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Identifying and Prioritizing Factors Affecting Sustainable Social Responsibility in a Private Mobile Operator Using Multi-Criteria Decision-Making Techniques

Nastaran Vedad, Tahmoures Sohrabi*

Abstract: Since considering the social factors in organizations in the current era is as important as the income and profitability of organizations, the present study seeks to identify and prioritize the factors affecting sustainable social responsibility. Today's organizations have found that by focusing on social responsibility, they can attract more customers and earn multiple their cost. Since several factors affect the social responsibility of companies, in this paper, first these factors are extracted and then, the factors related to a Private Mobile Operator are identified based on the Delphi method. Since no organization has the ability to define improvement projects for all factors of social responsibility, so they should be ranked to identify the most important factors of limited organizational resources allocated to them. The MABAK method has been used to rank these factors and its required initial weight were extracted by the SAVARA method. Finally, the results of factor prioritization are presented.

Keywords: MABAK; MADM; SAVARA; Sustainable Social Responsibility

1 INTRODUCTION

Many researchers have recently emphasized Corporate Social Responsibility (CSR) in business contexts and have mentioned CSR as a useful field for many businesses, practitioners, academics and managers [1]. Despite the use of CSR and numerous studies on this concept, there is no agreement on how to conceptualize CSR [2]. However, it is not clear exactly how social responsibility (SR) and sustainable development programs are integrated with corporate practices [3]. According to the existing literature, the integration of sustainability and social responsibility in organizational actions will not only reduce negative environmental impacts and improve social impacts, but will also improve better governance [4], improve financial performance [5] and leads to a better evaluation of the quality of institutions [6]. Accordingly, the present study was conducted with the aim of analysing and prioritizing sustainable social responsibility criteria in a Private Mobile Operator based on the experts' opinion.

2 PROBLEM STATEMENTS AND RESEARCH LITERATURE

Corporate social responsibility has been considered by many experts, researchers and organizations so that considering social responsibility has become one of the dimensions and components of their operational activities in organizations [7].

Corporate sustainability, according to Dyllick and Hockerts (2002), is based on six criteria including economic productivity, economic efficiency, environmental effectiveness, social effectiveness, adequacy and economic value [8].

In addition, a matrix is presented in the research of Van Marrewijk and Were (2003) that shows the distinction between organizations at different stages of development, their related institutional frameworks, and the level of performance of different companies. In their view, this matrix is a self-assessment tool that can be used to audit, analyze and interpret corporate sustainability. On the other hand, according to Salzmann, Ionescu-Somers and Steger (2005), firm sustainability is very complex because it is related to different parameters (e.g. technology, organizations and visibility) that vary in different industries, countries and places. However, corporate sustainability, according to them, is limited to reducing operational risk and measures to increase environmental productivity [9].

Accordingly and due to the importance of the research subject, the present study aimed to identify and prioritize sustainable social responsibility indicators in a Private Mobile Operator Therefore, the main question of the present study is what are the most important indicators of sustainable social responsibility in a Private Mobile Operator?

The research literature and background on this subject are reviewed in the following section.

With the advent of the Wall Street movement in the United States and other EU countries, general attitude is that a major part of the causes of these movements and dissatisfaction is caused by the global economic crisis. According to some experts, the lack of attention of organizations to social responsibilities by banks and credit institutions and other institutions and organizations to society caused a major part of this crisis.

A sustainable corporate development model is developed by Sharaei et al. (2017) in a research with the aim of explaining the role of corporate social responsibility, corporate governance, and creating shared value. The research statistical population was 13 companies that won national awards. According to their results, corporate social responsibility and shared value creation affect the development of corporate sustainability with the intensities of 69% and 63% and corporate governance improves the relationship between corporate responsibility and creating shared value for stakeholders. Also, it indirectly affects the development of corporate sustainability with an intensity of 27% [10].

Nadem et al. (2017) examined the effect of social media, transparency and social responsibility on business

performance with the mediating role of a sustainable brand. Their study aimed to investigate the factors affecting the business performance of Mehr Industrial Group. Data analysis showed that transparency and social responsibility can have a strong relationship with business performance in Mehr Industrial Group and this company must pay close attention to social media and sustainable brand in order to enhance its business performance [11].

The impact of transparency, social responsibility and marketing through social networks on business performance was also investigated by Pirchianloo (2018), considering the mediating role of organizational reputation and sustainable brand. The customers of Digikala Company formed the research statistical population. Content validity (CVR) and convergent (CV) and divergent (DV) constructs were used to evaluate the validity of the questionnaire, and Cronbach's alpha and combined reliability (CR) were used to calculate the reliability of the questionnaire. According to the obtained results, marketing through social networks, reputation building and sustainable brand has a positive and significant effect on business performance.

The integration of social responsibility and sustainability in practice is considered by Filho et al. (2019) by examining attitudes and practices in higher education institutions. According to the existing literature, integrating two related agendas can be problematic according to a range of factors including lack of public awareness or misconceptions about related programs. The attitudes and practices related to the integration of social responsibility and sustainability initiatives in government centres were examined in this research. This study theoretically highlighted the relative position and importance of economic factors - since it relates to differentiate instead of integration, for example social responsibility and sustainability. The main finding of this study was to provide useful insights into how top management can bring together two contemporary but potentially competing agendas [11].

The corporate social responsibility for sustainable social and socio-economic development of small and medium enterprises was also examined by Zuzek and Zvirbule (2018) in Poland and Latvia. The main purpose of this study is to describe the meaning of CSR actions in SME in Poland and In Latvia, considering the possibility of their implementation and the obstacles in their implementation. Their research aimed to: 1) discovering the main areas of CSR related to economic and economic enterprises and sustainable economic and social development; 2) Observation and analysis of key CSR areas for SMEs in Poland and Latvia; 3) Conclusions about the importance of CSR for SMEs in sustainable development [9].

Other research conducted and indicators related to sustainable social responsibility, highlighted by researchers, are provided in Tab. 1.

Table 1 Indicators related to sustainable social responsibility

Dimension	Indicators	Resources
Employees	Employees' occupational health and safety	[12], [13], [14], [5] [7], [1], [9], [3]
	Legal working hours and rest time	
	Wages and welfare	
	Employment	
	Education	
	Freedom of unions and their bargaining power	
Shareholders	Legal shareholder income	[15], [16]
	Accurate disclosure of the status of companies and development prospects	
	Participation in decision making	
Customers	Shareholder relationship management system	[17], [18], [19]
	Quality and safety of products and services	
	Customer satisfaction	
	Customer service culture	
	Innovation and development	
Suppliers and Partners	Disclosure of companies' actual performance information	[7]
	Maintaining a partnership	
	Strengthening relationships with partners / suppliers	
Government	Enhancing CSR performance of partners and suppliers	[20], [11]
	Paying tax	
	Following the rules and regulations	
Resources and the environment	Providing job opportunities	[21]
	Preserving energy and resources	
Local communities	Environmental Protection	[22], [8], [13], [23]
	Impact of projects on society	
Competitors	Creating a harmonious community	[9], [17], [24]
	Professional ethics	
	Fair competition	
NGO	Social and public service strategy	[25], [26]

3 RESEARCH METHODS

The present study is an applied research in terms of the purpose because the research results can be applied in the similar organizations. It is also a descriptive survey in terms of data collection approach and the researcher will not interfere in the data. The research statistical population is all experts and experienced managers of a Private Mobile Operator. The dimensions of the present research questionnaire are provided in the table below. In the present study, by examining similar questionnaires, articles, books and journals, initial questionnaires were designed and then, in order to confirm the questionnaire validity, 3 professors were consulted and the questions were reviewed and approved by them. In order to analyze the data obtained from the research questionnaires, first the appropriate weight was assigned to the indicators using the Savara technique and then the indicators were prioritized by the Mabak technique and the experts' opinion was used in each stage [27].

Table 2 The research questionnaire dimensions

Dimension	Indicators
Employees	Employees' occupational health and safety
	Legal working hours and rest time
	Wages and welfare
	Employment
	Education
	Freedom of unions and their bargaining power
Shareholders	Legal shareholder income
	Accurate disclosure of the status of companies and development prospects
	Participation in decision making
	Shareholder relationship management system
Customers	Quality and safety of products and services
	Customer satisfaction
	Customer service culture
	Innovation and development
	Disclosure of companies' actual performance information
Suppliers and Partners	Maintaining a partnership
	Strengthening relationships with partners / suppliers
	Enhancing CSR performance of partners and suppliers
Government	Paying tax
	Following the rules and regulations
	Providing job opportunities
Resources and the environment	Preserving energy and resources
	Environmental Protection
Local communities	Impact of projects on society
	Creating a harmonious community
Competitors	Professional ethics
	Fair competition
NGO	Social and public service strategy

4 DATA ANALYSIS

As the sustainable social responsibility variables have been collected from previous research as well as interviews with experts, they should be customized for a Private Mobile Operator. For this purpose, the Delphi method is used and experts were asked to express their opinions on the index by the numbers 1 to 5 by 1 indicating the least important and 5 indicating the most important. If the average of the numbers is less than 4, that variable is rejected and otherwise accepted. There is no agreement among researchers about the number of experts in this method and some believe that this number should be 5 to 15 experts.

Table 3 Experts' preferences about the research indicators

Factors	Expert1 (E1)	E2	E3	E4	E5	E6	E7	M
Employees' occupational health and safety	4.29	3	5	4	5	4	5	4
Legal working hours and rest time	3.57	3	3	4	5	4	3	3
Wages and welfare	4.29	3	5	4	5	5	4	4
Employment	3.57	3	3	4	5	4	3	3
Education	4.29	4	5	3	4	5	4	5
Freedom of unions and their bargaining power	4.29	4	5	4	3	5	4	5
Legal shareholder income	3.57	3	4	5	3	4	3	3

Accurate disclosure of the status of companies and development prospects	3.71	3	4	5	4	3	4	3
Participation in decision making	4.29	4	3	4	5	5	4	5
Shareholder relationship management system	3.86	3	3	3	5	4	5	4
Quality and safety of products and services	3.57	3	4	3	5	4	3	3
Customer satisfaction	4.43	5	3	5	4	5	4	5
Customer service culture	4.43	3	4	5	5	5	4	5
Innovation and development	3.43	4	3	4	3	4	3	3
Disclosure of companies' actual performance information	3.57	3	5	4	3	4	3	3
Maintaining a partnership	3.71	3	5	4	3	4	3	4
Strengthening relationships with partners / suppliers	3.71	5	4	3	3	4	3	4
Enhancing CSR performance of partners and suppliers	4.43	3	5	4	5	4	5	5
Paying tax	4.43	3	5	4	5	4	5	5
Following the rules and regulations	4.29	4	5	3	5	4	5	4
Providing job opportunities	4.43	4	5	4	4	4	5	5
Preserving energy and resources	4.43	3	5	4	5	4	5	5
Environmental Protection	4.43	5	3	5	4	5	4	5
Impact of projects on society	4.57	4	5	4	5	5	4	5
Creating a harmonious community	4.29	3	4	5	4	5	5	4
Professional ethics	4.29	4	5	5	4	4	3	5
Fair competition	4.29	5	3	5	4	5	4	4
Social and public service strategy	4.57	4	5	4	5	5	4	5

The results of the experts' opinion in the Delphi method are presented in the following table.

Table 4 Delphi method calculation results

Variables	Reject / Accept
Employees' occupational health and safety	Accept
Legal working hours and rest time	Reject
Wages and welfare	Accept
Employment	Reject
Education	Accept
Freedom of unions and their bargaining power	Accept
Legal shareholder income	Reject
Accurate disclosure of the status of companies and development prospects	Reject
Participation in decision making	Accept
Shareholder relationship management system	Reject
Quality and safety of products and services	Reject
Customer satisfaction	Accept
Customer service culture	Accept
Innovation and development	Reject
Disclosure of companies' actual performance information	Reject

Maintaining a partnership							Reject
Strengthening relationships with partners / suppliers							Reject
Enhancing CSR performance of partners and suppliers							Accept
Paying tax							Accept
Following the rules and regulations							Accept
Providing job opportunities							Accept
Preserving energy and resources							Accept
Environmental Protection							Accept
Impact of projects on society							Accept
Creating a harmonious community							Accept
Professional ethics							Accept
Fair competition							Accept
Social and public service strategy							Accept

According to the obtained results, among 28 variables, 10 variables were rejected and 18 variables were accepted based on the experts' opinion. Because each of the respondents have different opinions according to their expertise and background. Therefore, the weight of each opinion is different, so the Savara method is used to obtain these weights.

Table 5 Initial weights obtained by Savara method

Factor	Comparative importance of average value (S_j)	Coefficient $K_j = S_j + 1$	Recalculated weight $W_j = \dfrac{x_{j-1}}{K_j}$	Weight $q_j = \dfrac{W_j}{\sum W_j}$
Expert 1	0.33	1	1	-
Expert 2	0.17	0.52	1.94	0.94
Expert 3	0.09	0.27	1.81	0.81
Expert 4	0.09	0.28	1.71	0.71
Expert 5	0.1	0.3	1.63	0.63
Expert 6	0.1	0.32	1.49	0.49
Expert 7	0.11	0.35	1.37	0.37

Step 1: creating the initial matrix (average of respondents). The input weights of the Mabak technique can be obtained from other methods such as AHP, entropy, etc. that these weights is obtained by Savara method in this study and will be used in Mabak process. All indicators are considered positive [28].

Table 6 Initial decision matrix

Index name	E1	E2	E3	E4	E5	E6	E7
Participate in decision making	4	5	7	6	9	7	8
Customer service culture	8	7	6	7	9	8	9
Customer satisfaction	7	5	8	6	7	6	9
Impact of projects on society	7	6	5	3	4	6	6
Professional ethics	7	6	9	8	6	8	7
Employees' occupational health and safety	9	7	6	9	8	9	9
Following the rules and regulations	7	7	7	4	4	5	5
Preserving energy and resources	5	5	8	7	6	9	6
Providing job opportunities	5	8	4	5	4	6	6
Improving CSR performance of partners and suppliers	5	5	7	9	5	9	5
Education	4	9	9	8	6	7	5

Social and public service strategy	9	9	5	4	4	9	9
Fair competition	7	6	6	6	8	5	4
Creating a harmonious community	4	7	6	6	9	4	5
Environmental Protection	4	4	7	8	4	6	9
Wages and welfare	8	4	6	9	4	6	7
Paying tax	4	5	4	5	4	9	5
Freedom of association and their bargaining power	5	5	9	5	6	6	8
Maximum	8	9	9	9	9	9	9
Minimum	4	4	4	3	4	4	4
Weight	0.11	0.1	0.1	0.09	0.09	0.17	0.33

Step 2: normalization [29]: the data is normalized in this step, which is presented in the table below.

Table 7 Data normalization

Index name	E1	E2	E3	E4	E5	E6	E7
Participate in decision making	0	0.2	0.6	0.5	1	0.6	0.8
Customer service culture	1	0.6	0.4	0.67	1	0.8	1
Customer satisfaction	0.75	0.2	0.8	0.5	0.6	0.4	1
Impact of projects on society	0.75	0.4	0.2	0	0	0.4	0.4
Professional ethics	0.75	0.4	1	0.83	0.4	0.8	0.6
Employees' occupational health and safety	0	1	0.8	1	0.4	0.2	0.2
Following the rules and regulations	1	0	0	0.33	0.2	0.4	0
Preserving energy and resources	1	0.6	0.8	0.33	0.4	0	0.4
Providing job opportunities	0.75	0	0.4	0.5	0.2	0	0.4
Improving CSR performance of partners and suppliers	0.25	0.8	0.2	0.5	1	0.2	0.6
Education	0.75	0	0.2	0.67	0	0.8	0
Social and public service strategy	0.25	0	0.6	1	0.8	1	0
Fair competition	0.5	0.4	0.4	0.33	0.6	1	0.8
Creating a harmonious community	0	0.2	0.6	0.5	1	0.6	0.8
Environmental Protection	1	0.6	0.4	0.67	1	0.8	1
Wages and welfare	0.75	0.2	0.8	0.5	0.6	0.4	1
Paying tax	0.75	0.4	0.2	0	0	0.4	0.4
Freedom of association and their bargaining power	0.75	0.4	1	0.83	0.4	0.8	0.6

Step 3: creating a weighted matrix: a weighted matrix is formed in this step and the results are presented in the Tab. 8.

