized an analog dynamometer, due to the accessibility of its electrical diagrams, based on a bridge circuit, Fig. 2.a. Modernization is justified as it is budget oriented, and investment in new equipment can bring difficulties in the integration with other parts of the system, not to mention the risk of not having the available documentation of the processing of the measured signals regarding investigation of the measurement uncertainty. The process of modernization is done by the design of the amplifier circuit, providing additional benefit by expanding the knowledge of the researchers with the possible sources of errors from this part.

For the measuring of the average temperature, there is a wide palette of identification methods given by [8]. This measuring system integrates the method of nature thermocouple workpiece-cutting tool. Although this method is considered to be under the influence of many sources of errors, our approach can benefit from determination and quantification of these errors by the adopted system of uncertainty budget determination, and consequently dealing with them. As many as two paths for the signal conduction from the workpiece side are designed in order to detect any deviations and errors, Fig. 2.b. Conduction of the signal from the workpiece is done by slip-ring assemblies, Fig. 3, and reconstructed cutting tool with built-in conductors.

B. Measuring and computer interfacing components

This research system consists of our own developed interface between the sources of the signal and the personal computer. As we mentioned before, the benefits of developing our own system are significant regarding the open access of signal manipulation and errors identification. Excluding any influence of the measuring equipment to the source of the signals was of special concern. It has been done by application of voltage followers by high input impedance, galvanic separated power supplies of the amplifiers and optically amplifier insulation, by using the integrated circuit ISO100. Acquisition of the signals is done by our own developed data acquisition card, by our own software design which controls the measuring process, provides customization, provides uncertainty determination, and connects with our own developed personal computer application designed for conduction of a large number of experiments in a short time, Fig. 2.c.

C. Software

Our own developed software for conducting of the measurements is developed in C++, and provides the benefits

of the open access, customization and uncertainty determination as in the case with the PC interface, Fig. 2.d. The most important consideration, like decimal places in the

rounding and calculating procedure, biasing, etc., regarding the uncertainty is available for moderation and estimation.

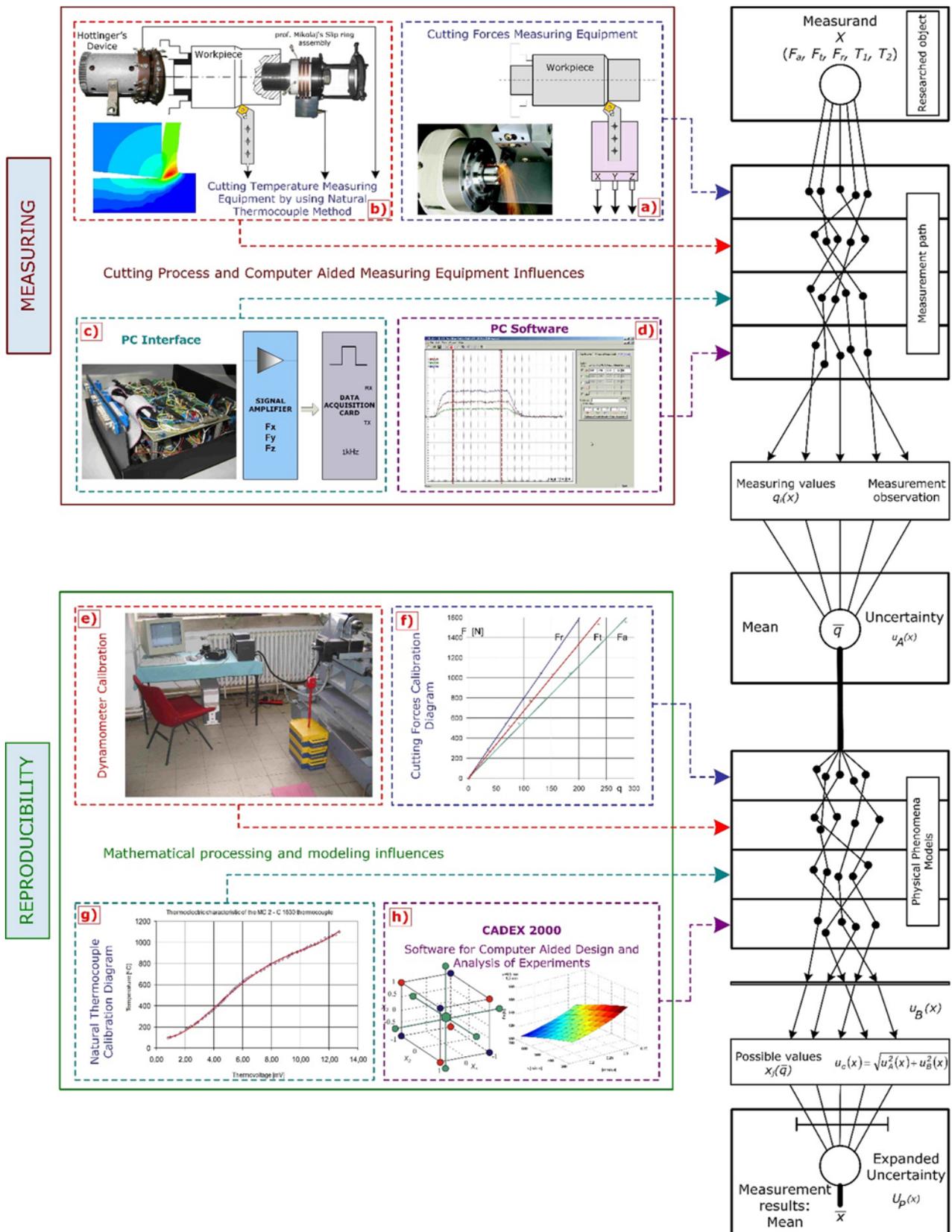


Figure 2. Machining process research system components and their influence on the empirical modeling

D. Calibration

The transformation of the raw generated signals into the measured quantity in the SI system units has been done by applying of the calibration curves. The calibration curves are calculated upon our own experimental data, providing very significant data about the amount of error generated by fitting them. Actually, this is one of the parts of the measuring system which is of high importance as it takes a big piece of the uncertainty budget pie. The thermo-voltage characteristic of the nature thermocouple workpiece-cutting tool has been done by special equipment in a furnace and is given by Fig. 2.g. The calibration of the dynamometer has been done by dead weights that were previously calibrated in the Bureau of Metrology in the Ministry of Economy in Skopje, Fig. 2.e., 2.f. and 4. Calibration by dead weights results in a significantly lower uncertainty rate regarding the force testing machine, which is usually available in the laboratories for testing forces.

E. Modeling and representation

The methodology implemented for the experimental research is by Design of Experiments (DOE) or factorial experiments. The CADEX 2000 software was developed for planning of the experiments. Fig. 2.h. A power mathematical model was adopted for the representation of the physical quantities of the cutting forces and cutting temperature related to the cutting process parameters. The exponents of the power mathematical models depicture the rising or decreasing of trend and rate. After fitting the model, a graphical representation is presented. There is plenty of research in the field of similar experimental setups and mathematical models in order to make comparisons between laboratories with the same or similar machining conditions. Although small changes in the cutting process conditions result with different mathematical models, the importance of empirical research has motivated many laboratories to have such experimental stands and to compare results under the same conditions. The results from different laboratories in general are not comparable, and there is no clear explanation of such discrepancies. Tracing of the reasons for that usually encounters the lack of the measurement uncertainty

parameter. As our research system is designed on an open platform and is dedicated to present the uncertainty detailed budget of such complex researches, we have developed and recommended a certain approach for measurement uncertainty determination [9]. The presentation of our experimental results is an ongoing process aimed at making a knowledge base in the field.

III. MEASUREMENT UNCERTAINTY

Regarding our dedication to achieve distinct results in the field of experimental investigation, an approach for measurement uncertainty parameter of the final mathematical model has been developed and proposed during our researches. Often, only partial approaches for measurement uncertainty evaluation are presented. They usually refer to the measurement uncertainty of the measuring instrument, like the uncertainty of the dynamometer, or at the most the uncertainty of a single measurement. However, our view is that such partial approaches are not depicting at all the uncertainty of the final product of the research, which is the mathematical model of the investigated quantity. Our proposal is that measurement uncertainty should be presented in a suitable manner same as the final result [10]. The final power mathematical model represents the investigated quantity with the determined exponents and coefficients. Consequently, the proposal is every fitted exponent or coefficient in the mathematical model to be accompanied by the uncertainty parameter. Although the exponents of the power mathematical model are a result of many additive and logarithmic or antilogarithmic mathematical calculations, we propose to propagate the combined measurement uncertainty in the same way in order to find the appropriate parameter. An example of the form of such a power mathematical model is given by (1).

$$\varphi = (C \pm U_C) \cdot v^{p_1 \pm U_{p_1}} \cdot f^{p_2 \pm U_{p_2}} \cdot a^{p_3 \pm U_{p_3}} \cdot r_e^{p_4 \pm U_{p_4}} \quad (1)$$

where φ is the researched quantity (cutting force component,

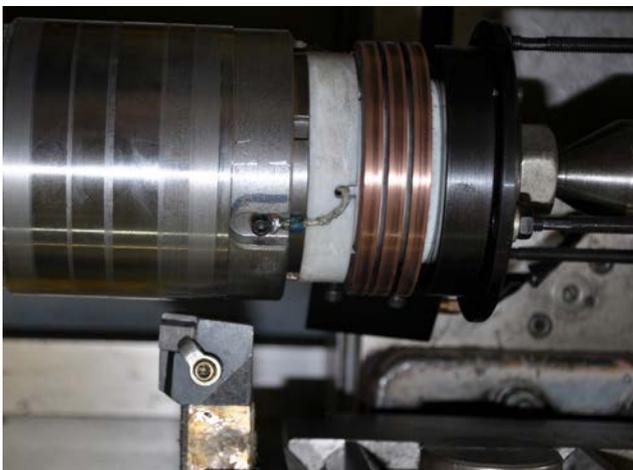


Figure 3. The cutting process and slip-ring assembly for conduction of temperature signals



Figure 4. Calibration of dead weight

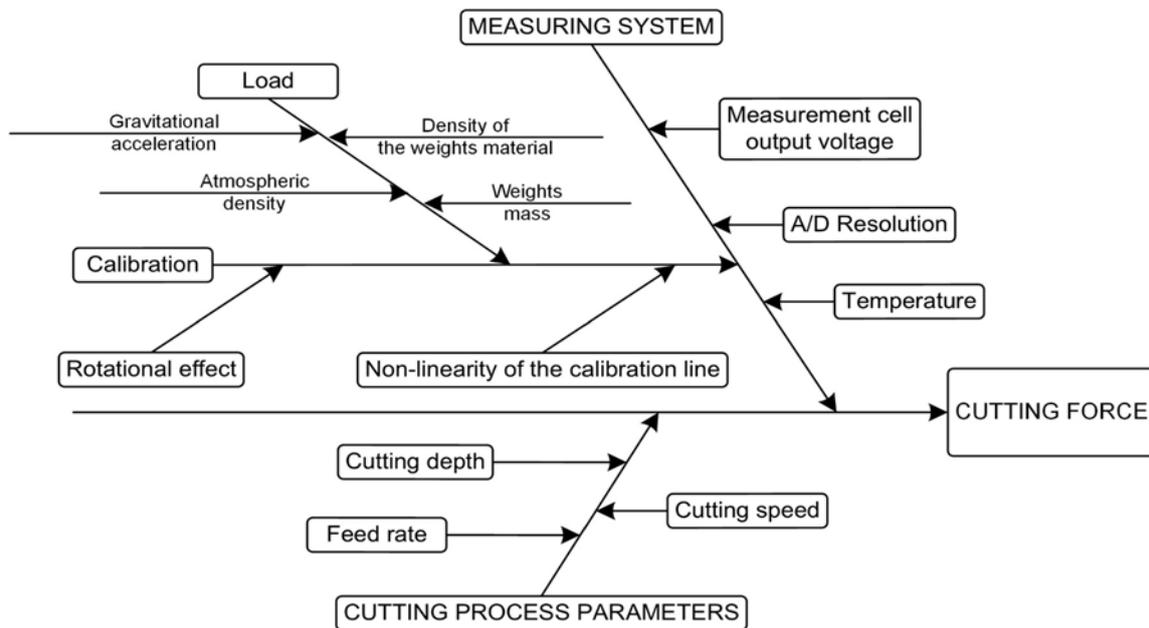


Figure 5. Ishikawa diagram of cutting force component measurement uncertainty contributors

cutting average temperature), v , f , a and r_ϵ are the cutting process parameters, cutting speed, feed rate, depth of cut and cutting tool nose radius, while C , p_1 , p_2 , p_3 and p_4 are the exponents and the coefficient of the mathematical model and U_C , Up_1 , Up_2 , Up_3 and Up_4 are the expanded uncertainty parameters.

Following the path of fitting the mathematical model and the chain of measuring and reproducing the investigated phenomena, Fig. 2, we can group the uncertainty contributors into:

- Measurement system contributors
- Mathematical modeling contributors
- Machining process contributors

On Fig. 5 an example is presented of braking the measurement system and machining process uncertainty contributors of single cutting force component by the Ishikawa diagram. The modeling contribution arises while combining (propagating) all the single measurement uncertainties by the DOE matrix equation, and it depends on the DOE plan size and structure.

While some of the presented uncertainty contributors on Fig. 5 are typical to consider, other must be well thought-out. Such are the contributors from the cutting process, which in the worst case are totally neglected. Even when they are taken in consideration, as in the case of determining the single measurement uncertainty, it is neglected that such measurement is just one point in the experimental hyperspace. For example, the error of the cutting depth is estimated by measuring the deviations from the mean value of many depths of cuts after the single cut. That is the main reason for underestimating the uncertainty from this contributor. We propose that this contribution should be calculated upon the

deviations from the assumed mean (planned and programed value according to the DOE plan matrix). The assumed mean should be also considered for the other cutting process parameters.

Another view is considering the contribution from the feed rate. The indirect approach with length-time readings can be substituted by estimating the real feed rate from the roughness parameter PS_m of the machined surface, Fig. 6. Here, the help of the laboratory of metrology of the geometric characteristics and research of quality is welcome.

The calculation of the measurement uncertainty has been done in the spirit of the Guide to the expression of uncertainty in measurement (GUM) [11]. Furthermore, as the propagation of the measurement uncertainty is based on complex additive models, we adopted the verification of the uncertainty value and distribution to be by the adaptive Monte Carlo numerical method (MCM). We recommend the verification by numerical method as it is ensuring avoiding the disadvantages of the GUM methodology.

Such an in-depth analysis of the possible contributors in the uncertainty budget results in as much as possible true estimation of the uncertainty parameter, which will accompany the exponents and the constants in the final mathematical model.

IV. INTEGRATION

The research system that is subject of this work is live matter of continuous development, growth of experience and expanding the knowledge base in the field. It is already an integral part of a wider system of computer aided engineering of the surface layer during machining process by material removal. This wider system integrates the research setups for: Monitoring system for transformation of the cutting layer into chips in the Wrocław University of Technology (WUT),

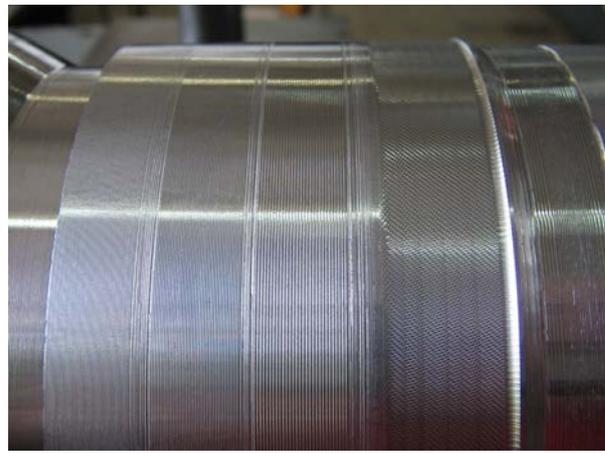
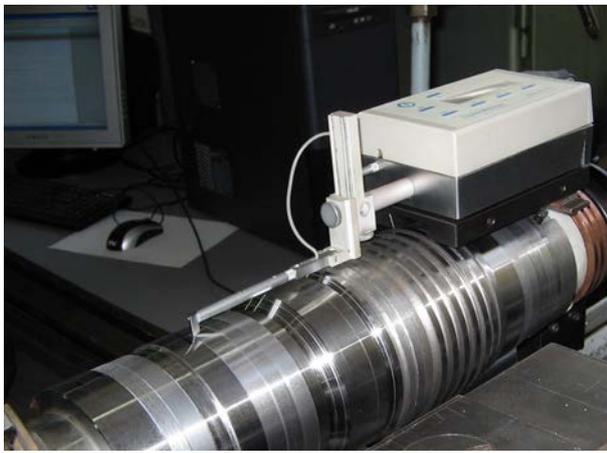


Figure 6. Measuring of the roughness parameter PS_m during experimental research of cutting forces and cutting average temperature

Monitoring system of cutting tool wear in the WUT, System for design of the geometrical characteristics of the surface layer in the WUT and the Faculty of Mechanical Engineering in Skopje (FME) and the System for investigation of the surface layer geometrical characteristics in the FME. The continuous developing knowledge base and the distinctive achievements of the results aim at integration in an SMS as part of the LCE.

V. EXPERIMENTAL RESULTS

The capabilities of the system for research of the machining process by turning are very wide, and some of them are: measuring of the cutting force components, measuring of the average cutting temperature, empirical modeling of the cutting force and average temperature in the cutting process, calculation of the measurement uncertainty of single measurement of force or average temperature, determination of the uncertainty of the empirical models, design of experiments within the DOE methodology, investigation of the influence of the design of the experimental plan on the uncertainty of the empirical results, estimation of the quality of the empirical researches, determining recommendations for lowering of the measurement uncertainty and different simulations.

As this work is focused on the description of the research system and its components (equipment and methods), herein, we want to present the results of one simulation of the necessity of implementing the procedure of verification of the uncertainty by numerical method Monte Carlo, as proposed in the penultimate paragraph in the third section of this paper. For that purpose we performed an experimental measurement of the average cutting temperature under the experimental features showed in Table I. The result of the experimental measuring is the value of $T_c=748.07^\circ\text{C}$ and the combined standard uncertainty determined by the GUM uncertainty framework (GUF) as presented in the first row in Table II, and by line on Fig.7.b. and 7.d. Verification has been done by adaptive MCM showed in Table II under MCM1, and we can see that the test within the given criteria for stabilization and validation of the adaptive MCM results in positive validation, presented by bars on Fig.7.b.

TABLE X. EXPERIMENTAL FEATURES

Workpiece material	Carbon steel: EN C55
Workpiece shape	Cylindrical bar, Diameter 100 mm
Cutting tool holder	KENNAMETAL, IK.KSZNR-064 25x25
Cutting insert	HERTEL, SNGN 120704, mixed ceramics MC2($\text{Al}_2\text{O}_3+\text{TiC}$)
Cutting tool geometry	$\kappa_r=85^\circ$, $\kappa_{r1}=5^\circ$, $\gamma_0 = -6^\circ$, $\alpha_0 = 6^\circ$, $\lambda_s = -6^\circ$
Cutting process parameters	$v=92\text{ m/min}$, $f=0.16\text{ mm}/2\pi\text{rad}$, $a=0.5\text{mm}$, $r_\epsilon=0.4\text{ mm}$

The combined measurement uncertainty is propagated considering the standard uncertainties and sources of errors as described before. For this example, we analyze the influence of only one source, the contribution of the mathematical modeling of the thermoelectric characteristic, Fig 2.g. The standard uncertainty of this parameter is $49\mu\text{V}$ normal distribution (showed by bars on Fig. 7.a), with a sensitivity coefficient of 85.26 results in the uncertainty contribution of 4.2°C in the budget of the measurement uncertainty. Now, if we make a simulation and we change only the type of the distribution of δc into rectangular as showed on Fig.7.c, then, although the results for the final propagated combined uncertainty by GUF method, stays the same, the MCM validation as presented in the last row of Table II and by bars on Fig.7.d, is negative and GUF results cannot be considered as reliable.

TABLE XI. GUF-MCM VALIDATION PROCEDURE PARAMETERS

Method	M	T_c [°C]	$u(T_c)$	95% coverage interval	Δ_{low}	Δ_{high}	δ_{stab} δ_{val}	Validated
GUF		748.08	5.662	[736.980 - 759.176]				
MCM1	5.1e5	748.05	5.654	[736.822 - 759.019]	0.158	0.157	0.05 0.25	yes
MCM2	2.7e5	748.03	5.668	[737.143 - 758.755]	0.163	0.421	0.05 0.25	no

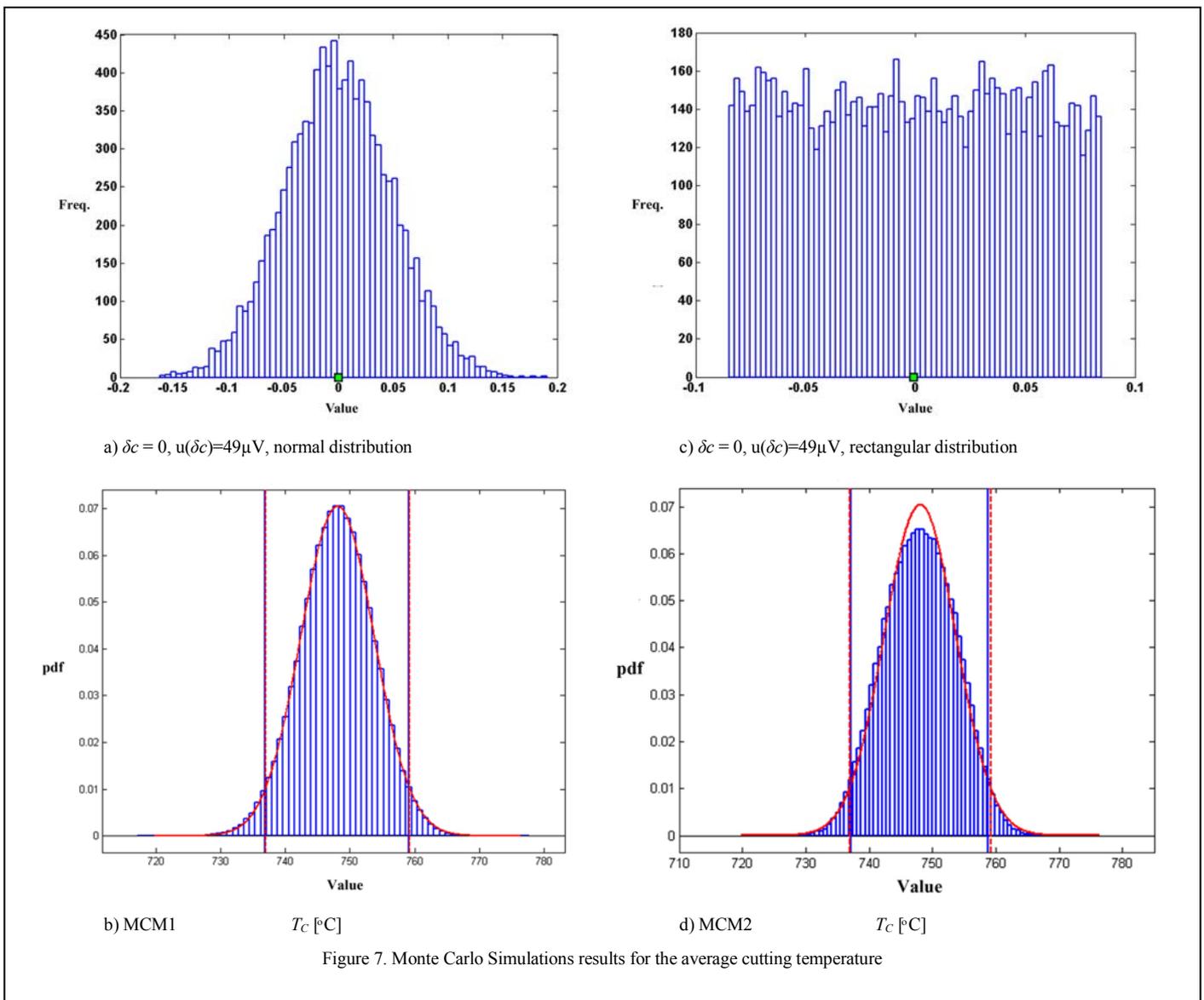


Figure 7. Monte Carlo Simulations results for the average cutting temperature

This simulation shows that the adopted procedure of MCM verification is sensitive and will be important when determining the uncertainty during the experimental research, because of the complex propagation models and many different types of input uncertainty contributor's distributions.

VI. CONCLUSIONS

The research system presented in this paper has been successfully developed, including the measurement equipment, calibration, methodology, the computer interfacing hardware and software. A full factorial experimental plans are designed and executed and mathematical models are developed including the measurement uncertainty for the model. As a result of the performed research, certain scientific conclusions, proposals and recommendations are in the process of publishing. The research system and adopted approach are aimed to meet the criteria of the newest trends in

the field as the Smart Machining Systems whose target is achieving optimal machining conditions. We consider that the developed open access architecture of the research systems makes it as an advanced tool for integration into the SMS or similar systems.

Our further efforts are aimed at creating bigger knowledge base of different machining materials and tools in order to demonstrate improvement in the reliability of the gained empirical mathematical models. Additionally, we consider as significant the scientific contribution of the proposed approaches for further experimental researches. As a final phase of all the efforts, we expect more reliable recommendations for the industry.

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Application of recursive methods for parameter estimation in adaptive minimum variance control of DC motor

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Abstract—The recursive methods for parameter estimation have to meet the requirements for identification algorithms in real time adaptive control. This is determined from the fact that the adjustment of the model after the submission of new data from monitoring, and the development of new control action should be made in a single cycle of discretization. In this article is proposed an application of recursive methods for parameter estimation in adaptive self-tuning control of DC motor based on minimum variance. It uses a recursive estimator, based on several recursive parameter estimation methods and a linear controller obtained directly from the current estimates.

Keywords- adaptive system, instrumental variable method, least squares method minimum variance, recursive methods for parameter estimation, self-tuning control, DC motor

I. INTRODUCTION

System control by default requires deep understanding the dynamic features of the processes [3]. Recursive methods for parameter estimation are only used for real-time system identification. The real dynamics of the system should be reflected in the dynamic of the control signal synthesis and in the model in accordance with the new data received. This is of crucial importance especially when the parameters are estimated for time variant systems. These changes are analyzed in terms of values of input and output variables for the purpose of synthesis of control signal for adaptive systems. Those recursive methods are often used in transmission and of signal processing as independent real time control instrument [1,2,7,8].

II. RECURSIVE VERSIONS OF LEAST SQUARES METHOD FOR PARAMETER ESTIMATION.

Short description of the methods used in the present paper will be presented below.

A. Recursive weighted least squares (RWLS)

Recursive estimates using weighted least squares method can be obtained with:

$$\hat{\theta}_{N+1} = \hat{\theta}_N + \frac{C_N f_{N+1}}{\frac{1}{w_{N+1}} - f_{N+1}^T C_N f_{N+1}} (y_{N+1} - f_{N+1}^T \hat{\theta}_N) \quad (1)$$

According to (1) the previous value $\hat{\theta}_N$ is adjusted proportionally to the difference $y_{N+1} - \hat{y}_{N+1}$ with a vector coefficient of proportionality:

$$\Gamma_{N+1} = \frac{C_N f_{N+1}}{\frac{1}{w_{N+1}} - f_{N+1}^T C_N f_{N+1}} \quad (2)$$

Where: $\hat{y}_{N+1} = f_{N+1}^T \hat{\theta}_N$ is predicted value for y_{N+1} , where $\hat{\theta}_N$ is the vector of the coefficients estimated in the previous iteration.

- Instead of using prediction errors it is possible residuals to be used as follows:

The prediction error included in formula (1) can be written also:

$$e_{N+1} = y_{N+1} - \hat{y}_{N+1}(\hat{\theta}_N) = y_{N+1} - f_{N+1}^T \hat{\theta}_N \quad (3)$$

for improvement of the accuracy of prediction instead of e_{N+1} is used the residual:

$$r_{N+1} = y_{N+1} - f_{N+1}^T \hat{\theta}_{N+1} \quad (4)$$

combining (2) and (3) gives:

$$r_{N+1} - e_{N+1} = -f_{N+1}^T (\hat{\theta}_{N+1} - \hat{\theta}_N) \quad (5)$$

If difference $(\hat{\theta}_{N+1} - \hat{\theta}_N)$ is derived using (2) and substituted in (5) it follows:

$$r_{N+1} = \frac{\frac{1}{w_{N+1}} e_{N+1}}{\frac{1}{w_{N+1}} - f_{N+1}^T C_N f_{N+1}} \quad (6)$$

- **Calculation procedure requirement.**

In order to obtain parameter estimates using the method of weighted least squares initial estimates of $\hat{\theta}_N$ and C_N should be available. This is only possible if $N \geq k$ observations for

$\hat{\theta}_N$ and C_N are obtained with non-recursive method of weighted least-squares. Then the procedure continues following the calculation procedure described with (1) and (7).

$$C_{N+1} = C_N - \frac{C_N f_{N+1} f_{N+1}^T C_{N+1}}{\frac{1}{w_{N+1}} - f_{N+1}^T C_N f_{N+1}} \quad (7)$$

The algorithm of the recursive weighted least squares method is the corner stone for many other recursive procedures. It could be shortly presented by steps 1 to 4:

1. $N \geq k$ observations are collected and processed with non-recursive method of weighted least-squares and the initial estimates $\hat{\theta}_N$ and C_N are obtained.

2. The new estimates are calculated by the formula

$$\hat{\theta}_{N+1} = \hat{\theta}_N + \frac{C_N f_{N+1}}{\frac{1}{w_{N+1}} - f_{N+1}^T C_N f_{N+1}} (y_{N+1} - f_{N+1}^T \hat{\theta}_N)$$

3. Recalculation of matrix C_{N+1} to be submitted for next iteration

$$C_{N+1} = C_N - \frac{C_N f_{N+1} f_{N+1}^T C_{N+1}}{\frac{1}{w_{N+1}} - f_{N+1}^T C_N f_{N+1}}$$

4. The new estimates $\hat{\theta}_{N+1}$ and C_{N+1} start the next iteration from point 2 of the algorithm presented above [2,3,4].