Table 8 The weighted matrix

Index name	E1	E2	E3	E4	E5	E6	E7
Participate in decision making	0.11	0.13	0.16	0.14	0.18	0.27	0.59
Customer service culture	0.23	0.17	0.14	0.16	0.18	0.31	0.66
Customer satisfaction	0.2	0.13	0.18	0.14	0.14	0.24	0.66
Impact of projects on society	0.2	0.15	0.12	0.09	0.09	0.24	0.46

Professional ethics	0.2	0.15	0.2	0.17	0.12	0.31	0.53
Employees' occupational health and safety	0.11	0.21	0.18	0.19	0.12	0.2	0.4
Following the rules and regulations	0.23	0.1	0.1	0.13	0.11	0.24	0.33
Preserving energy and resources	0.23	0.17	0.18	0.13	0.12	0.17	0.46
Providing job opportunities	0.2	0.1	0.14	0.14	0.11	0.17	0.46
Improving CSR performance of partners and suppliers	0.14	0.19	0.12	0.14	0.18	0.2	0.53
Education	0.2	0.1	0.12	0.16	0.09	0.31	0.33
Social and public service strategy	0.14	0.1	0.16	0.19	0.16	0.34	0.33
Fair competition	0.17	0.15	0.14	0.13	0.14	0.34	0.59
Participate in decision making	0.2	0.15	0.18	0.17	0.12	0.34	0.4
Customer service culture	0.11	0.17	0.16	0.13	0.11	0.24	0.4
Customer satisfaction	0.2	0.17	0.2	0.16	0.12	0.2	0.33
Impact of projects on society	0.23	0.13	0.12	0.16	0.09	0.2	0.46
Professional ethics	0.11	0.17	0.2	0.16	0.12	0.31	0.33

Step 4: Calculating the distance of the alternative from the estimation boundary and the region estimation boundary matrix.

Table 9 Calculating the distance of alternatives

Index name	E1	E2	E3	E4	E5	E6	E7
Participate in decision making	-1.07	-1.02	-1	-1.01	-0.95	-0.97	-0.76
Customer service culture	-0.95	-0.98	-1.02	-0.99	-0.95	-0.94	-0.69
Customer satisfaction	-0.98	-1.02	-0.98	-1.01	-0.98	-1.01	-0.69
Impact of projects on society	-0.98	-1	-1.04	-1.06	-1.04	-1.01	-0.89
Professional ethics	-0.98	-1	-0.96	-0.98	-1	-0.94	-0.82
Employees' occupational health and safety	-1.07	-0.94	-0.98	-0.96	-1	-1.04	-0.96
Following the rules and regulations	-0.95	-1.04	-1.06	-1.02	-1.02	-1.01	-1.02
Preserving energy and resources	-0.95	-0.98	-0.98	-1.02	-1	-1.07	-0.98
Providing job opportunities	-0.98	-1.04	-1.02	-1.01	-1.02	-1.07	-0.89
Improving CSR performance of partners and suppliers	-1.04	-0.96	-1.04	-1.01	-0.95	-1.04	-0.82
Education	-0.98	-1.04	-1.04	-0.99	-1.04	-0.94	-1.02
Social and public service strategy	-1.04	-1.04	-1	-0.96	-0.97	-0.9	-1.02
Fair competition	-1.01	-1	-1.02	-1.02	-0.98	-0.9	-0.76

Participate in decision making	-0.98	-1	-0.98	-0.98	-1	-0.9	-0.96
Customer service culture	-1.07	-0.98	-1	-1.02	-1.02	-1.01	-0.96
Customer satisfaction	-0.98	-0.98	-0.96	-0.99	-1	-1.04	-1.02
Impact of projects on society	-0.95	-1.02	-1.04	-0.99	-1.04	-1.04	-0.98
Professional ethics	-1.07	-0.98	-0.96	-0.99	-1	-0.94	-1.02

Step 5: ranking alternatives. The results are shown in the table below.

Table 10 Ranking Options

Index	Weight	Rank
Participate in decision making	5	-6.78
Customer service culture	1	-6.53
Customer satisfaction	2	-6.67
Impact of projects on society	14	-7.01
Professional ethics	3	-6.68
Employees' occupational health and safety	10	-6.95
Following the rules and regulations	18	-7.13
Preserving energy and resources	8	-6.9
Providing job opportunities	15	-7.04
Improving CSR performance of partners and suppliers	7	-6.86
Education	17	-7.05
Social and public service strategy	9	-6.94
Fair competition	4	-6.7
Participate in decision making	6	-6.8
Customer service culture	16	-7.05
Customer satisfaction	13	-6.98
Impact of projects on society	12	-6.97
Professional ethics	11	-6.96

5 CONCLUSIONS

Corporate social responsibility, as an initiative of public relations professionals, was ignored in the United States in the early 1990s because critics argued that it was an attempt to rebuild the damaged reputation of some and make a company different from its competitors. Today, however, many businesses adopted social responsibility as a smart business measure.

Corporate Social Responsibility (CSR) has become a sensitive and important issue in recent years. As accountable organizations, leading organizations express their values to make their performance transparent to their stakeholders and to fulfill their responsibilities in the area of social responsibility, and to ensure that these commitments are deployed throughout the organization. Therefore, social responsibility will have mutual benefits for them, so that the organization benefits from a more ethical and coherent approach and the community and stakeholders have a better understanding of the organization performance and strengths [30, 31, 32].

The aim of this study was to identify and prioritize the factors affecting sustainable social responsibility in a Private Mobile Operator using the multi-criteria decision-making technique and prioritize these factors. For this purpose, first 28 factors were extracted based on previous research and interviews with experts. Then, it is tried to align these factors

with a Private Mobile Operator by the Delphi method. The results of Delphi method showed that out of these 28 factors, 18 factors were accepted and 10 factors were rejected. Now, these factors should be ranked to help a Private Mobile Operator by identifying the most important factors so that it can play its social responsibility role in the best way and allocate its limited resources to the most important factors. The Mabak method was used to prioritize these factors, and since prioritization by this method requires initial weight, the Savara method was used to obtain the initial weight. According to the obtained results, among the 18 factors of sustainable social responsibility in a Private Mobile Operator l, the culture of customer service has the highest degree of importance. This means that if a Private Mobile Operator wants to achieve a high degree of sustainable social responsibility, it must strive to spread the culture of customer service throughout the company. a Private Mobile Operator Company has now serious and important competitors in the field of providing services, some of which, including Hamrahe Aval, are supported by the government. This government support can help Hamrahe Aval to provide better services and ultimately more profit. By focusing on this index, a Private Mobile Operator Company can fulfill its sustainable social responsibility and can gain a competitive advantage, surpassing its first or other competitors [33].

Difficult access to research experts due to their job as managers of the company under study was one of the limitations of the present study. Also, in this study, it was necessary to use two questionnaires to implement a combined method of Savara and Mabak, and therefore, due to the large number of criteria and sub-criteria, the number of tables in the TOPSIS method to be completed by experts was high and this led to a decreased reliability of the experts' answers and the length of the research process. As a suggestion for the future research, this model can be implemented in other companies in the telecommunications industry or can also be solved with other MADM methods such as WASPAS, MULTIMOORA, and so on.

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Calibration of Undrained Shear Strength Partial Factor Using Probability Theory

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Abstract: Design in accordance with Eurocode 7 applies the partial factors of geotechnical parameters to take into account uncertainties of various sources. The prescribed values of partial factors are unique, even though the degree of uncertainty can vary significantly. This can lead to an unequal reliability level of structures designed using the same procedures and methods. This paper analyses the influence of undrained shear strength variability on the reliability index (β), using reliability theory and statistical methods. Analyses were performed in the case of a shallow footing designed in accordance with Eurocode 7, design approach 3. It is shown that reliability indexes of a shallow footing could be lower than the target values prescribed in Eurocode. To meet these values, additional elaboration and calibration of undrained shear strength partial factor (γ_{cu}) was proposed.

Keywords: Eurocode 7; geotechnical design; partial factor; reliability analysis; uncertainty; undrained shear strength

1 INTRODUCTION

The measure of safety of geotechnical structures designed in accordance with Eurocode is regulated by the application of partial factors (PF) to actions, materials, and resistances. In this way, instead of one uncertainty applied to the whole model, they are considered separately for each component of that model [1]. The influence of PF values on structural reliability has been investigated by several authors [2-6]. These studies can generally be divided into two groups: direct studies, which directly calculate the reliability of structures using the prescribed values of PF, and indirect studies, which calibrate PF values to achieve the target value of the reliability index (β) [7]. The reliability index is defined as the negative value of the inverse Gaussian distribution of probability failure. Calibration of PF values can be performed using reliability methods [8]. However, almost all values used in modern codes have been calibrated against previous successful experience, with very little use of reliability methods [9].

One of Eurocode's objectives is to provide a similar level of structural reliability, regardless of the relationship between actions, material strengths, and resistances. Tab. 1 shows the three reliability classes associated with the recommended minimum reliability index (β) values for two reference periods [8].

Table 1 Recommended minimum values for reliability index for ULS

Reliability Class	Minimum values for β	
	1 year reference period	50 years reference period
RC3	5.2	4.3
RC2	4.7	3.8
RC1	4.2	3.3

A common reliability class considered in everyday practice is the RC2, which includes residential, commercial, and public buildings with medium failure consequences (e.g. office buildings). Reliability indexes shown in Tab. 1 are recommended minimum values for structures designed in accordance with the Eurocodes.

It can be noted that the reliability indexes for a lower reference period are higher, which may seem illogical at first glance. In geotechnical engineering, this can be interpreted

as the influence of time on soil degradation due to softening. This problem is addressed by [10]. In the example of a retaining wall, they showed that due to soil degradation, the reliability index would decrease from 4.7 to 3.8 over a period of 30-40 years. Analyses were performed using partial factors, which were calibrated to a reference period of 50 years.

Meyerhof [11] claims that the probability of failure of retaining structures and foundations, designed with the typical values of the overall factor of safety, is 10^{-3} to 10^{-4} ($3.1 < \beta < 3.7$), which he finds satisfactory.

Compared to Eurocode 7, which prescribes a unique partial factors value, the Canadian Standards Organization [12] distinguishes their values with respect to the "degree of understanding". The "degree of understanding" adjusts resistance factors as a function of site and model understanding. Concerning the above, three classes are defined: low, typical, and high "degree of understanding". A similar categorization of site variability in piles bearing capacity analysis, based on the values of the coefficient of variation (COV) of geotechnical parameters, is proposed by Paikowsky et al. [13]: low ($COV < 25\%$), medium ($25\% \leq COV < 40\%$) and high ($COV \geq 40\%$) site variability. The coefficient of variation is defined as the ratio between the standard deviation and the mean value of a random variable.

Based on several calibration studies, Phoon [14] proposes three categories of parameter variability (low, medium, and high) to achieve reasonable, uniform reliability levels of geotechnical structures (Tab. 2).

Table 2 Ranges of soil property variability for reliability calibration [14]

Geotechnical parameter	Property variability	COV (%)
Undrained shear strength	Low [a]	10-30
	Medium [b]	30-50
	High [c]	50-70
Effective stress friction angle	Low [a]	5-10
	Medium [b]	10-15
	High [c]	15-20
Horizontal stress coefficient	Low [a]	30-50
	Medium [b]	50-70
	High [c]	70-90

[a] typical of good quality direct lab or field measurements; [b] typical of indirect correlations with good field data, except for the standard penetration test (SPT); [c] typical of indirect correlations with SPT field data and with strictly empirical correlations.

2 STATEMENT OF THE PROBLEM

Regardless of the uncertainty degree, Eurocode 7 prescribes a unique value of a partial factor for a geotechnical parameter. The consequence is an unequal level of structural reliability, which does not correspond to the initial Eurocode's intention to ensure an equal reliability level.

In addition to the above, results presented by several authors ([3, 6]) indicate that the reliability index (β) of shallow foundations designed in accordance with EC7 could be lower than values prescribed in Tab. 1. Murakami et al. [6] investigated the relationship between the PF and β in the case of an open channel. They showed that the γ_{c_u} value prescribed in Eurocode 7 is not sufficient to ensure the recommended minimum reliability index, i.e. its value should be increased. More specifically, for the $COV_{c_u} = 0.3$, to reach $\beta \approx 3.8$, $\gamma_{c_u} \approx 2.8$ is required. Similar results were presented by Forrest & Orr [3], on the example of a shallow foundation designed according to Eurocode 7.

This paper considers a shallow foundation which is centrally loaded with permanent action. In order to define the relevant random variables, the Sobol sensitivity analysis was conducted. The analysis determined the contribution of individual random variables to the total system response variance. The variables with a smaller Sobol index (SI) value can be frozen. In this case, the overall factor of safety (FS) was chosen for system response, and the analysis considered three random variables: undrained cohesion (c_u), permanent and (V_G) i variable (V_Q) load. The following Sobol indices values were obtained: $SI_{c_u} = 0.98$, $SI_{V_G} = 0.013$ and $SI_{V_Q} = 0.007$. The results show that c_u is the dominant variable, whereas the contributions from V_G and V_Q are negligible. For the graphic presentation of the results, only two random variables were chosen (c_u and V_G), while V_Q was excluded from further analyses due to its negligible SI value.

The main goal of this paper is additional elaboration and calibration of the γ_{c_u} value prescribed in Eurocode 7, design approach 3. The partial factor is calibrated for the ULS (GEO) of shallow footing, RC2 reliability class and a 50-year reference period. To ensure a γ_{c_u} value that will provide the minimum recommended reliability index of 3.8, calibration was performed for the critical combination of geometry, load, and soil parameters. Additional γ_{c_u} elaboration was proposed based on the uncertainty degree of c_u that is quantified by the coefficient of variation (COV_{c_u}).

To meet the main goal, the following subsidiary goals are defined:
- the critical combination of geometry and load parameters determination using multiparameter analysis
- undrained shear strength variability quantification
- investigation of the influence of the marginal distribution of undrained shear strength on β and γ_{c_u}
- selection of the appropriate calibration method

- comparison of results obtained using calibrated partial factor values, with the results obtained using partial factors prescribed in EC7, DA3.

3 MATERIALS AND METHODS

Calibration of γ_{c_u} is performed in the case of the ultimate limit state (GEO) of a square footing under a permanent vertical load. The footing is analyzed in accordance with Eurocode 7, DA3. The influence of the force eccentricity on the β value was also considered. In this case, a permanent vertical force, along with moments, is applied on the footing.

In all analyses, the following equality is satisfied: the design action is equal to the design resistance, i.e. $E_d = R_d$. The model geometry is shown in Fig. 1.

Reliability analyses are performed using the following assumptions:
- c_u, γ and E_d are uncorrelated random variables
- foundation soil is coherent, homogeneous and isotropic
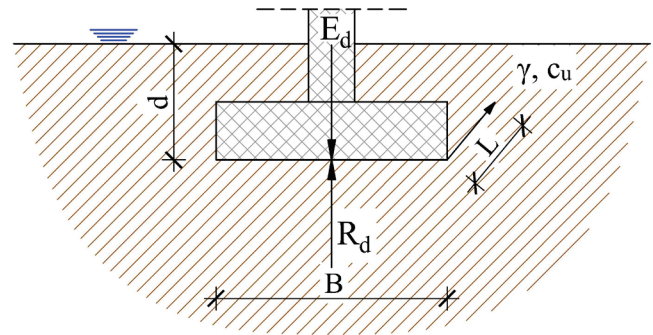- the foundation soil is saturated.

Figure 1 Geometry of the model

The First Order Reliability Method (FORM) was selected as the calibration method, and the design values of the random variables for partial factor calibration were determined from the graphical representation of the problem in the standard normal (U) space. The above is practicable due to the number of random variables. The performance function is relatively simple, so it is expected that the iterative procedure within the FORM analysis will converge relatively quickly, with negligible error. Based on FORM results, the calibrated PF values were calculated as follows:

$$\gamma_{c_u} = \frac{c_{u_k}}{c_{u_d}} \tag{1}$$

where: γ_{c_u} - undrained shear strength partial factor; c_{u_d} - the design value of c_u; c_{u_k} - the characteristic value of c_u.

Partial factor value for the permanent load is taken from Eurocode 7.

3.1 Random and Deterministic Variables in the Reliability Analysis

The reliability integral of the problem consists of two random variables: undrained shear strength (c_u) and permanent vertical load (V_G). The soil unit weight (γ) is considered to be a deterministic variable since its prescribed partial factor (γ_γ) value equals to one [15], i.e. $COV_\gamma \approx 0$. Similarly, Murakami et al. [6] showed that γ_γ for shallow foundation is in the range of 1-1.05. All other parameters are considered to be deterministic variables. The characteristics of random variables are shown in Tab. 3.

Table 3 Characteristics of random variables

Random variable	Designation	Statistical distribution	COV
V_G	X1	Normal	0.1
c_u	X2	Normal, Lognormal*	changeable

* reliability analyses are performed both for normally and lognormally distributed c_u

Due to low variability, a permanent load can be assumed to be normally distributed, and its characteristic value equals the mean [8].

Relevant literature gives different recommendations on the c_u statistical distribution. According to [16, 17], c_u is lognormally distributed, and the value of COV depends on the determination method. Hooper & Butler [18] investigated the properties of London clays. Based on the histograms, they concluded that the probability density function (PDF) of c_u is probably normal. Murakami et al. [6] concluded the same, but in the case of large variability, they recommend the use of lognormal PDF. Reliability analyses with both (normal and lognormal) assumptions were performed in this paper.

Characteristic values of geotechnical parameters were calculated from the mean values using Eq. 2 [19]. Corresponding design values are determined according to EC7, DA3 [15].

$$x_k = v_m \cdot \left(1 - \frac{COV_x}{2}\right) \tag{2}$$

where: x_m - is the mean value of X; COV_x - is the coefficient of variation of X.

3.2 Reliability Integral

The reliability integral is approximated using First Order Reliability Analysis (FORM). Because of a relatively simple mathematical expression of the performance function, relatively fast convergence and small error are expected.

3.2.1 Performance Function (PF)

Performance function is defined as follows [20]:

$$g = R - S \tag{3}$$

where $R = r(R)$, and $S = s(s)$ - random variables related to resistances and actions.

In the case of a shallow foundation, R and S can be expressed in the following way [15]:

$$S = E_d = \gamma_G \cdot V_G = 1.35 \cdot V_G \tag{4}$$

$$R = \frac{R_k}{\gamma R_v} = R_d = \left[(\pi + 2) \cdot c_{u,d} \cdot s_c \cdot i_c + q\right] \cdot A' \tag{5}$$

where: E_d - design value of the effect of actions, V_G - characteristic value of permanent load, γ_G - partial factor for a permanent action, $c_{u,d}$ - undrained shear strength design value; s_c, i_c - dimensionless factors for the shape of the foundation and the inclination of the load; q - the design total overburden pressure at the level of the foundation base.

Dimensionless factors s_c and i_c are calculated using equations from [15].

Substituting the terms in the expressions (3) with the expressions (4) and (5), and by replacing the designation of random variables in accordance with Tab. 3, the performance function in the physical space (X space) yields:

$$g(x_1, x_2) = \left[(\pi + 2) \cdot x_2 \cdot s_c \cdot i_c + q\right] \cdot A' - x_1 \tag{6}$$

To simplify the reliability analysis, random variables are transformed from the X space to the standard normal space (U space). The Nataf transformation is used to construct a normal cumulative probability density function (Nataf model) by transforming original variables into standard normal variables [21]. The Nataf transformation is an approximate method, for which the following input parameters are required: the covariance matrix and marginal cumulative density functions (CDF) of random variables [22, 23]. Because all variables are uncorrelated, and either normal or lognormal, the Nataf transformation is very efficient. Since analyses are performed with the assumptions that c_u is both normally and lognormally distributed, results of the transformations are two performance functions in the standard normal space, Eq. (7) and Eq. (8).

$$g(x_1, x_2)* = \left[(\pi + 2) \cdot (\mu_{x_2} + \sigma_{x_2} \cdot u_2) \cdot b_c \cdot s_c \cdot i_c + q\right] \cdot A' - \\ -(\mu_{x_1} + \sigma_{x_1} \cdot u_1) \tag{7}$$

$$g(x_1, x_2) = \left[(\pi + 2) \cdot e^{\lambda_2 + \xi_2 \cdot u_2} \cdot b_c \cdot s_c \cdot i_c + q\right] \cdot A' - \\ -(\mu_{x_1} + \sigma_{x_1} \cdot u_1) \tag{8}$$

where: $u_i = \dfrac{x_i - \mu_{x_i}}{\sigma_{x_i}}$ - transformed random variable; μ_{x_i} - mean value of the random variable x_i; σ_{x_i} - standard deviation of the random variable x_i; λ_2, ξ_2 - lognormal distribution parameters of variable x_2.

3.2.2 Integrand

Since two different analyses are performed, it is necessary to define two reliability integrals, and thus two integrands. Both integrands were transformed into the standard normal space using Nataf transformations. In the standard normal space, their contours are concentric circles. The first integrand is a bivariate joint PDF (Eq. 9), and the second hybrid joint PDF of the normal and lognormal distribution (Eq. 11).

$$\tilde{f}_{x_1 x_2}(x_1, x_2)* =$$

$$* = \frac{1}{2\pi\sqrt{1-\rho_{12}^2}} exp\left\{-\frac{1}{2(1-\rho^2)}\left[u_1^2 - 2\rho_{12}u_1 u_2 - u_2^2\right]\right\} \quad (9)$$

where:

$$u_i = \frac{x_i - \mu_{x_i}}{\sigma_{x_i}} \quad (10)$$

ρ_{12} - correlation coefficient between x_1 and x_2

$$\tilde{f}_{x_1 x_2}(x_1, x_2)* =$$

$$* = \frac{1}{2\pi\sigma_1\xi_1\sqrt{1-\rho_{12}^2}x_2} exp\left\{-\frac{1}{2}\left[\frac{u_2 - \eta_2 u_1}{\sqrt{1-\eta_2^2}}\right]^2 - -\frac{1}{2}u_1^2\right\} \quad (11)$$

where:

$$u_1 = \frac{x_1 - \mu_{x_1}}{\sigma_{x_1}} \quad (12)$$

$$u_2 = \frac{\ln(x_2) - \lambda_s}{\sigma_{x_1}} \quad (13)$$

$$\eta_2 = \frac{\rho_{12}\kappa_2}{\xi_2} \quad (14)$$

ρ_{12} - correlation coefficient between x_1 and x_2

Reliability integrals for the normally and lognormally distributed c_u are shown in Eq. 15 and Eq. 16, respectively.

$$P_f = \int_{g(x_1, x_2)*<0} \tilde{f}_{x_1 x_2}(x_1, x_2)*dx_1 dx_2 \quad (15)$$

$$P_f = \int_{g(x_1, x_2)<0} \tilde{f}_{x_1 x_2}(x_1, x_2)dx_1 dx_2 \quad (16)$$

3.3 First Order Reliability Method (FORM)

The method was developed by [24], to address the main shortcomings of the First Order Second Moment (FOSM) method. Unlike the FOSM, in which limit state function is linearized at the point where all variables have a mean value, in the FORM, it is linearized at the point on the failure surface (or linearized at point A, or at the point OF). The procedure

includes the random variables and limit state function transformation from the physical to the standard normal space. Rosenblatt or Nataf transformations can be used for this purpose [25]. Reliability analysis using FORM requires knowledge of statistical distributions of random variables.

In this paper, the Nataf transformation is used for transformations of random variables and the limit state function into the standard normal space. Then, the reliability index (β) is calculated performing the iterative procedure shown in Fig. 2. The reliability index is defined as the shortest distance from the origin to the failure surface (Fig. 3). The point on the failure surface closest to the origin is named the Most probable Point (MPP). FORM analyses were performed using a script written in the MATLAB programming language.
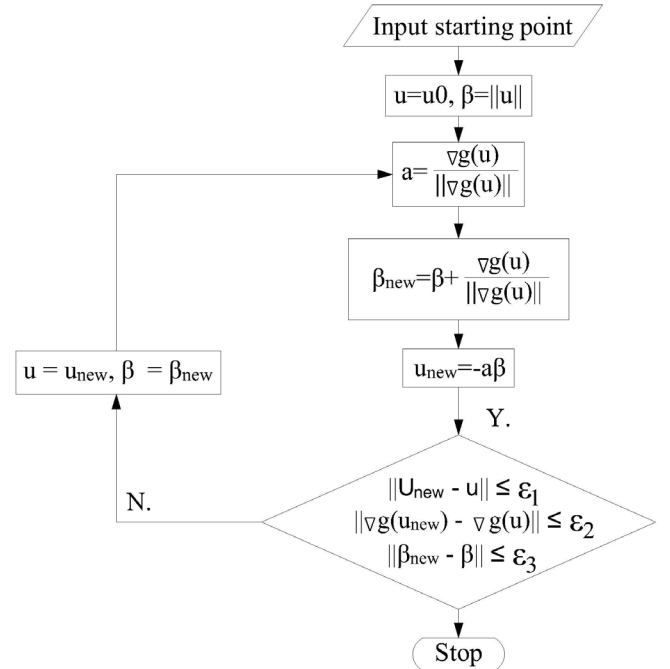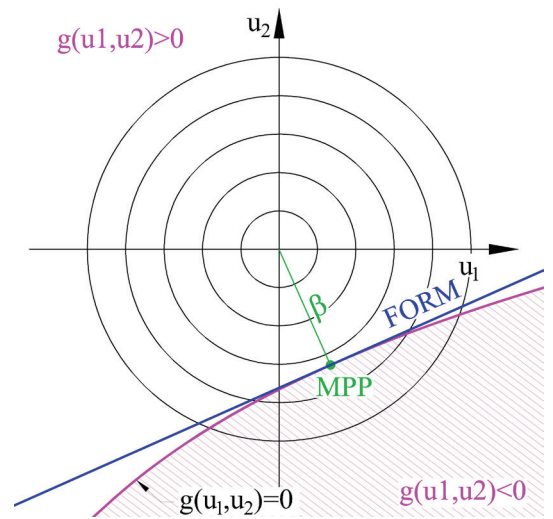

Figure 2 Flowchart of the FORM [26]

Figure 3 Geometry representation of the reliability index (β)

3.4 Geotechnical Parameter Degree of Variability Quantification

Degree of geotechnical parameter variation is quantified by the values of the corresponding coefficient of variation (*COV*). In this paper, the classification by Phoon [14] is adopted (Tab. 2). Values of *COV* are divided into 3 classes, and reliability indexes were calculated for the mean of each class. Regarding the undrained shear strength, low, medium, and high variability corresponds to the following COV_{c_u} ranges: 10-30%, 30-50% and 50-70% respectively.

3.5 Partial Factor Calibration

The undrained shear strength partial factor (γ_{c_u}) is calibrated using the First Order Reliability Method (FORM). Calibration was performed iteratively, by conducting a series of reliability analyses to determine γ_{c_u}, which corresponds to the recommended minimum reliability index value of 3.8. Analyses were performed using a script written in the MATLAB programming language.

4 RESULTS AND DISCUSSION
4.1 Results of Multiparameter Analyses

Multiparameter analyses results are shown in Figs. 4 and 5. Influences of foundation geometry, load eccentricity, and COV_{c_u} on the reliability index value were examined. Analyses were performed for COV_{c_u} = 0.2, 0.4, and 0.6, but only the results for the case of COV_{c_u} = 0.2 are presented. The reason are similar trends obtained from the other two analyses. The influence of load eccentricity on the β value is shown in Fig. 4. The difference between the extreme β values is in the 3rd decimal place, so its influence was excluded from further consideration. The B/L ratio also has no significant impact on β (Fig. 5). The depth of the foundation base has a significant effect on the β value, which can be seen in Fig. 5. Regarding the foundation reliability index, the most unfavorable depth is $d = 0$. The reason for this is the absence of the total overburden pressure from soil bearing capacity, at the foundation base level.
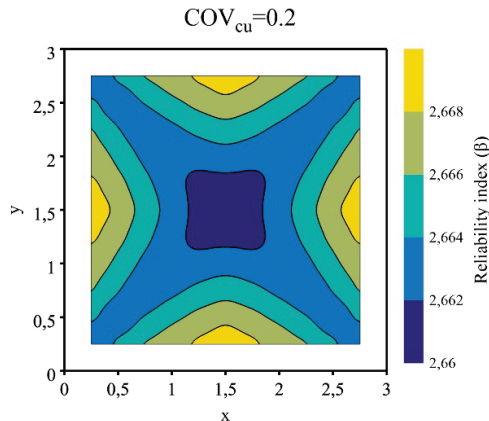

Figure 4 The influence of the load eccentricity on β value
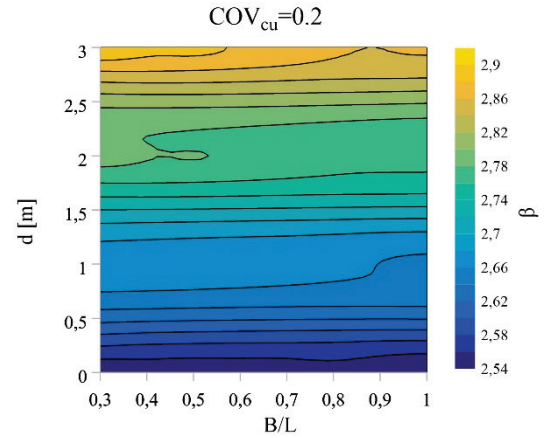

Figure 5 The influence of B/L ratio and the foundation base depth on β value

Based on the multiparameter analyses results, the foundation geometry and the load position used in the partial factor calibration are selected as follows: $B = L = 3.0$ m, $d = 0$ m and $e_x = e_y = 0$ m.

4.2 The Influence of Marginal Statistical Distribution of c_u Strength on β Value

Results of the reliability analyses with different statistical distributions of the c_u are shown in Figs. 6, 7, and 8. The limit state function $g*(U) = 0$ (magenta) represents the case of normally distributed c_u, and the $g(U) = 0$ (green) the case of lognormally distributed c_u. The trend of decreasing β by increasing COV_{c_u} is visible when comparing their values from Figs. 6, 7 and 8, which is within expectations. Also noticeable is a significant difference between the β values obtained with normally and lognormally distributed c_u.
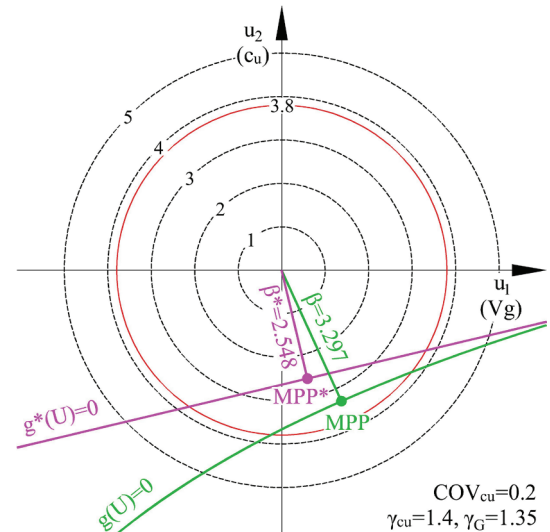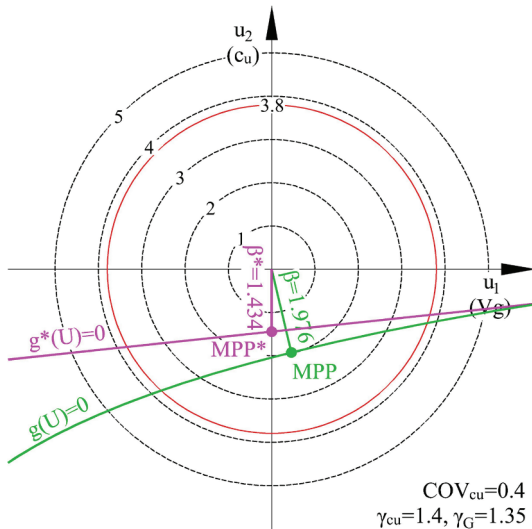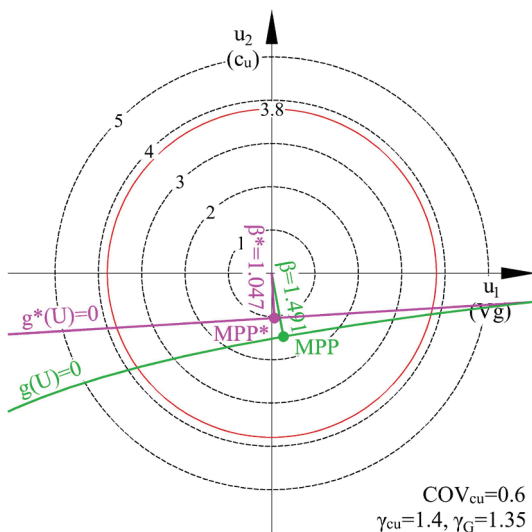

Figure 6 Comparison between reliability indexes, calculated with normally and lognormally distributed c_u, case $COV_{c_u} = 0.2$

The differences between reliability indexes calculated using normally and lognormally distributed c_u are shown in Tab. 4.

Table 4 The difference between reliability indexes, calculated using normally and lognormally distributed c_u

COV_{c_u}	$|\Delta\beta|$ (absolute value)	$\beta_{lognormal}/\beta_{normal}$
0.2	0.749	1.29
0.4	0.542	1.38
0.6	0.444	1.42

**Figure 7** Comparison between reliability indexes, calculated with normally and lognormally distributed c_u, case $COV_{c_u} = 0.4$

Figure 8 Comparison between reliability indexes, calculated with normally and lognormally distributed c_u, case $COV_{c_u} = 0.6$

4.3 Partial Factor Calibration (γ_{c_u})

Undrained shear strength partial factor was calibrated for a normally and lognormally distributed c_u. Calibration results are shown in Fig. 9.