B. Recursive ordinary least squares.

Recursive least squares is also a special case of RWLS when $W = I$. This means that all weights are significant and unbiased estimates when equal values are assigned (1), which is only possible if $\rho = 1$. subsequently, the recursive least squares method (RLS) can be applied using the same procedure, as described in paragraph 1.1. to substitute $\rho = 1$ where possible [3,4,5].

III. DC MOTOR CONTROL SYSTEM

DC motors are widely used in terms of automation, robotics and various control systems. They are suitable where a precise regulation of torque and velocity is needed, while maintaining the torque at low and zero velocity [1,6,7].

A. DC Motor

The dynamics of the DC motor may be expressed by the following equation:

$$\begin{cases} U_a = R_a(T_a p + 1)i_a + c\Phi\omega \\ M_e = c\Phi i_a \\ M_e - M_c = Jp\omega \end{cases} \quad (8)$$

where: $T_a = L_a / R_a$ and U_a – armature voltage, i_a – armature current, R_a – armature winding active resistance, L_a – armature induction - ω – angular velocity, M_e – electromagnetic torque, M_c – load torque, Φ – magnetic flux, c – armature constant, J – moment of inertia. The block

diagram of the DC motor used in the present study is shown in figure [1,6,7]:

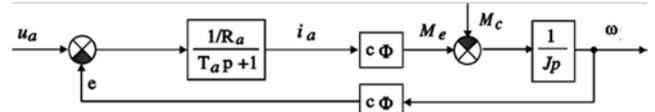


Figure 1. Block diagram of the DC motor

B. DC motor control using pulse-width modulation

Modern DC motor control systems use pulse-width modulation, which is found to be characterized with better energetic parameters, smaller current and velocity pulsations, which in turn leads to reduction of energetic losses and expansion of the control span.

In fig.2 is presented block diagram of DC motor control with PWM, where: TWG- Triangle Wave Generator, C – comparator, TDB – time delay block, IS– Impulse shaper, UR – uncontrolled rectifier, PTC – power transistor commutator, M– DC motor [1,6,7].

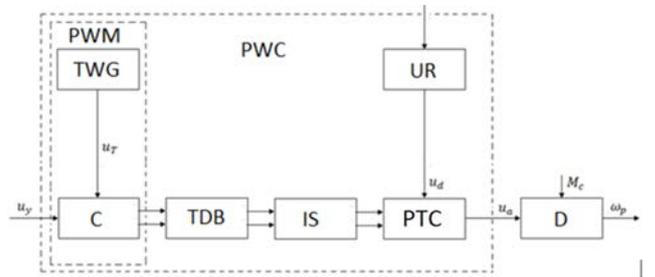


Figure 2. Block diagram of PWM - DC motor

C. Self-tuning controller

Self-tuning controllers (STC) use a combination of recursive process identification based on selected model process and controller synthesis based on apriory knowledge for control process system features, parameters estimates and ranges of variability.

Block diagram of STC (with direct identification) is shown in fig.3.

Self-tuning control (STC) is one of the control methods

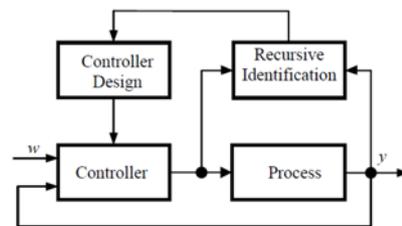


Figure 3. Block diagram of STC

which have been developed considerably over the past years. Self-tuning control is focused on discrete or sampled models of processes. Computation of appropriate control algorithms is then realized using discrete model of representation of the system.

STC has three main elements (fig. 3). The first element presents classic feedback system. The second shows implementation of identification block. The third realizes the algorithm of parameters adjustment of controller, based on estimates of the process parameters. This block diagram can be used in both stationary systems with unknown parameters and is also applicable for systems with distributed parameters which are expected to vary within certain limits. The present study investigates application of direct STC with minimal variance (STC-MV) [1,8,9].

D. Synthesis of adaptive control system with self-tuning regulator with minimum variance

The combination of the estimation method and the minimum variance regulation law leads to the following algorithms

1) Algorithm-1- Direct STC - MV

a) Based on input/output data for the process at a given k -th time sample, the estimates $\hat{a}_i(k), \hat{b}_i(k), \hat{c}_i(k)$ obtained using one of the methods described above

b) Under the principle of unambiguous equivalence, estimates are assumed to be the actual values of the parameters. The polynomials $E(z^{-1})$ and $F(z^{-1})$ are determined by solving the Diophant's equation (12)

$$C(z^{-1}) = A(z^{-1})E(z^{-1}) + z^{-d}F(z^{-1}) \quad (12)$$

c) The coefficients of the polynomial $G(z^{-1}) = E(z^{-1})B(z^{-1})$ are determined

d) That forms the control signal $u(k)$:

$$u(k) = -\frac{1}{g_0} [f_0 y(k) + f_1 y(k-1) + \dots + f_{n-1} y(k-n+1) + g_1 u(k-1) + g_2 u(k-2) + \dots + g_{m+d-1} u(k-m-d+1)] \quad (9)$$

e) Once the new data is received and processed the procedure is repeated from steps 1 to 2.

2) Algorithm-2- Indirect STC - MV

a) Based on input/output data for the process at a given k -th time sample, the estimates $f_i(k)$ and $g_i(k)$ of the polynomials $F(z^{-1})$ and $G(z^{-1})$ are obtained using one of the methods described in paragraphs 2 and 3

b) The estimates derived at step 1 form the control signal $u(k)$:

$$u(k) = -\frac{1}{g_0} [f_0 y(k) + f_1 y(k-1) + \dots + f_{n-1} y(k-n+1) + g_1 u(k-1) + g_2 u(k-2) + \dots + g_{m+d-1} u(k-m-d+1)] \quad (10)$$

c) Once the new data is received and processed the procedure is repeated from steps 1 to 2.

It is clear that when the direct method of estimation of $F(z^{-1})$ and $G(z^{-1})$ is applied, the use of more complicated algorithms as well as solving the Diophantine equation is not needed and could be skipped [1,8,9].

IV. EXPERIMENTAL RESEARCH AND RESULTS

The present research is mostly focused on the performance capabilities of the described recursive methods for parameter estimation used in real time adaptive control of DC motor. For this purpose the study is completed using random input signal which is simulating noise at the input of the system under investigation.

The research has been done using the System Identification Toolbox in Matlab\Simulink. For simulation purposes custom blocks in Simulink are developed each one corresponding to a certain recursive parameter estimation algorithm as follows: recursive least squares (RLS), recursive least squares with using the residuals modification instead of the prediction errors (RLSr) for both direct and indirect MV controller accordingly MV1 and MV2.

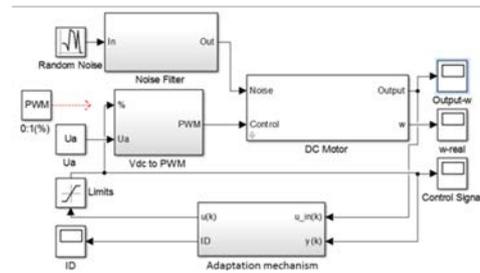


Figure 4. Block diagram of adaptive DC motor control with STC-MV in Simulink

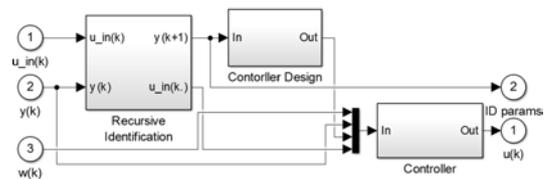


Figure 5. Block diagram of the subsystem "Adaptation mechanism"

On fig.6 and fig.7 are presented the speed of the DC motor in an adaptive system with direct self-tuning controller with minimum variance, using the above-described RLS and RLSr methods with a set speed $\omega = 152,35 \text{ rad / s}$, $\omega = 10,1567 \text{ rad / s}$

On fig.8 and fig.9 are presented the speed of the DC motor in an adaptive system with indirect self-tuning controller with minimum variance, using the above-described RLS and RLSr methods with a set speed $\omega = 152,35 \text{ rad / s}$, $\omega = 10,1567 \text{ rad / s}$

V. CONCLUSIONS

The simulation results prove the applicability of described recursive methods for parameter estimation in adaptive control of DC motor. The results show that in the low speed interval the variation of the signal from the reference is the highest even if it still belongs to acceptable limits. As it was formulated the recursive instrumental variable method require a second (external) noise signal in the output of the object for the purpose of better estimates of parameters however it strongly affects the quality of the control process. The described methods for parameter estimation can be further modified for better performance and process quality in other adaptive control systems. If there is an option for direct selection of the estimates weights the algorithms described can be used to facilitate a variety of robust estimates that can be noise resistant. Future research will be focused on this issue.

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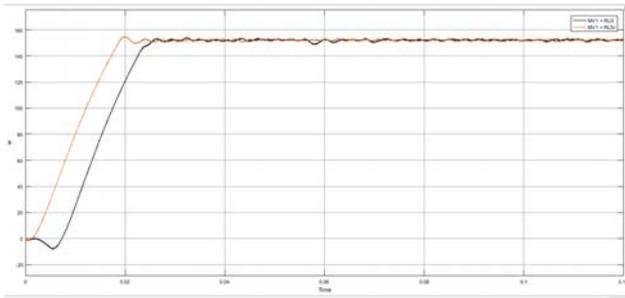


Figure 6. Speed of DC motor with MV1 + RLS(b) and MV1 + RLSr(r) for set speed $\omega = 152,35\text{rad / s}$

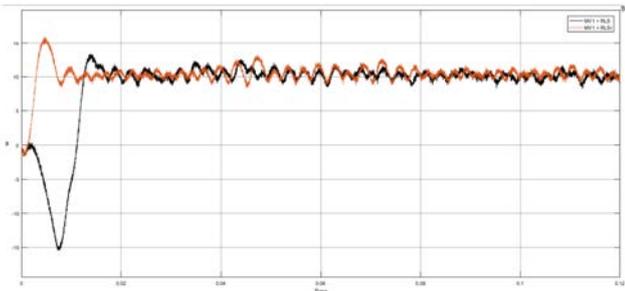


Figure 7. Speed of DC motor with MV1 + RLS(b) and MV1 + RLSr(r) for set speed $\omega = 10,1567\text{rad / s}$

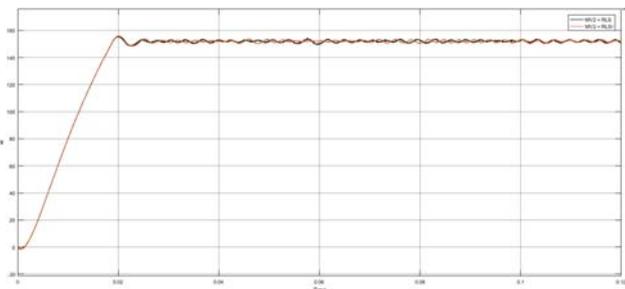


Figure 8. Speed of DC motor with MV2 + RLS(b) and MV2 + RLSr(r) for set speed $\omega = 152,35\text{rad / s}$

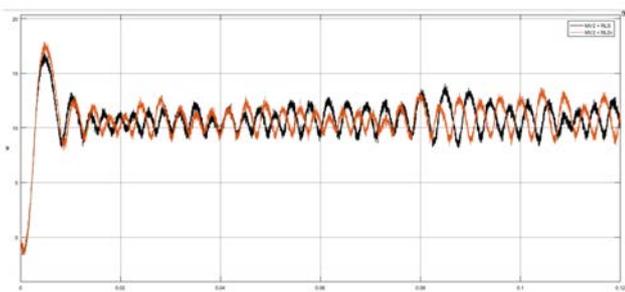


Figure 9. Speed of DC motor with MV2 + RLS(b) and MV2 + RLSr(r) for set speed $\omega = 10,1567\text{rad / s}$

Simulation Framework for Realization of Handover in LTE Network in Urban Area

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Abstract - The LTE technology provides simultaneously voice, data and video with different priority on networks. LTE cellular network provides uninterrupted delivery of these services while on the move, and this is possible through the Handover procedure. In this paper is proposed a simulation framework for realization the Handover procedure in LTE technology into the urban area, which realizes the UE mobility, prioritizes the different types of traffic and reorder the resource blocks on UE after prioritization has been done. The implemented prioritization mechanism is used to study and improve the QoS parameters in LTE networks.

Key words - 4G, LTE, Horizontal Handover, QoS

I. INTRODUCTION

In [1] the European Commission presents coordinated designation and authorization of the 700 MHz band for wireless broadband by 2020 and coordinated designation of the sub-700 MHz band. According to this decision this frequency bands will be used for terrestrial systems capable of providing wireless broadband communications services and for deployment of 5G technologies.

LTE is a widely used 4G technology defined by 3GPP, capable of realizing Broadband Wireless Access services. According to [2] between 2016 and 2017, the total data traffic in mobile networks increased by 65% and number on LTE subscriptions is growing rapidly. The widely spreading of LTE is a result from high spectrum efficiency low latency scalable bandwidth from 1.4 MHz to 20 MHz, using MIMO technology, OFDM technique for downlink and SC-FDMA for uplink, and from allowing the user to access the service in a state of moving both in one cell or between cells (Handover) without any termination of communication.

To keep mobile users satisfy, carrying out a Handover requires providing good QoS. This paper presents simulation framework, which helps to investigate QoS parameters for LTE network. By the simulator it can be studied parameters like throughput, and packet delivery ratio during Handover, and how is prioritized the different types of network streams after the Handover is done.

II. ESSENCE OF THE LTE HANDOVER

According to [3], there are two basic Handover technologies: Hard Handover – also called break-before-make; Soft Handover – also called make-before-break. Furthermore Handover procedure is divided into two categories:

- Horizontal handover – automatic switching between access points in one technology;
- Vertical handover - automatic switching from one technology to another at the point where the service is delivered.

The realization of Handover procedure depends on eNodeB's Reference Signal Receive Power (RSRP) values measured from UE. According to [4, 5] Time To Trigger (TTT) is a length of time which starts when the RSRP of target eNodeB is greater than RSRP of source eNodeB, plus hysteresis value, and enters in A3 event. The hysteresis represents the difference in RSRP between the serving and target cells that must be maintained for an amount of time known as TTT before handover. A3 event should be greater than hysteresis to avoid ping-pong Handover. After passing the time to trigger the handover is triggered.

As shown in [6] the Horizontal handover at LTE is realized through the X2 interface of the eNodeB. The X2 is a point-to-point interface, and it can be established between the serving eNodeB and its neighbors. In case the X2 interface is not configured or the connection is blocked, the Handover procedure can be implemented via MME using S1 interface.

III. RELATED WORKS

There are many developments using Handover mechanisms on LTE cellular networks that offer different solutions to improve QoS parameters of the serving network.

Research [7] investigates the impact of mobility on the LTE network for video streaming services with Distributed Antenna System (DAS) approach. The results show that the scenario with DAS model improves the quality of performance when the user plays a video streaming.

Research [8] describes the QoS performance evaluation of voice over LTE network using OMNET++ and SimuLTE. The study of QoS for VoLTE traffic is based of the factors MOS, End-to-End Delay, Packet Loss Rate and Jitter. The results show that the speed of the sender and receiver are the crucial factors that can affect to the quality of the call.

Research [9] proposes a quality-adaptive scheme for Handover and forwarding that supports mobile-video-streaming services in MIMO-capable, heterogeneous wireless access networks. As a result is shown that the proposed scheme is a mechanism that is more robust for mobile video streaming.

Research [10] focuses on the analysis of specific type of LTE traffic, the video streaming in frequency division duplex (FDD) mode in Handover process on LTE network. The

results show that the QoS for the high speed UEs, which generates video stream, is not increased significantly.

IV. LTE SIMULATION MODEL IN URBAN AREA

The main concept of cellular networks is the division of services into small areas called cells. Each cell has its own coverage area and operates with different parameters. Each of them contains an eNodeB, which serves all users in the range, and ensures UE mobility between cells.

This study will focus on analyzing QoS for mobile users performing the Handover between neighboring eNodeB's within LTE cellular network.

According to [11] the Fig. 1 shows distribution of built eNodeB's from different PLMN in central urban area of Varna, Bulgaria on the crossroad of avenue "Vladislav Varnenchik" and "Hristo Botev".



Figure 1. Distribution of eNodeB's on central urban area of Varna, Bulgaria

As shown in Fig. 1 eNodeB's are built up as a dense network topology, because the UEs can move in all directions. The distribution presented is taken into account when building the simulation network topology as shown in Fig. 2.



Figure 2. The crossroad of avenue "Vladislav Varnenchik" and "Hristo Botev" in Varna, Bulgaria [12]

Fig. 2 shows the Handover topology used for simulation. In the beginning every eNodeB has different number of connected UE's. They can be static or mobile, but this research focuses on mobile users. According to topology UE's can move in all directions (i.e. East, West, North, South,

Southeast, Southwest, Northeast and Northwest). Every UE moves with different speed in one of the directions, and when reaches the end of serving cell initiates Handover. Unlike realization of Handover in suburban area where every eNodeB has all the time two neighbors in urban area of the city the number of neighbors is more. Before the Handover is occur, the serving eNodeB according to the information sent from UE form its neighbor table. Based on this information every eNodeB know which is the neighbor in the specific direction. After that, according to the moving direction the UE connects to the next eNodeB. Stages when UE performs the Handover process on the LTE network are as in Fig. 3.

The scheduler of every eNodeB performs proposed prioritization mechanism. According to this mechanism faster mobile users are with greater priority from slower users, because faster ones will reach end of cell first. So, faster UEs receive more resource unlike the others.

After the Handover is completed the number of UEs is changed dynamically for every eNodeB. Unchanged is just the number of static users, if available. The scheduler of eNodeB then prioritizes users and redistributes resources according to priority.

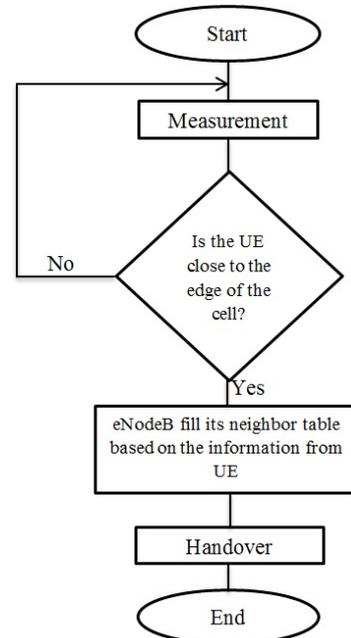


Figure 3. Handover process diagram

V. PROPOSED ALGORITHM FOR PRIORITIZATION OF UES IN LTE

This simulation framework uses the same prioritization, presented from authors [13]. According to the priority the scheduler of eNodeB arranges UEs, where the order of priority is as: first, the users are ordered by payed priority – value from 0 to 7 where greater value indicates greater priority, second criteria is distance to eNodeB – users which are closer to eNodeB has greater priority, next criteria is speed of UE, if the user is mobile, where the high speed users has greater priority, in the end the users are prioritized according different type of service from required traffic flow.

VI. SIMULATION FRAMEWORK FOR REALIZATION OF LTE HORIZONTAL HANDOVER IN URBAN AREA

The simulation framework presented in this paper is improved version of simulator shown in [13, 14]. Improvements consist in the fact that for mobile UEs a direction of movement can be selected in the range of the eNodeB, which allows implementation of mechanism for realization of Handover. Before the Handover is realized, it is necessary to add the information for neighbor eNodeBs of serving cell, and checked at what speed and what direction the subscriber moves. After that, is calculated the distance that the UE will travel within five minutes in meters. The calculated value is added to distance to eNodeB given to the UE. After that, if the distance to eNodeB is greater than the radius of the serving eNodeB, the Handover to the target eNodeB is realized in to the movement direction. For the mobile UEs for which the value of distance to eNodeB is not greater than radius of cell, the Handover is not occurs, and they stay at the range of the serving eNodeB. The Handover is realized by the standard, and the context of the UE is transmitted to the next eNodeB. After the Handover is completed, the scheduler of eNodeB then prioritizes users by proposed mechanism, and redistributes resources according to priority. The Fig. 4 shows the new field in which every eNodeB add the number of neighbors.

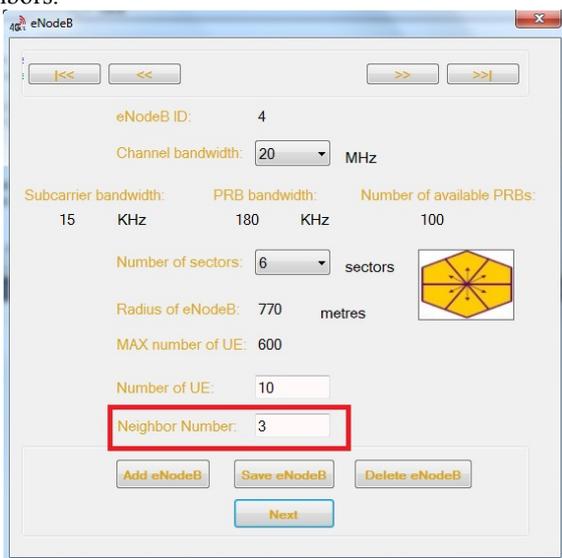


Figure 4. Configuration parameters for eNodeB

After the number of neighbor cells is selected into the next form is needed to fill information about the neighbors of every eNodeB for organizing the network topology as shown in Fig. 5. The figure shows the tab with fields for configuration the neighbors and the tab which shows the information for configured neighbors.

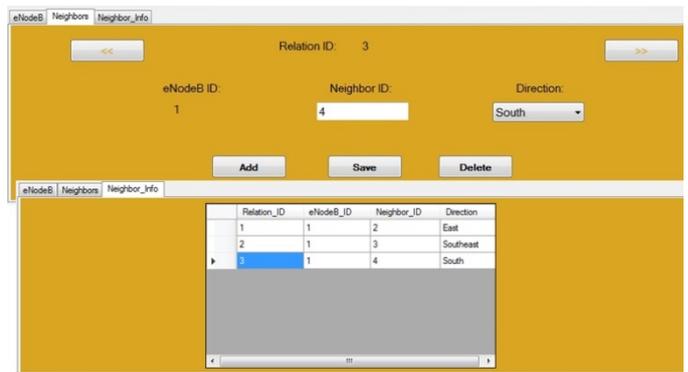


Figure 5. Configuration parameters for neighbors

The Fig. 6 shows the new fields for selecting moving direction of UE. Because in the urban area UEs can move everywhere, there can be selected one of eight moving directions.

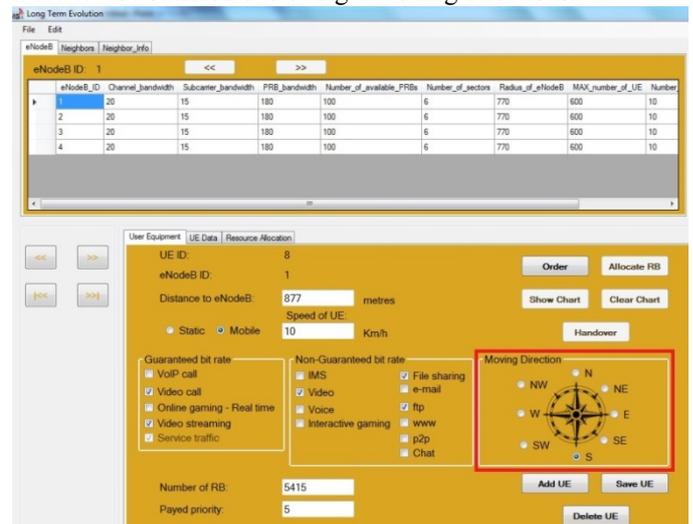


Figure 6. Data of UE connected to eNodeB

Fig. 7 shows the base station information database and the related UEs. In the database for UE was added the fields “East”, “West”, “North”, “South”, “Northeast”, “Northwest”, “Southeast” and “Southwest”. These fields show the selected moving direction of UE, if in the field is written “True”.

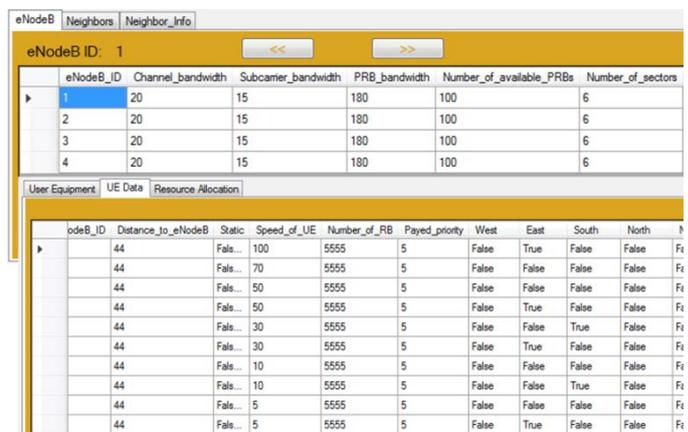


Figure 7. Database with information of eNodeB 1 and related UEs

According to the speed of UE, selected movement direction and inserted neighbor information, the high speed UEs, which first are connected to eNodeB 1 initiates the Handover. In the first iteration after realizing the Handover, high speed UEs are connected to eNodeB 2, eNodeB 3 or eNodeB 4. On the other hand low speed UEs are still in range of eNodeB 1 and connected to it.

Figure 8. UE data after realizing of the Handover on eNodeB 1

After the Handover is realized, according to selected direction the UE context was sent to eNodeB 2 – in first iteration UE with ID 5, 4, 8 in second iteration UE with ID 1, eNodeB 3 – in first iteration UE with ID 6, 9, 2 and there are no UE in second iteration or eNodeB 4 – in first iteration UE with ID 10, 3 in second iteration UE with ID 7 as shown in Fig. 9, Fig. 10 and Fig. 11.

Figure 9. Realized handover in first and second iteration for eNodeB 2

Figure 10. Realized handover in first iteration for eNodeB 3

Figure 11. Realized handover in first and second iteration for eNodeB 4

VII. TESTS AND DISCUSSION

In this study, three tests with different number of UEs were carried out, which moves at different speeds. During the tests, users are moving from serving to the next eNodeB by performing a Handover procedure. After the Handover is completed, it is determined the number of realized and unrealized Handover procedures as shown in Fig. 12. This figure shows that when the number of UEs increases, the realized Handover procedures increase too. According to the simulator the realization of Handover depends on location of UE (i.e. distance to eNodeB) and movement speed of UE. Because of this, mostly high speed UEs realizes more Handovers unlike the low speed UEs. For providing good QoS during the Handover for the moving UEs, mostly for high speed UEs, is need to be improved network parameters like throughput and packet delivery ratio (PDR). The throughput and PDR values are calculated respectively with the equations (1) and (2):

$$\text{Throughput} = \frac{\text{Number of RB sent in 1 Frame}}{\text{Transmission time}} \quad (1)$$

$$\text{PDR} = \frac{\text{Number of delivered RB in 1 Frame}}{\text{Sent RB}} * 100 \quad (2)$$

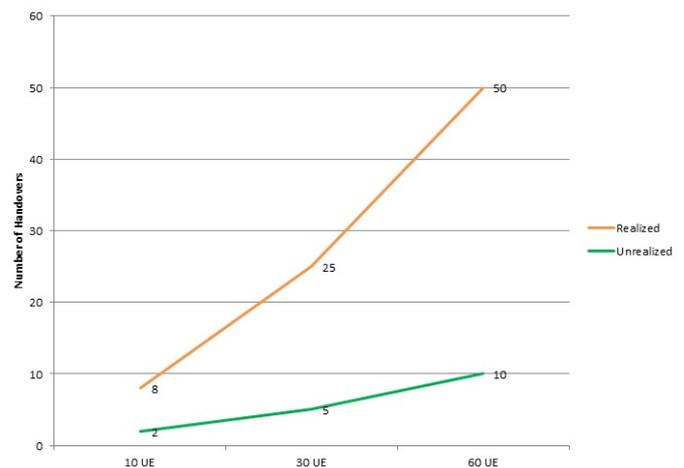


Figure 12. Number of realized and unrealized Handover procedures

When a Handover is performed, improvement of the QoS may be achieved with increasing the throughput, and PDN values

for high speed UEs. This is performed from the scheduler of eNodeB and the prioritization mechanism on it. According to the prioritization mechanism the high speed UEs gain more resource blocks, and their requests are executed first. These UEs have greater priority, because they moves with high speed, and they may reach first the end of the cell, and will perform the Handover.

Fig. 13 and Fig. 14 shows respectively the throughput and PDN values for UEs moving with different speed. The figures show throughput and PDN values for all UEs with and without traffic prioritization. As shown in Fig. 13 prioritization mechanism significantly increases throughput for high speed UEs, but the throughput for low speed UEs has lower values. However, this isn't decrease QoS, because low speed UEs won't initialize many handovers.

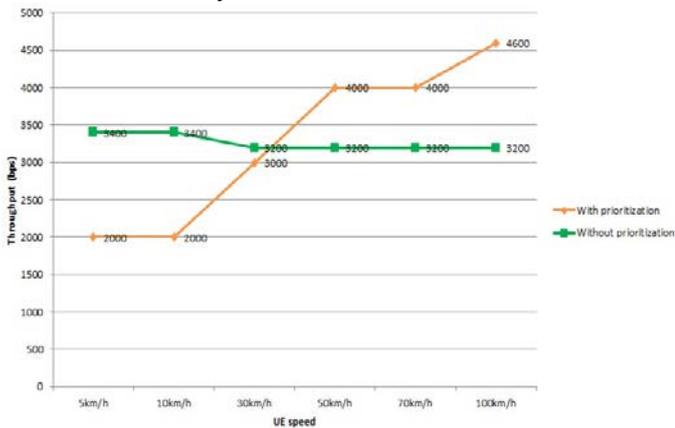


Figure 13. Throughput values for UEs moving with different speed

As shown in Fig. 14 packet delivery ratio for high speed UEs increases, which guarantee improved QoS for high speed UEs. All tests are done for 60 UEs. Values for throughput and packet delivery ratio are calculated as average value from realized tests for resource allocation in one frame.