The results obtained using normally distributed c_u are not presented, because even in the case of low COV_{c_u}, γ_{c_u} values are unreasonably high, and therefore not applicable in practice. The same conclusion was presented by Murakami et al. [6]. A trend of increasing γ_{c_u} with the COV_{c_u} increase is visible in Fig. 9. All presented values are higher than those

prescribed in EC7, and their application would result in a significantly more conservative design, compared to current practice.
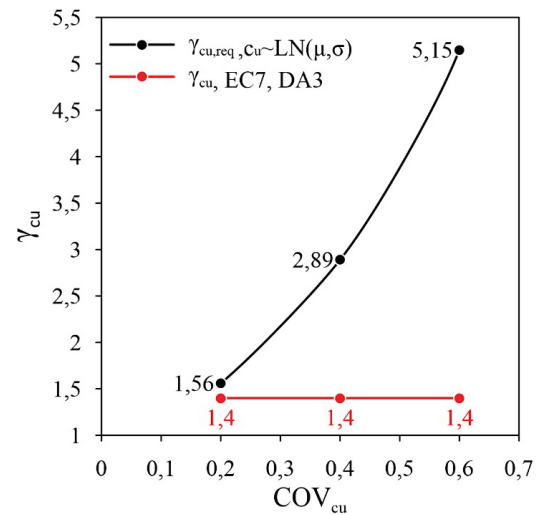
Figure 9 The results of γ_{c_u} calibration

5 NUMERICAL EXAMPLE

Analyses of shallow footings using undrained shear strength partial factors, presented in Fig. 9, were performed. The main goal was to determine the required footing width, such that the ultimate limit state (GEO) is satisfied. The results were compared to the footing width obtained by the analysis performed with $\gamma_{c_u} = 1.4$ [15]. The partial factor applied to the permanent load in all cases is equal to 1.35. Geometry of the problem, along with the load and geotechnical parameters, are shown in the Fig. 10. Three cases regarding the COV_{c_u} were analyzed: $COV_{c_u} = 0.2$, 0.4 and 0.6.
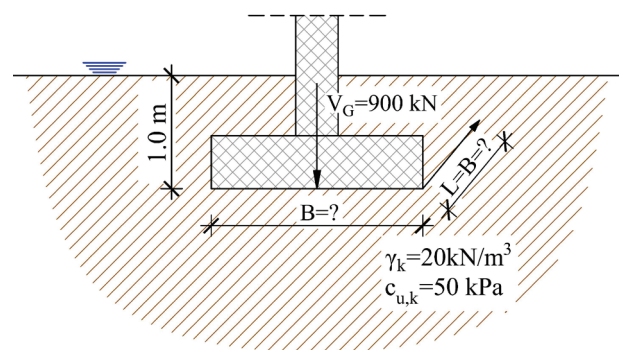
Figure 10 Geometry of the problem

Tab. 4 shows results of the four ultimate limit state analyses, which were performed in accordance with Eurocode 7, design approach 3. A deviation from the calculation procedure was made in analyses 2-4. Instead of the prescribed γ_{c_u} value, values shown in Fig. 9 were used. As expected, a positive trend between COV_{c_u} and the required footing width can be seen.

As it can be seen from Tab. 5, the footing width is the function of the $c_{u,d}$, which is calculated using the corresponding partial factor, γ_{c_u}. The purpose of γ_{c_u} is to consider the soil's natural variability, along with uncertainties of various origin. In the ultimate limit state analysis, the aforementioned can be quantified by the coefficient of variation, *COV*. This way, its value can provide a meaningful tool for additional elaboration of partial factors.

Table 5 Required footing widths for different γ_{c_u} values

No.	Analysis	γ_{c_u}	$c_{u,d}$*	$B_{required}$
1	EC7, DA3	1.4	35.71	2.25
2	$COV_{c_u} = 0.2$	1.56	28.85	2.48
3	$COV_{c_u} = 0.4$	2.89	13.84	3.40
4	$COV_{c_u} = 0.6$	5.15	6.80	4.43

* design value of undrained shear strength

6 DISCUSSION

With the goal of additional elaboration and calibration of the γ_{c_u} value prescribed in Eurocode 7, reliability analyses were performed. Calibration was performed in the case of a footing ULS (GEO) analysis under a permanent vertical load. To meet the minimum recommended β value, analyses were carried out for the critical combination of geometry, load, and statistical distribution of c_u. Reliability class RC2 and a reference period of 50 years were considered. Corresponding recommended minimum value of reliability index equals to 3.8 [8]. Analogous to Canadian Standards Organization (2014), γ_{c_u} is divided into three ranges concerning the COV_{c_u} value. Because of a relatively simple form of the performance function, the First Order Reliability Method (FORM) was selected as a method for reliability index calculation.

Reliability analysis with normally distributed c_u resulted in unreasonably low β; therefore, these results were not considered in partial factor calibration. They were calibrated only using a lognormally distributed c_u. A similar conclusion was presented by Murakami et al. [6] in reliability analyses of a shallow foundation under open channels.

It is shown that even in the case of $COV_{c_u} = 0.2$ (Fig. 6), the reliability index of a shallow footing is lower than the recommended minimum value. To achieve this value, $COV_{c_u} = 0.17$ is required. It is therefore concluded that $COV_{c_u} \leq 0.17$ will ensure that footings designed in accordance with EC7, DA3 will meet the minimum target reliability index. According to [6, 27, 28] COV_{c_u} ranges from 15 to 40%, depending on the natural variability of the soil, the method of measurement, and the transformation model. Such a wide range of possible values, i.e. high uncertainty, is supporting the idea of additional elaboration of partial factors to achieve a reasonably constant reliability level.

Instead of a single value of the partial factor γ_{c_u}, three values with respect to *COV* are proposed (Tab. 6).

Table 6 Required partial factors of undrained shear strength for different COV_{c_u} values

COV_{c_u}	γ_{c_u}
0.2	1.56
0.4	2.89
0.6	5.15

The proposed values are valid only in the case of Design Approach 3. An alternative to the additional elaboration of partial factors may be to reduce the minimum recommended β value in the range between 3-3.5.

That way, footings designed using the currently prescribed γ_{c_u} value would satisfy the criteria regarding the minimum recommended reliability index. According to [11] reliability index in a range of 3.1-3.7 would provide a satisfactory reliability level, and according to [29], $\beta > 3$ ensures above-average structure performance level.

7 CONCLUSION

The absence of consideration of soil variability in geotechnical analyses can lead to unreliable results, and consequently to constructions with reliability values lower than required. The unique value of the partial factor of the geotechnical parameter does not reflect the actual state of site-specific variabilities in a specific task. Using reliability analyses, we have demonstrated that higher variability requires a greater partial factor in order to ensure meeting the required reliability level. Introducing an additional classification of partial factors of geotechnical parameters (with the respect to the coefficient of variation) would enable designers to adjust their designs to actual soil conditions. This would ensure a similar level of design reliability for all geotechnical constructions. For further research, we suggest a calibration, and an additional classification of the partial factors of the remaining geotechnical parameters, for different types of geotechnical tasks.

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Genetic Algorithm-Based Parametrization of a PI Controller for DC Motor Control

Marko Mavrinac, Ivan Lorencin*, Zlatan Car, Mario Šercer

Abstract: This paper analyses the application of a genetic algorithm (GA) for the purpose of designing the control system with separately excited DC motor controlled according to the rotor angle. The presented research is based on the utilization of a mathematical model designed with separate electrical and mechanical sub-systems. Such an approach allows fine-tuning of PID controllers by using an evolutionary procedure, mainly GA. For purpose of PID tuning, the new fitness function which combines several step response parameters with the aim of forming a unique surface which is then minimized with a genetic algorithm. From the results, it can be seen that the elitism-based algorithm achieved better results compared to the eligibility-based selection. Such an algorithm achieved a fitness value of 0.999982 resulting in a steady-state error of 0.000584 rad. The obtained results indicate the possibility of applying a GA in the parameterization of the PID controller for DC motor control.

Keywords: Control system design; Fitness score; Genetic algorithm; PID control; separately excited DC motor

1 INTRODUCTION

Automatic control represents one of the key elements of modern society. Feedback regulation represents a standard procedure in automatic control [1, 2]. Such a configuration is characterized by controller utilization [3]. In most practical applications, a simple PID controller represents an optimal solution [4]. PID controller parametrization, alongside mathematical modelling, represents one of the key challenges in the design of an automatic control system [5]. The classical approach used for PID parametrization and tuning is based on experimental design and mathematical modelling [6]. Such an approach requires expertise in the field of automatic control and electric drives [7]. In addition, such an approach can be time-consuming and error-prone [8].

Another approach to PID parametrization is the utilization of evolutionary algorithms, mainly GA. Evolutionary computation, alongside artificial intelligence (AI) and machine learning (ML) represents one of the most propulsive fields of science and technology with application in various fields ranging from propulsion systems [9, 10], through medicine [11-13] to satellite surveillance [14].

GA represents a meta-heuristic algorithm that is based on Darwin evolution theory [15]. This algorithm has a long history of utilization in various fields of science and engineering, ranging from robotics [16], through modelling of energy systems [17] to maritime affairs [18]. Such an approach can offer a simpler and more effective method for PID parametrization.

Following the presented facts, the aim of this paper is to present a GA-based method for PID controller parametrization that will be used for parametrization of 3 PI controllers used in the control of separately excited DC motor according to the rotor angle. Controllers will be parametrized by using different variations of GA. Results achieved with each of these GA methodologies will be used in the evaluation of, not only GA but also the PID regulation itself.

2 DESCRIPTION OF THE CONTROL SYSTEM

The mechanical sub-system defines the rotor angle in dependency of motor and load torques. The rotor angle can be defined by the angular speed of the rotor as its integral. By using presented formalism, the mechanical relation can be defined as [19]:

$$\frac{d\omega}{dt} = \frac{1}{J_u} \cdot (M_m - M_t), \tag{1}$$

where J_u represents the total moment of inertia defined as a sum of motor and load inertia, M_t represents a load torque including friction, and M_m represents the shaft torque. Shaft torque can be defined as [20]:

$$M_m = k_m \psi_{ex} i_a, \tag{2}$$

where k_m represents the motor constant, ψ_{ex} represents the flux linkage and i_a represents the armature current. For motor operation at rated values, flux linkage can be defined as a constant [21]. For this reason, Eq. (2) can be rewritten as a linear equation, yielding [22]:

$$M_m = K i_a. \tag{3}$$

Such a mathematical model can be represented with its block scheme used for simulation in Simulink, presented in Fig. 1.
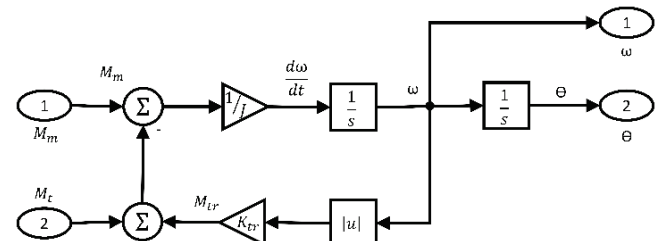

Figure 1 Mechanical sub-system

It must be noticed that such a model is constructed by using the absolute value of rotor angular speed. This property is introduced in order to annul the influence of rotation

direction (clockwise or counterclockwise) on the control system and its mathematical behavior.

The differential equation that describes the behavior of the electrical subsystem of a DC motor can be defined as:

$$\frac{di_a}{dt} = \frac{1}{L_a} \cdot (U_a - i_a R_a - e), \tag{4}$$

where U_a represents armature voltage, L_a represents armature inductance, R_a represents armature resistance and e represents an induced voltage. Such a voltage can be defined with [21]:

$$e = k_e \psi_{uz} \omega, \tag{5}$$

where ψ_{uz} represents the excitation flux linkage. It should be noted that, as it is in the case of armature flux linkage, in this case, voltage equation can be derived to linear, yielding:

$$e = K\omega. \tag{6}$$

It should be noticed that the constant K is the same constant as it is in the case of Eq. (3).

As it is in the case of the mechanical sub-system, the electrical sub-system is also designed and simulated in Simulink. A block-diagram used for the simulation of the mechanical sub-system is presented in Fig. 2.
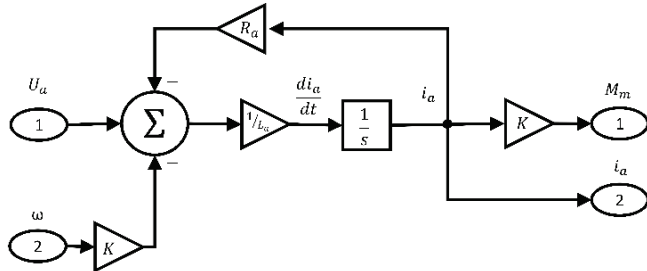

Figure 2 Electrical sub-system

The control system used in the control of DC motor rotor angle is based on three control loops:

- loop for armature current control,
- loop for rotational speed control and
- loop for rotor angle control.

Each of the aforementioned control loops must be designed by using a separate controller. In the case of motor control, due to the derivative nature of its behavior, it is necessary to include only proportional and integrational components of the PID controller (PI controller). The output value of such PI controller can be defined as:

$$y(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau, \tag{7}$$

where K_p represents the proportional coefficient and K_i represents the integrational coefficient of a PI controller. The

whole system for DC motor control composed of mechanical sub-system, electrical sub-system and PI controllers is presented in Fig. 3. This block diagram is used for simulation of the control system in Simulink.
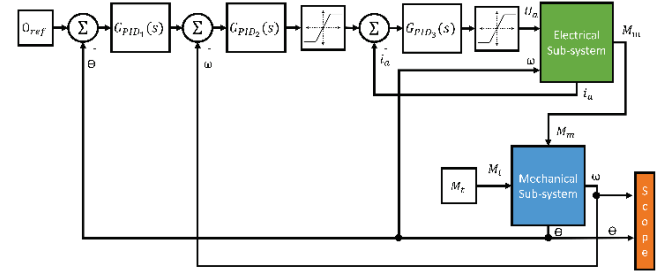

Figure 3 Block-diagram of whole regulation system

For purposes of this research, the control system was simulated and parametrized in Simulink and by using custom Python program. In both cases, DC motor model is designed by following the above presented mathematical formalism and by using parameters presented in Tab. 1.

Table 1 DC motor parameters used for the design of the control system

Rated armature voltage (V)	420
Rated power (W)	31500
Rated armature current (A)	90
Armature resistance (Ω)	0.65
Armature inductance (H)	0.0066
Rated speed (min^{-1})	995
Rated torque (Nm)	302
Rated induced voltage (V)	361.5
Rotor inertia (kgm^2)	3.5
Friction coefficient (Nms/rad)	0.05

3 DESCRIPTION OF GA USED FOR PID PARAMETRIZATION

In this chapter of the article, a brief description of used GA will be presented. The description will include a description of population initialization, variation procedures, and fitness determination. All three parts will be enriched with block diagrams.

The goal of each GA is to generate generations of quality individuals from a set of randomly generated solutions [23]. New generations are generated from selected individuals on which variation procedures are performed. Solution quality is determined by using the fitness function [24].

3.1 Population Initialization

The initial phase of the genetic algorithm is population initialization. Depending on the default size population, the genetic algorithm generates a series of solutions with random parameters. At this stage, it is possible to use heuristic methods of creating solutions to obtain a better initial population. The flowchart of the population initialization procedure is presented in Fig. 4. Population created by the heuristic method will have a higher average of the suitability ratings of the individuals than the one created randomly, but there is a risk of premature convergence of the algorithm, less diversity of results due to favoring certain individuals from the beginning of the algorithm execution.
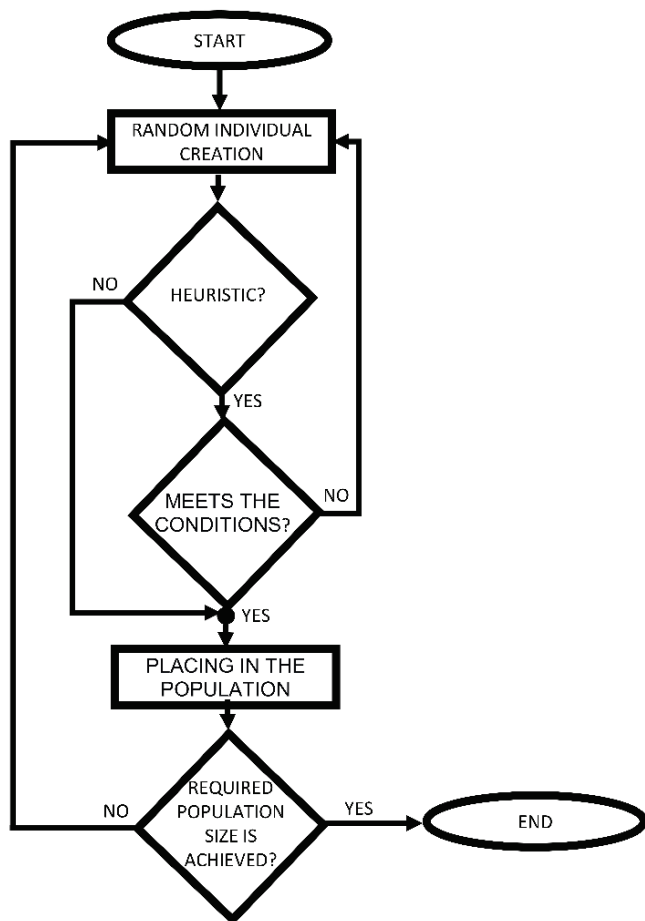
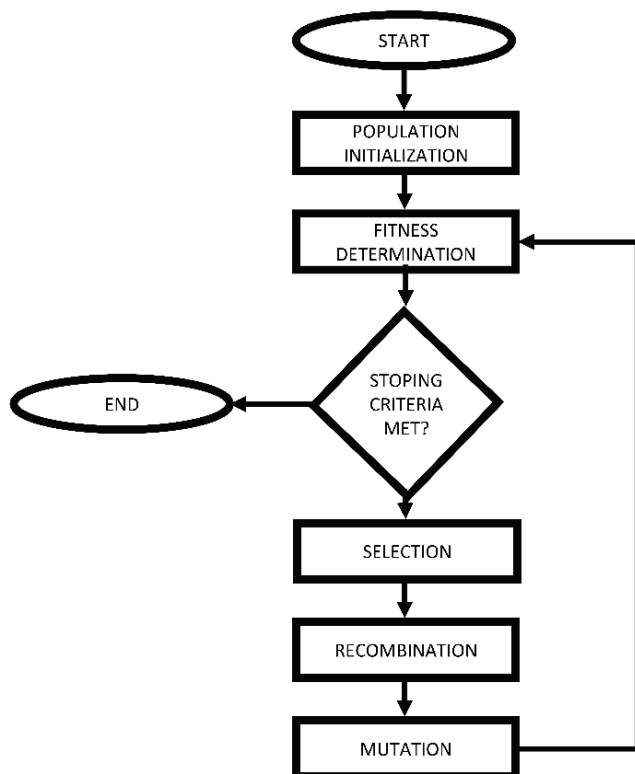**Figure 4** The flowchart of the population initialization procedure

Figure 5 The flowchart of GA procedure

3.2 Variation Procedures

Population initialization is followed by the application of selection, recombination, and mutation to create new generations of the initial population. Each new individual is assigned an appropriate fitness score, and depending on the stopping conditions, the mean fitness score of the population is calculated. If the new generation meets the stop conditions, the algorithm lists it as the optimal solution and stops it. Additional checks on solutions can determine whether the set of algorithm solutions is of appropriate quality. The low quality can be ascribed to premature convergence of the algorithm or a poorly defined fitness function. The flowchart of the genetic algorithm is shown in Fig. 5.

3.3 Fitness Function Definition

In this paper, as a quality measure of the DC motor control system, step response quality indicators such as:
- Rise time,
- Peak time,
- Settling time,
- Overshoot and
- Steady-state error

will be used during the definition of the fitness function. The goal of the GA is to minimize all above-presented indicators. Such an approach will result in a step response that closely follows the reference signal. The fitness function used in this research is designed to reduce several goals to only one goal. This approach is achieved by defining the area between the reference value and step response signal. In this way, a minimization of above-presented quality indicators is achieved. An example of such an area is presented in Fig. 6.
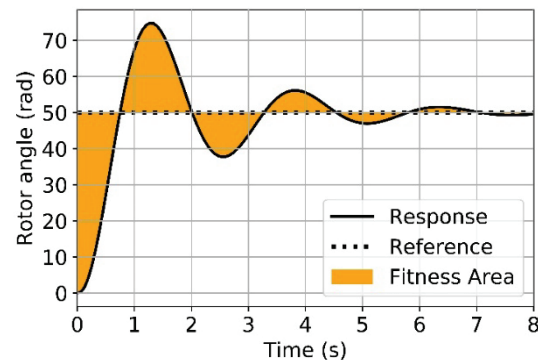
Figure 6 Example of a step response with defined fitness area

Depending on the fitness function and the system model used for the determination fitness of the individual, the algorithm needs to be optimized to minimize run time without affecting its functionality. The chromosome save function returns the parameters of an individual to a string record, and the fitness function uses this record to compare the genetic code of an individual with an already calculated fitness. The calculated fitness values are stored in a variable.

In this case, the keys are variable correspond to the genetic code of individuals, and their values correspond to

calculated fitness values. The optimized fitness determination process is shown in Fig. 7.
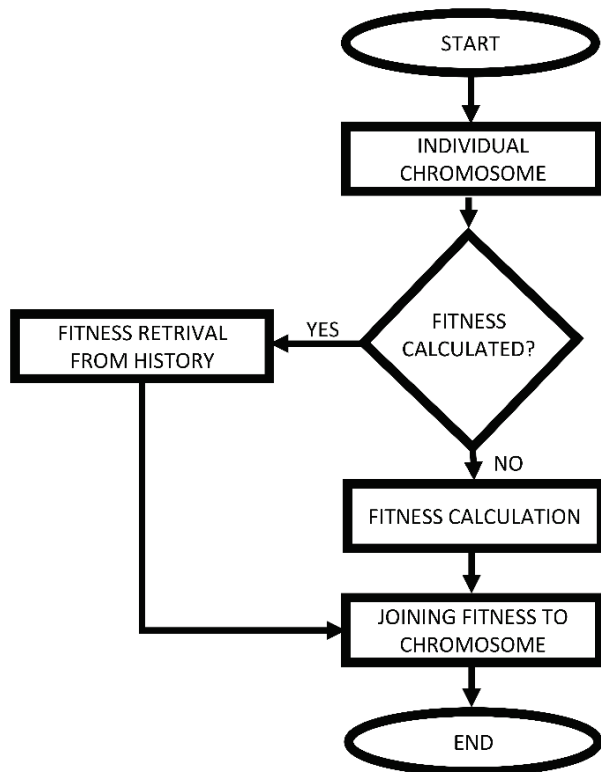

Figure 7 Flowchart of the optimized fitness function

4 RESEARCH METHODOLOGY

In order to define GA parameters that will produce the best performances, from both GA and control system standpoints, multiple GAs will be executed and compared. For all GAs, fitness values (individual and average) will be presented alongside control system quality indicators. The aforementioned measures will be used for the evaluation of different GA methodologies.

A comparison of the two different GAs will be based on:
- population size,
- mutation probability,
- selection method, and
- relative tolerance of the fitness function.

For each comparison, statistics related to response quality indicators, algorithm execution time, and success rate will be presented. The algorithm is considered successful if the rotor angle in the steady-state is the inside limit of 2% of the rotor angle reference value. From this rule, a success rate will be calculated for each variation of GA.

5 RESULTS AND DISCUSSION

Changing population size directly affects execution time, convergence rate, and in many cases also the quality of the final solutions, PI controllers. The impact on the quality of the ultimate solutions is the largest in GAs with selection by

rank. The root of this property lays in the fact that small populations often die out before convergence due to the relatively high probability of not selecting population members for recombination.

For elitism, with an algorithm with a larger population, the settling time is somewhat shorter, and the overshoot is noticeably lower. This is also reflected in the fitness of the whole generation. It can be observed that the execution time is three times longer for the population with a double number of members. Similar results are achieved if the rank selection is utilized, as shown in Tab. 2.

Table 2 Comparison of results achieved with GA with elitism for different population sizes

	GA configuration			
	P1	P2	P3	P4
Population size	10	20	20	30
Selection	Elitism	Elitism	Rank	Rank
Duplicates allowed	No	No	No	No
Mutation Probability	0.1	0.1	0.2	0.2
Rise time (s)	1.3776	1.3414	1.3171	1.3334
Peak time (s)	2.9854	3.1172	3.0395	3.1731
Settling time (s)	2.7765	2.2468	2.8522	2.2951
Overshoot (%)	2.0343	0.3816	2.0939	0.4944
Steady-state error (rad)	0.1219	0.0691	0.1189	0.0712
Best individual fitness	0.97078	0.99982	0.95238	0.99976
Best population fitness	0.96954	0.99982	0.94272	0.99921
Execution time (s)	330.85	1047.39	739.55	1185.58
Success rate	98	100	82	98

Increasing the probability of mutation indirectly increases the diversity of the population within the algorithm. Genetic algorithms whose population size is less than ten individuals often will not converge close to the optimal solution if the probability of mutation is not high enough. For these reasons, for GAs with rank selection and elitism for different values of mutation probabilities are 0.1 and 0.2. From Tab. 3 it can be seen that there are no significant differences between GAs. A difference can only be noticed for the case of overshoot, which is significantly lower when elitism is used. On the other hand, there is no significant difference in other relevant quality measures. The execution time of the algorithm is shorter for a higher mutation probability. Furthermore, it can be noticed that the algorithm with a higher probability of mutation converges much faster.

Table 3 Comparison of results achieved with GA for different mutation probabilities

	GA configuration			
	M1	M2	M3	M4
Population size	15	15	25	25
Selection	Elitism	Elitism	Rank	Rank
Duplicates allowed	No	No	No	No
Mutation Probability	0.1	0.2	0.1	0.3
Rise time (s)	1.3688	1.3482	1.2461	1.3819
Peak time (s)	2.9686	2.7948	2.9534	2.9725
Settling time (s)	2.2492	2.2414	2.8668	2.7393
Overshoot (%)	0.4902	0.3874	3.2741	1.1643
Steady-state error (rad)	0.0645	0.0639	0.1216	0.0951
Best individual fitness	0.99981	0.99986	0.98450	0.98185
Best population fitness	0.99966	0.99974	0.98046	0.980865
Execution time (s)	648.82	572.08	956.57	870.61
Success rate	100	100	94	96

Tab. 4 shows that GA without copies generally has better results. Furthermore, it is necessary to consider the fact that the diversity of the population, in this case is significantly lower, therefore the average fitness also depends on the size of the population. It can be seen that in the case of rank selection, the influence of duplicates is significantly higher. This property is a consequence of the premature convergence of GA.

Table 4 Comparison of results achieved with GA with and without duplicate elimination

	GA configuration			
	D1	D2	D3	D4
Population size	15	15	20	20
Selection	Elitism	Elitism	Rank	Rank
Duplicates allowed	Yes	No	Yes	No
Mutation Probability	0.1	0.1	0.1	0.2
Rise time (s)	1.3394	1.334	1.1993	1.3131
Peak time (s)	3.1256	2.8815	3.0029	2.9394
Settling time (s)	2.4374	2.3544	3.4517	2.8198
Overshoot (%)	1.0892	0.4524	6.3599	1.4884
Steady-state error (rad)	0.1152	0.0739	0.2046	0.22
Best individual fitness	0.998615	0.999511	0.914317	0.9913
Best population fitness	0.99856	0.99937	0.90143	0.99021
Execution time (s)	385.64	624.39	418.19	738.49
Success rate	100	100	84	96

In the later stages of GA where the solutions approach locally optimal points, there is less and less room for improvement or the difference in average fitness between two generations is getting smaller. When the difference in fitness becomes smaller than defined relative tolerance, the stop condition is satisfied, and the genetic algorithm ends. With the smaller tolerance parameter, the genetic algorithm will have multiple generations or longer performance, but also more accurate results. Relative fitness tolerance has an impact solely on later stages of the genetic algorithm. Tab. 5 shows the differences between the solution quality of the algorithms of different relative tolerances. GA with less relative tolerance has a longer execution time, but also better results.

Table 5 Comparison of results achieved with GA for different fitness tolerance

	GA configuration	
	T1	T2
Population size	15	15
Tolerance	0.01	0.000001
Selection	Elitism	Elitism
Duplicates allowed	No	No
Mutation Probability	0.1	0.1
Rise time (s)	1.3699	1.3704
Peak time (s)	3.0255	3.0256
Settling time (s)	2.4227	2.2318
Overshoot (%)	1.0435	1.0436
Steady-state error (rad)	0.1179	0.0414
Best individual fitness	0.99188	0.99994
Best population fitness	0.99288	0.999919
Execution time (s)	505.70	1086.36
Success rate	98	100

Selection proportional to fitness, in this case, cannot be used in the initial steps of the algorithm since each individual would have an extremely low probability of recombination. Therefore, the parameter for proportional selections was introduced. A parameter of 0.5 was chosen since then the smallest number of individuals will have secured or disabled recombination. Since this type of selection favors better solutions, it often reduces the diversity population, and thus the quality of the end solutions.

Tab. 6 shows the difference between fitness and the end of algorithm execution. A small saving in performance time, caused by a selection that is proportional to fitness, can also be noticed. As in the case of selection by rank, at small population sizes, selection proportional to fitness did not bring great advantages.

Table 6 Comparison of results achieved with GA for different selection methods

	GA configuration		
	S1	S2	S3
Population size	15	15	15
Selection	Elitism	Rank	Proportional to fitness (0.5)
Duplicates allowed	No	No	No
Mutation Probability	0.1	0.1	0.1
Rise time (s)	1.4024	1.2036	1.4008
Peak time (s)	2.8408	2.8488	2.9829
Settling time (s)	2.4048	3.5436	2.2652
Overshoot (%)	0.6001	5.9579	0.2493
Steady-state error (rad)	0.0731	0.1781	0.0571
Best individual fitness	0.99446	0.7367	0.98783
Best population fitness	0.99439	0.703505	0.98759
Execution time (s)	679.31	591.94	585.46
Success rate	100	50	96

When all achieved results are compared, it can be noticed that the results higher of 0.95 are achieved in the majority of cases. It is interesting to notice that the majority of GA configurations that have achieved high fitness values are designed by using elitism. Furthermore, it can be noticed that no significant changes in fitness values when larger populations are used. This property can particularly be noticed in cases of configurations marked with *M*. All described facts are presented in Fig. 8.
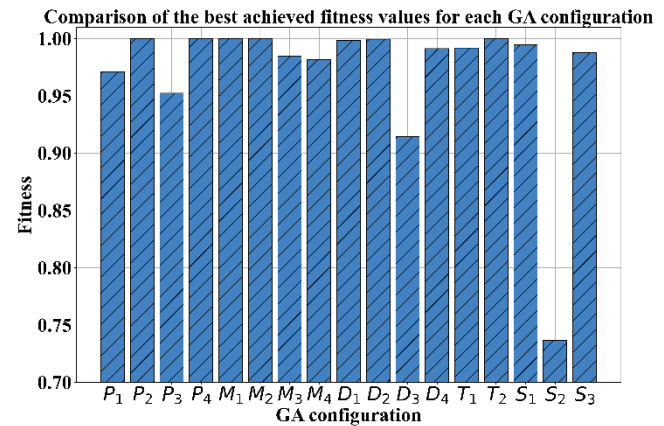
Figure 8 Comparison of best individual fitness values achieved with presented GA configurations

Similar results are achieved when population averages are compared. In this case, it can be noticed that the majority of the highest results are achieved with GA configurations designed with selection based on elitism. Furthermore, it can be noticed that there is no significant difference between best

fitness and population averages. From this fact, it can be seen that by using such GA configurations, multiple individuals with high-quality performances are achieved. All above-mentioned facts are presented in Fig. 9.
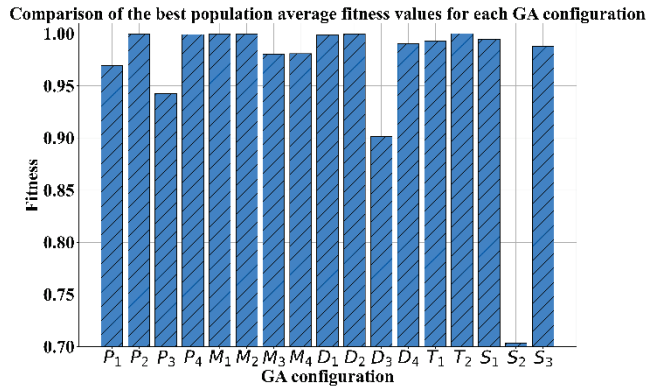

Figure 9 Comparison of best population average fitness values achieved with presented GA configurations
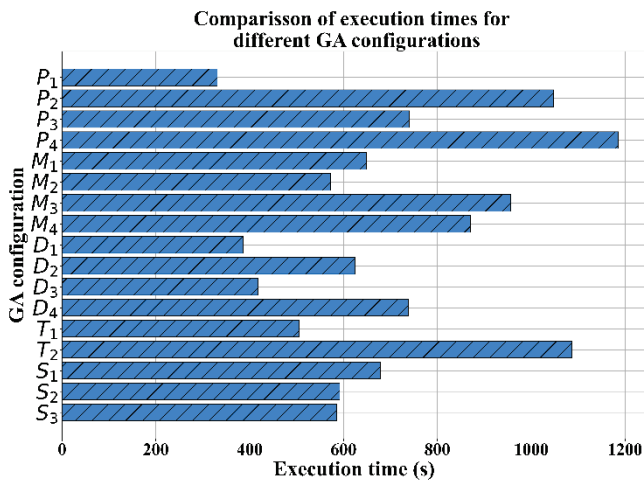

Figure 10 Comparison of execution times for all presented GA configurations

Table 7 GA parameters with which the best result was achieved

Selection	Elitism
Mutation probability	0.2
Tolerance	0.000002
Population size	26
K_{p1}	1.05
K_{i1}	0
K_{p2}	8.65
K_{i2}	9.94
K_{p3}	0.42
K_{i3}	12.81
Fitness score	0.999982
Steady-state error (rad)	0.000584

When execution times are compared, it can be noticed that GA configurations designed with larger populations are demanding a longer execution time. It can also be noticed that GA with lower tolerance is also demanding a longer time for execution. This property has its roots in the fact that configurations with lower tolerance will take more iterations to converge. When observing the influence of the selection method, it is interesting to notice that elitism-based GA will

take a longer time to execute. All aforementioned facts are presented in Fig. 10.