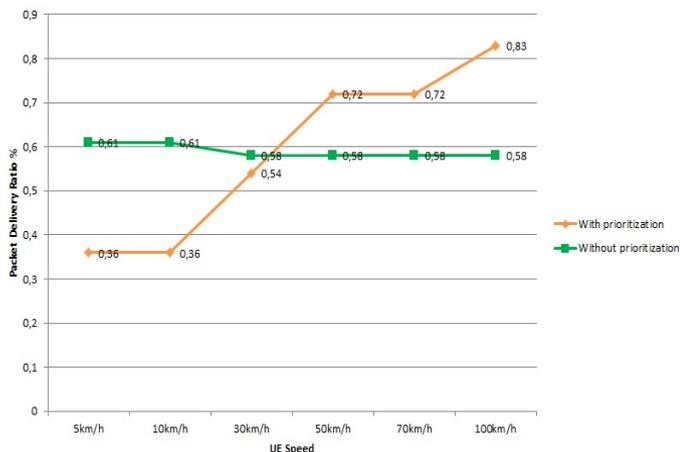


Figure 14. PDN values for UEs moving with different speed

VIII. CONCLUSION

In this paper is proposed simulation framework for realization of horizontal Handover in LTE network into the urban area. In this framework is realized an algorithm for realization of users

mobility between neighboring cells according to the prioritization mechanism. Simulation's results show that the proposed prioritization mechanism improves QoS for high speed UEs. There are presented number of realized and unrealized Handovers, throughput values and PDN values for resource allocation by users. It was always assured a greater throughput and PDN values for allocated resources for high speed users, which realizes the Handover.

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Routing and Traffic Load Balancing in SDN-NFV Networks

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Abstract - With the rapid development of Internet applications and the growing number of network services, the requirements for network communications are increasing. Network Function Virtualization (NFV) separates network functions from hardware and provides the flexibility of software-based network functionalities in addition to optimal shared physical infrastructure. The development of a Software-Defined Network and integrating it with NFV can help address a number of challenges to the dynamic resource management and organization of intelligent services. This paper presents the architectural benefits of SDN-NFV networks, the used routing techniques and the route balancing methods used for SDN and NFV networks.

Keywords - Network Function Virtualization, Software-Defined Network, Virtualization

I. INTRODUCTION

With the rapid development of Internet applications and the growing number of network services, the requirements for network communications are increasing. They need to be fast, to carry large amount of traffic, and to provide variety of dynamic applications and services. The acceptance of the terms “interconnected data centers” and “server virtualization” have significantly increased the requirements for communication networks [1].

Today’s networks depend on IP addresses to identify and locate servers and applications. This approach works well for static networks where any physical device can be recognized through an IP address, but it is extremely difficult for large virtual networks. Managing such complex environments through traditional networks is expensive and time-consuming, especially when migrating virtual machine (VM) and network configuration is needed. To simplify the task of managing large virtual networks, the administrators need to solve issues related with physical infrastructure that increase the complexity of management. In addition, most modern vendors use Control Plane to optimize data flow and achieve high performance [2]. This control platform, which is based on switches, gives network administrators very little opportunity to increase the flow of data on the network.

Using the virtualization technology, the Industry Specification Group (ETSI) offers Network Function Virtualization (NFV) [3], which network functions were previously performed by dedicated hardware. By decoupling network functions from hardware, NFV provides the flexibility

of software-based network functionalities in addition to optimal shared physical infrastructure.

With the development of a software-defined network (SDN) [4] and the introduction of more units in network architectures, the tendency to integrate SDN with NFV (software defined NFV architectures) to achieve different control methods of the network and for managerial purposes, reported significant increase [5]. Applying SDN to NFV can help address a number of challenges to the dynamic resource management and organization of intelligent services. Through NFV, SDN dynamically creates a virtual service environment for a particular service chain type. This avoids usage of individual hardware and complex work to secure an application for forthcoming new services. With the use of SDN, NFV provides an additional opportunity to create dynamic real-time and flexible traffic redirection [6].

This paper presents the architectural benefits of SDN-NFV networks, the used routing techniques and the route balancing methods used for SDN and NFV networks. In conclusion, an overview of the studies is made.

II. NETWORK ARCHITECTURE OF SDN-NFV

The software-defined NFV system consists of a control module, packet relaying devices and an NFV platform at the edge of the network (Fig. 1). The logic of packet forwarding is determined by the SDN controller and implemented in forwarding devices by routing tables. Effective protocols (e.g. OpenFlow [7]) can be used as standardized interfaces for communication between the centralized controller and the distributed sending devices. The NFV platform provides servers with the ability to deploy high-speed networking features at a low-cost. Hypervisors are running on servers and manage virtual machines that perform network functions. Thus, the platform allows customizable and programmable data processing features such as firewall middlebox, IDSes and proxy servers that run as software on virtual machines, where network functions are delivered as pure software to the network operator.

The SDN controller and the NFV orchestration system compose the logic control module. The NFV management system provides virtualized networking features and it is managed by the SDN controller via standard interfaces.

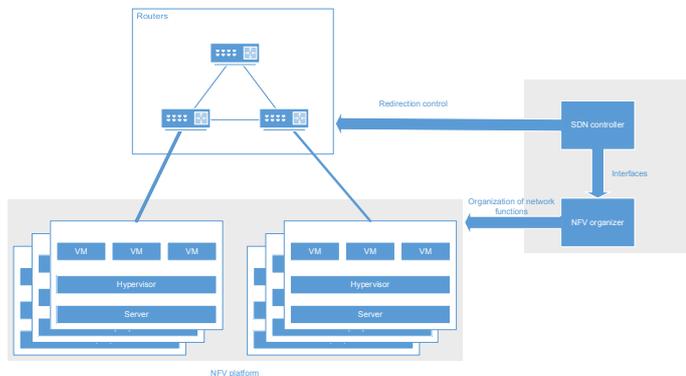


Figure 1. SDN-NFV architecture

After receiving the network topology and the required rules, the control module calculates the optimal tasks of the functions (assigns network functions to the virtual machines) and converts the logical policy specifications into optimized routes. Function assignment is applied by the NFV managing system, and the controller manages the traffic flowing through necessary and appropriate sequence of virtual machines and pre-devices by entering the forwarding rules into them.

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III. SDN ROUTING TECHNIQUES

A. VRS: Virtual Routers as a Service

This architecture features a virtual routing user, which is responsible for the management of distributed senders and is called a Virtual Router System (VRS) [8, 9]. Virtual routing instances communicate with Point-Of-Presence (POP) and follow an initial topology where one central node is connected to Customer Edge Gateways (CEG). VRS instances are associated with redirecting mechanisms that can be programmed using OpenFlow [10]. The route path selection for the packets is calculated on the base node.

Another module of this architecture is Path Management Controller (PMC). It is used to calculate the minimum route. It should be noted that the cost of VRS increases with the increase in CEG nodes. The virtual routing system takes into consideration the following parameters while calculating the minimum path:

- Customers' geographic location.
- Networks traffic;
- Corresponding capacity.

As a best path is selected the node with maximum capacity and minimum cost

B. RaaS: Routing as a Service

A logically centralized route control level is used, which has a comprehensive network topology plan [11]. This global plan allows centralized control over routing decisions. The main block of centralized routing level consists of:

- Link detection module – defines physical connections between devices.
- Topology manager – supports network status information.
- Virtual routing machine – creates a virtual topology to combine traditional routing via virtual router.

Routing decision is based on information stored in the database attached to the centralized routing level. The accuracy of the routing decision is guaranteed by tracking the MAC address and port numbers of each connected device. The best route is calculated using the Dijkstra algorithm [9].

C. RFCP: RouteFlow Routing Control Platform through SDN

RFCP is a hybrid model of two major parts (Routing Control Platform and Routing Traffic). It is presented as an extra layer for calculating routes within and between autonomous systems. RFCP adds to the central data storage platform:

- RFCP kernel status information.
- Network plan.
- Network Base Information (NBI).

The communication between the network operating system, SDN controller and the virtual environment is accomplished through OpenFlow protocol management messages.

In order to integrate this architecture with traditional networks, the Routing Reflector (RR) in BGP domain is interconnected with Provider Edge (PE) routers via iBGP. It in turn communicates with a BGP controller, which is also called the RFCP controller. The RouteFlow controller serves as a gateway between the routing reflector and the OpenFlow switch. The RouteFlow client retrieves routing information from the routing machine, which has a virtual image of physical topology. Automatic configuration of RFCP is accomplished by introducing a locating controller.

The improved version consists of five modules:

- RouteFlow controller.
- Topology controller.
- Remote Procedure Call (RPC) client.
- RPC server.
- FlowVisor.

The topology controller keeps track of a topology changes. If one exists, it performs the topology detection module and sends the configuration information to the RPC client. The

configuration contains switch ID and port number. Based on this configuration information, the RPC server generates a virtual machine with the same physical network and port identifier. To the virtual machine is assigned an IP address which is allocated by the topology controller. All this information is stored in RF controller in the form of configuration files. In turn, they are forwarded to the RPC server using an RPC client that configures this information in the newly created virtual machine [9]

D. SoftRouter

The main goal of the architecture of the SoftRouter [9, 12] is separating the Control Element (CE) and Forwarding Element (FE). The control functionality is provided by a centralized server that can be very far away from the FE. SoftRouter is described in two ways – physical and routing. The management protocol is executed through CE, and the topology detection module is controlled by the FE. In this way, the Network Element (NE) is formed.

E. RouteFlow IP routing

The purpose of RFIP is to provide IP routing as a service in a virtual environment. RouteFlow basically consists of three components during its creation:

- RouteFlow controller.
- RouteFlow server.
- Virtual network environment.

The RouteFlow [13] controller interacts with the RouteFlow server using the RouteFlow protocol. The Virtual Environment (VE) consists of a RouteFlow client and a routing machine. The RF client collects the Forwarding Information Bases (FIB) from the router. The RF client converts these FIBs into OpenFlow types that are forwarded to the RF server, which is responsible for establishing a routing logic of these types.

The routing logic is transferred to the RF controller, which determines the field matching and the action to be performed for each machine. The virtual machine is connected directly to the RF controller via a virtual switch. The direct link between the virtual machine and the controller reduces the delay by providing a direct link between physical and virtual topology.

RF performs multiple operations in different scenarios:

- Logical separation.
- Multiplication.
- Aggregation.

All routing tasks are performed by the virtual environment, thus providing flexibility. RF is considered as the main architecture for SDN networks [9, 14].

IV. NETWORK LOAD BALANCING IN SDN AND NFV

One of the main problems of computer networks is the load balancing of the traffic. With the advent of SDN and NFV are made a number of studies and researches for load balancing [15,16,17,18,19,20]. Evenly distributed packet traffic in

software defined network virtualization can be achieved at two levels: NFV level and SDN level.

A. Load balancing through NFV

NFV framework has three core components: Virtual Network Functions (VNF), Network Function Virtualization Infrastructure (NFVI), and NFV control system. In NFVI the network functions are defined as software that runs on standard multi-core architecture. One of the NFV services may require a network service that includes many virtual network functions that have to be performed according to certain functionality. When processing the requested service, the NFV management system determines the location required for VNF disposal based on resources available in the NFVI. Unlike routing schemes on a one-time basis, the load balancing strategy divides traffic between several paths.

The NFV system supports load balancing in both ways – chooses routing paths and divides traffic between them under NFVI resource constrains. With the inclusion of functionality for changing the functions of NFV, each requested data flow must pass through a series of VNF dynamically allocated NFVI units depending on application requirements.

Another solution to the problem of NFV load balancing traffic is the Online algorithm for load Balancing In network functions virtualization (ORBIT) [21]. The main idea of ORBIT is to regulate a portion of traffic that passes through a NFVI partition. NFVI is divided into partitions in which the link between the individual parts is limited. By redirecting traffic through individual partitions, the possibility of using an unnecessary link between the partitions is limited. In this way the network is effectively used and congestion is avoided.

B. Load balancing through SDN

In order to achieve a load balancing in the SDN network, multiple selections for the least loaded/busy real-time server (RLSs) are made. RLS is used to determine the end server for the new data stream as well as to calculate the path to the intended server when a new stream enters for the first time in the domain. The task of RLS is to choose the most appropriate route for forwarding each new stream. It is based on network time statuses.

The update of controller Network Information Bases (NIB) is determined by the synchronization controller pattern that significantly affects the efficiency of load balancing. Existing schemes for synchronization status of controllers based on periodic synchronization have two main issues: achieving high synchronization of controllers and forwarding organization [22].

Other solutions for load balanced traffic are by using the controller for analyzing information response from the OpenFlow switch and to modify the flow tables [23-26]. In this way, it is possible to plan the way for data transmission and to achieve a balance of the SDN load. These strategies belong to the static load balancing method, which is unable to make a real-time dynamic routing schedule depending on the state.

A Dynamic Load Balancing algorithm (DLB) is proposed for the dynamic solution of the balanced load [27]. He applies the greedy strategy to choose the link between the next hop that

has the least load. Although this algorithm performs a balanced load on a multi-way SDN network, it determines the load of the links of each subsequent hop without combining the advantages of the global network plan in SDN.

Another load balancing strategy offers the use of a heuristic method [28], classifying the best way and the best servers combined with SDN's global networking plan. This heuristic method uses the Ant Colony Optimization algorithm to select the transmission path and the servers. It collects the information in order to calculate the use of the link and monitors the delays in the links [29].

V. CONCLUSIONS

This paper discusses a basic architecture of the SDN-NFV network. The techniques and methods used for routing in SDN based networks are examined. This paper also addresses the issue of data load balancing in SDN and NFV and the different methods for solving it. After the studies, both the architectural advantages of SDN integration with NFV were identified, as well as the advantages and disadvantages of routing methods in SDN and NFV. The main problem in SDN and NFV-based networks – the network load balance, was also established.

As a guideline for future work in-depth research into existing solutions and load balancing are provided. New methods for routing and load balanced in SDN-NFV based networks will also be developed, while maintaining the benefits of SDN and NFV. For this purpose, simulation techniques for building SDN-NFV network and comparing some of the routing and balancing algorithms will be used.

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Model for Research of Li-Fi Communication

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Abstract – This paper shows a developed physical prototype for transmitter and receiver sides of the Li-Fi devices. The proposed model has been tested and fully operational. The study of the model focuses on the influence of the distance and the transmission angle between transmitter and receiver in Li-Fi communication.

Key words: Li-Fi, IoT, Wireless Communication

I. INTRODUCTION

Since 2011 with the introduction of the IEEE 802.15.7 standard to the attention of the wireless communications research community is presented the term called Li-Fi. Li-Fi stands for Light-Fidelity. The technology is very new and was proposed by the German physicist Harald Haas in 2011. [1] Li-Fi provides transmission of data through illumination by sending data through an LED light bulb that varies in intensity faster than human eye can follow. Until now there are created more than 30[2][3] working prototypes of transmitting data through LED light bulbs. Li-Fi can be considered better than Wi-Fi because there are some limitations in Wi-Fi. Wi-Fi uses 2.4 – 5 GHz radio frequencies to deliver wireless internet access and its bandwidth is limited to 50-100 Mbps. With the increase in the number of Wi-Fi hotspots and volume of Wi-Fi traffic, the reliability of signals is bound to suffer. Security and speed are also important concerns. Wi-Fi communication is vulnerable to hackers as it penetrates easily through walls. In his TED talk, Professor Haas highlighted the following key problems of Wi-Fi that need to be overcome in the near future:

a) *Capacity:* The radio waves used by Wi-Fi to transmit data are limited as well as expensive. With the development of 3G and 4G technologies, the amount of available spectrum is running out.

b) *Efficiency:* There are 1.4 million cellular radio masts worldwide. These masts consume massive amounts of energy, most of which is used for cooling the station rather than transmission of radio waves. In fact, the efficiency of such stations is only 5%.

c) *Availability:* Radio waves cannot be used in all environments, particularly in airplanes, chemical and power plants and in hospitals.

d) *Security:* Radio waves can penetrate through walls. This leads to many security concerns as they can be easily intercepted.

Li-Fi addresses [4] the aforementioned issues with Wi-Fi as follows:

a) *Capacity:* The visible light spectrum is 10,000 times wider than the spectrum of radio waves. Additionally, the light

sources are already installed. Hence Li-Fi has greater bandwidth and equipment which is already available.

b) *Efficiency:* LED lights consume less energy and are highly efficient.

c) *Availability:* Light sources are present in all corners of the world. Hence, availability is not an issue. The billions of light bulbs worldwide need only be replaced by LEDs.

d) *Security:* Light of course does not penetrate through walls and thus data transmission using light waves is more secure.

In this paper is developed a prototype for communication with Li-Fi with which are researched and overcome part of the presented problems, especially related to the influence of the distance and the transmission angle between transmitter and receiver.

II. ESSENCE OF THE LI-FI TOPOLOGIES

The topologies supported by the MAC layer are peer-to-peer, broadcast and star as illustrated in Fig. 1 [5]. The communication in the star topology is performed using a single centralized controller.

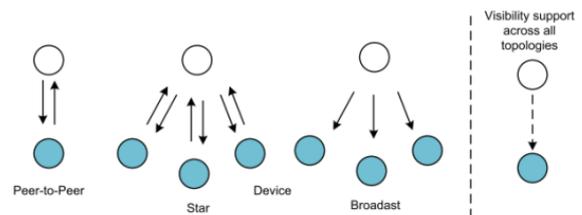


Figure 1. Supported MAC topologies by IEEE 802.15.7

All the nodes communicate with each other through the centralized controller as shown in Fig. 1. The role of the coordinator in the peer-to-peer topology is performed by one of the two nodes involved in communication with each other as illustrated in Fig. 1.

The Physical layer provides the physical specification of the device and also, the relationship between the device and the medium. Fig. 12 shows the block diagram of the general physical layer implementation of the VLC system. First of all, the input bit stream is passed through the channel encoder (optional). Linear block codes, convolutional codes and the state of the art turbo codes can be used to enhance the performance of the VLC system. Then, the channel encoded bit stream is passed through the line encoder to yield the encoded bit stream. After line encoding, modulation (such as ON-OFF keying, PPM and PWM, etc.) is performed and

finally, the data is fed to the LED for transmission through the optical channel.

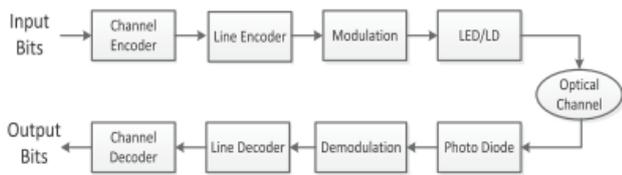


Figure 2. Typical physical layer system model of VLC

III. PROPOSED MODEL PROTOTYPE

On Fig. 3 is presented a model for physical prototype of Li-Fi Wireless Communication between two personal computers – one transmitting date (Tx) and one for receiving that data (Rx) using a LED bulb, transmitter and receiver and Arduino Uno controllers for programming them.

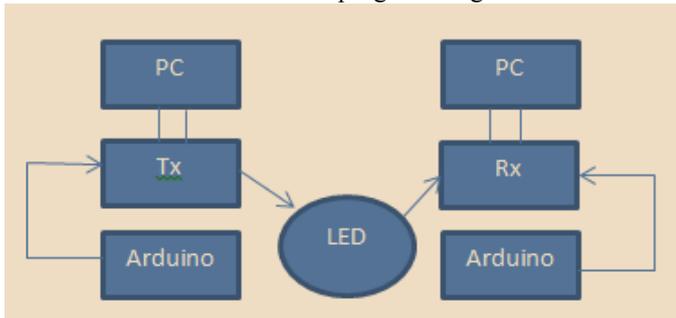


Figure 3. Principle scheme for the proposed model for physical prototype

IV. REALIZED MODEL

Based on the Fig 3 is realized fully-working physical prototype for the needs of the paper researches on the influence of the distance and the transmission angle between the transmitter and receiver in Li-Fi communication. The fully-working prototype is showed on Fig.7. Communication system components are:

1. A high brightness white LED bulb which act as a communication source (Fig. 4).



Figure 4. LED bulb used for data transmit

2. Silicon photo diode which shows good response to visible wavelength region.
3. Li-Fi Tx side - The Tx side will transmit the data.
 - It is connected to arrays of led through which data is transferred.
 - This data will be received by the receiving side (Rx) side.

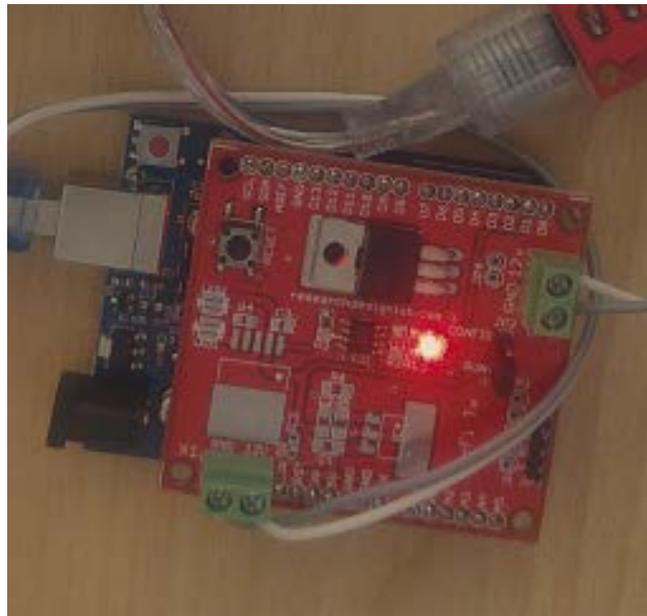


Figure 5. Transmitter side

4. Li-Fi Rx side (Fig. 6) - The receiver side will receive the data that is transmitted through the led panel This led can be displayed to the HyperTerminal of the PC by connecting a serial uart. In our case the transmitted data is showed on Arduino environment.

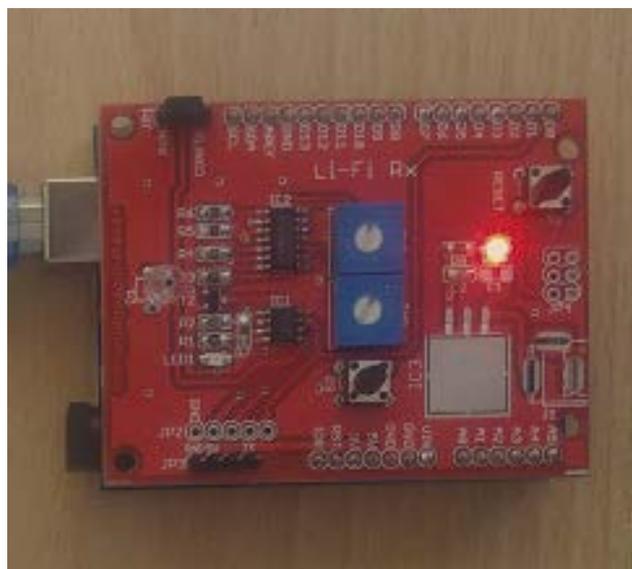


Figure 6. Receiver side

LED illumination can be used as a communication source by modulating the LED light with the data signal. The LED light appears to be continuous to the human eye due to the fast flickering rate. The high data rate can be achieved by using a high speed LED's and appropriate multiplexing technique. Each LED transmits at different data rate which can be increased by parallel data transmission using LED arrays.

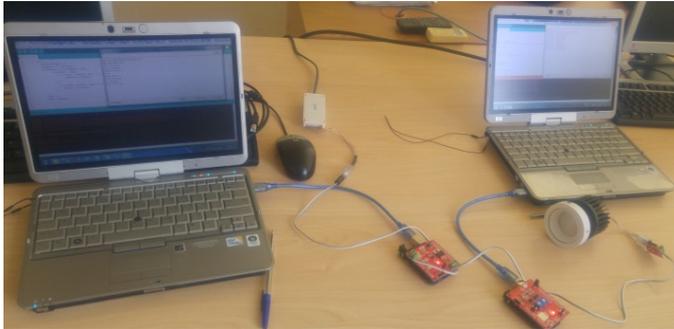


Figure 7. Fully-working physical model of Li-Fi communication
Programming code, used for transmit serial data:

```
#include <Servo.h>

Servo myservo;
int angle = 0;
int newAngle = 0;
const int MaxChars = 4;
char strValue[MaxChars+1];
int index = 0;
void setup()
{

Serial.begin(38400);
myservo.attach(10);
angle = 90;
while (!Serial){}
void loop(){
void serialEvent()
{
while(Serial.available())
{
char ch = Serial.read();
Serial.write(ch);
if(index < MaxChars && isDigit(ch)) {
strValue[index++] = ch;
} else {
strValue[index] = 0;
newAngle = atoi(strValue);
if(newAngle > 0 && newAngle < 180){
if(newAngle < angle)
for(; angle > newAngle; angle -= 1) {
myservo.write(angle);
}
else
for(; angle < newAngle; angle += 1){
myservo.write(angle);} }
index = 0;
angle = newAngle;
}
}}
```

Programming code used for receive the transmitted data:

```
#include <Servo.h>

const byte numChars = 50;
char receivedChars[numChars]; // an array to store the
received data
boolean newData = false;
void setup() {
Serial.begin(38400);
Serial.println("<Arduino is ready>");
}

void loop() {
recvWithEndMarker();
showNewData();
}

void recvWithEndMarker() {
static byte ndx = 0;
char endMarker = '\n';
char rc;

while (Serial.available() > 0 && newData == false) {
rc = Serial.read();
if (rc != endMarker) {
receivedChars[ndx] = rc;
ndx++;
if (ndx >= numChars) {
ndx = numChars - 1;
}
}
else {
receivedChars[ndx] = '\0'; // terminate the string
ndx = 0;
newData = true;
}
}

void showNewData() {
if (newData == true) {
Serial.print("This just in ... ");
Serial.println(receivedChars);
newData = false;
}
}
```

V. EXPERIMENTAL RESULTS

The experiments about the influence of the distance and the transmission angle between the transmitter and receiver are made in a South-facing room in daylight between 1pm and 4pm without trees in front of the windows. That means there is a direct sunlight through the window.

First part of the experiments, are about how sunlight influences the distance to transmit information. All experiments are made with 90 degree angle (Fig. 8).

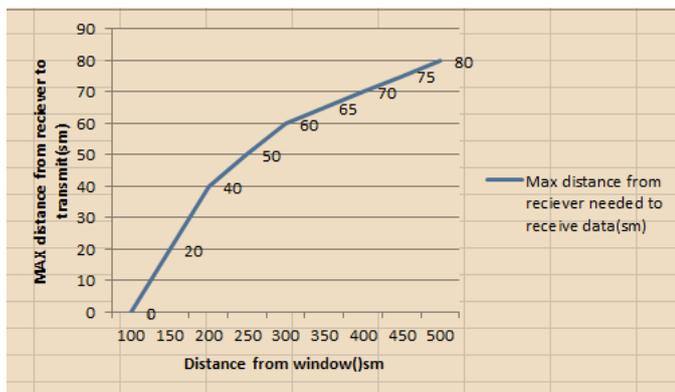


Figure 8. Influence of the sunlight on transmit distance

From Fig 8 can be made the following conclusion that the direct sunlight makes interference that causes 100% lost of transmit data even if the led bulb is on 1 cm from the receiver. When it comes to 2 meters from the window and there is no more direct sunlight we can send data from 20 centimeters and then proportionally the distance between the bulb and the receiver is increased. When it comes to 3 meters from the window it comes to 60 centimeters from the receiver and increases more and more every 50 centimeters moving away from the window it increases by 5. It comes to his maximum 80 centimeters transmit distance from the receiver. This distance is also achieved in condition of fully dark room at night.

Second part of the experiments is about the transmit angle based on fully dark room at night without sunlight (Fig.9).

From Fig.9 can be made the conclusion that under 40 degree angle of transmit we can't receive any data. With increasing the angle of transmit we get better and better distances for receiving data from the LED bulb.

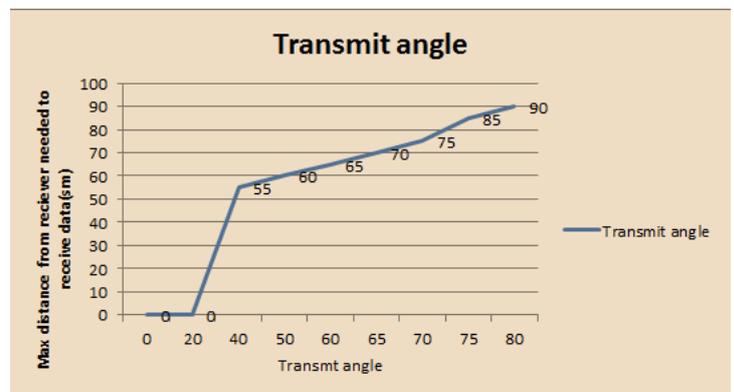


Figure 9. Influence of the transmit angle

VI. CONCLUSION

In this paper is proposed and realized prototype for Li-Fi data transmitting. The model focuses on the influence of the distance and the transmission angle between transmitter and receiver in Li-Fi communication. After the made experiments are found the prototype limits for maximum transmit distance and angle of transmit, and how the sunlight affects them.

VII. FUTURE WORKS

For future researches are planned to investigate how this prototype will transmit data through glass surface and how it will work in water environment.

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Social Media Changing the World

Theory and Practice

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Abstract - Social media refers to the means of interactions among people in which they create, share, and/or exchange information and ideas in virtual communities and networks. Some aspects of social media show that social media it is about conversations, community, connecting with the audience and building relationships. It is not just a broadcast channel or a sales and marketing tool. Social media touches ethical issues, we can speak about ethics of social media and how it can be used in order to make some idea or problem widely visible. There are already examples where social media had role in creating public opinion and bring some change. We can discuss is it that always right or sometimes is a result of manipulation. Ethical categories as authenticity, honesty and open dialogue can be key for work in social media. Emerging platforms for online collaboration are fundamentally changing the way we work, offering new tools to engage with individuals, communities, colleagues, partners, and the world at large. Social media have become the way to inspire, educate and connect.