According to the presented methodology, the optimal configuration is chosen. This configuration is chosen to balance the best fitness, average population fitness, and execution time. This configuration is presented in Tab. 7.

6 CONCLUSION

From the presented results it can be concluded that there is a possibility for utilization of GA for parametrization of the control system based on DC motor. It can be noticed that the highest performances were achieved if the selection procedure based on elitism is used. Furthermore, the performances with a fitness score up to 0.999982 were achieved if the GA with mutation probability of 0.2 and tolerance of 0.000002. Presented GA was executed by using a population of 26 individuals. GA configuration described above has resulted in a steady-state error of 0.000584 rad. It can be noticed that such a configuration did achieve high accuracy, and at the same time, lower oscillations of the step response.

A main advantage that such an approach offers is a possibility for utilization of such algorithm in design of control system. The GA-based approach can be used for designing a control system without knowledge of modeling and automatic control. Furthermore, such an approach can be used for automatic and autonomous design of control systems that can offer robust performance regardless of parameter change. Future work will be focused on the evolutionary approach for fine-tuning the controller parameters that will be used in order to annul the influence of system decay.

Aknowledgment

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Capacity Optimization in Dynamically Routing Computer Network Systems

Nuşin Uncu*, Rızvan Erol

Abstract: A computer network system is a complex system with a great number of dynamic components. There are many devices in the system, such as computers, routers, lines, hubs, and switches. In addition to these hardware systems, many protocols are integrated to set the rules and provide the way of communication. Due to the nature of the system, it is hard to formulate and solve problems analytically without making any assumptions. One of the prominent problems that occur in computer systems is the line capacity assignment problem. In the previous mathematical models, message routes were predetermined and the dynamic nature of the system was neglected. This study deals with the line capacity assignment problem under a dynamically routing policy. Four different computer network topologies are used and solved by two heuristic algorithms via simulation. A dynamic search approach based on the occupancy rate of lines is used to define the consecutive routes of messages. The performances of harmony search and genetic algorithms via simulation are compared with the results of OptQuest, one of the optimization packet programs embedded in simulation software Arena®.

Keywords: computer networks; harmony search; genetic algorithms; optimization via simulation

1 INTRODUCTION

Studies on computer network systems date back to the 1970s. The common goal is to minimize the cost of the system while reducing congestion and latency in a perfectly designed network system under well-defined routing policies. Computer network optimization problems range from the physical structure of network to the optimization of parameters in the network. They can be classified under three categories:
1) Topology optimization or network design problems
2) Routing problems
3) Line capacity and resource allocation problems.

A minimum cost topology design is given in [1]. Topology optimization and network design problems have been solved with search algorithms, relaxation methods and evolutionary algorithms [2-5]

The routing problem is formulated in [6] as a nonlinear multi-product flow problem and solved with the decomposition method. ARPA, which is a wide area packet switching network, and NASDAQ as a distributed network structure are used in [7]. They investigated the location, capacity determination, routing and reliability problems of specific connections for each structure. They proposed queuing theory, pure approach, functional simulation approach, Moore-Shannon approach and iterative heuristic approaches to solve these problems and highlighted the shortcomings in the literature for possible studies. Another network routing problem is solved in [8] using Lagrange relaxation and subgrade optimization methods minimizing the transmission times using four different topologies. The problem of multi-packet routing was addressed in the $n \times n$ mesh topology with the rule of sending wormhole by dividing the packets into their link capacity in [9]. The primary and secondary routing problem in backbone network structures was formulated in [10]. The problem of determining the primary routes as well as the secondary routes in case of traffic density occurring in the backbone network structure was discussed in [11]. They solved the

nonlinear integer mathematical model based on minimization of waiting times of messages in the system with a heuristic algorithm based on Lagrange relaxation and compared the results with the ones using greedy and Dijkstra's algorithms. Two routing policies were introduced in [12]: fixed routing, where once routes are set up they are always followed by the messages, or adaptive routing, where the routes are defined as a function of the information available when the messages arrive.

The constrained routing optimization problem in network systems was solved by particle swarm optimization algorithm in [13]. The optimum path strategy was suggested in [14] for maximum node density probability (betweeness) minimization to prevent congestion in complex networks. A FuzzyAntNet algorithm was developed in [15] using fuzzy logic and AntNet algorithm together. They compared the simulation results with the Destination Sequenced Distance Vector and AntNet algorithms. A novel routing algorithm that integrates static and dynamic routing policies using virtual clustering and flow divergence algorithms was introduced in [16]. Two traffic congestion control techniques were proposed in [17] for flow assignment and packet scheduling, for effective routing in computer networks. Dynamic routing and static routing policies were compared in [18] and emphasized that dynamic routing algorithms give better results in terms of system performance if they work fast, but any miscalculation in the routing table may increase the waiting time in the system.

The line capacity problem in packet switching computer networks was first introduced in [19]. The problem of line capacity and flow assignment in computer networks was modelled as m-M/M/1 queuing system in [20]. They formulated the objective function according to the multi-product flow network and solved it by flow deviation method. Towards 1990s, the problem of capacity and route determination has begun to be combined into a mathematical model. The first study in this area is the work in [21]. They formulated a nonlinear integer model determining the routes and connection capacities that will minimize the cost in computer networks, where network topologies and candidate

route sets for each node pair in communication were given, and solved it using Lagrange approximation. Resource allocation problem was considered in [22] on time-varying directed communication networks using distributed optimization method. In [23], line capacity and flow assignment problem was solved by bender decomposition method. The cost of installation was based on quality of service on different topologies and fixed capacities. A new genetic algorithm approach was developed in [24] for network line capacities and routing problem and better results than previous studies with parallel computing technique were obtained. A heuristic was proposed for continuous capacity and flow assignment problem in [25]. In the context of queuing theory, a mathematical model dealing with capacity assignment in computer networks was given in [26]. Predicting the link availability in computer network systems, especially on mobile ad-hoc has gained importance. The link availability was predicted by [27] in Mobile Ad hoc Network (MANET) considering the capacity optimization. A new topological system called as MECPerf enabling online collection of network measurements was proposed in [28]. The proposed architecture is useful on edge computing domain for online network optimization to increase system performance.

Besides the most dedicated problems on computer networks, some miscellaneous problems are noticed in the area of communication network such as path planning, resource utilization, risk analysis and reliability [29-33].

In large-scale computer communication networks (e.g. the nowadays Internet), the assignment of link capacities and selection of routes (or the assignment of flows) are extremely complex network optimization problems [23]. Even when there is no uncertainty, optimization can be very difficult if the number of design variables is large, the problem contains a diverse collection of design variable types, and little is known about the structure of the performance function [34]. The optimization via simulation methods (OvS) are used to overcome the difficulties in optimization of large scale complex systems. The related problems occur in real world systems such as health systems, telecommunications, supply chain networks, computer network systems, manufacturing systems, etc. OvS were classified in [35] according to the problem characteristics such as shape of the response surface (global as compared to local optimization), objective functions (single or multiple objectives) and parameter spaces (discrete or continuous parameters). Because of the dynamics and the complexity of the computer network systems, the method applied in this study is the OvS technique that enables to get the expected value of functions considering dynamic behaviour of the system. The part of the evaluation and generation of solutions are under considered in optimization phase. Each candidate solution is obtained by simulation then feasible solutions are evaluated and improved by optimization methods.

In this study, the capacity assignment problem in computer networks is considered with dynamically routing policies. As a contribution to the existing literature, two OvS methods are suggested to figure out the applicability and effectiveness of these methods for computer network systems.

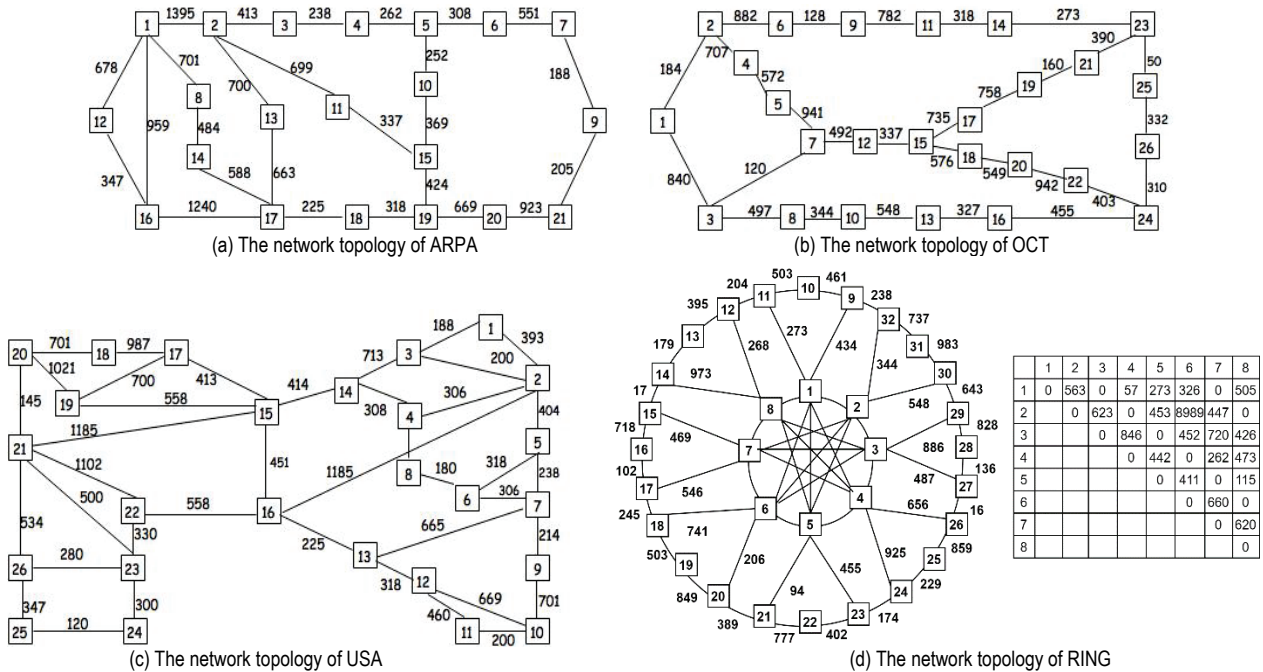**Figure 1** Computer network topologies

2 PROBLEM DEFINITION

A computer communication network can be described as a connected and undirected graph $G = (N, E)$, where N is the set of nodes and E is the set of lines. Each node is considered to act as a store-and-forward switching station with infinite storage capacity, and each line is considered to be an error-free communication channel or link.
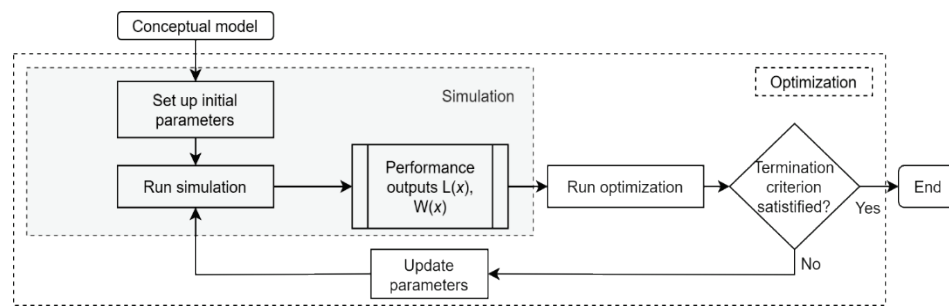
Table 1 The number of nodes and links for each type of topologies

	Topologies			
	ARPA	OCT	USA	RING
Number of nodes	21	26	26	32
Number of links	26	29	41	60

Table 2 Link capacities and costs

Types of links	Capacities (bit/sec)	Setup Cost ($/month)	Distance Cost ($/month/mile)	Variable Cost ($/month/bps)
1	4800	650	0.4	0.360
2	9600	750	0.5	0.252
3	19200	850	2.1	0.126
4	50000	850	4.2	0.030
5	108000	2400	4.2	0.024
6	230000	1300	21.0	0.020
7	460000	1300	60.0	0.017

The topologies and distances between links are taken from [36] are given in Fig. 1. In order to avoid figure complexity, the distances between nodes 1 to 8 in RING topology is represented on the right side of RING network.

Number of nodes and links for each topology is summarized in Tab. 1. Line capacities and costs for each type of line is taken from [36] and given in Tab. 2. The unit delay cost for all the topologies is $20 per sec.

3 OPTIMIZATION VIA SIMULATION

The concept of using simulation and optimization methods simultaneously has been widely studied since 1970s. Although the performance of the methods differs from case to case, the general idea of the application is to find the optimal value of a function which depends on a parameter that is changed by optimization and evaluated by simulation. Starting with the conceptual model of the problem, general OvS steps followed for each metaheuristics in this study are shown in Fig. 2.

Figure 2 The OvS process

3.1 Computer Network Simulation Optimization Model

Computer network system can be illustrated basically in Fig. 3. In this study, the nodes shows routers and the links between these nodes are cables. There are routing protocols embedded to the nodes and there may occur queues in front of the router based on the online usage of the corresponding line.
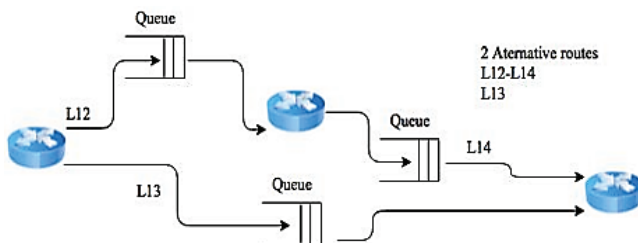
Figure 3 An exhibition of queuing model for each node

In the suggested model, messages occur on any node and destination is randomly assigned to each message. The occurrence rate of messages is exponentially distributed and inter arrival time is 4 seconds. The message visits the nodes dynamically throughout the system depending upon the links' online occupancy rate until it reaches to its destination node. So, the message finds its best route throughout the online progress. The time spend at nodes is ignored, while the delays are considered due to a congestion on the links.

If the messages do not reach its destination node in a reasonable amount of time or hop number, the message is classified as failed.

Other assumptions are explained below.
- Messages spend time relatively to the capacity of lines they visited.
- Length of messages are assigned equally likely as the sizes of 200, 300, 400, 500 and 600 MB.
- The capacity of the lines declines throughout the occupancy rate.
- The destination nodes are not predefined and have equal chance to be selected.