Keywords- social, media, ethic, changes, world, collaboration

I. INTRODUCTION

Social media and other emerging communication technologies can connect millions of voices to increase the timely dissemination and impact of information, leverage audience networks to facilitate information sharing, expand reach to include broader, more diverse audiences, personalize and reinforce social and environmental messages, facilitate interactive communication, connection and public engagement and empower people. Social media are also important part of life of young people, thus youth workers and organizations should move to the place where their target groups are and learn to use new technologies for good of their communities.

II. WHAT PEOPLE ARE SAYING ABOUT SOCIAL MEDIA?!

A. Books and authors in the filed of Social Media

Guy Kawasaki's in his book “The Art of Social Media: Power Tips for Power Users” is saying: *The biggest daily challenge of social media is finding enough content to share. We call this ‘feeding the Content Monster.’ There are two ways to do this: content creation and content curation.*¹

Also he is mentioning that: *Content curation involves finding other people's good stuff, summarizing it, and sharing it. Curation is a win-win-win: you need content to share; blogs*

*and websites need more traffic; and people need filters to reduce the flow of information.*²

In the book “Social Media Analytics: Effective Tools for Building, Interpreting, and Using Metrics” Marshall Sponder explains that practically overnight, social media has become a critical tool for every marketing objective—from outreach and customer relations to branding and crisis management. For the most part, however, the data collected through social media is just that: data. It usually seems to hold little or no meaning on which to base business decisions. But the meaning is there . . . if you're applying the right systems and know how to use them.

With Social Media Analytics, you'll learn how to get supremely valuable information from this revolutionary new marketing tool. One of the most respected leaders in his field and a pioneer in Web analytics, Marshall Sponder shows how to:

- Choose the best social media platforms for your needs
- Set up the right processes to achieve your goals
- Extract the hidden meaning from all the data you collect
- Quantify your results and determine ROI

Filled with in-depth case studies from a range of industries, along with detailed reviews of several social-monitoring platforms, Social Media Analytics takes you beyond “up-to-date” and leads you well into the future—and far ahead of your competition. You will learn how to use the most sophisticated methods yet known to find customers, create relevant content (and track it), mash up data from disparate sources, and much more. Sponder concludes with an insightful look at where the field will likely be going during the next few years.

Whether your social media marketing efforts are directed at B2B, B2C, C2C, nonprofit, corporate, or public sector aims, take them to the next step with the techniques, strategies, and methods in Social Media Analytics—the most in-depth, forward-looking book on the subject.³

Reviewers for Sponder's book are going in some of these directions:

² <https://www.goodreads.com/work/quotes/42819808-the-art-of-social-media-power-tips-for-power-users> / <01.05.2018>

³

https://books.google.mk/books/about/Social_Media_Analytics_Effective_Tools_f.html?id=83AVmMiEiKAC&redir_esc=y <02.05.2018>

¹ <https://www.goodreads.com/work/quotes/42819808-the-art-of-social-media-power-tips-for-power-users> / <01.05.2018>

“Two or three years from now, every public relations firm that wants to be taken seriously in the C-suite and/or a lead marketing role will have someone like Marshall in its senior leadership ranks, a chief analytics officer responsible for ensuring that account leaders think more deeply about analytics and that the firm works with the best available outside suppliers to integrate analytics appropriately.” Paul Holmes, The Holmes Report

“Marshall has provided much-needed discipline to our newest marketing frontier—a territory full of outlaws, medicine men, dot com tumbleweeds, and snake oil.” Ryan Rasmussen, VP Research, Zócalo Group

“Marshall Sponder stands apart from the crowd with this work. His case study approach, borne of real-world experience, provides the expert and the amateur alike with bibliography, tools, links, and examples to shortcut the path to bedrock successes. This is a reference work for anyone who wants to explore the potential of social networks.” W. Reid Cornwell, Ph.D., Chief Scientist, The Center for Internet Research

“Marshall is a solutions design genius of unparalleled knowledge and acumen, and when he applies himself to the business of social media, the result is a timely and important commentary on the state of research capabilities for social media.” Barry Fleming, Director, Analytics & Insights, WCG, and Principal, DharmaBuilt.com

III. PRACTICAL EXPERIENCE

The Youth in Action programme, which ran from 2007 to 2013, aimed to inspire active citizenship, solidarity and tolerance and involve young people in shaping the future of the European Union.

Youth in Action (YiA) promoted mobility, non-formal learning, intercultural dialogue and inclusion, primarily among people aged 13-30 and supported youth workers and civil society organisations through training and networking.

The programme supported around 8,000 projects and provided opportunities for around 150,000 young people and youth workers every year.

An overview of YiA, covering the period 2007-2011, outlines the programme's key achievements.

The Commission also carried out a major survey (171 kB) in 2011 to assess the impact of Youth in Action projects.

Among the young participants:

67% said their job prospects increased thanks to their YiA experience.

Among the youth workers:

92% said they acquired skills and knowledge they would not have gained through projects organised at national level.

86% said would now pay more attention to an international dimension in their work.

Among the youth organisations:

90% said participating in YiA increased their project management skills;

89% said it increased their appreciation of cultural diversity.

Since 2014, Erasmus+, the new EU programme for education, training, youth and sport, continues to offer similar opportunities in the areas of youth and non-formal learning.⁴

A.

Project title: TC The Voices of freedom

Project acronym: TCVoF

TC The Voices of freedom is follow up project. This is a project for the fundamental changes that are happening in today's world with the emerging platforms for online collaboration. This tools are offering new ways to engage with individuals, communities, colleagues, partners, and the world at large. Social media has become the way to inspire, educate and connect. This is a training course for youth workers, youth project managers and volunteers that will introduce them to the contexts, forms and tools of social media. Main aim of this course is to equip learners with the knowledge, critical thinking ability, and practical skills they need to improve the effectiveness of their work and meet the personal, professional, and civic challenges posed by social media. Program includes a mix of hands-on, practical tuition together with theory, case studies and strategy tips. Participants will discover the possible pitfalls of using social media, learn appropriate etiquette, and look at examples of how to best construct and spread their messages to get results. With help of practical group and individual exercises blogging, micro-blogging, document, image and video sharing applications, social networks and social bookmarking will be explored. Learners will become familiar with a range of online communication tools, analyze their uses and implications, explore how can social media help non-governmental organizations to increase active participation and citizenship of young people, to foster inclusion, to achieve organizational goals and promote their causes. The knowledge acquired will be immediately applied as participants will develop a concrete social media strategy for their organizations or projects at the end of the course. The TC will be in Borjomi, Georgia from 13-20 June 2014 with 42 participants, trainers and support staff from 15 countries from EEC and EU.

Members of the project have participated in 12 trainings and exchanges under Youth in action programme and have gain very valuable experience in project development. Our team is working regularly on different projects in Georgia and have good experience in project management.

Working with Youth in action and having the possibility to directly apply will only increase our level of participation in the programme and will give us an opportunity to developed even further this area of our work.

In our team we have two member who had an opportunity to participate on a training concerning promotion and marketing of ngos and this project is developed as a follow up. Till now we have finished 3 youth in action project with a great success.

The project:

⁴ https://ec.europa.eu/youth/success-stories/youth-in-action_en <04.05.2018>

- promote young people's active citizenship in general and their European citizenship in particular
- develop solidarity and promote tolerance among young people, in particular in order to foster social cohesion in the European Union
- foster mutual understanding between young people in different countries
- contribute to developing the quality of support systems for youth activities and the capabilities of civil society organisations in the youth field
- promote European cooperation in the youth field

Training was designed to explore uses of online tools in work with young people. It prioritizes European citizenship, participation, entrepreneurship and inclusion. Group will discuss utilization of social networking tools to increase the youth participation in the civic life, in the system of representative democracy, and to provide greater support for various forms of transnational action. Participants will learn to use social networking tools for maintaining partnerships, promoting causes, developing innovative solutions, and thus gain also competencies that foster entrepreneurship. As follows, we've formulated a learning objective:

-To establish a common framework within which social networking sites can be used safely and efficiently in youth work and social inclusion practice, youth educational and participation programs, youth research and policy.

Course contributes to developing capabilities of youth organizations. Participants will explore the potential of social media and their importance for NGOs, learn new tools that can be adapted for different contexts and needs, principles of social media for social change and gain a better understanding of how to use new technologies for learning. Thus our other objectives are to increase participants' abilities to:

- Understand the underlying principles of social media to engage with their target audience;
- Use social media tools to improve efficiency, effectiveness and outreach of their work;
- Create compelling web content and increase online presence of the organization;
- Formulate and evaluate a communication strategy that combines the key social media networks and tools;
- Recognize the importance of intellectual property, security and privacy issues in relation to social media.

Course will foster understanding between young people in different countries, as chosen methods contribute to the youth participation in the civic life, in the system of representative democracy, and to provide greater support for various forms of transnational action. Participants will learn to use social networking tools for maintaining partnerships, promoting causes, developing innovative solutions, and thus gain also competencies that foster entrepreneurship. As follows, we've formulated a learning objective:

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- Formulate and evaluate a communication strategy that combines the key social media networks and tools;
- Recognize the importance of intellectual property, security and privacy issues in relation to social media.

Course will foster understanding between young people in different countries, as chosen methods contribute to the development of participants' intercultural communication, teamwork and cultural expression skills.

Course consists of four thematic blocks, all of them related to media and communication, and part of them - to cultural influences on media content and vice versa, production of creative media content, cultural expression and social media:

1. BROAD PICTURE - exploring important concepts and trends that stem from using new technologies. What is networking society? What is new media participatory culture? What is social networking site? Why do young people flock to these sites? What are they learning from their participation? How social media are changing participation and citizenship?

2. TOOLS - learning about various social media technologies, their functions and capabilities. Participants will exchange best practices, formulate tips and tricks, learn to produce content for internet, to use different engagement and promotion strategies and facilitate online conversations. 16 online communication platforms will be revised: social networks, reviews and ratings, video sharing, document sharing, events, music, Wikis, picture sharing, online forums, social bookmarking, blogging, crowdsourcing, micromedia, social aggregators, widgets and feedback tools.

3. USES - practical methods to employ social media for education, promotion, inclusion and participation. Participants will learn to create social media communication strategy and action plan, to design and maintain online communities, to use social media for organizing a collective action, learn how to establish organizational identity and message, to use digital storytelling for organizational needs, as well as discuss other possible uses of social networking tools and generate specific ideas how and for which purposes particular online technologies might be used.

4. SOCIAL MEDIA MONITORING AND EVALUATION - participants will learn to create listening dashboards, explore

content syndication tools, learn to use technologies for monitoring environment, receive feedback, identify trends and hot topics to discuss.

This project is a follow up project and the idea was developed in cooperation of 9 promoters that participated in the first edition of the project, other partners were involved using our existing professional networks. Host organization will be in charge for coordinating cooperation and communication among partners and for logistical arrangements, cooperation with local community, work with local media. Other two promoters will facilitate learning program. All partners have equal responsibility for selecting and preparing participants, providing course's visibility, disseminating and exploiting its results, implementing follow-ups. Roles and responsibilities, aims, values and principles of partnership will be described in internal agreement that has been prepared during preparation of this application.

PREPARATION ACTIVITIES - analysis of participants' needs, motivation and expectations using information provided in their application forms, informing local institutions and media about the project, adjusting the program, logistical arrangements. In addition participants will have a home task to create their personal blog, Twitter, Facebook and LinkedIn profile, start to put content in these media and follow social media of each other. Project group page on Facebook will be created.

IMPLEMENTATION - Course will start with ice-breaking and team building activities, discussing important concepts and trends will follow. Then participants will explore usage options of different social media tools, move on with learning to create social media strategies, communication campaigns and policies. Program will be concluded with discussion on ethical, legal and safety issues.

EVALUATION - course includes several mid-term evaluations, final evaluation with group of participants and final evaluation with partners that will be done after discussing training experience with participants and implementation of follow-ups back in participants' countries.

Participants improved life-long learning competencies that are important in their professional work and civic activities - communication in mother and foreign language, civic skills, cultural awareness and expression and especially digital competence: knowledge of the role and opportunities of information technologies, awareness of issues around the validity and reliability of information and of the legal and ethical principles involved in the interactive use of new technologies, skills to use tools to access, monitor and produce complex information, to use technologies for harnessing innovation and critical thinking, interest to engage in communities and networks for cultural, social or professional purposes. Increased professionalism in organizational and project management, increased organizational capabilities should result in expanding scope and influence of work of volunteers and their organizations.

Participants shared with their colleagues gained knowledge and skills, and promoters will become more efficient in online communication, in engaging and communicating with wider

publics, in developing social media strategies and start to exploit useful online tools organizations did not know before. Participants provide multiplier effect and sustainable impact of the training, as during the course they will develop social media strategy for their organizations or projects and put it into action back home.

The intention is to continue cooperation among involved organizations. We will encourage the participants to exchange ideas for common future projects. Special focus will be putted on developing new pedagogical approaches that would utilize potential of online communication, also computer games that can serve for learning purposes and be attractive means for engaging youngsters in third sector activities. Experience of this training will be used also to develop short local trainings about social media. Learning process were documented in photos and video blog, thus the results of the project, learning conclusions and outcomes will be distributed on a regular basis using social media. During the course and after its completion participants will be invited to share links to various materials produced during the training also in their personal internet pages and networks, thus the information will be disseminated also outside the participating organizations.

One of the program elements is learning to use wikis - websites whose users can add, modify, or delete its content via a web browser.

Participants used gained contacts for developing further project ideas and continuing exchange of experiences, best practices and ideas. Improved intercultural competence will be useful in their work when managing international projects, cultural knowledge will be distributed within participating organizations and communities of the participants.

How Social Media is Changing the World



Figure 1. How Social Media is Changing the World

B.

Project title: TC Knowledge 2020

Project acronym: Knw2020

TC Knowledge 2020 is a TC whose main project goal is to support the development of basic knowledge and experience in the domain of entrepreneurial business and entrepreneurial culture, with the young, as one of eight key elements in the development of civil society based on learning and education.

Specific goals: Initiating the development of entrepreneurial spirit and entrepreneurial atmosphere amongst young people so that they would become active citizens in their own community, Helping young people to develop personal qualities such as self-initiative, self-confidence, innovation and creativity, ability for a team work, responsibility, willingness to take a risk and motivation for achievements, Getting knowledge and skills needed for development of a business plan with its key elements, Reducing unemployment with the young as the social category with the highest risk for poverty and social exclusion.

Key topics are: Significance of development of small and medium enterprises for the economy of the community, team work and the ability for team work, changing of established mental habits, developing the potential and creativity in thinking through creative work techniques, elements of a business plan, development of a business ideas, personal qualifications knowledge, skills, people network, product service matrix, reasons for purchasing, competition, profitability assessment; Need for investments, fixed costs, operating budget, financial sources; critical factors, list of liabilities.

Activities are implemented by active work methods – through workshops, working in groups and in a team on group assignments as well as resolving problems, group discussions and presentations. All activities are to receive media coverage. Project duration is from 13-22 June 2014 in Borjomi, Georgia with 44 participants, trainers and support staff coming from Georgia, Armenia, Azerbaijan, Ukraine, Bulgaria, Lithuania, Turkey and Poland.

Statistics show that in most European countries the highest unemployment rate is with in the young. Also, the realistic employment offer, especially after the great economic crisis, can not respond to the challenge of high unemployment rate. In the sector of the large companies the crisis is particularly high. The solution to youth unemployment lies in the entrepreneurial activities of young people and development of the economy based on innovation as opposed to economies based on resources and efficiency. Since social actions aimed at helping young people to increase their capacity for employability, especially through the empowerment of small companies, are not enough, our project empowers young people to take initiative considering their own employment as well as reducing poverty and marginalization of youth. The paradox is that the youth potentials in most countries are actually much higher than the current situation shows. Young people have creative and innovative potentials higher than the older; they are more willing to learn and are open to change. They are carriers of change and European activism. If their activism and promotion of European values reduces their main problem - unemployment, then they are multiply motivated promoters and activists. Development of entrepreneurial knowledge and skills of young people will help that the capacities of youth for self employment, particularly those from marginalized groups, become higher and a real way out of poverty and marginalization.

The basic idea of the project is active participation of the young people in solving one of their key problems - unemployment. By gaining knowledge, skills and attitudes related to the field of entrepreneurship and entrepreneurial culture which implies innovation, creativity, taking responsibility and willingness to accept changes as well as taking a risk, young people become bearers of positive changes that make the opportunity for development in both urban and rural areas of the European continent and promote the basic values of the European civil society. Youth workers and those working with young people after the final training in their communities become promoters of the idea of active participation in reducing their own poverty by increasing their own capacity for self employment and employment. They educate the youth in their community, encourage them, especially the young people from multiply marginalized groups so that the issue of their own employment and reduction of poverty is solved by the active building of capacity and contribution to sustainable development of their own communities at the same time. Also, young people and those working with them become empowered to lead a competent communication on the subject of employment of the youth with youth policy and decision makers in their communities from local to national level. Through entrepreneurship training, participants master a set of skills that open the possibilities for new numerous projects under the Youth in Action programme and Erasmus +.

We have cooperation with some partners from earlier projects, and we have found other new partners thanks to the recommendations of some organizations in Georgia. We established the communication before writing of the project in order to agree on the topic and their interest to participate in the project, as well as their ideas and recommendations. All organizations that were selected as partners actively participated in the writing of the project. During the preparation, project and evaluation, all partners will be involved in all aspects of the work. In the preparatory phase each partner will be responsible to prepare their participants to come to the training. Participants will have to prepare themselves on the elements foreseen for the workshops for youth entrepreneurship, before the beginning of the training. The preparation will concern also the identification of forces for future projects on which the training will dedicate specific sessions. With the starting of the workshops we will try to give possibility to youth to realize that from passive observers in the economical way, they should change with activism and active participation in economic movements in their countries and in Europe. Our activities will contribute to optimistic viewing of the problem of unemployment and the key is to change the perspective of a young person towards this problem. In the following days we will put a focus on team work as an important factor of professional and entrepreneur development. The following training activities encourage participants to teamwork as a key factor for business success to the second part of the press for the adoption of technology and the development of business ideas that work to increase the sensitivity to the needs of people from the environment

which could be met by developing products and services, through the review of personal protection and abilities to develop a product or service to test the feasibility of monetary business ideas and plans.

Listening to the needs of young people, we came to the joint conclusion that young people are very disappointed with their position in society and want something for yourself to take to improve their position. Capacity building for the employment of young people increase their chances to meet many of your needs, from basic needs for survival to a whole range of other important psychological needs, including the need to integrate into the community and an active contribution to the development of the community. Training topics promote the capacity of young people for employment primarily by changing attitudes towards the development of the initiative, personal responsibility, caring about their competence and the need to develop one.

Part of this TC are already actively indirectly involved in creation of this project through the representatives of their organization that were involved in writing process. Our working method put trainers, facilitators and resource persons in horizontal level with participants and that approach give space to participants to have influence to flow of the project during the whole duration. In follow up activities we expect that participants will become main actors, to take initiative and continue to carry out "fire" of knowledge.

Working methods encourage the development of positive changes in participants active at all times: - they are involved in problem-solving tasks, making decisions by consensus within the team, in the simulation development of specific business ideas from its origins to its financial framework, the presentation of the plan to the representatives of various interest groups, and devising fairs, business ideas that represent the local community establishing cooperation with njom. Teme and synergistic method leaves a strong impression on the participants who are working in their communities to educate young people and to promote ways of solving the problem of youth unemployment through innovative entrepreneurial approach.

Project reflects intercultural dimension, on first place by the meeting of people coming from countries with strong cultural, geographical, economical, political and other social differences. Intercultural dimension will also be ensured by intercultural sharing during the activity, not only during intercultural evening, but also by sharing knowledge and approaches that depends very much of each national, regional or local context, or political and social environment. In fact a specific workshop will be organized in order to give to participants the opportunities to discuss about the relationship among different cultures and social contexts around Europe, and their importance for the inclusion, promotion of tolerance and fight against any kind of discrimination on which the partners are working since long time in their local environment. This aspect is important especially for those partners from countries coming out from conflicts. We will research different attitudes around Europe by personal engagement, giving intercultural dimension to our daily work.

Young people who participate in the project should become aware of their intercultural dimension. The project will stimulate awareness and reflection of differences in values. Young people will be supported to the respect and sensitivity of looked points of the challenges, which will perpetuate inequality or discrimination. Intercultural working methods will be used to enable project participants to the participation on equal bases.

We can not expect that with one exchange we will make a large turnover and break all prejudices, but one small step that will make young people to review their thinking and attitudes is enough.

This project is a good example of representing an European dimension. Project offers an informal-learning opportunities to all partners in this project. Project is preventing xenophobia. The new experience will be added to local community life through involving a foreigner from other culture. The fear against foreigners will fall and the interest towards other countries will raise. The youngsters world view and knowledge will widen. The interest towards other cultures living in Europe is raised and knowledge will increase. We are based on that the project will have strong "European dimension" and to stimulate thinking about European society in development and its values.

European dimension is a broad conceptual term. To emphasize this concept, we'll try to offer youth a chance to identify mutual values which are shared with young people from different countries no matter on their cultural values. Project will stimulate youth to think about basic characteristics of European society and above all, encourage them to play an active role in their own communities. To feel like true Europeans, young people must be aware of the fact that they play a role in building Europe now and in the future. Because of all that, project with European dimension shouldn't only "reveale" Europe, but also has as a goal of building it – which is the most important of all.

The project itself should not have impact only on the participants directly involved in it, but also on all who come in contact with the project. We expect the young people to expand the knowledge acquired in the training course in their local areas and to be, in a way, peer educators. We hope that this project will only be the first step in a series of planned joint projects and upgrading of the topic. Even now, while writing this project, partners think about its continuation and further step which would take place in another country. Depending on its success, we wish to include in the future another partner country.

We will pay special attention to the very visibility of the project and the entire program Youth in Action and Erasmus+. All of our activities so far have been accompanied by media and we have always printed material so this time it will not be left off, as well. We will particularly emphasize the fact that we come from a small environment where young people do not have too many opportunities to get acquainted with the program and the possibilities that it offers so that we will give our best to make it visible and accessible. Prior to the beginning of the specific activities we will keep a news

Modelling the Quality of User-perceived Travel Experience

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Abstract—The conventional evaluation of transport systems considers the travel time as one of the largest costs of transportation. In this way, the traffic congestion has a negative impact on the economy and on the quality of citizen's lives. By having a more accurate and on-time information on the travel conditions simply by using the mobile services (e.g. suggesting alternative routes), citizens can avoid the traffic congestion. Depending on the context of travelling the passenger's travel time can be subjectively experienced as valuable time. In this direction, this research will find out how passengers perceive that a particular travel time brought a value for them. To be able to understand the end-user perceived travel experience we have proposed a concept of using the mobile sensing capability of travellers smartphone devices to be used for tracking and reporting the value of travel. This new concept will give multidimensional aspect to the value of a travel time for the end users. The main aim of this paper is to understand the individual preferences, behaviours and lifestyles that influence travel and mobility choices. In other words, what does the value of travel time mean for the end users, in relation to their quality of travel experience? The proposed model will identify the most influencing factors that have an impact on the quality of travel experience.

Keywords- travel time, travel experience, mobile sensing, perceived quality, value of travel

I. INTRODUCTION

The existing services of a sustainable *Intelligent Transportation Systems* (ITS) mainly aim to make traveling safer, comfortable and environmentally friendly. These providers are in constant search for appropriate tools that will help them to determine and measure the traveller's satisfaction. In this regard, service providers use empirical research, which consists of questionnaires and user opinion surveys, for the offered travel services. These empirical methods are using quality ratings on a certain scale, such as *MOS scale*, or a qualitative feedback description provided by the respondents. After finishing the survey, the ITS providers usually conduct a cost-benefit analysis on the collected public opinion data. The ultimate goal is to form a complete assessment of the customer satisfaction degree on the offered travel services.

The development of the mobile technology and ICT can significantly increase the passenger's flexibility and mobility. The variety of mobile applications improves the social interaction, working habits and enjoyment, leading towards more ubiquity. Availability of mobile services gives more

opportunity to leverage the quality of time spend in travelling. In this way, the envisioned solution *Mobility as a Service* (MaaS) will be the basis for the development of *smart cities*. Certainly these services will need a metrics for quality perception that takes into account the needs of the citizens.

From the perspective of *citizens*, this research will provide an insight on how citizens can *actively engage and contribute to estimating the quality of travel time*, hence providing useful feedback to mobility stakeholders (public and private ones) on the development of smart mobility infrastructure and services. In near future, each individual will have a *personalized* user profile with *customized travel preferences* and a possibility to express its *perceived quality expectations*. By collecting and analysing a rich dataset obtained via smartphone applications, citizens will have a better understanding of their time spend while traveling and a visual presentation of their *mobility behaviours*.

Furthermore, the proposed research will study the short commuting distances, which have been neglected by the standard survey approaches done for a specific traveling modes. Another important aspect concerns the collection of data on the whole journey experience, including planning (i.e. *door-to-door*) and covering data on the multi-tasking activities while traveling, waiting and arriving at the destination. This is a new trend, since in the past the focus was on travel time to destination and activities at destination (based on a given travel purpose).

Travellers needs and preferences change, meaning that some aspects, such as comfort and enjoyment are more meaningful to some, whereas others prioritise availability of services, which provide more efficiency or productivity. Moreover, the value of time spent while traveling has a subjective dimension and it can change based on the endogenous and exogenous factors. The main challenge of this research was to study and understand the traveller's attitudes to both mobility and travel time. This has contributed to advance the research on *Value of Travel Time* (VTT) by introducing a conceptual framework for the estimation of perceived quality at an individual level based on the value proposition of mobility. In order to study and understand the traveller's attitudes to both mobility and travel time, the *MoTiV* (Mobility and Time Value) project has been founded by the H2020 programme.

The research conducted in this paper will be used to refine the proposed conceptual framework for the estimation of VTT

grounded on the notion of *Value Proposition of Mobility* (VPM). The VPM perspective is based on the idea that each transport mode, or combination of transport modes, provides a different value proposition to the traveller in a specific mobility situation. Time and cost savings represent only two of these factors, not necessarily the one contributing the most to VTT. Depending on the situation, other factors such as increased comfort or well-being may influence traveller's choice as much as or more than time and cost, therefore considered more valuable.

In this paper, Section 2 provides the background information on value, utility and human experience. Section 3 describes the used travel time metrics in this research. The travelling concepts and definitions declared are given in Section 4. The benefit of using mobile devices sensors to track the user experience is presented in Section 5. Section 6 describes the citizen's involvement in data collection process. Finally, Section 7 describes the potential benefits on using the research outcomes in the given project.

II. RELATED WORK

Research on decision-making in intelligent transport systems has been conducted using economic decisions scenarios can also be used as a theoretical framework to better understanding user's motivations and preferences in other contexts, including transport and mobility. However, the value from a traveller's perspective cannot easily (not objectively) be quantified in monetary terms. In this sense, Kahneman, Wakke, and Sarin, in [1], elaborate on the definition of the utility of an action in terms of the pleasure or pain obtained, and proposes taxonomy of four types of utility.

Experienced utility (or instant utility): the moment-to-moment hedonistic reward of an experience while it is being experienced, therefore measured in real time. The experience includes events that involve individuals in a personal way and therefore experience is memorable, which is different from commodities, goods and services. Therefore, science introduced the *Quality of Experience* (QoE) as a measure designed to measure how good a service is offered from a user's point of view and not only from a technical point of view, as it is currently done by the providers [2]. In this way, the *quantification of end user experience* expressed with the QoE metric will deliver improved understanding of relations between the subjective citizen's perception and objectively measurable quality standards [3]. The proposed QoE framework for evaluating the perceived quality, in [3], will provide improved estimation on the *quality of travel experience*.

Remembered utility: the memory of the hedonistic reward obtained from a past experience. Although intuitively one may think that the way we experience events when they are occurring and the way we remember them is quite similar, research has demonstrated that there are important differences between them. For instance, the hedonistic value remembered from an experience is not the average hedonistic value experienced during the experience, but it is commonly calculated as the mean between the most salient moments of the experience (i.e. the most pleasurable or unpleasant moments or *peaks*), which is called the *peak-end-rule*.

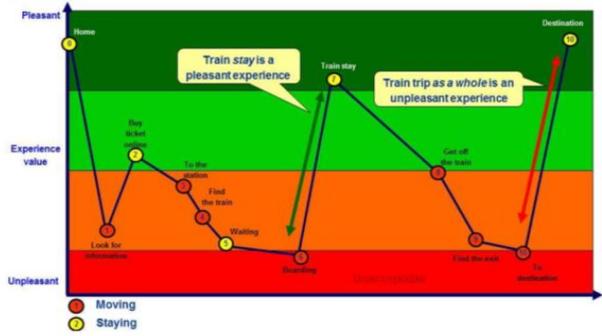


Fig. 1. How peak experiential value affects the overall traveller's experience [5]

Relatedly, a duration-neglect heuristic may affect the way the duration of the pleasurable or unpleasant outcomes of the experience are weighted and recalled [4]. This concept is well illustrated in Fig. 1.

Predicted utility: the expectation of how rewarding (pleasurable or painful) an experience will be. Research on social cognition shows that, when evaluating the hedonistic properties of future experiences, we create mental simulations (or previews) of them, and we use such simulations to analyse how we would feel during experience and to make our judgments on their hedonistic qualities [6]. Such previews are not perfect simulations of the future experience, but they are constrained by limited cognitive capacity [7] and cognitive biases, and therefore tied to systematic sources of error. Specifically, previews of future events are essentialized, unrepresentative, truncated, and are also problematic when comparing dissimilar contexts (for details, see [6]).

Decision utility: the hedonistic utility of a certain option as assessed during the decision and it is intrinsically connected to predicted utility [8], [1]. In the case of transport, decision utility usually refers to travel mode choice, whereas experienced utility refers to travel satisfaction [9].

The distinction between different types of utility is crucial, since there is empirical evidence that the predicted, experienced, and remembered utility of a same event may vary considerably due to the presence of diverse cognitive biases. In this research all these forms of utility are of interest, but will be measured differently (e.g. experienced utility, with contextual notifications and user feedback; remembered and predicted utility, through user surveys to be filled at the beginning and during the data collection; and decision utility, through automated collection of mobility and behavioural variables associated to transport and mobility choices).

III. TRAVEL TIME METRICS

Have you ever considered how productive is the time that you spent while travelling? Traditional approaches treat the time spent travelling as separate value from the time spent undertaking activities carried out at origin or destination. In this way, the trip-based approach considers the travel time has a negative value because it is associated to non-productive time. However, experienced travellers having an on-time

information on the travel conditions can make their travelling time-gap to be productively spent.

The conventional view of *Value of Travel Time* (VTT) is defined as the cost of time spent on transport. Therefore, studies done in optimization of travel time are intended to re-organisation of transport routes and schedule, without the incorporating knowledge on users' attitudes and choices with respect to travel time. Confirming that majority of the existing projects normally are aiming at achieving time and cost savings. Moreover, the *Value of Travel Time Savings* (VTTS) is associated to the benefits of faster travel that saves time. From this viewpoint, the enhancement of transport infrastructure to reduce road congestion could be an example of effort to increase VTT. In fact, current VTT definitions and methodologies for its assessment and subsequent recommendations focus on time and cost savings related to the personal "*Travel Time Budget*" (TTB) [10], the amount of time one invests in daily mobility. Less known is instead what value of travel time means for the end users, in relation to their needs, expectations, and lifestyles. For instance, people do not always consider more meaningful or pleasant time that is spent more efficiently or productively. One's time valuation fluctuates, also for the same activity performed in different circumstances: time remains a largely subjective entity influenced by internal and external factors. As perceived quality of time influences individual well-being [11], it is important to understand and reflect on one's own time use, for instance to adjust one's own behaviour and to consider alternative choices that would better fulfill one's needs, goals, and expectations.

The term *Reasonable Travel Time* (RTT) originally appeared in Banister's paper [12] about a shift of paradigm towards sustainable mobility, and subsequent articles by the same author that questioned the pursuit of higher speeds, suggesting that there is a reasonable time travel should take, and reducing travel time should therefore not come at *any* cost (i.e. actual infrastructure investment costs or wider social or environmental costs). In particular, the satisfaction of travellers' needs and expectations during the journey will be quantified by the amount of "worthwhile time" spend while on the move. **The concept of Reasonable Travel Time (RTT) is adopted to both develop the MoTiV conceptual framework and to decompose the multiple dimensions of the VPM into a set of hypotheses to be verified through the MoTiV data collection.** The RTT is a holistic conceptualization of travel time that essentially is composed of three elements, to be seen as combined decision factors to understand the traveller perspective on time [13]:

1. RTT is about the full *door-to-door* trip, and it therefore includes access, egress, the time spent interconnecting between modes and the issue of the 'last mile';
2. RTT comprises the full *experience* of the trip, beyond the concept of productivity, with a view of the potential to reclaim the otherwise 'lost' or 'wasted' travel or waiting time and turning it into 'free' or 'usable' time, therefore using this time for something 'worthwhile' for the traveller;

3. RTT is also about *activities at destinations*, in the sense that the number of potential available activities and their characteristics at locations - the destinations traveller travels to and through - also matter.

Because RTT is an overarching concept relating to travel time that is both taking an explicit traveller perspective and that is rooted in concepts of sustainable mobility, it is particularly well suited to the objectives of this research.

The transport and mobility domain is well suited to the application of the Quantified Self approach [14], which was adapted already in 2011 to introduce the idea of "quantified traveller" [15]. Therefore, in this research the VTT will be investigated by collecting and analysing a rich dataset obtained via a "quantified traveller" approach, by self-tracking and collection of personal data about mobility behaviours over a prolonged period of time. In this way, it **will contribute to advance the research on Value of Travel Time (VTT) by introducing and validating a conceptual framework for the estimation of VTT at an individual level based on the Value Proposition of Mobility (VPM)**. Introduced by Lugano, in [16], VPM is a perspective on value of travel time that focuses on the "*promise of value to be delivered, communicated, and acknowledged to the individual traveller*". As such, "*The value proposition of mobility is the subjective, dynamic and contextual valuation of available (or preferred) mobility options. This can be regarded as the value embedded in individual mobility choices. As such, the value proposition of mobility is focused on the individual traveller and his/her perceived travel experience*". The perceived value proposition of a certain travel option may not match the actual value delivered to the traveller. When the actual experience has a lower value than the perceived one, this could affect future mobility choices toward the use of other transport modes in similar situations. Knowledge on barriers and factors playing a role in the traveller's choice is therefore key to align expectations and actual experience.

This research introduces an enlarged conceptual framework for the estimation of VTT grounded on the notion of VPM. This multi-dimensional VPM has been mapped with the input on the data collection of mobility and behavioural experience that will be used for the development of mobile application requirements specification. Therefore, different sets of predictors that will determine the needed data will be collected to verify all the hypotheses proposed. The concept of VPM is particularly relevant today, as Internet-based travel planners (e.g. single-mode vs multimodal, local vs national or international), peer-to-peer real-time mobility services (e.g. ride-sharing, Uber), crowd sourced micro-tasks, including delivery of small goods (e.g. PiggyBaggy) and, ultimately, *Mobility as a Service* (MaaS) is shaping and redefining the value of technologies, products, and services, and on the other introducing new actors in the mobility eco-system.

IV. TRAVELLING KEY CONCEPTS AND DEFINITIONS

The term 'trip purpose' (and most models in transport) often assumes one single purpose to a trip, which is in practice rarely the case. A journey can often be justified by a number of purposes where, for example, one activity serves as an *anchor*

to a number of other activities. Similarly, there may also be other activities undertaken 'on the way', implying detours, *transfers between modes*, and *wait times*.

One suggestion is to avoid the term 'travel purpose' (as for the term 'utility') to not give in to the simplifying bias of conventional survey-based economic approaches from the start. Another approach is to talk of travel *purpose*, and adopt the concept of 'primary' or 'anchor' activities, and 'secondary' activities to determine which *activities at destinations* act as main drivers (and time constraints, see next section) for justifying a trip.

An important pre-requisite of this research is to clarify the travelling key concepts and definitions, not all self-explanatory or without ambiguities, that will be employed in the conceptual framework. These are listed below, with a brief description of their related meanings.

- **Trip, travel and journey:** these are regarded as synonyms and used in relation to the main concept of door-to-door trip (one of the RTT pillars). This includes both the time spent in transport ("moving") and the time spent at transfer locations ("staying", which covers waiting, parking, transferring).
- **Trip leg and trip route:** the trip leg is the fundamental unit of the door-to-door trip, which consists of one or more trip legs. Each trip leg is associated with one transport mode only. A trip route is a sequence of trip legs, which are followed by a traveller to reach destination based on personal criteria (trip duration, cost, or even mood etc).
- **Transfer locations and interchanges:** transfer between trip legs takes place at transfer locations, which can consist of any type of interchanges: bus stops, bus and train stations, car- or bike-share parking, hubs, airports etc. Transfer locations and interchanges are used as synonyms. Interconnectivity refers to the ease of connecting between transport modes at transfer locations, which enables multimodal travel.
- **Activities:** it refers broadly to any type of human activity. In the mobility context, activities may be classified as travel activities or location activities.

Travel activities are activities that the traveller engages in while travelling, which includes both activities while in transport or at transfer locations. Some travel activities apply only to certain modes. For example, relaxing while in the train or getting exercise while cycling or waiting for the bus are both travel activities. Travel activities are potentially supported by a range of carried items, such as a book (reading), a mp3 player (listening to music or podcast), or food and drinks (eating and drinking). The traveller may be engaged in one or more travel activities in parallel, which is called multi-tasking, some of which may be more relevant than others (primary, or anchor activities).

Location activities are the range of possible activities available at locations, either while in transfer or at destination, like shopping or playing bowling. Location activities are therefore connected to a location's offering in terms of

infrastructure and services, and constraints, such as opening and closing times. Location activities are usually the purpose of travel.

Travel or trip purpose: a trip purpose is typically understood as an activity at a specific location (i.e. location activity) that justifies the travel such as work or shopping. Accordingly, a trip purpose applies to a whole trip and not to a single trip leg. If a specific purpose is the main reason for taking the trip, it is an **anchor purpose**. In other words, without this purpose, the trip would not take place. Other purposes may be added; they may be secondary or anchor (i.e. two or more reasons justifying a trip). **Secondary purposes** are activities added to a trip: they do not contribute to the justification for the trip itself. In MoTiV, a travel purpose can apply to either travel activities or location activities to acknowledge the travelling as a purpose in itself (e.g. this includes, among others, going out for a walk without any other specific purpose in mind). In other words, a traveller may choose to travel to enjoy the ride or to exercise, which is the value from the time spent in transport for a specific leg (also called intrinsic utility in economic terms). Or a traveller may choose to travel to reach a location to engage in an activity at destination, which is the value derived from the time spent in transport (or derived utility in economic terms). Destinations are a type of location marked by the traveller with at least one anchor purpose.

Activities while travelling are a subset of all activities that one can undertake, e.g. while at home. Each trip leg has a specific measurable duration, called **clock time**. This differs from **perceived time**, which is related to the quality of time experienced from the perspective of the traveller. Perceived time is quantified with the worthwhileness of time invested in activities during the trip leg, see Fig. 2.

Travel experience, satisfiers and dissatisfies: travel experience is affected by multiple factors that can have different impact under different circumstances, thus influencing the overall perceived value of travel time. The focus of the study is on the comfort dimension, it is broad enough to overlap with most relevant dimension of the value proposition of mobility (VPM). In this respect, value may be rather referred to the ideas of pleasant, meaningful or worthwhile travel time [17]. It is worth noting that worthwhile travel time does not exclude the idea that this may be productive, and multiple types of "value" may be associated to each specific journey.

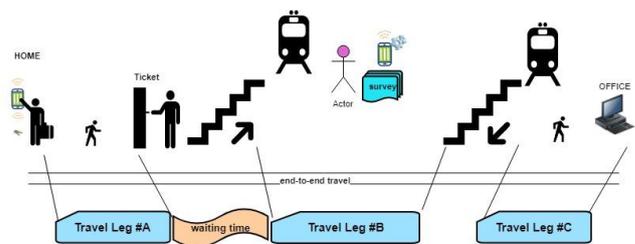


Fig. 2. Established travelling concepts and definitions

V. MOBILE DEVICES USE SENSORS TO TRACK USER EXPERIENCE

Research has acknowledged that digital personal devices have an empowering and emancipatory potential on individuals and self-organising communities [18]. Ubiquitous and high-speed connectivity to social networks and, more generally, to knowledge and services, is felt to have an intrinsic positive effect on VTT (i.e. to increase the marginal utility of travel time) since it allows carrying out productive activities while on the move. Furthermore, the digital personal devices also lead travellers to engage in "travel multitasking" [19], [20], a complex and cognitively demanding task. To make best use of time, a category of apps functioning as personal trackers and often including a "coach" function has emerged.

At a methodological level, the analysis will rely on mobility and behavioural data to be collected throughout Europe via a smartphone app (the MoTiV app) developed within the project, see the proposed model in Fig. 3. The MoTiV app is tailored to the specific project needs and aims at gaining an understanding of traveller's reasons for his/her travel choices in line with the perceived value proposition of mobility. In addition to automatically collecting mobility-related variables, the MoTiV app will also allow users to enter qualitative input both to further edit automatically collected data and to provide additional relevant details on the user (e.g. demographic and socio-economic information), time use and travel experience.

The use of smartphones for collecting mobility and activity behaviour over a rather long period and from a large number of subjects, allows in-depth behavioural analysis that was not possible with traditional survey methods such as paper travel diaries or telephone surveys. Accelerometer data can be used to classify a user's movement activities: Running, Walking, and Stationary [21]. Combining motion classification with GPS tracking can recognize the user's mode of transportation: Subway, bike, bus, car, walk and etc. The transportation modes classification can be done using mobile device low-power-consumption sensors, such as the accelerometer, magnetometer, and gyroscope [22]. Tracking user position data: for calculation of indicators related to the trips. Use of mobile device detection: record when the user is using the device, to understand in which travel situations the user is applying his or her time to use the device.

- **Mode detection:** the app will detect the mode of transport being used by the mobile device user. This will occur on the background (i.e. without need to open the app) and minimum battery consumption, applying open source APIs
- **Surveys module:** provide integration of a survey API through which the user can for instance describe activities carried out while on the move, questions on role of ICT, and satisfaction on mobility choices and time use.
- **Mobility coach:** collecting data from external sources, user past travel behavior, user preferences for travelling, and future trips.
- **Mobility engine:** (1) processing and aggregating the mobile tracking data; (2) user reported data from the trip module; (3) Mobility coach learned data.
- **User profile module:** Provide registration/login and collect and let user manage user profile data, including demographics, travel preference, activity routines and personal attitudes related to travel experience.
- **Trip module:** Automatically detect user mobility data
- **Service engine:** Perform analytics of the collected user data during the campaigns and produce analytics data for the Admin UI and the Insights module
- **Travel planner:** user entering destination, by user entering destination and start location, or by querying with performed start location and destination.

Once knowledge on the motivational factors are gathered, it is possible to go further and explore possibilities to enhance VTT by considering options for optimal time allocation and transport mode(s) fulfilling individual expectations. Group of travellers with similar needs, aspirations, motivations, and expectations are likely to have also a similar general judgment for different transport options. Being a complex ecosystem, there is no single actor in charge of shaping the Value Proposition of Mobility. It is rather a joint outcome of actors co-creating meaning and value to transport and mobility options through policy, implementation, deployment, and participation.

VI. CITIZEN'S INVOLVEMENT IN DATA COLLECTION PROCESS

Transport service providers are in constant search for appropriate tools that will help them to determine and measure the satisfaction of end users. An important aspect of the proposed framework is collecting all possible activities on the whole journey experience, while traveling, waiting and arriving at the destination. In terms of efficient utilization of mobile devices, the background sensors will constantly monitor and automatically detect the different transport modes. The citizen's feedbacks in the mobile app will collect valuable information on the quality of the transport infrastructure, including terminals, waiting stations and accessibility to destinations. In this way, the smartphone can provide personalized coaching recommendations targeted to travellers

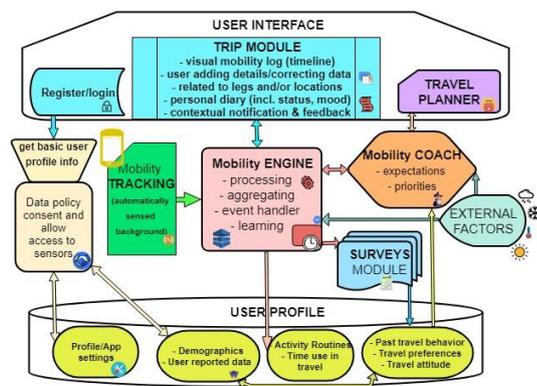


Fig. 3. Basic modules of the proposed MoTiV smartphone app

based on location. The proposed a concept of using the mobile sensing tracking capability and reporting on the activities that bring value to travel time provides understanding the perceived travel experience, see Fig. 4.

Most providers usually collect user data from the systems themselves, depending on how users access the service offered. Example, in relation to the location of the user, the type of the terminal device, the access network, and the application they use. Next, based on the collected set of data, algorithms for data mining are applied to determine and categorize the problems that users most often face. To continuously monitor user problems in this way it is necessary to repeat the data collection process and their analysis. Thus, today there are techniques for processing such a large number of data, known as large data processing techniques. In this direction, an analysis of the user data is made in order to determine the user habits for using certain mobility services.

Thanks to digital devices, smartphones and wearable's in particular, as well as open datasets, it is increasingly easy to "quantify" one's life and to obtain a visual representation of personal activities, including statistics, trends and comparisons to a specific population. Personal data collected by MoTiV application are carefully chosen as important inputs for analysis of value of travel time and in order to keep the principle of data minimization. The data collection will involve tracking of participants for a limited period of time (i.e. at least two weeks). The variables to be collected are mobility-related, activity-related and demographics related data as well as various external influence factors. The purpose of data collection is to collect relevant data from project participants in order to achieve research goal and to analyse value of travel time not only from its economic dimension, but also motivations, preferences and behaviours linked to the broader concept of individual well-being. The personal data will be processed solely based on the consent of data subjects (participants).

Participants in the data collection processes will be clearly informed about the purposes and means of processing by

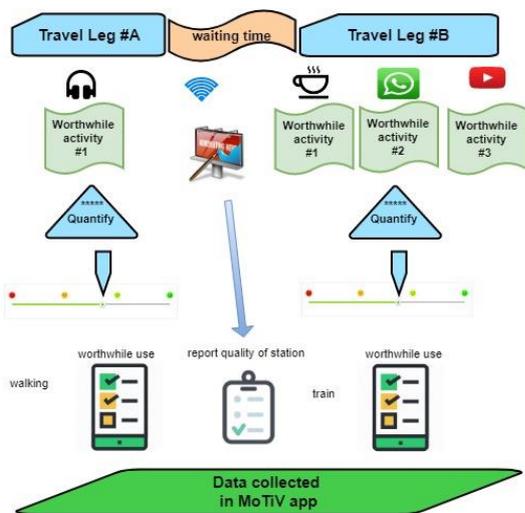


Fig. 4. Citizen's involvement in data collection process.

information sheet and informed consent form that will be all the time available in the application as well published on project website. The participation is always voluntary, meaning that the app will include an option to "stop tracking" and also the possibility to request the deletion of personal data from the server. Participants will have the right to withdraw the consent and participation at any time according to GDPR Article 6 (1) and Article 9 (2) without any consequences. From collected data validation and conceptual framework for the estimation of value of travel time will be determined. Personal data collection is performed only because there is no other way how to achieve the research goal. Furthermore, the research outcomes have given input on the data collection of mobility and behavioural experience that will be used for the MoTiV mobile application requirements specification.

Personal data will be processed and stored only during the time of collection and analysis of data and will be anonymised right after the analysis will be finished. Access to the raw data will be strictly limited, and researchers performing the analysis will have access only to the pseudo-anonymised data. The aim of anonymisation is to render data anonymous in a manner that the individual to whom the data relates is no longer identifiable. On the other hand, the pseudonymisation focuses on the reduction of link-ability of a data-set to not eliminate identification but rather to complicate it. In order to reduce the link-ability, pseudonymisation involves the replacing of names or other identifiers by a pseudonym such as numbers, codes or signs. After the project is completed anonymised data will be made available as an open dataset for further research. It is important that any potential ethical issue arising from the processing of personal data is managed according to the applicable regulatory framework and ethical standards not only in preparation phase, during the project but also after its completion.

The app will combine features of personal mobility/time tracker, travel/activity diary and journey planner supporting a qualitative and quantitative description of the traveller. It is expected that the campaign will involve at least 5,000 participants from at least 10 EU countries. The core personal data (e.g. mobility patterns and citizen behaviors) will be collected in several European countries and metadata via the smartphone app.

VII. CONCLUSION AND FUTURE WORK

This research was carried out in direction of using smart services to improve the process of estimation and delivery of content for mobile users while traveling. In practice, the main outcome of this research was the work done in the field of Value of Travel Time (VTT), in particular on the quality of travel experience. Initially, we identified the main research challenges and the establishment of hypothesis to be verified during the MoTiV data collection campaign, once the MoTiV app is implemented. The citizen's feedback reported in the application will collect valuable information on the quality of the transport infrastructure, including terminals, waiting stations and accessibility to destinations. The gamming user interface and application interaction approach are expected to engage wider population. Improved user acceptance will be achieved with the mobility self-tracking and time/event

triggered surveys that will collect personal data, preferences, and expectations.

The research has contributed to the on-going H2020 MoTiV project, providing valuable suggestions and defining research hypothesis for the refinement of MoTiV conceptual framework. The outcomes of this research will provide a more clear understanding of the human-perceived value of travel time, in relation to their needs, expectations, and lifestyles. This research is strongly related to the general objective of the COST Action CA15212 WG 5, which requires integrating data and knowledge collated through citizen science initiatives and suggest mechanisms for standardization, interoperability, and quality control. Future research will enable the expansion and development of quality perception models to be applied in intelligent transport systems when assessing travel experience.

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An Approach of Modelling of Breast Lesions

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Abstract — The goal of this study is to create and evaluate a methodology for generation of realistic three dimensional (3D) computational models of breast tumors with irregular shapes and import them into real mammographic images. These hybrid images are to be used for development of new breast cancer detection technologies.

Keywords - simulation, irregular masses, breast, tumor, mammography.

I. INTRODUCTION

Breast cancer is the most common heterogeneous malignancy in women [1]. New technologies are constantly under development, which aim to detect and diagnose the findings during screening of the breast as earlier as possible. Development of new detection systems relies on the virtual clinical research, which insist availability of a large number of images with realistic looking pathologies. For this purpose, as realistic as possible models of the breast lesions are needed. Computerized modelling tools and simulation techniques could create data for these needs and replace expensive conventional clinical trials. The goal of this study is to create and evaluate a methodology for generation of realistic three dimensional (3D) computational models of breast tumors with irregular shapes and import them into real mammographic images. These hybrid images are intended for the development of new breast cancer detection technologies.

II. MATERIALS AND METHODS

The overall methodology of creation of mammograms with breast lesions is schematically shown in figure 1. Each part of the block diagram is presented in the following subsections.

A. Methodology for creation of breast lesions

The methodology for the creation of breast masses with irregular shapes consists of two major steps: (a) use of random walks to create the initial diffusive tumor shape, which is realized by either a Brownian motion or by nearest neighbor random walks, (b) creating of a solid tumor shape by applying a set of 3D filters, as well as morphological operations. In particular, the initial diffusive models were smoothed by applying the following image processing methods: averaging, repeated dilatations, morphological opening and closing and final smoothing, all utilized in 3D. Then, the originally created tumor shape is compared to the shapes generated after each step of the methodology, and consequently volumes were visually compared and analyzed. Thereafter, a technique for

embedding of the simulated masses in real tissue mammography images was created and applied.

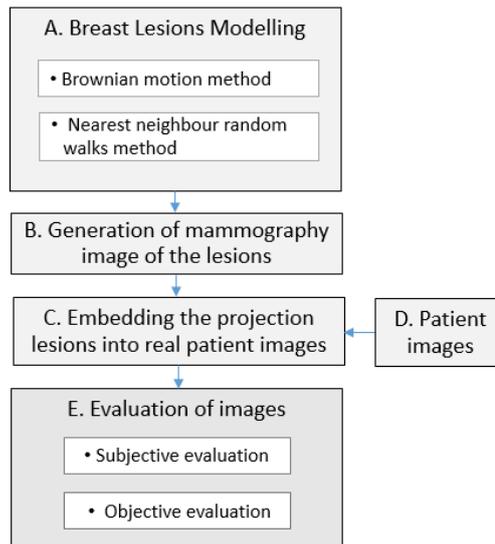


Figure 1: An outline of the process of creation of an x-ray mammogram with a breast lesion.

The *Brownian motion random walk* begins by assigning the central pixel of a 3D array, a value of 1 as a tumor pixel [2]. The tumor size is a function of the size of the voxel matrix and the voxel resolution, defined by the user. The user also assigns a number of random walks. Each random walking process stops either at the matrix boundaries or when the assigned number of steps is reached. The random walk starts from the center of the matrix and each step moves randomly to one of the neighbouring voxels, assigning it as the abnormality composition.

The resulting structure is converted to an abnormality with solid geometry by applying further processing with morphological operations: averaging, dilation, erosion. In these operations, the structuring element is a cube. For instance, the repeating dilation is made with a large cube size (5x5) followed by dilation with a smaller cube size (3x3), while averaging is reached with uniform averaging filter (arithmetic mean). Other morphological image processing methods, closing and smoothing have also cube as a structuring element. Size of the structuring element as well as its shape can be changed.

By changing the number of walks, number of steps per walk, degree of averaging, dilation and erosion, the shape of modelled

tumor is also changed as well the malignancy is also altered. Examples of generated abnormalities are shown in figure 3 a, b and c.

The Nearest neighbor random walk algorithm is based on the model used by Ruschin et.al. [3]. The random walk begins by assigning a value 1 to the center pixel of the 3D array. For each iteration, the nearest neighbor of the pixel chosen on the last iteration, are randomly selected from a uniform distribution and subsequently a non-zero value is assigned to them as a new tumor pixels. The walk is completed when the border of the 3D array is reached. [8] Examples of generated irregular abnormalities are shown on figure 3 d, e and f.

B. Generation of mammography image of the lesions

X-ray projection images of 3D breast lesions were generated by using an in-house developed XRAYImagingSimulator software application [2], capable to simulate the x-ray transport through the computational tumors. The geometry and the parameters of the simulated x-ray imaging are shown in figure 2.

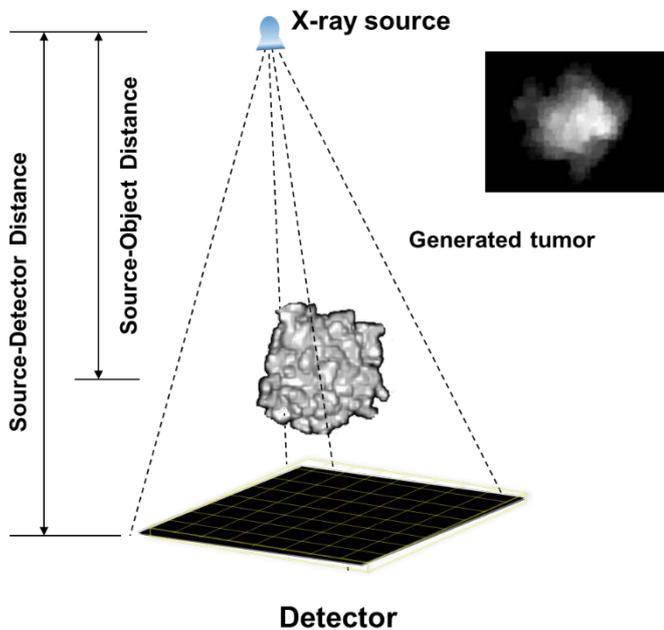


Figure 2: Scanning geometry and parameters. Three acquisitions at 0° (CC), 60° (MLO), 90° (ML) were simulated. Source to detector distance is 800 mm, while source to patient table distance is 600 mm. The insert of this figure shows the simulated projection image of the breast lesion.

X-ray images were simulated for monochromatic x-ray beams with energy of 20 keV. Distances from the source to the isocentre point, where the centre of the tumour was placed and to the detector surface were 600 mm and 800 mm, respectively. The size of the images was 500 x 500 pixels, while the pixel resolution was 0.1 x 0.1 mm. Analytical relationship between the initial intensity of the x-rays and the intensity registered at

the detector is exploited. The transmitted intensity reaching the detector pixel is calculated using the Beer’s law:

$$I = I_0 * \exp\left(-\int_{\parallel} \mu(x, y, z) dl\right) \tag{1}$$

where $\mu(x, y, z)$ is the spatially dependent linear attenuation coefficient, l is the path length through the object and I_0 is the intensity of radiation at the source segment that emits to the area of the detector. The generated images are free of scatter, since they exploit the analytical relationships for x-ray matter interaction.

A more complex level of simulation of the radiation interaction at the absorber and the detector includes Monte Carlo techniques. These are used to calculate the photon transport by sampling the interactions with the matter and the distances that x-rays travel until the next interaction. Since these techniques are time consuming, the use of powerful multi-core computers or cloud computing.

Three mammography views were simulated: mediolateral-oblique (MLO), cranio-caudal (CC), and mediolateral (ML) views, which correspond to 60°, 0° and 90°.

C. Embedding the projection of the lesions within the patient projection images

Anonymized planar and free of breast abnormalities patient images obtained with Giotto Tomo IMS system, were used⁵. The pixel size of the images is 100 μ m x 100 μ m. The created projection image of the breast tumor is then added to the patient image by using the following approach. Initially, patient and lesion images were normalized to their maximal values. Then, the values of the lesion pixels are transferred to the patient images at a position defined by the medical doctors. No further image processing is applied at this stage. The program script implementing the embedding procedure was written in Matlab [5]. Images are then stored in a database and used in the subjective assessment and research and educational activities.

D. Evaluation of images

The realism of the projected breast masses on 2D projection images was evaluated both subjectively and quantitatively. Subjectively, images with embedded projection lesions were visually assessed by a medical doctor involved in screening and diagnosing of mammography images. The focus of the evaluation is the realism of the lesions: brightness, shape, size and location on patient mammogram. For the objective evaluation, the recently developed software application for quantitative assessment of x-ray images was used [6]. Specifically, the tool is used to compute a set of features from x-ray images such as standard deviation, skewness and kurtosis, fractal and spectrum analysis. These features are then compared to features extracted from real patient images with breast lesions.

⁵ All images were acquired with ethical approval and with written consent from women undergoing regular mammography screening.

III. RESULTS AND DISCUSSION

A. Created breast lesions

Thirty irregular masses with different sizes and shapes were generated with the proposed two methodology: 15 irregular masses by using the Brownian motion method and 15 such by using the Nearest-neighbour random walks method. The parameters used for their generation are summarized in table 1 (A and B). Each voxel of the three-dimensional array represents an elemental composition, which can be either air (no abnormality) or water. Water was chosen as an elemental composition to represent the mass abnormality, since their x-ray properties are very similar [7].

The data format used for this representation is 16bit unsigned integer. The size of the three-dimensional arrays varied between 100 x 100 x 100 voxels to 200 x 200 x 200 voxels, which corresponded to approximately 15 and 30 MB, respectively. Number of walks and steps varied between 500 to 2000 and 1000 to 5000. These numbers were found to reflect the variety of the shapes which can be obtained with the discussed algorithms.