The simulation model includes events such as receiving the message, message enter to the first route, and subsequent events of travel on network lines based on dynamically searching algorithm of line availability, end with reaching target message node and message dispose from the network system. Through entire model the message are given attributes and variables that are used to find model statistics. An instance of simulation model and main blocks are given in Fig. 4 with a superficial flow of message due to the difficulties to screen out all the blocks in model.
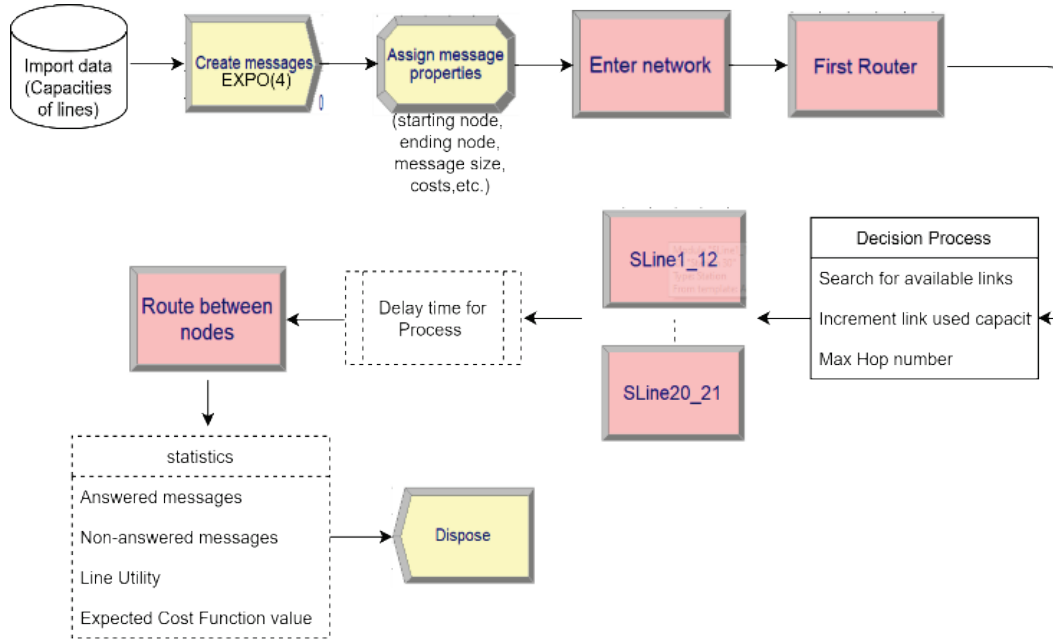
Figure 4 An instance of model main blocks used in Arena

The notations used in the equations are explained in Tab. 3.

Table 3 The notation

Decision Variable
$y_{ij} = \begin{cases} 1 \\ 0 \end{cases}$ type line(capacity) j is used by link i otherwise
$i = 1, …, n, \; j = 1, …, k$
Parameters
s_j - set up cost of link j ($/month)
d_j - unit distance cost of link j ($/month/mile)
m_i - length of link i (mile)
v_j - unit operation cost of link j ($/month)
$L_i(x)$ - expected total message length passed through link i (bits)
b - unit delay cost ($/month)
$W_i(x)$ - expected waiting time on link i (month)
x - length of message (bits)
n - number of links
k - number of line types

Objective function in Eq. (1) is the minimization of the total cost while assigning the optimal link capacities.

$$\min z =$$
$$= \sum_{i \in I, j \in J} \left(s_j y_{ij} + d_j m_i \right) + \sum_{i \in I, j \in J} v_j y_{ij} L_i(x) + \sum_{i \in I, j \in J} b W_i(x) \quad (1)$$

In Eq. (1), the first sum is for set up cost and cost of lines used for each link, the second is operational cost depending on the size of the messages and assigned line capacity and the third is delay cost. The operational and delay costs are expected costs and obtained by the simulation. These functions depend on the size of messages that travelled through the network as the system proceeds. Eq. (2) restricts each node to be connected just one type of line. Eq. (3) restricts the decision variables to be binary.

$$\sum_{j \in J} y_{ij} = 1 \quad \forall i \in I \quad (2)$$

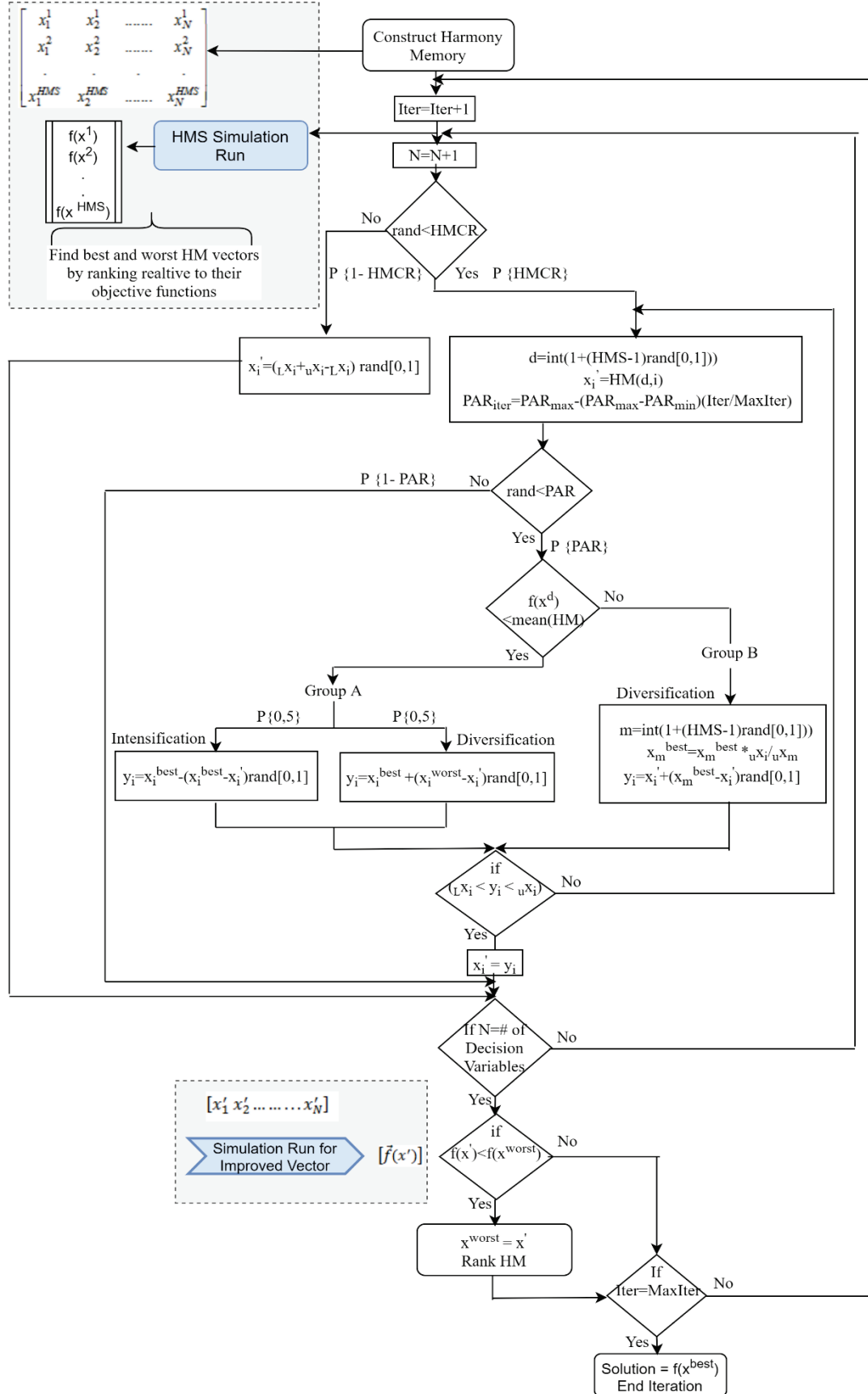$$y_{ij} \in \{0, 1\} \quad \forall i \in I, \forall j \in J \quad (3)$$

The travel times of the messages change according to the capacity of the link and size of the message. The related formula is given in Eq. (4). It is mentioned that the time that a message reaches to its destination node increases as the utility of the link increases. The online occupancy rate is given in Eq. (5). The online occupancy rate provides the decision of route selection in the dynamically changing states of computer network system.

$$\frac{1}{\mu} = \frac{Message\ length/\ Link\ capacity}{(1-Online\ occupancy\ rate)} \quad (4)$$

$$Online\ Occupancy\ Rate = \frac{Online\ Usage}{Total\ Capacity} \quad (5)$$

3.1.1 Harmony Search Algorithm via Simulation

The harmony search algorithm is one of the challenging metaheuristics presented in [37]. It is inspired from the idea of harmony of instruments. Harmony search algorithm has two parameters, harmony memory size (HMS) and harmony memory consideration rate (HMCR). HMS is the number of candidate solutions in the population. HMCR is the probability of selecting a member in HMS. In this study, an extended version, intelligent tuned harmony search algorithm, which is proposed in [38] is applied and the integration with simulation is depicted in Fig. 5.

$$\begin{bmatrix} x_1^1 & x_2^1 & \cdots & x_N^1 \\ x_1^2 & x_2^2 & \cdots & x_N^2 \\ \vdots & \vdots & & \vdots \\ x_1^{HMS} & x_2^{HMS} & \cdots & x_N^{HMS} \end{bmatrix}$$

Construct Harmony Memory

$\begin{bmatrix} f(x^1) \\ f(x^2) \\ \vdots \\ f(x^{HMS}) \end{bmatrix}$

HMS Simulation Run

Iter=Iter+1

N=N+1

Find best and worst HM vectors by ranking realtive to their objective functions

No ← rand<HMCR

P {1- HMCR}   Yes   P {HMCR}

$x_i' = (_Lx_i +_u x_i -_L x_i)$ rand[0,1]

d=int(1+(HMS-1)rand[0,1])
x_i'=HM(d,i)
$PAR_{iter}=PAR_{max}-(PAR_{max}-PAR_{min})$(Iter/MaxIter)

P {1- PAR}   No   rand<PAR

Yes   P {PAR}

$f(x^d)$ <mean(HM)   No

Yes

Group A

Group B

Diversification

Intensification   P{0,5}   P{0,5}   Diversification

$y_i=x_i^{best}-(x_i^{best}-x_i')$rand[0,1]

$y_i=x_i^{best}+(x_i^{worst}-x_i')$rand[0,1]

m=int(1+(HMS-1)rand[0,1])
$x_m^{best}=x_m^{best}*_u x_i/_u x_m$
$y_i=x_i'+(x_m^{best}-x_i')$rand[0,1]

if
$(_L x_i < y_i <_u x_i)$ No

Yes

$x_i' = y_i$

If N=# of Decision Variables   No

Yes

$[x_1'\ x_2'\ \ldots\ldots\ldots x_N']$

Simulation Run for Improved Vector $[\vec{f}(x')]$

if
$f(x')<f(x^{worst})$ No

Yes

$x^{worst} = x'$
Rank HM

If
Iter=MaxIter   No

Yes

Solution = $f(x^{best})$
End Iteration

Figure 5 Intelligent tuned harmony search algorithm via simulation

The grouping approach in intelligent tuned harmony search algorithm enables the heuristic to provide the opportunity of selecting a new member from sub-population. If the function value of selected member is less than the average function value of *HMS*, that member is classified in the group of A, otherwise in the group of B. For the members in group A, the chance of intensification or diversification is applied by a probability of 50 percent. For the members in the group B, only diversification is applied. Intelligent tuned harmony search algorithm has a new parameter, dynamic pitch adjustment rate (*PAR*), which provides a deep and detailed search.

Each member in the population has a cost function which is estimated by simulation. Then the members are sorted by ascending order according to the value of their cost functions. An update of the harmony memory is done based on *HMCR* or *PAR*. The probability of updating any member with choosing a member in harmony memory is HMCR, while randomly change is $(1 - HMCR)$. Then, another adjustment can be made by a probability of PAR_{iter} or no adjustment by $(1 - PAR_{iter})$. It is calculated in Eq. (7).

$$\sum_{j \in J} y_{ij} = 1 \quad \forall i \in I \tag{6}$$

$$PAR_{iter} = PAR_{max} - (PAR_{max} - PAR_{min}) \left(\frac{current_{iter}}{max_{iter}} \right) \tag{7}$$

After some trial, the appropriate values of the harmony parameters are chosen with a *HMS* of 150 and a *HMC*R of 0.90 as depicted in Tab. 4.

Table 4 HarSimOpt results with different parameters

HMS	# of Iterations	HMCR			
		0,10	0,50	0,90	CPU Time
20	30	141,17	141,17	143,74	35"
	50	139,34	141,17	141,17	46"
	100	139,11	139,77	141,17	1'20"
	200	139,11	139,77	141,17	2'26"
50	30	129,51	129,51	129,51	35"
	50	129,51	129,51	128,74	46"
	100	129,51	129,51	128,52	1'20"
	200	129,51	129,51	127,78	2'26"
150	30	128,70	128,70	128,70	35"
	50	128,70	128,70	128,70	46"
	100	128,70	128,70	128,70	1'20"
	200	128,70	128,70	**127,71**	2'26"

3.1.2 Genetic Algorithm via Simulation

Genetic algorithm was first introduced in [39] to solve some common mathematical problems. Two important operators are crossover and mutation. One way crossover is considered and ranking selection method is used to select the members that are exposed to genetic algorithm operators. Mutation rate is set to 0.01 and population size is 20. Genetic algorithm via simulation steps are given in Fig. 6.
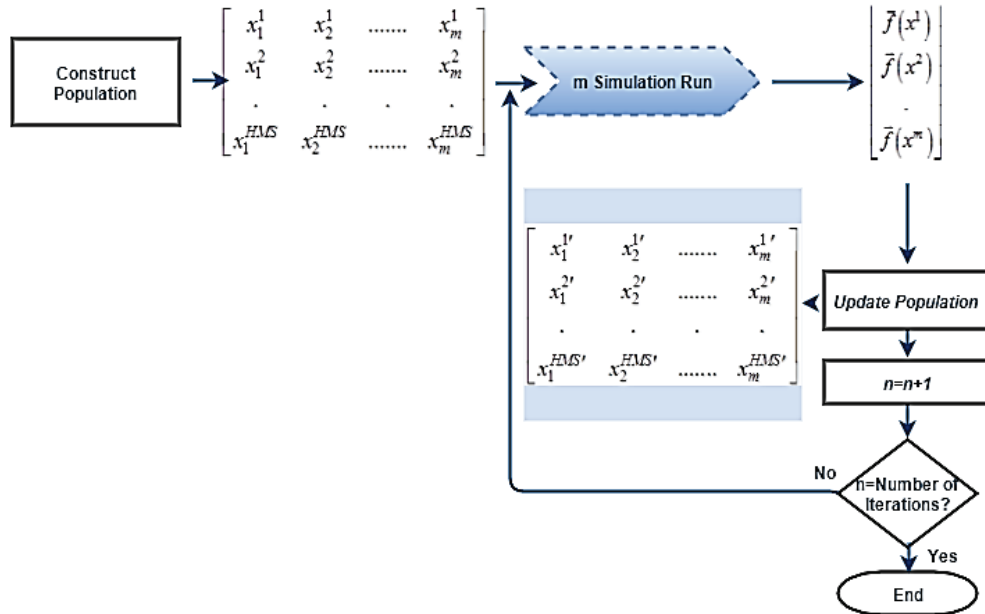
Figure 6 Genetic algorithm via simulation

Table 5 GenSimOpt with different parameters

# of Iterations	Crossover Rate			
	0,50	0,75	0,90	CPU Time
30	122,84	118,30	120,74	4'
50	118,67	118,30	120,21	6'30"
100	117,54	117,06	120,19	11'44"
150	116,92	109,45	119,23	16'47"

Genetic algorithm via simulation is run for different crossover rates and iterations. The optimal costs per cases and CPU times are given in Tab. 5. It is seen that with a crossover rate of 0.75 and 150 iterations, algorithm provides desirable result.

3.1.3 OptQuest

OptQuest is an optimization tool embedded in simulation software Arena®. Optimization algorithms in OptQuest are not explicitly known, but it is known as the combination of scatter search, advanced taboo search, linear programming, integer programming, neural networks and linear regression. OptQuest allow users to find a feasible solution for a mathematical model that imports the parameter values from simulation runs simultaneously.