TABLE XII. A. PARAMETERS OF THE TUMORS GENERATED USING BROWNIAN MOTION METHOD

No	Parameters		
	Tumor size, pixel	No of walks	No of steps
1	100x100x100	500	1000
2	100x100x100	500	2000
3	100x100x100	500	3000
4	100x100x100	500	4000
5	100x100x100	1000	1000
6	100x100x100	1000	3000
7	100x100x100	1000	4000
8	100x100x100	1500	3000
9	100x100x100	1500	5000
10	100x100x100	2000	4000
11	200x200x200	500	1000
12	200x200x200	500	3000
13	200x200x200	1000	1000
14	200x200x200	1500	1000
15	200x200x200	2000	1000

Examples of generated models of tumors are shown in Figure 3. As was already mentioned, variation of the parameters in tumor-modeling affects the irregularity of the mass. As shown in the figure 3, examples of masses simulated with nearest neighbor random walk look smoother and more benign, whereas those generated with Brownian motion method look speculated and malignant.

TABELE II. B. PARAMETERS OF THE TUMORS GENERATED USING NEAREST NEIGHBOUR RANDOM WALKS METHOD

No	Parameters		
	Tumor size, pixel	No of walks	No of steps
1	100x100x100	500	1000
2	100x100x100	500	2000
3	100x100x100	500	3000
4	100x100x100	1000	1000
5	100x100x100	1000	2000
6	100x100x100	1500	2000
7	100x100x100	1500	4000
8	100x100x100	2000	1000
9	100x100x100	2000	2000
10	100x100x100	2000	4000
11	100x100x100	2000	5000
12	200x200x200	500	3000
13	200x200x200	1000	1000
14	200x200x200	1500	1000
15	200x200x200	2000	1000

1 pixel = 0.1 mm

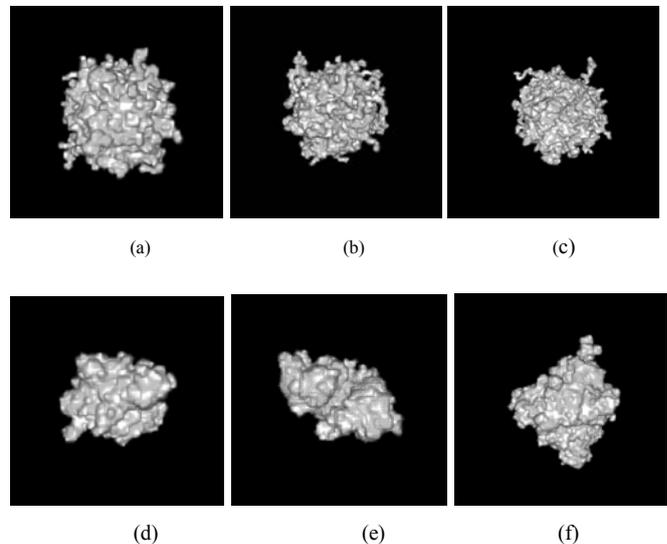


Figure 3: Breast lesion models, generated by (a, b, c) the Brownian motion method; and (d, e, f) by the Nearest neighbour random walks method. Specifically, the lesions in (a-c) correspond to lesions 2, 11 and 14 from Table 1, while lesions in (d-f) correspond to lesions 3, 9 and 14 from Table 2.

The computational time for the generation of the lesions by the two algorithms was similar. For a tumor array of size 100 x 100 x 100 pixels and 500 walks, the needed computational time was around 5 min., while for a tumor array of 200 x 200 x 200 pixels and 2000 walks this time was approximately 15 min. All simulations ran on a laptop configuration RAM 8GB, Processor Intel(R) Core(TM) i5-32320M CPU @ 2.60 GHz, 64-bit operating system.

The biggest generated mass created with the Nearest-neighbour method was 50mm x 50mm x 50mm, and this process took about 11 hours. This tumor-model is shown in figure 4.

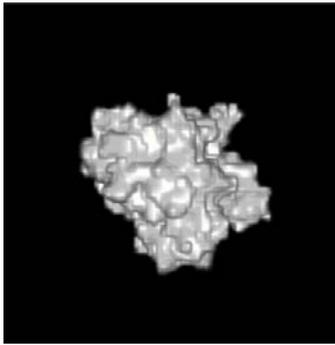


Figure 4: The biggest model 50mm x 50mm x 50mm generated by using the nearest-neighbour random walks method with 500 walks and 1000 steps in each walk.

B. Mammography images

The created three-dimensional lesions were processed with the *XRAYImagingSimulator*, developed in our Laboratory[2] and mammography images at three different mammographic views (60°, 0° and 90°) were received. Two such examples are shown in Figure 5a, b.

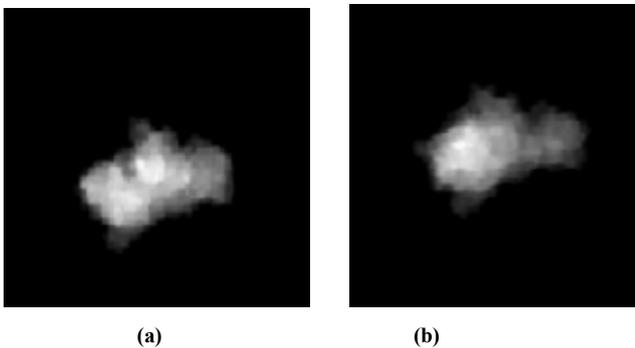


Figure 5: Projection images of two of the generated tumors: (a) Tumor generated with Brownian motion random walk 200x200 pixels, 500 walks and 1000 steps; and (b) Tumor generated with Nearest-neighbour random walks motion random walk 100x100 pixels, 500 walks and 2000 steps.

By using a Matlab script [5], the projection images of the created tumor were mapped to the real mammography images, which are free of lesions. Images are then stored in a database and used in the subjective assessment and research and educational activities.

Mammograms with the inserted projections of the abnormalities are shown in figure 6a, b. In figure 6a, the projection image of the lesion is inserted into a patient MLO view projection, while in figure 6b the projection image of a small abnormality is inserted into a patient CC view.

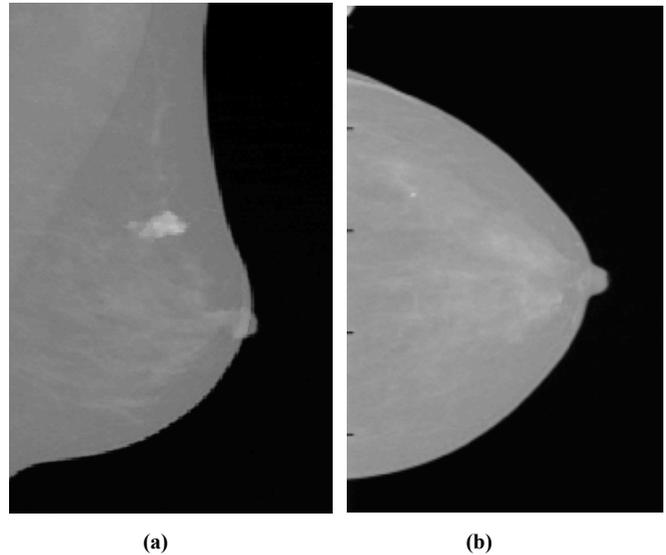


Figure 6: Real patient images with inserted lesions in (a) MLO view and (b) CC view.

C. Evaluation

The generated thirty mammographic projection of tumour images were visually inspected by a medical doctor with experience in mammography imaging. While the realism of the shapes on the image is quite promising, the comments were mainly to improve the contrast appearance of the abnormality as well as to smooth the tumor outlines. Another limitation of the proposed approaches is the long computational time when high-resolution models are to be generated. This limitation may be overcome with parallel implementation of these algorithms or by using cloud technology.

Objectively, four parameters: skewness, kurtosis, fractal dimension and the power spectrum parameter β were evaluated from these images. The skewness and kurtosis were 0.14 ± 0.30 and 2.55 ± 0.29 , while the evaluated fractal dimension was 2.60 ± 0.08 . The power spectrum parameter β was 2.79 ± 0.15 . These values are well within the ranges of values for these parameters, reported by other researchers [9, 10]. Currently, we are collecting patient images with breast lesions which will be used to evaluate these parameters precisely and perform the comparison with the simulations correctly.

IV. CONCLUSIONS

The methodology for the creation of breast masses with irregular shapes will be used to generate unique and at the same time realistic in shape and size computational models of breast adenoma, intraductal papilloma, cysts and duct hyperplasia. These computational models are powerful tool in the hands of all professionals working toward the creation of new technology for screening and diagnosing of the breast.

ACKNOWLEDGMENT

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Three dimensional breast cancer models for x-ray imaging research

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Abstract Breast cancer is by far the most frequently diagnosed cancer and the leading cause of cancer-related death among women worldwide. Despite technological advances, such as the digital mammography, the national screening programs, the introduction of the computer-aided design systems in clinical routine, screening and diagnosing of cancers hidden in breast dense parenchyma still remains a challenging task. The development, optimization and testing of new methods make an extensive use of both physical and computational cancer models. This paper addresses the methods used in generation of models of the breast cancer and their use in emerging x-ray breast imaging. Selected examples are presented from the current work of the biomedical engineering unit at Technical University of Varna, Bulgaria.

Keywords: *physical and computational breast cancerous models, breast imaging techniques*

I. INTRODUCTION

Breast Cancer is by far the most common incident form of cancer for women below seventy years of age with an estimated 1.4 million new cancer cases diagnosed in 2012 (23% of all cancers), and ranks second overall (10.9% of all cancers). Despite the indisputable successes of science in the cancer practice, morbidity and mortality rates are on the rise [1]. Early diagnosis is recognized as a critical factor that improves the chance of survival.

Despite technological advances, such as the digital mammography, the national screening programs, the introduction of the computer-aided design systems in clinical routine, screening and diagnosing of cancers hidden in breast dense parenchyma still remains a challenging task. New methods for early detection and correct diagnosis of breasts are needed. Dedicated machine learning systems may also assist in the detection and classification of the various types of the breast cancers. For this purpose, a large number of images containing different types of benign and malignant formations is required for their development and adjustment. The best approach in this case is to obtain simulated images with breast cancer. Thus, realistic three-dimensional (3D) computational models of the breast tumours are a requirement.

Tumour modelling is an important part of the realistic breast modelling. Tumour models are built to be incorporated into the existing or developed breast models to further allow performing of reliable virtual studies in the field of breast imaging and cancer detectability and diagnosis.

In general, tumour modelling can be performed through two basic approaches: by segmentation of breast lesions from 3D patient images and by using mathematical modelling. The first approach is applied on patient images obtained from breast tomosynthesis and Computed Tomography (CT) modalities, as well as, cadaver samples scanned at CT. The whole procedure usually includes filtering of the original images in order to reduce the noise, binarization of the area of the lesion, applying morphological operations to remove the remaining artefacts and region growing techniques to segment the lesion. This procedure may be also applied to high-resolution 3D microCT images of breast histology samples, followed by image segmentation and further characterizing: sizes, shapes, type of abnormality.

The second approach is the mathematical modelling, which offers the undoubted advantage to parametrically describe the 3D shapes or their generation. The use of mathematical modelling strongly relies on 3D random walks, followed by a set of image processing operations, which aim to deliver a solid based tumour. The level of simulated details is related to the required model complexity and heavily depends on the available computational power.

Researchers from the biomedical engineering unit at the Technical University of Varna has started the development of a database (MaXIMA Project Database) with computational models of breast tumours with irregular and speculated shapes. Research in this group is focused on the development of phase contrast breast imaging, which is a technique under development and may have the potential to add more information on tissue structure, as for example improvement in the visibility of edges. Successful investigation, however, is strongly related to the use of computer models and simulations in studying the feasibility of a given breast imaging technique. Since the model of this new imaging technique was already developed [2], the final key element needed to complete the simulation framework turns out to be the model of the cancer. The availability of such models is a powerful tool in the hands of biomedical engineers, physicians and physicists, which tolls are used in the development of new advanced technologies for precise definition of the boundaries of these cancers. These models offer a flexible, simple and cost-effective way to investigate and optimise different aspects of 2D and 3D breast imaging techniques in respect to cancer visualization and better detection, to perform accurate breast dosimetry, to investigate various computer-extracted texture features for the development of new CAD systems. This keynote speech will

address the methods used in generation of models of the breast cancer and their use in emerging x-ray breast imaging. Selected examples are presented from the current work of the biomedical engineering unit at Technical University of Varna, Bulgaria.

II. METHODS FOR MODELLING OF BREAST LESIONS

a region, containing the breast lesion is selected. A region growing method is applied to segment initially the breast lesion. Finally, post-processing is used to correct wrongly segmented tissue parts. Image processing operations are the following morphological operations: erosion, area opening, and dilation. The order of these operations is based mainly on the experience of the group, acquired after performing multiple tests in various order configurations.

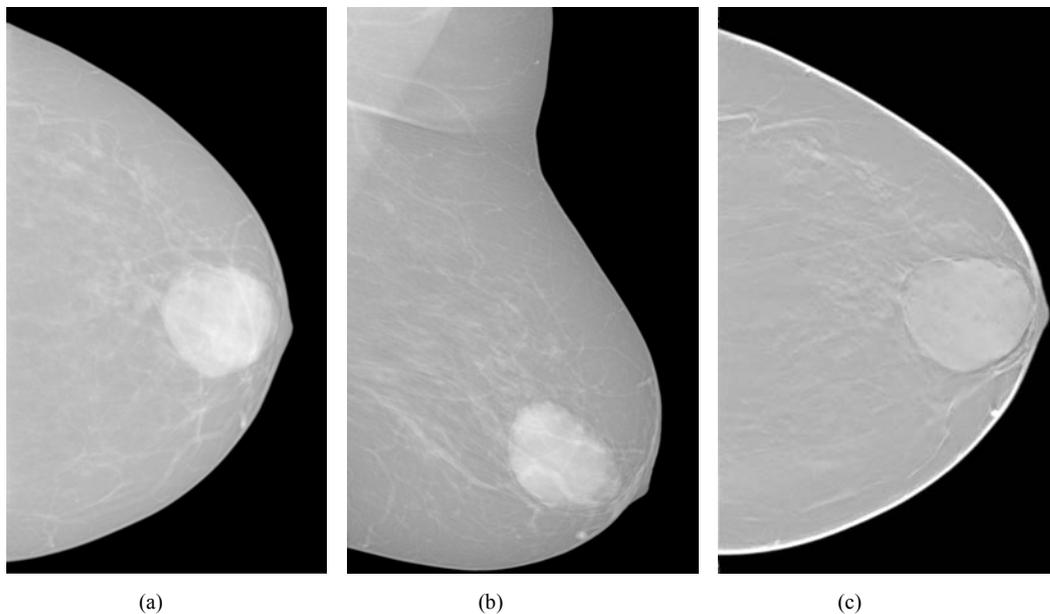


Figure 1. Patient mammography data with a breast lesion: (a) cranio-caudal view (CC), and (b) planar mediolateral-oblique (MLO) image and (c) the respective tomosynthesis image.

Modelling of 3D breast lesions includes two basic approaches: (a) segmentation of breast lesions from patient images and (b) using mathematical modelling.

A. Segmentation of lesions from patient data

Three-dimensional breast images may be obtained from breast tomosynthesis and breast cone beam CT modalities [3], as well as, cadaver samples scanned at CT. The most available data are from breast tomosynthesis, which is currently a very promising techniques used to screen and diagnose dense breasts for low contrast breast lesions. An example of breast tomosynthesis image compared to planar mammography images of the same patient is shown in figure 1a-c.

A general outline of the approach for segmenting lesions from 3D breast imaging techniques is depicted in figure 2. The patient clinical data in the form of 3D image is the input for the algorithm. Before processing of data, a proper anonymizing of patient data is performed. Filtering of data is necessary to remove the artefacts due to the reconstruction algorithm. Then,

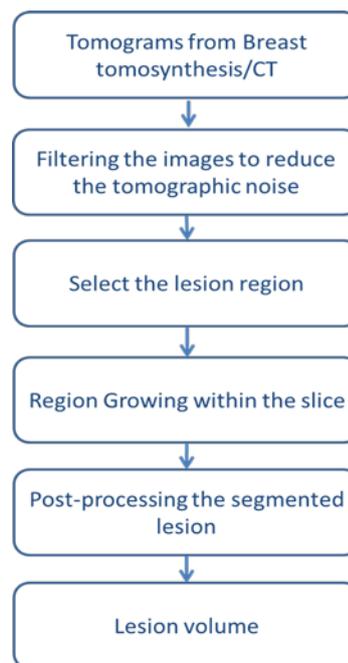


Figure 2. Outline of an algorithm for segmentation of lesions from breast 3D imaging techniques.

The proposed algorithm, recently reported by the group [4, 5], is semi-automatic as the initial selection of the region of the lesion and the choice of the seeds for the region growing process are performed interactively. Respecting the relevant ethical issues, all patient images obtained with Giotto Tomo and Siemens Mammomat were anonymized in advance. Breast cadaver images, obtained with Siemens Somatom Definition CT system, were exploited as well.

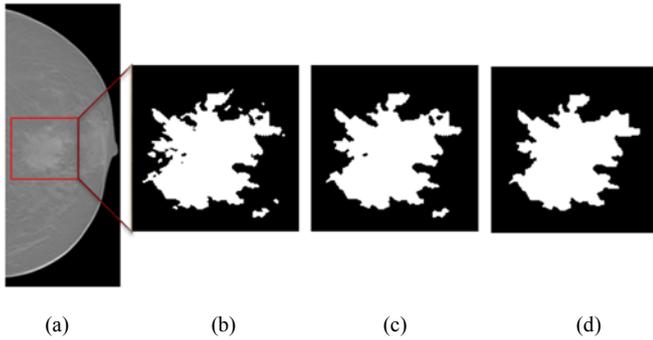


Figure 3. Screenshot from the presentation at RAD 2017 conference [5], presenting the approach. The main steps are: (a) original image, (b) after region growing, (c) after removing of artefacts and (d) final image.

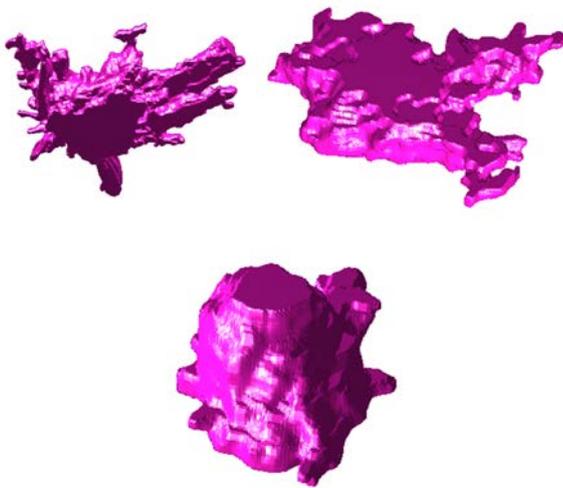


Figure 4. Segmented breast cancer models as a result of applying the procedures outlined in figure 2 and figure 3.

The main steps of the algorithm applied on tomosynthesis images are shown in figure 3, while selected three-dimensional breast cancer models are shown in figure 4.

B. Modelling of lesions

The base of the algorithm is the generation of 3D random walks in a predefined space. Since the objects are voxel-based objects, the algorithm is modified to the so called nearest neighbour random walk. The basic steps in generating cancerous models are shown in figure 5 and include three major steps:

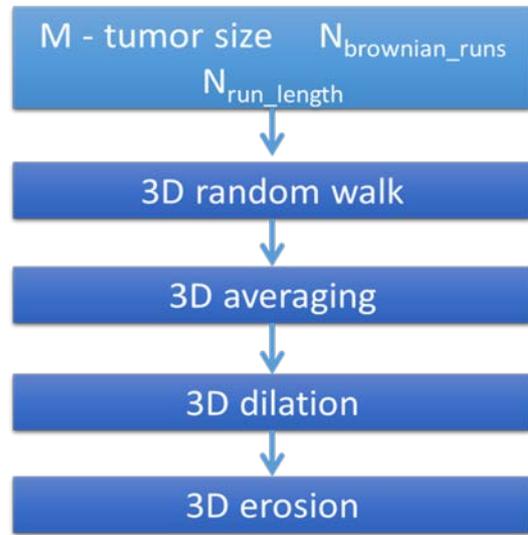


Figure 5. An algorithm for creation of irregular tumours, based on 3D random walk.

(a) The lesion is outlined in a 3D voxel matrix. The tumour size is function of the size of the voxel matrix marked as $M \times M \times M$ and the voxel resolution, res , defined by the user. Initially, the voxel values of the abnormality matrix are set to zero. The user assigns a number of random walks. This number is marked as $N_{brownian_runs}$. Each random walking process stops either at the matrix boundaries or when the assigned maximum number of discrete steps, N_{run_length} (number of voxels per walk) is reached.

(b) The random walk starts from the centre of the matrix and each step moves randomly to one of the neighbouring voxels, assigning it the abnormality elemental composition.

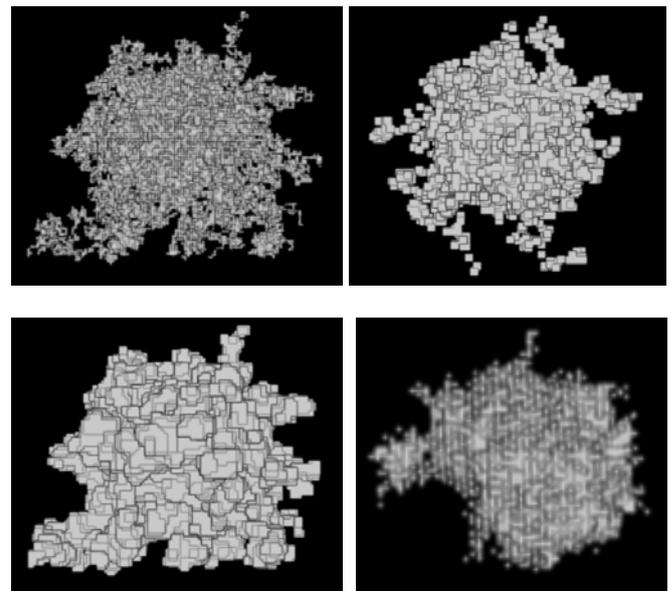


Figure 6. Three-dimensional images of computational solid irregular tumours, based on 3D random walk algorithm.

(c) The received powderish structure is converted to an abnormality with a solid geometry by applying further processing: averaging, dilation, erosion morphologic operations. In all operations, the structuring elements is the cube. For instance for the dilation operation, the repeating dilation is obtained with a larger cube size (5x5) followed by dilation using a smaller cube size (3x3), while averaging is reached with uniform averaging filter (arithmetic mean). Other morphological image processing methods, closing and morphological smoothing (opening followed by closing), have also cube as a structuring element. The size of the structure element as well as its shape can be changed. Closing and dilation operations were used also for binary image processing.

Selected examples are shown in figure 6. The choice of the parameters is critical for obtaining the realism of the simulated abnormality structure. In general, the use of more and longer walks results in realistic in shape breast abnormalities.

III. STUDIES WITH THE DEVELOPED LESION MODELS

Selected applications include database development, use in studies to optimize the parameters of breast tomosynthesis and use in training activities.

A. Database development

One of the goals of the Horizon 2020 EU project *Maxima* is to create computational breast models by using the two approaches for creation of lesions and place them in a database, which to be accessible by researchers working in this field. In short, the database 'Maxima' contains four tables, summarized as following:

- *patients* – it contains a list of records for 3D images and its attributes: name of the record, object of examination, imaging modality, data source, name of user, who adds the record, path to the images' directory, other additional information;
- *modalities* – it contains a list of imaging modalities with additional information;
- *medical sources* – it contains a list of data sources with corresponding information (name; country; city; name, e-mail, phone number of the contact person; other additional information);
- *users* – it contains a list of the users, who can use the application with the corresponding information (username; password (encrypted); level of access; personal information – name, e-mail, phone number, address, organization, other additional information).

All four tables are connected amongst each other by means of primary and secondary indexes to create the relations in the database. The database is currently in a process of filling its tables and will be opened to the scientific community after the end of the project.

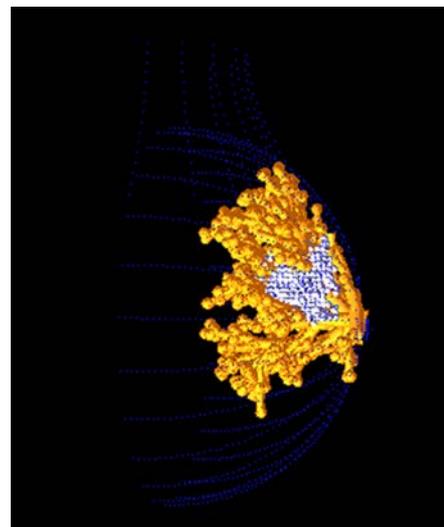


Figure 7. Generated 3D breast model with an irregular mass. The abnormality is generated based on the 3D random walk approach.

B. Testing tomosynthesis

To test the visibility of the low contrast masses in breast

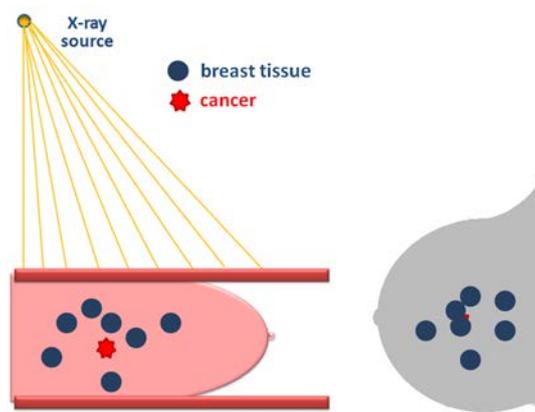
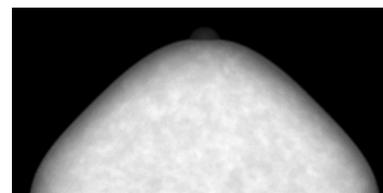


Figure 8. Compressing the generated 3D breast model with the irregular mass.



(a)

tomosynthesis and mammography we generated an anthropomorphic 3D model of the breast by using the dedicated *BreastSimulator* software [6]. The computational model is shown in figure 7 and it is composed of an external shape, glandular tree and an irregular mass, generated by using the random walk algorithm. The breast model is with a glandularity of 21%.

To be suitable for studies with breast imaging, the breast model was compressed and the resulted breast had a thickness of 4 cm, similarly to the mammography application (figure 8). Twenty six projection images in a tomosynthesis mode are simulated by using [6]. The incident beam energy was 20keV and the beam was monochromatic. Scatter and detector responses were not simulated. Distances from the source to the breast support table, where the phantom is placed, and to the detector surface, were 600 mm and 650 mm, respectively. The size of the images was 1200 x 1200 pixels. The pixel resolution was 0.085mm in each direction. A mammography image simulated at craniocaudal view is shown in figure 9a.

The 26 projection images are reconstructed with the FDKR software application, which is an application for reconstruction of tomosynthesis slices [7]. Figure 9b shows the reconstructed

tomosynthesis image at a plane where the lesion is detected. Clearly, the use of breast tomosynthesis brings on focus lesions, which are not visible on a planar mammography image.

C. Training purposes

Modelled lesions from the database have turned out to be very useful for training of the Medical Physics Experts. Specifically, they have been exploited in the two training courses (September 2015 and May 2017 in Varna <http://www.eutempe-rx.eu/>) by the participants of module 5 “The use of physical and virtual anthropomorphic phantoms for image quality and patient dose optimization” from the EUTEMPE-RX project (European Training and Education for Medical Physics Experts in Radiology). The main purpose of this course is participants to develop skills for the design and evaluation of anthropomorphic phantoms, as well as to design, manage, implement and evaluate virtual clinical studies with such phantoms, and to discuss and interpret the results of the virtual studies. The use of realistically modelled lesions was a necessary prerequisite in this challenging course. The following two work projects demonstrate the use of irregular lesion models carried out during this training.

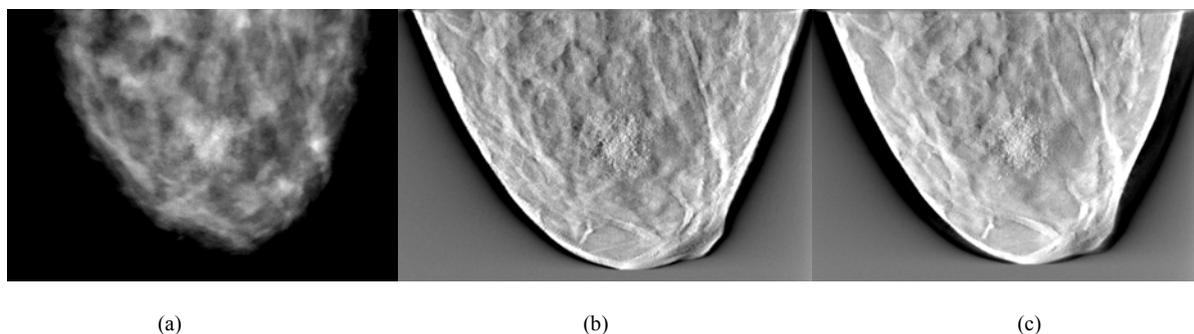


Figure 10. Visualisation using (a) mammography and breast tomosynthesis modalities with (b) -9° to 9° arc and (c) -25° to 25° arc (images and text are from the work of *Marius Laurikaitis* and *Anastasios Konstantinidis* during the Eutempe-Rx course in Varna, 2015).

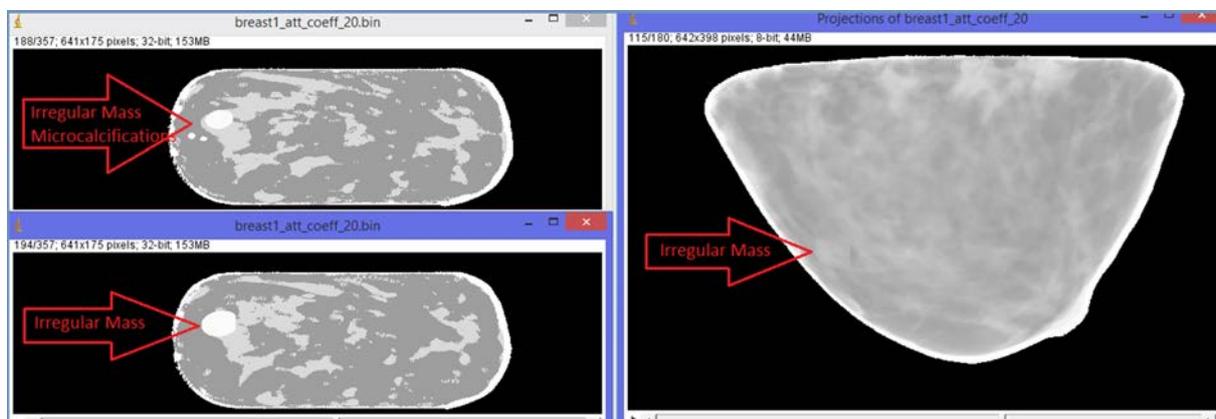


Figure 11. Slices and 3D Volume of the combined phantom (images and text are from the work of *Rita Demou* and *Simona Avramova-Cholakova* during the Eutempe-Rx course in Varna, 2015).

Work Project Example 1:

Marius Laurikaitis and Anastasios Konstantinidis were working on the development of computational breast phantoms to be used in a virtual study, which aimed to determine the potential of breast tomosynthesis for detectability of breast abnormalities, compared to conventional mammography.

They created a voxel-based phantom of size 641 x 357 x 175 voxels (0.3 mm voxels) composed from segmented CT slices. Then, an abnormality mass lesion of size 200 x 200 x 200 pixels was inserted into this volume. Conventional mammographic images and tomosynthesis images were simulated with the *BreastSimulator*, as the three dimensional imaging was modelled for two different gantry arcs: 18 degrees and 52 degrees, respectively and incident x-ray energy of 20keV. Reconstruction of tomographic images was realized via the dedicated software application FDKR.

Figure 10 shows simulated mammography (a) and tomosynthesis images using 10 planar projections (b) and 26 projections (c). The visual evaluation shows that breast tomosynthesis resulted in better visual detection of the abnormality compared to mammography case. In addition, tomosynthesis with larger arcs resulted in better mass visibility.

Work Project Example 2:

Rita Demou and Simona Avramova-Cholakova investigated whether dual-energy imaging improves detectability of breast abnormalities compared to conventional mammography. They used the same 3D breast matrix constructed from breast CT slices. Then, five microcalcifications with dimensions randomly sampled between 0.3mm and 1.2mm and an irregular mass were inserted in the phantom, as shown in figure 11. Then, they simulated four mammography images at 20keV, 50keV, 65keV and 80keV. Afterwards, they were properly weighted and combined into one image, called dual-energy image.

Figure 12 shows the visual assessment of the two different techniques, with an advantage of the dual energy images to improve the contrast of the microcalcifications and masses. They also concluded that the improvement of the contrast of the microcalcifications is more substantial while increasing energy difference of the dual energy images. Low contrast irregular masses are well visible when the second x-ray energy is above 65keV.

The limitations of the modelling approaches are related mainly to the different quality of 3D images provided by the different manufacturers. This implies sometimes modification of the algorithm developed in the filtering step of the approach outlined in figure 2. Another limitation is related to the low image resolution in z direction in case of limited arc 3D breast imaging. This may be overcome by using images of breast from Computed Tomography modality.

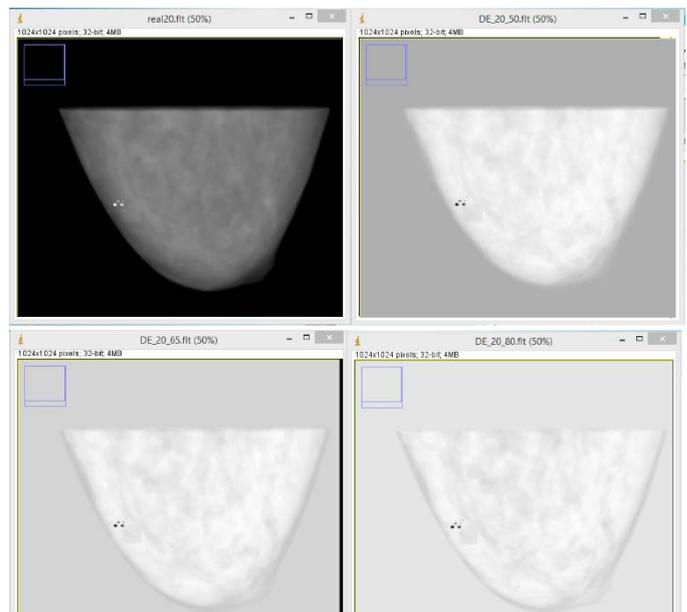


Figure 12. The 20keV planar projection and the dual energy images. Images are from the work of Rita Demou and Simona Avramova-Cholakova during the Eutempe-Rx course in Varna, 2015.

There are several benefits of this running research. The approaches of generation of cancerous models are currently used to generate computational breast cancerous models and to populate the dedicated database, which will be open to the scientific community at the end of the project. These models are intended for studies which aim is the development and optimization of x-ray breast imaging techniques. Another benefit is that the realistic computational breast cancerous models will be used to produce physical cancer prototypes to be introduced in physical breast phantoms, dedicated for x-ray imaging research.

IV. CONCLUSIONS

Models play an important role in our life. In particular, they are very important when new technology is under development, testing and optimization. This paper addressed two methods used in generation of models of the breast cancer and their use in emerging x-ray breast imaging. The selected examples are from the current work of the biomedical engineering unit at Technical University of Varna, Bulgaria.

ACKNOWLEDGMENT

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Bioinformatics approach in finding similarity of Haemophilus influenzae and Escherichia coli

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Abstract — Nowadays, bioinformatics has become the most significant field in realizing the full potential of genomics. The explosion of new data management challenges pulls the need of interdisciplinary approaches in solving complex problems in life sciences. This paper describes an approach for genome analysis based on sequencing and assembly of unselected pieces of DNA from the whole chromosome. It is used high-throughput DNA sequencing to investigate differences in genome content. The analysis of Haemophilus influenzae consists of statistical sequence analysis of the whole genome as well as nucleotide sequence, protein and amino acid sequence analysis. The whole genome is analyzed, by using various bioinformatics functions, which give us both the statistical and visual representations of the sequences, in order to obtain more useful information and understanding. The research in this paper includes study of hydrophobicity in predicting the primary and secondary structure of the *H. influenzae* amino acids. The proposed genome analysis approach also includes finding Open Reading Frames (ORF) in order to predict the most probable coding region, which will make complementary depicting of the bacteria features. For the final goal of this study - finding the similarities of the *H. influenzae* and *Escherichia coli* genomes was using the method of global sequence alignment using the Needleman-Wunsch algorithm. The results from the research confirmed that *H. influenzae* and *E. coli* have similar genomes. This paper shows that, bioinformatics is one of the most capable toolset for making accurate analysis rapidly and effectively at a low cost.

Keywords-Bioinformatics, Genome analysis, Predicting primary and secondary structure, Global sequence alignment

I. INTRODUCTION

Nowadays, bioinformatics has become the most significant field in realizing the full potential of genomics. Its tools are used to handle, store and analyze genome sequence data in a very effective manner. [1] The explosion of new data management challenges pulls the need of interdisciplinary approaches in solving complex problems in life sciences. Computer based methods of genomic analysis allow identification, measurement or comparison of genomic features, very fast, without a specific resource demand. Since complexity, redundancy, structuring, and noise in biological data, finding an acceptable solution for genomics analysis required not only biological expert knowledge but using computational methods also. These methods give an

opportunity for comprehensive analysis, which will help in understanding dynamic biological processes at both cellular and organismal levels. Here should be mentioned that computational methods in bioinformatics include mathematical modeling, statistical analysis, implementation of data mining techniques etc.

In the following paper, first are given details of the materials and methods used in the research. Data description, statistical DNA analysis, nucleotide and amino acid sequence analysis, hydrophobicity of *H. influenzae* amino acids are included in this part. In the third session is provided report for the implementation of the method of Open Reading Frames in *H. influenzae* nucleotide sequence. The next session refers to Needleman-Wunsch algorithm. Before last section, where the concluding remarks are given, is the section where are discussed the obtained results.

II. MATERIALS AND METHODS

A. Data

The genome analysis in this paper is based on sequencing pieces of DNA from the whole chromosome obtained from the nucleotide sequence of the genome from the bacterium Haemophilus Influenzae. The DNA sequence of the *H. influenzae* was obtained from the GenBank database with the accession number NC_000907 (*H. influenzae* Rd KW20 chromosome, complete genome, BioProject: PRJNA57771, Assembly: GCF_000027305.1). The data description is given in Tab.1.

Statistical analysis of the sequences can provide important biological information, especially concerning the evolution of DNA molecules. It is also essential for the understanding of the physical properties of DNA. The physical properties of DNA depend on the sequence of pairs. The genome structure of *H. influenzae* consist of 1,830,138 nucleotide base pairs. The DNA molecule of the *H. influenzae* consists of the four nitrogen bases Adenine (A), Thymine (T), Guanine (G) and Cytosine (C). From the distribution of the nucleotide bases in *H. influenzae* genome (Fig.1) we can notice that in the *H. influenzae* DNA molecule, the Adenine (A) is the base pair that occurs the most. The number of the Thymine (T) is approximately same as the Adenine (A).

TABLE XIII. DATA DESCRIPTION

Name	NC_000907			
	Size	Bytes	Class	Base pairs
Hflu	1 x 1830138	3660276	char	1,830,138

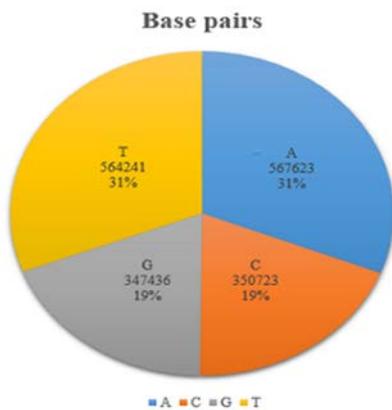


Figure 1. Distribution of the nucleotide bases for *H. influenzae* genome

This means that the two hydrogen bonds will occur more frequently, than the three hydrogen bonds that are formed by the Guanine (G) and Cytosine (C). (Fig1.) Because the number of the A and T, and G and C is not equal, we can conclude that the *H. influenzae* DNA molecule consists of unpaired bases also.

B. Nucleotide and amino acid sequence analysis

Codons are three-letter codes that make up the genetic code. Both RNA and DNA have triplets known as codons. Each codon codes one of 20 amino acids that the body uses to synthesize amino acids. In the *H. influenzae* DNA genetic code, most amino acids can be coded for by more than one codon. This allows the same amino acids to be included in DNA and protein synthesis.

The nucleotide and amino acid sequence analysis is done in several steps (Fig.2). To analyze the codons that are present in the *H. influenzae* DNA molecule, function for counting of the codon was used in order to show all of the codons and their number in the nucleotide sequence. The next step that was done was calculating the codon frequency for each amino acid coded for in *H. influenzae* nucleotide sequence. The calculation was done with creating function without biasing. Since the biological code is degenerate, the frequencies of occurrence of codons are not uniquely determined by the amino acid frequencies in proteins. Some researchers assumed that the anti-sense strand of DNA consists of a sequence of codons juxtaposition, as is indicated by the statistically random sequence of amino acids in proteins. They used experimental data on average frequencies of amino acids in proteins, and on nearest neighbor frequencies and frequencies of pyrimidine runs flanked by purines in DNA, to write equations expressing constraints on the codon frequencies. The method has been tested on hypothetical DNA molecules. The solutions are rather insensitive to errors in the estimates of amino acid

frequencies, but are very sensitive to errors in the estimate of doublet frequencies and pyrimidine runs [2]. After the calculation the codon frequency, we can see all of the amino acids, their codons and the frequency in the *H. influenzae* DNA sequence. With this function, it was detected some of the amino acids such as: Alanine (Ala), Asparagine (Asn), Glutamine (Gln), Isoleucine (Ile), Proline (Pro) and so on. With this function, it was detected some of the amino acids such as: Alanine (Ala), Asparagine (Asn), Glutamine (Gln), Isoleucine (Ile), Proline (Pro) and so on. With this we can extract information for each amino acid, for instance, if we take the Alanine amino acid we can notice that is consisted of four amino acids 'GCA', 'GCC', 'GCG' and 'GCT', with respective frequencies 0,340286, 0,198228, 0,205359, 0,256125.

In order to find some specific features in the genome of interest, in this study were used the high-density single-nucleotide polymorphism maps of the *H. influenzae*. The density of nucleotides along sequence was plotted also. Before the plotting of the density, a random *H. influenzae* DNA sequence with 2500 nucleotides was generated. The polymorphism maps allow to obtain specific information very useful for the biologists. For the purpose of this research, several maps were obtained (Fig.3). This two maps showed two different ways of calculating the density of the nucleotides of the random generated sequence. In this case the minimum density has the Guanine with a value of 0.15 between the 1500 and 2000 nucleotide. The maximum density has also the Guanine with a value of 0.35 between the 500 and 1000 nucleotide, and 1000 and 1500 nucleotide. In the second plot the nucleotide density is calculated in A-T and C-G pairs. For this sequence of 2500 nucleotides the density of the base pairs appears to be symmetrical along

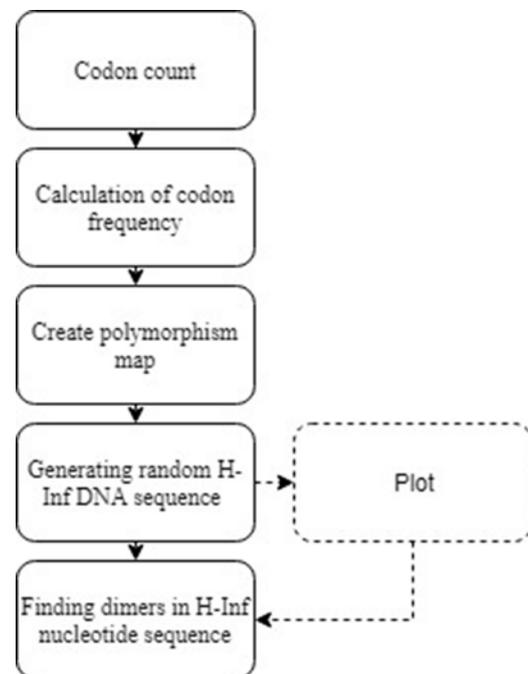


Figure 2. Steps in sequence analysis

the plot. This means that in this randomly generated *H.*

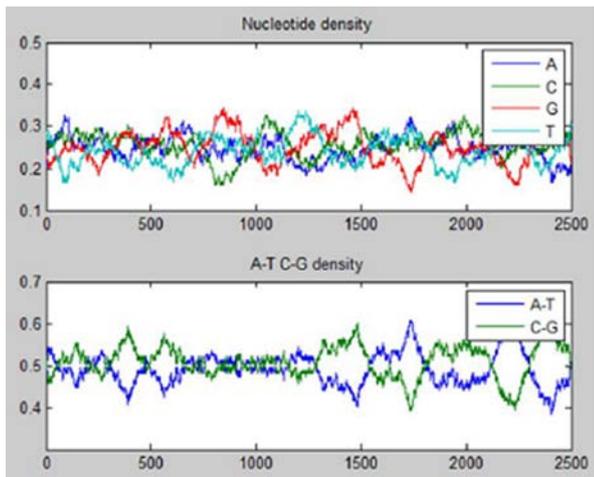


Figure 3. Polymorphism maps of the *H. Influenzae*

influenzae sequence we have an equal number of Adenine and Thymine, and Cytosine and Guanine.

The next step was the investigation of the dimers that can be found in the *H. influenzae* nucleotide sequence.

In biochemistry, a dimer is a macromolecular complex formed by two, usually non-covalently bound, macromolecules such as proteins or nucleic acids. A homodimer is formed by two identical molecules (a process called homodimerisation). A heterodimer is formed by two different macromolecules (called heterodimerisation) [3]. To find and calculate the dimers in the *H. influenzae* nucleotide sequence was created function for it, which returns a 4-by-4 matrix with the relative proportions of the dimers in *H. influenzae* nucleotide sequence.

C. Hydrophobicity of *H. influenzae* amino acids

The research in this paper includes study of hydrophobicity in predicting the primary and secondary structure of the *H. influenzae* amino acids. Amino acids are grouped according to what their side chains are like. The nine amino acids that have hydrophobic side chains are glycine (Gly), alanine (Ala), valine (Val), leucine (Leu), isoleucine (Ile), proline (Pro), phenylalanine (Phe), methionine (Met), and tryptophan (Trp). These side chains are composed mostly of carbon and hydrogen, have very small dipole moments, and tend to be repelled from water. This fact has important implications for proteins' tertiary structure. However, glycine, being one of the common amino acids, does not have a side chain and for this reason it is not straightforward to assign it to one of the above classes. Generally, glycine is often found at the surface of proteins, within loop- or coil (without secondary structure) regions, providing high flexibility to the polypeptide chain at these locations. This suggests that it is rather hydrophilic. Proline, on the other hand, is generally non-polar and is mostly found buried inside the protein, although similarly to glycine, it is often found in loop regions. In contrast to glycine, proline provides rigidity to the polypeptide chain by imposing certain torsion angles on the segment of the structure. Glycine and proline are often highly conserved

within a protein family since they are essential for the conservation of a particular protein fold [4]. Since in the *H. influenzae* DNA sequence can be found codons that code for these types of amino acids, the hydrophobicity of the amino acids is necessary and needed for predicting the primary and secondary structure of the *H. influenzae* amino acids. For this purpose another random nucleotide sequence was generated out of the whole *H. influenzae* DNA with 3500 nucleotides. The sequence was placed into the new variable which was converted into an amino acid sequence.

III. OPEN READING FRAMES IN *H. INFLUENZAE* NUCLEOTIDE SEQUENCE

The proposed genome analysis approach also includes finding Open Reading Frames (ORF) in order to predict the most probable coding region, which will make complementary depicting of the bacteria features.

In molecular genetics, an open reading frame (ORF) is the part of a reading frame that has the potential to be translated. An ORF is a continuous stretch of codons that contain a start codon (usually AUG) and a stop codon (usually UAA, UAG or UGA).

The ribosomes actually will read those frames and those frames are the sequence of DNA. The DNA sequence contains an initiation point of translation, a termination point of translation and inside gene, which will be transcribed into proteins or simply they are codons of nucleotide which will code for different types of amino acids which will be added with each other by a peptide bond and they will form a fully functional protein in the cell. That whole nucleotide sequence presents the open reading frame or ORF. For most common purposes, a prokaryotic gene can be defined simply as the longest ORF for a given region of DNA. Since DNA is interpreted in groups of three nucleotides (codons), a DNA strand has three distinct reading frames. The double helix of a DNA molecule has two anti-parallel strands, with the two strands having three reading frames each, there are six possible frame translations [5].

Today the scientists use various ORF finding tools. Some of the tools are: Tmhe ORF Finder [6], which is a graphical analysis tool which finds all open reading frames of a selectable minimum size in a user's sequence or in a sequence already in the database. This tool identifies all open reading frames using the standard or alternative genetic codes. ORF Investigator is a program which not only gives information about the coding and non-coding sequences, but also can perform pairwise global alignment of different gene/DNA regions sequences. OrfPredictor [7] is a web server designed for identifying protein-coding regions in expressed sequence tag (EST)-derived sequences. For query sequences with a hit in BLASTX, the program predicts the coding regions based on the translation reading frames identified in BLASTX alignments, otherwise, it predicts the most probable coding region based on the intrinsic signals of the query sequences.

In prokaryotes, genes act as a basic organizational unit at the genome level, since the coding density of bacterial genomes is quite high compared to eukaryotes [8]. The genome of a typical bacterium is somewhere in the range of

106 to 107 base pairs (bp), containing about 103 to 104 annotated genes. However, the total number of possible ORFs is usually in the order of 106 to 105. Although the number and the typical length of ORFs may vary, bacteria share common characteristics of their open reading frame length distribution, which is correlated to their GC-content. Most ORFs are rather short. It is a well-known fact that the distribution of the overall ORF lengths correlates with the GC-content of a genome, simply because stop codons being AT-rich [9,10].

The *H. influenzae* genome is estimated to have 1,740 genes that code for a specific protein. The ORF I-encoded protein was approximately 90 kDa and bound 3H-benzylpenicillin and 125I-cephradine. This high-molecular-weight penicillin-binding protein (PBP) was also shown to possess transglycosylase activity, indicating that the ORF I product is a bifunctional PBP. The ORF I protein was capable of maintaining the viability of *E. coli* delta ponA ponB::spcr cells in transcomplementation experiments, establishing the functional relevance of the significant amino acid homology seen between *E. coli* PBP 1A and 1B and the *H. influenzae* ORF I product. In this study, it was performed a computational search, on all *H. influenzae* coding sequences to identify possible forward-reading ORFs that could be translated into novel viral proteins. For this purpose it was performed specific function of the whole nucleotide sequence and this function displayed the sequence with all open reading frames highlighted, and it returns a structure of start and stop positions for each ORF in each reading frame.

IV. NEEDLEMAN-WUNSCH ALGORITHM

To analyze the sequences and to find the similarities of the *H. influenzae* and *E. coli* genomes, the method of global sequence alignment using the Needleman-Wunsch algorithm was used.

The Needleman-Wunsch algorithm is an algorithm used in bioinformatics to align protein or nucleotide sequences. For this algorithm the principles of dynamic programming are used to compare biological sequences. The Needleman-Wunsch algorithm consists of three steps. The first step is *initialization of the score matrix*. The second step is *calculation of scores and filling the trace-back matrix*. The last step in this algorithm is *deducing the alignment from the trace-back matrix*. Key feature in the Needleman-Wunsch algorithm is dynamic programming recursion. Finding the best alignment with this algorithm not depend on length or complexity of sequences and is appropriate for finding the best alignment of two sequences which are (i) of the similar length; (ii) similar across their entire lengths. The algorithm is successful in finding out the structural or functional similarity between sequences.

The data for the *E. coli* DNA sequence for this study was obtained from EcoGene which is manually curated resource containing genomic and proteomic information about this kind of bacteria. Also, for the purpose of this research was created a function that use the Needleman-Wunsch algorithm. The next step that was done was generating a random sequence out of the whole *E. coli* genome and comparing with the randomly selected one

from Haemophilus Influenzae. The function result with a visual representation of the alignment as well as the information for the number of identities which are bases that can be found in the both sequences in the same place. The number of positives or the value of the score of the alignment.

On Fig.4 we can notice that the alignment between the two randomly generated sequences, respectively of the both bacteria, shown a result of: 136 Identities out of the 297 and score of 193 out of 297 which means that there is 65% similarity. This step simply shows that even if we analyze randomly generated sequences of these bacteria, the percentage of the similarity will have a high value, as result of the similar genomes. The next step consisted of creating dot plot of the two bacteria sequences. The dot plots can be easily created by specific function for that. This function requires two arguments and in this case those are the actual sequences of the *H. influenzae* and *E. coli*. This approach is used in order to create plot that gives the visual representation of the similarities between these sequences.

Fig. 5 presents the dot plot where the two sequences are represented as a matrix of dots. Sequence 1 refers to the *H. influenzae* and Sequence 2 refers to the *E. coli*. The black dots represent the matches or the actual similarities along the genomes of the both bacteria. The frequency of these black dots is really high because of the evolutionary similarities that these two bacteria have in their genomes.

Even *H. influenzae* and *E. coli* have similar genomes, the life styles of the two bacteria are very different. *H. influenzae* is an obligate parasite that lives in human upper respiratory mucosa and can be cultivated only on rich media, whereas *E. coli* is a saprophyte that can grow on minimal media. A detailed comparison of the protein products encoded by these two genomes can provide valuable insights into the bacterial cell physiology and genome evolution [15].

V. DISCUSSION

The number of bacterial diseases present on public health has become enormous, as a result of the increasing trend of antibiotic resistance displayed by bacterial pathogens. Sequencing of bacterial genomes has significantly improved the overall understanding about the biology of many bacterial pathogens as well as identification of novel antibiotic targets. Since the advent of genome sequencing two decades ago, about 1,800 bacterial genomes have been fully sequenced. Recently, there is a lot of scientific works and studies of bacterial genome data and is due to the development of next generation sequencing



Figure 4. Sequence alignment between the two sequences

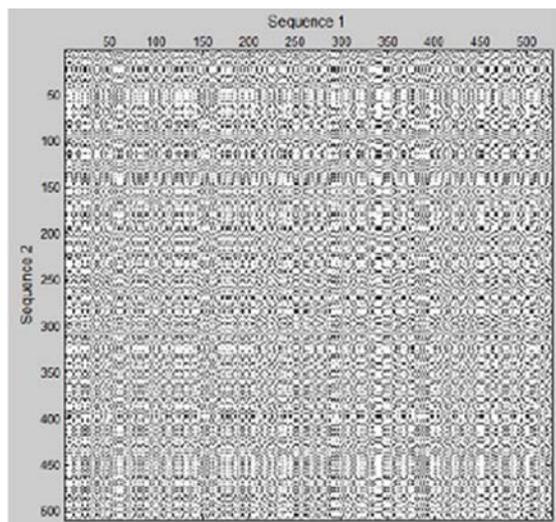


Figure 5. Dotplot of the two sequences

technologies, which are evolving so rapidly [16].

Drug-resistant Gram-negative infections have emerged as major concerns in hospitals, nursing homes and other healthcare settings. The resistance rates of *H. influenzae* to different antibiotics and ampicillin during the past years created a great concern in the medicine and science.

Treating Gram-negative bacterial infections in most of the cases can be difficult because of several unique features of these bacteria. These kind of bacteria have a unique nature and characteristics of their cell wall, which makes them resistant to several types of antibiotics and ampicillin. The main reason why scientists and researchers do many analysis on the bacterial DNA and genome is to find an appropriate medicine and drugs that will have a positive effect against these harmful bacteria. It is a fact the discovery of the new drugs to combat Gram-negative bacterial infections are needed very much [17]. *H. influenzae* and *E. coli* are among the most frequently affected bacteria. One of the common disease that can be caused by the *H. influenzae* is meningitis. This bacterial meningitis causes infections of the membranes covering the brain and spinal cord and is very serious and can be deadly. Death can occur in as little as a few hours.

Because of this frightening problem, many scientists are dedicating their work and are focusing on doing bacterial genomics analysis. Many genomics approaches can be implemented for microbial enumeration and identification, control of bacterial growth as well as monitoring of antibiotic-resistant strains. The methods that are used in genomics study can detect, quantify, and examine the activities of the pathogens such as the *H. influenzae* and *E. coli* and can find out how they affect the environment. The results that genomics study of the bacteria can have, today are really important because they can provide novel approaches to the diagnosis and treatment of infectious diseases. This study paper presents the main and basic, but still very important steps in analyzing the bacterial genome

of the harmful pathogen- Haemophilus Influenzae. The methods that are used give the basic information and discovery of the GC content of the sequence, as well as the codons and possible amino acids. The discovery of the amino acids as well as the open reading frames has a great impact in predicting genes and protein binding sites of the bacterial organism. Identifying the location of binding sites of proteins is of fundamental importance for a wide range of applications including molecular docking, structure identification, and comparison of functional sites and most importantly for designing new drugs against these bacteria [18].

Comparing and finding similarity between bacteria has been commonly used method in genomics, not just to discover if they are evolutionary connected but also to find detailed information and explanations about specific characteristics that the bacteria have. Finding out the characteristics of the bacteria helps scientists to design and create an appropriate cure that will have a positive impact and protection for the public health of the environment. The results is this study confirmed that *H. influenzae* and *E. coli* have similar genomes. Because of their similarity, today scientists find out that the J5 mutant of *E. coli* 0111 can be used as a vaccine for induction of immunity against lethal *H. influenzae* type b.

VI. CONCLUSION

The results from the research confirmed that *H. influenzae* and *E. coli* have similar genomes. This paper shows that, bioinformatics is one of the most capable toolset for making accurate analysis rapidly and effectively at a low cost.

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(2,3)-Generation of the Special Linear Groups of Dimension 9

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Abstract - In the present paper we prove that the group $SL_9(q)$ is (2,3)-generated for any q . Actually, to verify that fact, we provide explicit generators x and y of respective orders 2 and 3 for these groups. Our considerations are based only on the known list of maximal subgroups of $SL_9(q)$.

discussing the group $SL_9(q)$ in the light of the method used in our works [14], [16] and [19]. We prove the following:

Theorem. *The group $SL_9(q)$ is (2,3)-generated for any q .*

Index Terms - (2,3)-generated group.

II. PROOF OF THE THEOREM

I. INTRODUCTION

It has been proved that any finite simple group can be generated by a pair of appropriately chosen elements. As far back as 1901 Miller [1] was first who proved that fact for alternating groups, for the groups of Lie type it is a result of Steinberg [2] and, finally, for the sporadic groups it is due to Aschbacher and Guralnick [3]. A natural question is then to ask about the minimal orders of the possible generating elements. Since two involutions generate a dihedral group, the smallest case of interest is if the group is generated by an involution and an element of order 3; such a group is called (2,3)-generated.

It is known that many series of finite simple groups are (2,3)-generated. Most powerful results of Liebeck-Shalev and Lübeck-Malle state that all finite simple groups of Lie type, except the families $PSp_4(2^m)$, $PSp_4(3^m)$, $Sz(2^{2m+1})$, and a finite number of other exceptions (classical groups), are (2,3)-generated (see [4],[5]).

We have especially focused our attention to the (projective) special linear groups defined over finite fields. Many authors have been investigated the groups $PSL_n(q)$ with respect to that generation property. (2,3)-generation has been proved in the cases $n = 2, q \neq 9$ [6], $n = 3, q \neq 4$ [7],[8], $n = 4, q \neq 2$ [9], [10], [11], [12], $n = 5$, any q [13], $n = 6$, any q [14], $n = 7$, any q [15], $n = 8$, any q [16], $n = 11$, any q [17], $n = 12$, any q [18], [19], $n \geq 5$, odd $q \neq 9$ [20], [21], and $n \geq 13$, any q [22]. In this way the only cases that still remain open are those for $n = 9$ or 10, even q or $q = 9$. In the present paper we give our contribution to the problem by

Let $G = SL_9(q)$, where $q = p^m$ and p is a prime. Set $Q = q^8 - 1$ if $q \neq 3, 7$ and $Q = (q^8 - 1)/2$ if $q = 3, 7$. The group G acts naturally on a nine-dimensional vector space V over the field $F = GF(q)$. We identify V with the column vectors of F^9 , and let v_1, \dots, v_9 be the standard base of the space V , i.e. v_i is a column which has 1 as its i -th coordinate, while all other coordinates are zeros.

We shall need the following result, which can be easily obtained by the list of maximal subgroups of G given in [23] and simple arithmetic considerations using (for example) Zsigmondy's well-known theorem.

Lemma 1. *For any maximal subgroup M of the group G either it stabilizes one-dimensional subspace or hyperplane of V (M is reducible on the space V) or M has no element of order Q .*

2.1. We first suppose that $q \neq 2, 4$. Let choose an element ω of order Q in the multiplicative group of the field $GF(q^8)$ and $p(t) = (t - \omega)(t - \omega^q)(t - \omega^{q^2})(t - \omega^{q^3})(t - \omega^{q^4})(t - \omega^{q^5})(t - \omega^{q^6})(t - \omega^{q^7}) = t^8 - at^7 + bt^6 - ct^5 + dt^4 - et^3 + ft^2 - gt + h$. Then $p(t) \in F[t]$ and the polynomial $p(t)$ is irreducible over

the field F . Note that $h = \omega^{\frac{q^8-1}{q-1}}$ has order $q - 1$ if $q \neq 3, 7$, $h = 1$ if $q = 3$, and $h^3 = 1 \neq h$ if $q = 7$. Now let

$$x = \begin{bmatrix} -1 & 0 & 0 & 0 & 0 & 0 & eh^{-1} & 0 & e \\ 0 & -1 & 0 & 0 & 0 & 0 & dh^{-1} & 0 & d \\ 0 & 0 & 0 & -1 & 0 & 0 & ch^{-1} & 0 & f \\ 0 & 0 & -1 & 0 & 0 & 0 & fh^{-1} & 0 & c \\ 0 & 0 & 0 & 0 & -1 & 0 & bh^{-1} & 0 & b \\ 0 & 0 & 0 & 0 & 0 & 0 & ah^{-1} & -1 & g \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & h \\ 0 & 0 & 0 & 0 & 0 & -1 & gh^{-1} & 0 & a \\ 0 & 0 & 0 & 0 & 0 & 0 & h^{-1} & 0 & 0 \end{bmatrix},$$

$$y = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}.$$

Then x and y are elements of $G(=SL_9(q))$ of orders 2 and 3, respectively. Denote

$$z = xy = \begin{bmatrix} 0 & 0 & -1 & 0 & 0 & 0 & 0 & e & eh^{-1} \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & d & dh^{-1} \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & f & ch^{-1} \\ 0 & -1 & 0 & 0 & 0 & 0 & 0 & c & fh^{-1} \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 & b & bh^{-1} \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & g & ah^{-1} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & h & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 0 & a & gh^{-1} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & h^{-1} \end{bmatrix}.$$

The characteristic polynomial of z is $p_z(t) = (t - h^{-1})p(t)$ and the characteristic roots $h^{-1}, \omega, \omega^q, \omega^{q^2}, \omega^{q^3}, \omega^{q^4}, \omega^{q^5}, \omega^{q^6}, \omega^{q^7}$ of z are pairwise distinct. Then, in $GL_9(q^8)$, z is conjugate to the matrix $\text{diag}(h^{-1}, \omega, \omega^q, \omega^{q^2}, \omega^{q^3}, \omega^{q^4}, \omega^{q^5}, \omega^{q^6}, \omega^{q^7})$ and hence z is an element of $SL_9(q)$ of order Q .

Let H is the subgroup of $G(=SL_9(q))$ generated by the above elements x and y .

Lemma 2. *The group H can not stabilize one-dimensional subspaces or hyperplanes of the space V or equivalently H acts irreducibly on V .*

Proof: Assume that W is an H -invariant subspace of V and $k = \dim W, k = 1$ or 8 .

Let first $k = 1$ and $0 \neq w \in W$. Then $y(w) = \lambda w$ where $\lambda \in F$ and $\lambda^3 = 1$. This yields

$$w = \mu_1(v_1 + \lambda^2 v_2 + \lambda v_3) + \mu_2(v_4 + \lambda^2 v_5 + \lambda v_6) + \mu_3(v_7 + \lambda^2 v_8 + \lambda v_9) \quad (\mu_1, \mu_2, \mu_3 \in F)$$

Now $x(w) = \nu w$ where $\nu = \pm 1$. This yields

consecutively $\mu_3 \neq 0, h = \lambda^2 \nu$, and

$$(1) \quad \lambda \nu \mu_1 + \mu_2 = (\lambda \nu c + \lambda f) \mu_3,$$

$$(2) \quad \mu_2 = (a - \lambda \nu + \nu g) \mu_3,$$

$$(3) \quad (\nu + 1)(\lambda \mu_2 - b \mu_3) = 0,$$

$$(4) \quad (\nu + 1)(\mu_1 - \lambda e \mu_3) = 0,$$

$$(5) \quad (\nu + 1)(\mu_1 - \lambda^2 d \mu_3) = 0.$$

In particular, we have $h^3 = \nu$ and $h^6 = 1$. This is impossible if $q = 5$ or $q > 7$ since then h has order $q - 1$. According to our assumption ($q \neq 2, 4$) only two possibilities left: $q = 3$ (and $h = 1$), $q = 7$ (and $h^3 = 1 \neq h$). So $\nu = 1, h = \lambda^2$ and (1), (2), (3), (4), (5) produce $a = \lambda^2 b - g + \lambda, c = \lambda b + \lambda^2 d - f$ and $e = \lambda d$. Now $p(-1) = (1 + \lambda + \lambda^2)(1 + b + d) = 0$ both for $q = 3$ and $q = 7$, an impossibility as $p(t)$ is irreducible over the field F .

Now let $k = 8$. The subspace U of V which is generated by the vectors $v_1, v_2, v_3, v_4, v_5, v_6, v_7$ and v_8 is $\langle z \rangle$ -invariant. If $W \neq U$ then $U \cap W$ is $\langle z \rangle$ -invariant and $\dim(U \cap W) = 7$. This means that the characteristic polynomial of $z|_{U \cap W}$ has degree 7 and must divide $p_z(t)$ which is impossible as $p(t)$ is irreducible over F . Thus $W = U$ but obviously U is not $\langle y \rangle$ -invariant, a contradiction.

The lemma is proved. (Note that the statement is false if $q = 2$ or 4 .) ■

Now, as $H = \langle x, y \rangle$ acts irreducibly on the space V and it has an element of order Q , we conclude (by Lemma 1) that H can not be contained in any maximal subgroup of $G(=SL_9(q))$. Thus $H = G$ and $G = \langle x, y \rangle$ is a $(2, 3)$ -generated group.

2.2. Let now $q = 2$ or 4 . Below we provide elements x_q and y_q of orders 2 and 3, respectively, for each one of the groups $SL_9(q)$, and prove that $\langle x_q, y_q \rangle = SL_9(q)$. In our considerations, counting the orders of some elements in the corresponding groups $\langle x_q, y_q \rangle$, we rely on the possibilities of Magma Computational Algebra System. We also use the orders of the maximal subgroups of $SL_9(q)$ which can be derived from [23].

Take the following two matrices of $SL_9(2)$:

$$x_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix},$$

$$y_2 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}.$$

Then x_2 and y_2 are elements of respective orders 2 and 3 in the group $SL_9(2)$, and x_2y_2 has order 73; also $x_2y_2(x_2(y_2)^2)^2$ is an element in $\langle x_2, y_2 \rangle$ of order 3.127. Since in $SL_9(2)$ there is no maximal subgroup of order divisible by 73.127 it follows that $SL_9(2) = \langle x_2, y_2 \rangle$. Now continue with the desired matrices of $SL_9(4)$:

$$x_4 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & \eta \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix},$$

$$y_4 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}.$$

(Here η is a generator of $GF(4)^*$.) Besides that x_4 and y_4 have orders 2 and 3, respectively, x_4y_4 has order 3.5.43.127 and in $\langle x_4, y_4 \rangle$ the order of the following element $(x_4(y_4)^2)^2(x_4y_4)^3x_4(y_4)^2(x_4y_4)^2x_4(y_4)^2(x_4y_4)^2x_4(y_4)^2x_4y_4$ is 3.7.19.73. But no one maximal subgroup of $SL_9(4)$ has order divisible by 43.73. Thus $SL_9(4) = \langle x_4, y_4 \rangle$ is a (2,3) - generated group too. This completes the proof of the theorem. ■

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(2,3)-GENERATION OF THE GROUPS $SL_{10}(q)$

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Abstract - We prove that the special linear groups of dimension 10 defined over finite fields $GF(q)$ are (2,3)-generated for any q . In fact, we provide explicit generators x and y of orders 2 and 3, respectively, for these groups.

Index Terms - (2,3)-generated group.

I. INTRODUCTION

(2,3)-generated groups are those groups which can be generated by an involution and an element of order 3 or, equivalently, they appear to be homomorphic images of the famous modular group $PSL_2(\mathbb{Z})$. A remarkable class of (2,3)-generated groups is the class of so called Hurwitz groups, namely, the groups having (2,3)-generators whose product has order 7. In 1893 Hurwitz proved that the automorphism group of a compact Riemann surface with genus $g > 1$ always has order at most $84(g - 1)$ and that this upper bound is attained precisely when the group has got the last mention generation property.

The alternating and sporadic simple groups are fully investigated with respect to the (2,3)-generation property in [1] and [2], respectively. According to the result of Lübeck and Malle [3] all simple exceptional groups are (2,3)-generated, except for the Suzuki groups $Sz(2^{2m+1})$.

In this way, the groups that left to be considered are the finite simple classical groups. Liebeck and Shalev proved in [4] that, except the infinite families of symplectic groups $PSp_4(2^m)$, $PSp_4(3^m)$, all finite simple classical groups are (2,3)-generated with a finite number of exceptions. Their result is based on probabilistic methods and neither gives any estimates on the number of these exceptions nor can localize them.

Now the problem concerning the (2,3)-generation (especially) of the finite special linear groups and their projective images is completely solved (see [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21] and [22]). A short survey can be found in [18]. In the present paper we provide our contribution to the problem by discussing the last remaining groups $SL_{10}(q)$. Our considerations are easily traceable and rely only on the known list of maximal subgroups of these groups. We prove the following:

Theorem. *The group $SL_{10}(q)$ is (2,3)-generated for any q .*

II. PROOF OF THE THEOREM

Let $G = SL_{10}(q)$, where $q = p^m$ and p is a prime. Set $Q = q^9 - 1$ if $q \neq 3, 7$ and $Q = (q^9 - 1)/2$ if $q = 3, 7$. The group G acts naturally on a ten-dimensional vector space V over the field $F = GF(q)$. We identify V with the column vectors of F^{10} , and let v_1, \dots, v_{10} be the standard base of the space V , i.e. v_i is a column which has 1 as its i -th coordinate, while all other coordinates are zeros.

2.1. We first assume that $q > 4$. Now, let us choose an element ω of order Q in the multiplicative group of the field $GF(q^9)$ and set

$$f(t) = (t - \omega)(t - \omega^q)(t - \omega^{q^2})(t - \omega^{q^3})(t - \omega^{q^4})(t - \omega^{q^5})(t - \omega^{q^6})(t - \omega^{q^7})(t - \omega^{q^8}) = t^9 - \alpha_1 t^8 + \alpha_2 t^7 - \alpha_3 t^6 + \alpha_4 t^5 - \alpha_5 t^4 + \alpha_6 t^3 - \alpha_7 t^2 + \alpha_8 t - \alpha_9.$$

Then $f(t) \in F[t]$ and the polynomial $f(t)$ is irreducible over the field F . Note that $\alpha_9 = \omega^{\frac{q^9-1}{q-1}}$ has order $q - 1$ if $q \neq 3, 7$, $\alpha_9 = 1$ if $q = 3$, and $\alpha_9^3 = 1 \neq \alpha_9$ if $q = 7$.

Now, the matrices

$$x = \begin{bmatrix} 0 & 0 & 0 & -1 & 0 & 0 & 0 & \alpha_2 \alpha_9^{-1} & 0 & \alpha_3 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & \alpha_4 \alpha_9^{-1} & 0 & \alpha_7 \\ 0 & 0 & -1 & 0 & 0 & 0 & 0 & \alpha_5 \alpha_9^{-1} & 0 & \alpha_5 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_3 \alpha_9^{-1} & 0 & \alpha_2 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_1 \alpha_9^{-1} & -1 & \alpha_8 \\ 0 & -1 & 0 & 0 & 0 & 0 & 0 & \alpha_7 \alpha_9^{-1} & 0 & \alpha_4 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & \alpha_6 \alpha_9^{-1} & 0 & \alpha_6 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_9 \\ 0 & 0 & 0 & 0 & -1 & 0 & 0 & \alpha_8 \alpha_9^{-1} & 0 & \alpha_1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_9^{-1} & 0 & 0 \end{bmatrix}$$

$$y = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

are elements of G of orders 2 and 3, respectively. Denote $z = xy =$

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & \alpha_3 & \alpha_2 \alpha_9^{-1} \\ 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & \alpha_7 & \alpha_4 \alpha_9^{-1} \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & \alpha_5 & \alpha_5 \alpha_9^{-1} \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_2 & \alpha_3 \alpha_9^{-1} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & \alpha_8 & \alpha_1 \alpha_9^{-1} \\ 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & \alpha_4 & \alpha_7 \alpha_9^{-1} \\ 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_6 & \alpha_6 \alpha_9^{-1} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_9 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & \alpha_1 & \alpha_8 \alpha_9^{-1} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \alpha_9^{-1} \end{bmatrix}$$

The characteristic polynomial of z is $f_z(t) = (t - \alpha_9^{-1})f(t)$ and the characteristic roots $\alpha_9^{-1}, \omega, \omega^q, \omega^{q^2}, \omega^{q^3}, \omega^{q^4}, \omega^{q^5}, \omega^{q^6}, \omega^{q^7}$, and ω^{q^8} of z are pairwise distinct. Then, in $GL_{10}(q^9)$, z is conjugate to the matrix $\text{diag}(\alpha_9^{-1}, \omega, \omega^q, \omega^{q^2}, \omega^{q^3}, \omega^{q^4}, \omega^{q^5}, \omega^{q^6}, \omega^{q^7}, \omega^{q^8})$ and hence z is an element of $SL_{10}(q)$ of order Q .

Let H is the subgroup of G generated by the above elements x and y .

Lemma 1. *The group H acts irreducibly on the space V .*

Proof: Assume that W is an H -invariant subspace of V and $k = \dim W, 1 \leq k \leq 9$.

Let first $k = 1$ and $0 \neq w \in W$. Then $y(w) = \lambda w$ where $\lambda \in F$ and $\lambda^3 = 1$. This yields

$$w = \mu_1 v_1 + \mu_2(v_2 + \lambda v_3) + \mu_3(\lambda v_4 + v_5 + \lambda^2 v_6) + \mu_2 \lambda^2 v_7 + \mu_4(\lambda v_8 + v_9 + \lambda^2 v_{10}) (\mu_i \in F)$$

Moreover $\mu_1 = 0$ if $\lambda \neq 1$.

Now $x(w) = \nu w$ where $\nu = \pm 1$. This yields consecutively $\mu_4 \neq 0, \alpha_9 = \lambda^2 \nu$, and

- (1) $\mu_1 = -\nu \lambda \mu_3 + (\lambda \alpha_3 \alpha_9^{-1} + \lambda^2 \alpha_2) \mu_4,$
- (2) $\mu_2 = -\nu \lambda^2 \mu_3 + (\lambda \alpha_7 \alpha_9^{-1} + \lambda^2 \alpha_4) \mu_4,$
- (3) $\mu_3 = (-\nu + \lambda^2 \alpha_1 + \lambda \alpha_8 \alpha_9^{-1}) \mu_4,$
- (4) $(\nu + 1)(\mu_2 - \lambda \alpha_5 \mu_4) = 0,$
- (5) $(\nu + 1)(\lambda^2 \alpha_6 - \alpha_5) = 0.$

In particular, we have $\alpha_9^3 = \nu$ and $\alpha_9^6 = 1$. This is impossible if $q = 5$ or $q > 7$ since then α_9 has order $q - 1$. According to our assumption $q > 4$, that is $q = 7$ (and $\alpha_9^3 = 1 \neq \alpha_9$). Thus

$\nu = 1$ and $\alpha_9 = \lambda^2 \neq 1$. So $\lambda \neq 1, \mu_1 = 0$ and from (1), (2), (3), (4), (5) we can extract that $\alpha_1 = \lambda^2 \alpha_2 + \lambda^2 \alpha_3 - \alpha_8 + \lambda, \alpha_5 = -\lambda^2 \alpha_2 - \lambda^2 \alpha_3 + \lambda \alpha_4 + \lambda \alpha_7$ and $\alpha_6 = -\alpha_2 - \alpha_3 + \lambda^2 \alpha_4 + \lambda^2 \alpha_7$. Then $f(-1) = -(1 + \lambda + \lambda^2)(1 + \alpha_4 + \alpha_7) = 0$, an impossibility as $f(t)$ is irreducible over the field F .

Now let $2 \leq k \leq 9$. Then the characteristic polynomial of $z|_W$ has degree k and has to divide $f_z(t) = (t - \alpha_9^{-1})f(t)$. The irreducibility of $f(t)$ over F leads immediately to the conclusion that this polynomial is $f(t)$ and $k = 9$. Now the subspace U of V which is generated by the vectors $v_1, v_2, v_3, \dots, v_9$ is $\langle z \rangle$ -invariant. If $W \neq U$ then $U \cap W$ is $\langle z \rangle$ -invariant and $\dim(U \cap W) = 8$. This means that the characteristic polynomial of $z|_{U \cap W}$ has degree 8 and must divide $f_z(t) = (t - \alpha_9^{-1})f(t)$ which is impossible. Thus $W = U$ but obviously U is not $\langle y \rangle$ -invariant, a contradiction.

The lemma is proved. (Note that the above considerations fail if $q = 2, 3$ or 4).

Lemma 2. *Let M be a maximal subgroup of G having an element of order Q . Then M belongs to the class of reducible subgroups of G .*

Proof: Suppose false. The list of maximal subgroups of G is given in Tables 8.60 (subgroups of geometric type) and 8.61 (other, non-geometric type subgroups) in [23].

We use the well-known Zsigmondy's theorem to take a primitive prime divisor of $p^{9m} - 1$, i.e., a prime r which divides $p^{9m} - 1$ but does not divide $p^i - 1$ for $0 < i < 9m$. Obviously $r \geq 19$ (as $r - 1$ is a multiple of $9m$) and also r divides Q . Now it is easy to verify that the only geometric type subgroup of order divisible by r is $SU_{10}(q_0)$. $(10, q_0 - 1)$ if m is even and $q = q_0^2$. However, then

$$|SU_{10}(q_0) \cdot (10, q_0 - 1)| = (10, q_0 - 1) q_0^{45} (q_0^2 - 1) (q_0^3 + 1) (q_0^4 - 1) (q_0^5 + 1) (q_0^6 - 1) (q_0^7 + 1) (q_0^8 - 1) (q_0^9 + 1) (q_0^{10} - 1)$$

and it is not difficult to see that $|SU_{10}(q_0) \cdot (10, q_0 - 1)|$ is not divisible by Q . As far as it concerns the other (non-geometric) type of maximal subgroups of G , having orders divisible by r , there is only one such group with the following structure $(10, q - 1) \circ 2L_2(19)$ if $q = p \equiv 1, 4, 5, 6, 7, 9, 11, 16, 17 \pmod{19}$ and $r = 19$. The order of the last group is a divisor of $2^4 \cdot 3^2 \cdot 5^2 \cdot 19$, and then we have $Q \geq \frac{5^9 - 1}{2} > 2^4 \cdot 3^2 \cdot 5^2 \cdot 19 \geq |(10, q - 1) \circ 2L_2(19)|$ which is impossible. The lemma is proved.

To finish our considerations in this case ($q > 4$) it is enough to summarize the facts already established above. The group $H = \langle x, y \rangle$ has an element of order Q and H is irreducible on the space V by Lemma 1. Then Lemma 2 implies that H cannot be contained in any maximal subgroup of $G (= SL_{10}(q))$. Thus $H = G$ and $G = \langle x, y \rangle$ is a $(2, 3)$ -generated group.

2.2. Now we proceed to prove the $(2, 3)$ -generation of the remaining groups $SL_{10}(2), SL_{10}(3)$ and $SL_{10}(4)$ for $q = 2, 3$ and 4 , respectively, the cases we have not cover so far. We

choose appropriate elements x_q and y_q of orders 2 and 3, respectively, for each one of the groups $SL_{10}(q)$, and prove that $\langle x_q, y_q \rangle = SL_{10}(q)$. In our considerations, counting the

orders of some elements in the corresponding groups $\langle x_q, y_q \rangle$, we rely on the possibilities of Magma Computational Algebra System. We also use the orders of the maximal subgroups of $SL_{10}(q)$ which can be derived from [23].

One suitable pair of elements in the group $SL_{10}(2)$ is:

$$x_2 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix},$$

$$y_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}.$$

Here we obtain that the order of x_2y_2 is 3.11.31 and $x_2y_2(x_2(y_2)^2)^2$ has order 73. But there is no maximal subgroup in $SL_{10}(2)$ of order divisible by 11.73. So $SL_{10}(2) = \langle x_2, y_2 \rangle$.

Further, let us deal with the group $SL_{10}(3)$ and choose:

$$x_3 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix},$$

$$y_3 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}.$$

The product of the last two matrices has order $11^2 \cdot 61$ and the following element

$$(x_3y_3)^2x_3(y_3)^2(x_3y_3)^2x_3(y_3)^2x_3y_3x_3(y_3)^2x_3y_3$$

is of order 2.13.757. Checking the orders of the maximal subgroups of $SL_{10}(3)$ we can see that no one of them is a multiple of 61.757 which means that $SL_{10}(3) = \langle x_3, y_3 \rangle$.

Lastly, we finish with the proof of the (2,3) - generation of the group $SL_{10}(4)$ by taking its elements:

$$x_4 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & \eta \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix},$$

$$y_4 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}.$$

(Here η is a generator of $GF(4)^*$.)

In this case x_4y_4 has order 3.19.73 and the element $(x_4(y_4)^2)^3x_4y_4(x_4(y_4)^2)^6$ has order 5.11.31.41. Similarly, as in the previous cases, we can conclude that $SL_{10}(4)$ is generated by the above matrices because no one of its maximal subgroups has order divisible by 41.73.

This completes the proof of the theorem.

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Shapes of a halftone point for high quality and special effects.

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I. INTRODUCTION

The recent development of digital technologies has led to a boom in the development of electronic media. Electronic editions now have applications for smartphones and tablets. By using Enhanced Virtuality Technology, each user can read the press in real time or get to see exhibitions in museums and galleries around the world. To implement a digital drawing it is necessary to have the following tools for work:

- a computer or a tablet;
- a scanner;
- a printer;
- tablets
- video camera;
- a camera.

It is also necessary to install the corresponding software for image processing and graphic design. The creation of illustrations and books through modern digital technologies is applied, both in the education of students and in their professional publishing.

The human eye quickly detects the presence of a color shade in the neutral zone. Comparing two shades of gray scale is much easier than comparing color rendered by the process ink in the original. There is a difference in the colors reproduced by the monitor and the printer. The colors in the computer monitor are made up of red, blue and green dots, and can amount to more than 16.7 million colors, of which we can see approximately 8 million. Printers use a mixture of yellow, magenta, cyan and black. Due to the limitations of printing inks, about 5000 color shades are reproduced. Gray scale is a way to check and balance the gray tones in production. The

rendered gray scale exactly matches the original gray scale. For this reason, the levels of the printed gray scale are compared with the levels of the original gray scale.

Printers print an image through small black dots called Dot. These dots are of fixed size and shape. An important parameter for each printer is its resolution. It shows the number of dots that can be printed in one inch and is measured in dots per inch (dpi). The higher the resolution of a printer, the better image you can get..

II. SHAPES OF A HALFTONE DOT FOR HIGH QUALITY AND SPECIAL EFFECTS.

The image is exposed on a plate by using the light property called diffraction. Diffraction occurs when the light passes through a grid called a raster. The process is called rasterization. The printed image is constructed as a grid of spotted (pluton) spots (Spot). The human eye has the ability to average the colors. With predominant black dots and the presence of white ones, a shade of gray is obtained. The more white the dots, the more lighter the gray. In this way, different areas of gray are formed. Gray images obtained in this way are called halftone images.

Полутоннови точки

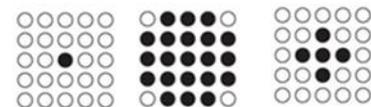


Fig1. Example for halftone dots.

The halftone dot - spot is seen as a dotted cell. In its printing, the cell is made up of printer dots. The number of printer points depends on the gray shade to reproduce a halftone point. When a white color is printed, a print point is missing. For black color reproduction, the whole halftone cell is filled with printer dots.

The frequency of the halftone points per unit of measure (most often inches) is called linetype (Lpi). It is measured in lines per inch (lpi). There is a direct relationship between the

liner and the resolution of the print device. The print image is formed by the frequency of the halftone dots per inch. The larger the halftone cell, the more grayscale can be reproduced.

Another important parameter is the angle of rotation of raster grid - the Screen Angle. Halftone print points create a horizontal line. When rotated at certain angle to the horizon of these lines, the print quality of the gray color shades increases. When colors are superimposed to one another the unwanted effect is called moire. By rotating the raster grid for each color the moire effect is avoided.

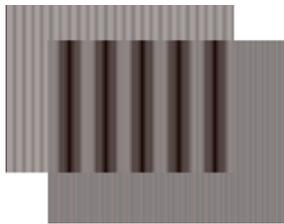


Fig. 2. Moire Effect

It is necessary before work to balance the shade of the gray color using a special calibration procedure. This procedure consists in programming the percentage ratios between yellow, magenta and cyan. Gray calibration balance is said to be when the ratio of the yellow color, magenta and cyan, mixed together on the scanner, is reproduced in the same way as for printing. Gray balance is a factor in determining the overall color palette. [1÷11]

Shape of halftone dots:

The shape of the halftone points affects the final perception of the image. Types of forms of halftone dots:

- Round shape - this is the basic form and most common in printing;
- Elliptical form;
- Diamond shape;
- Square shape;

Apply Euclid's law to modify the shape of the halftone points.



Fig. 3. Types of sections of the grid

A raster is called the point structure of a graphic image in digital printing and polygraphy. In the standard layout, the raster point is circular in shape and the printer points are centered on the raster grid. In the stochastic raster, both the size and the position to each of the raster halftone points change.

III. SPECIAL EFFECTS

➤ **Trimming part of the image**

The Select tool and the Free Form Select tool cuts parts of an image. The option allows cropping a rectangular area. This is done by placing the cursor at one end of the area, cropping and dragging the mouse to close the area. After releasing the mouse the screen portion is marked between these two points.

With the Free Form Select tool an area with a random loop is also marked. Selecting a point in the image and dragging the mouse along the border of the image closes the outline. The dotted line appears indicating the closed rectangular area and marking it. The selected area can be copied and moved to other images with the tools: Copy (Cut), Paste from the Edit menu. Inserting image is done in the top area of the workspace. The selected area is moved by dragging to a random position of the workspace. Deselecting is done by clicking the mouse at a random position in the work area. [1÷11]

If a duplication of repetitive objects is needed, they are copied as often as necessary. The Graphic Editor allows you to select options for performing the following actions on the cropped object:

- Rotating selected objects;
- Reduce the size of selected objects;
- Increase the size of selected objects.

These actions are performed from the Image menu and the corresponding dialog boxes with Flip / Rotate and Stretch / Skew commands

➤ **Free drawing**

Pencil and Brush tools are used. Random lines can be drawn. For corrections of the drawing are used Erasers.

➤ **Scaling.** The following menus are used for work in different image scales:

- View,
- Zoom,
- Large Size.

➤ **Working with colors.**

Choose the Color Box palette. Select the writing tool from the toolbar: for example pencil. Each mouse click on a pixel on the screen colors it in the desired color.

➤ **Change the size of the image**

Returning the image from an enlarged to normal size is done with View, Zoom, Normal Size. You can also use the magnifying tool and choose how many times to increase the area marked with this tool and return to normal size. (with the extra palette). Creating a point-by-point drawing will take too long, and this mode only serves for fine changes. For large images you can use predefined drawing forms.

The Line tool is used to draw a line. There is a possibility to change the thickness of the drawing line. The curve tool draws a curved line

To draw shapes that are closed areas, the following options are selected:

- Contour with the current color and inner space with the background color;
- Contour with the current color and transparent internal area;
- Transparent contour and internal area with the background color.

Choose the type of figure to draw. Next, select one of the three options above for contour and background color. The default contour thickness is set with the Line button

➤ **Drawing the image itself can be done in the following two ways:**

- With the File With Color tool;
- With the Airbrush tool.

Through the Text tool you can enter text for clarification in the image, such as title, explanations and more. Formatting this text is done by a palette that appears automatically when selecting the Text tool.

III. CONCLUSION

Digital drawing is a term for artistic works that use digital technology in the creative process. Digital art is not feasible without basic knowledge and principles for drawing and painting with pencil or paint. The most commonly used programs for creating digital drawings are Photoshop and Illustrator. Using tablets, artists have the opportunity to see the image of their work from near or far. Digitizer is a computer peripheral device that allows you to draw images and graphics in the same way as if on a sheet of paper. The difference is that the drawing on the tablet can be edited multiple times. [1÷11]

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