4 COMPUTATIONAL RESULTS

Delphi™ 7.0 is used to write the algorithms. Simulation tool Arena® is embedded inside the user interface module in order to execute the OvS methods simultaneously. The harmony search and genetic algorithms are population based algorithms. The advantage of using harmony search is that it needs fewer configurations than genetic algorithms, but has a disadvantage because; only one of the candidate solutions can be renewed per each population generation. While using genetic algorithms, a group of population is updated proportionally to crossover and mutation rates. So, the process of converging optimum in simulation optimization progress is longer in time in harmony search algorithm than in genetic algorithms as seen in Fig. 7. The number of simulation runs are different. But, actually the number of population members updated for each algorithm is the same. The convergence to the optimum in genetic algorithm seems better than harmony search algorithm. The optimal is reached after 120 runs in genetic algorithms while 300 runs in harmony search. Due to the connection structures of nodes in the topologies, the performances of the algorithms result in differ. For example, genetic algorithms converges to optimal with a less number of iterations for USA topology and greater number of iterations for OCT topology among others. However, harmony search algorithm converges to optimal with a less number of iterations for ARPA topology among others.
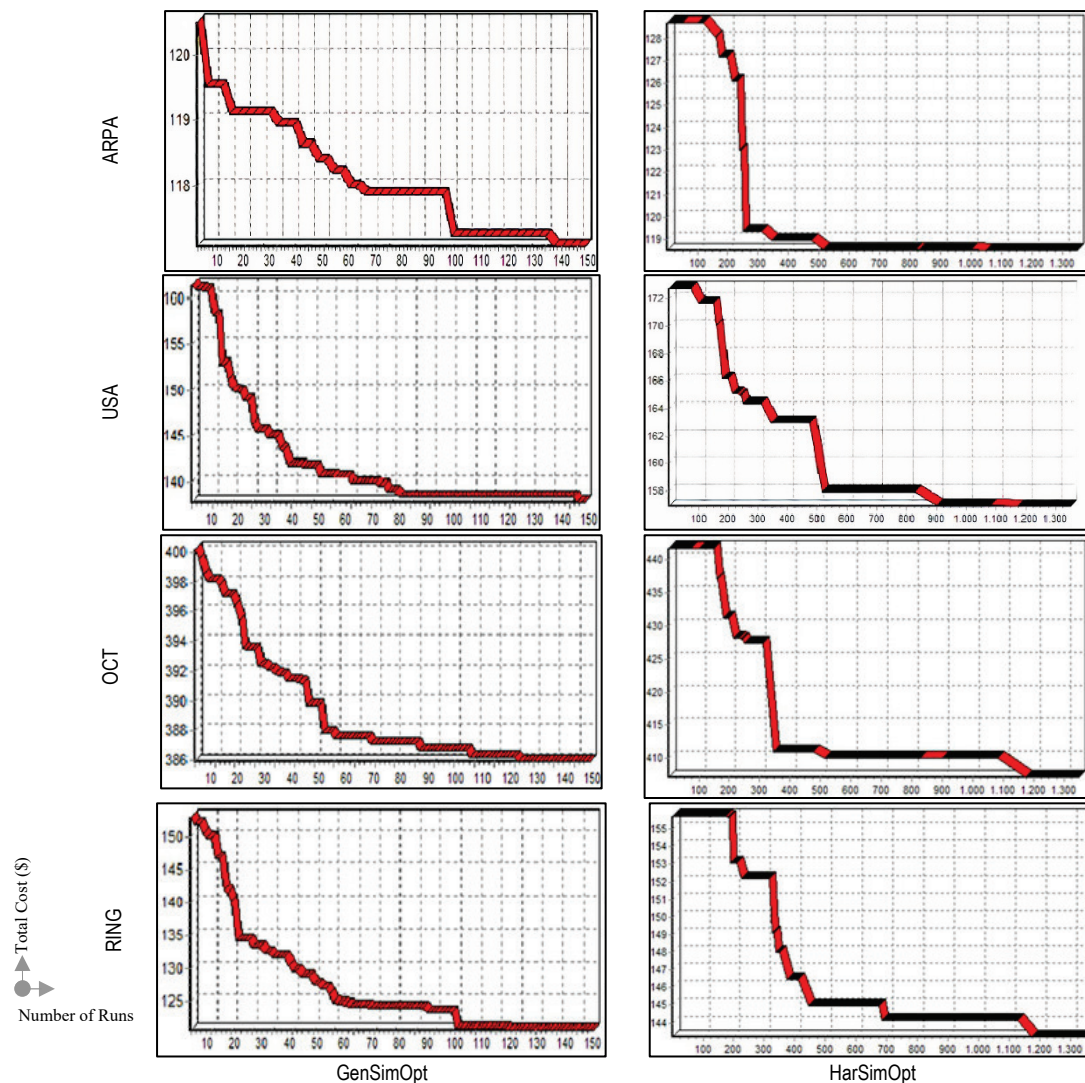

Figure 7 Improvement in total cost through number of simulation runs for each metaheuristics and topology

OptQuest is reached a desirable optimal value after 2000 simulation runs. Fixed, variable, delay and total costs for each network topology obtained using three methods are given in Tab. 6. Based on the costs of the network system, GenSimOpt gives the minimum total cost for each topology, while the HarSimopt and OptQuest performances of converging to minimum cost change for different topologies of networks.

Table 6 Optimal costs per topology obtained by three OvS methods

	Methods	Fixed Cost ($)	Variable Cost ($)	Delay Cost ($)	Total Cost ($)
ARPA	HarSimOpt	72,63	33,31	12,57	118,51
	GenSimOpt	70,77	29,47	9,21	109,45
	OptQuest	74,09	32,34	13,67	120,10
OCT	HarSimOpt	90,88	42,54	23,46	156,88
	GenSimOpt	85,23	30,49	22,01	137,73
	OptQuest	91,6	24,39	23,9	139,89
USA	HarSimOpt	105,11	25,17	266,61	396,89
	GenSimOpt	96,43	21,67	267,83	385,93
	OptQuest	112,55	16,92	266,79	396,26
RING	HarSimOpt	95,43	20,38	25,27	143,20
	GenSimOpt	82,28	17,2	17,6	120,22
	OptQuest	92,91	12,59	18,19	124,81

The results are illustrated in Fig. 8. The USA topology have a higher delay and total cost because of the messages wait in the system to reach its destination node up to the maximum number of hops. The USA topology has two bottleneck nodes 15 and 16 that are only two nodes placed on the connections of other nodes. Once looking at the topologies one can conclude that the RING network would have been a higher cost, but the mesh structure of RING gives messages opportunities to reach its destination node via different alternative ways.
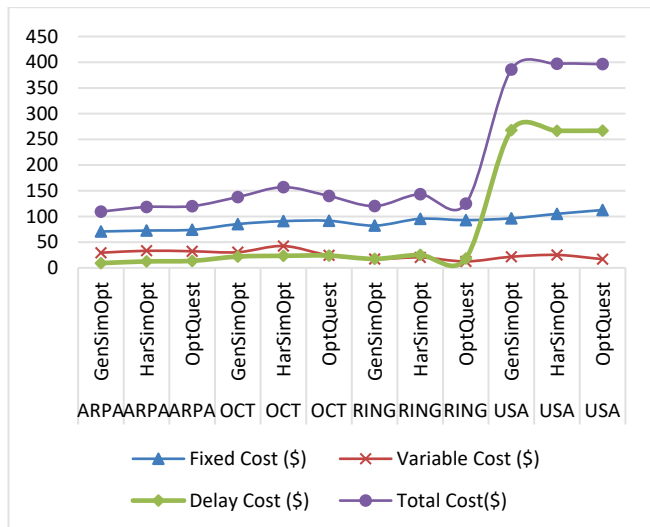
Figure 8 The results of each method for each network topology

5 CONCLUSION

The capacity assignment problem of computer network systems under dynamic routing conditions is solved by OvS methods involving heuristic algorithms in this study. Since there is no remarkable study for discrete event simulation

(DES) of computer network systems in the literature, the main contribution of this paper is providing the DES model of such a complex system. As another contribution, the costs are estimated not under restricted, fixed, and finite combinations based on the end-to-end routing of messages as handled in the previous studies. The simulation and optimization methods are used simultaneously with high consideration of steady-state conditions to increase the precision level. The results show that genetic algorithm gives the best results for nearly the same CPU time compared with other methods. In addition, although OptQuest is used by several researchers, its performance is not highly appreciated in computer network systems simulation optimization problem.

In this study, it is observed that due to the great amount of CPU time of simulation runs, it would be less time consuming at least the optimization method converging to the optimum by a small number of iteration. Otherwise, the OvS method becomes less efficient to solve complex optimization problems. Each heuristic used in this study is a population-based algorithm. Although they are very efficient for solving general optimization problems, the trade-off is important among the simplicity of the algorithm, applicability, and success of convergence to optimum in a reasonable time. It can be concluded that harmony algorithm is better than genetic algorithms in simplicity and applicability. However, the success of genetic algorithms in convergence to optimum is reported as better in this study. For further, one can apply other efficient metaheuristic methods to decrease the number of simulation runs that take a considerable amount of CPU time.

Acknowledgement

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Stacked Cross Validation with Deep Features: A Hybrid Method for Skin Cancer Detection

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Abstract: Detection of malignant skin lesions is important for early and accurate diagnosis of skin cancer. In this work, a hybrid method for malignant lesion detection from dermoscopy images is proposed. The method combines the feature extraction process of convolutional neural networks (CNN) with an ensemble learner called stacked cross-validation (CV). The features extracted by three different CNN architectures, namely, ResNet50, Xception, and VGG16 are used for training of four different baseline classifiers, which are support vector machines, k-nearest neighbors, artificial neural networks, and random forests. The stacked outputs of these classifiers are used to train a logistic regression model as a meta-classifier. The performance of the proposed method is compared with the baseline classifiers trained individually as well as AdaBoost classifier, another ensemble learner. Feature extraction with Xception architecture, outperforms all other benchmark models by achieving scores of 0.909, 0.896, 0.886, and 0.917 for accuracy, F1-score, sensitivity, and AUC, respectively.

Keywords: Convolutional Neural Networks; Cross Validation; Deep Learning; Dermoscopy; Skin Cancer; Stacking

1 INTRODUCTION

The medical science is facing the challenging task to detect and cure of cancer in human beings. Skin cancer is the most common cancer type in the United States of America and the most common form of the skin cancer is melanoma [1]. Among different types of skin cancers, malignant melanoma itself causes more than 10,000 deaths annually in the United States [2, 3]. The development of melanoma begins with the production of cysts in the pigment melanin, which is responsible for the color of the skin. It can spread to the lower part of the skin, enter the bloodstream and then spread to other parts of the body. The treatment of this cancer type is a demanding task in its growing stage. Therefore, the early-stage detection of melanoma is important to successfully treat the patient and reduce the rate of mortality.

The early diagnosis of skin cancer is possible through computer-aided devices and tools. The computer-aided diagnostic tools can help the clinicians to improve the clinical diagnosis accuracy for cancer detection. Dermoscopy is the most important non-invasive computer-aided tool for the detection of melanoma as well as the other pigmented skin cancer types [4]. The conventional method for identification of the primary features of melanoma is the eye-based examination of dermoscopy images. These features are the surface structure and the skin color. This examination strategy allows for better differentiation between different cancer types based on their color properties and morphological features [5]. However, visual inspection of dermoscopy images by clinicians relies on expertise and experience. Since human interpretation is a subjective operation, computer-aided intelligent systems are important tools for automatic analysis of the dermoscopy image and reduce the human-related diagnostic errors [6]. For the identification of melanoma, utilization of dermoscopy images together with computer-based tools may improve the diagnostic accuracy of the disease because dermoscopy provides magnified and illuminated images of the skin. As a result, dermoscopy can be considered as a useful tool for computer-based diagnosis systems that implement various methods in image processing, computer vision and machine learning [7].

Nowadays, deep learning has become the most popular and robust technique for various image classification problems. The conventional classification techniques were restricted to the transformation of raw input to formatted features to perform classification task [8]. The deep learning methods allow for automated classification and prediction system because they enable automatic extraction of features from the given images. For performance improvement and high accuracy based results, researchers are turning towards the development of hybrid approaches using deep learning methods [9]. Information regarding the previous studies of skin cancer identification reveals that there is a large scope of studies based on deep neural network approaches. However, there is not sufficient evidence of research on the use of deep learning methods together with stacking algorithms for analyzing dermoscopy images.

In this paper, a hybrid method for classification of dermoscopy images belonging to malignant and benign skin cancer is proposed. The method employs stacked cross-validation (CV) algorithm together with deep neural networks. Convolutional layers of deep neural networks are used for extracting the features from the images, hence they are called as deep features in this work. These features are used to train for different classifiers whose outputs are then stacked to generate a meta-classifier.

The proposed method is named as Stacked Cross-Validation with Deep Features (SCV-DF) and implemented on three levels. At the first level, the deep learning methods are applied to the original dataset to extract features from the images. The outcome of the first level is used as features for the second level, where four different classifiers namely, support vector machines (SVM), k-nearest neighbors (KNN), artificial neural networks (ANN), and random forest (RF) are trained separately. The outcome of the second level is used as features for the third level. The logistic regression method is used in training for third level folds. The output of the level three models is the final prediction and is used as outcome results. The results of the proposed method are compared

with six benchmark models, and it has been shown that the usage of SCV-DF improves the classification performance. Therefore, the main contribution of this work is the proof of concept about the suitability of the deep learning based ensemble models for malignancy detection in skin cancer.

The rest of the paper is structured as follows: Section 2 involves the related work. Details of the experiments as well as the dataset are provided in Section 3. Results and relevant discussion are given Section 4, and Section 5 presents the final conclusions.

2 RELATED WORK

In the past decade, numerous amount of research has been done for the detection and identification of malignant and benign skin cancer. Various methods based on splitting, merging, clustering, and classification was used by the researchers for this task. Each method has some limitations and advantages for the experimental analysis and helps the medical experts in decision making.

The visual properties of the lesions are the most commonly used features for skin cancer identification. These properties are analyzed under three main methods, namely, ABCD method, Seven-point checklist method, and Menzies method. Asymmetry, border, color and diameter are the properties inspected under the ABCD method. In the seven-point checklist method, blue-white veils, atypical pigment and vascular networks, regression structures, and irregularities in globules, blotches and streaks are analyzed. The Menzies method investigates the features of positive and negative lesions by observing the symmetry and color based features. The strategies proposed by these methods are utilized by the researchers to develop computer-based algorithms [10].

One common method for feature extraction of the skin cancer images is the wavelet transform. The texture, border, and geometry features were extracted using the wavelet-decomposition and boundary-series model explained by Rajasekhar et al. [11]. The classification of skin cancer was performed using well-known machine learning algorithms such as SVM, RF, logistic model tree, and hidden Naive Bayes methods. In another method utilizing wavelet transform, feature extraction together with texture analysis were implemented [12]. The extracted features were passed as an input to the stack auto encoders towards classification of malignant and benign skin cancer.

Segmentation methods are also used for feature extraction purposes. A particular segment of the tissue was extracted from melanoma images using watershed segmentation [13]. A measure of asymmetry, border irregularity, color variation, diameter, and texture features were used for the classification of the images. The classification was implemented using KNN, RF and SVM methods. The SVM classifier was found to be robust and dominant when compared to other methods.

There are a number of other works in which traditional machine learning methods like SVM [14, 15], ANN [16, 17] and decision trees [12, 18] are utilized. However, with the advancement of deep learning, various possibilities for skin cancer detection have emerged. One example application may be the segmentation of skin lesions with deep learning methods [19] as well as the classification of the obtained segments [20].

Various convolutional neural network (CNN) architectures are widely used in classification of dermoscopic images. Hekler et al. proposed a method that combines the decisions of humans and ResNet50 models to improve the detection accuracy [21]. A gradient boosting method, XGBoost is used to fuse the decisions and it was shown that this procedure might improve the detection accuracy for some of the classes. On the other hand, S. H. Kassani and P. H. Kassani performed transfer learning on five well known CNN architectures, namely AlexNet, ResNet50, VGG16, VGG19, and Xception [22]. They used a seven-class dataset and reported results with and without data augmentation applied to it. In a study by Codella et al., an ensemble of deep residual network (DRN), CaffeNet and fully convolutional U-Net architectures is proposed for the detection of malignant skin lesions [23]. They used weights for pre-trained models of DRN and CaffeNet for feature extraction from the images and showed that generating an ensemble model together with a segmentation step may improve the detection performance. Region-based CNN (RCNN) methods are also utilized for detecting malignant skin lesions. For example, utilization of faster RCNN was proposed by Jianni et al. and it was shown that it outperforms the mean accuracy of the decisions made by dermatologists [24].

As can be seen from the previous works about skin cancer classification, the majority of the researchers either apply an image processing step followed by a machine learning method or feed images of a deep learning model for the training of the model. Therefore, it can be concluded that utilization of ensemble learning techniques together with deep learning models has not been studied in the literature yet. With this study we aim to fill this existing research gap by proposing a novel method for skin cancer detection. In this work, only the convolutional layers of different CNN architectures are used for feature extraction that is followed by stacking multiple classification models for detecting malignant and benign lesions. The novelty of the proposed method is due to involvement of a stacking ensemble that is trained using the features extracted by CNN models. The ensemble model contains four classifiers (SVM, KNN, ANN, and RF) and performances of features extracted by ResNet50, VGG16 and Xception models are compared for suitability to the proposed model.

3 MATERIALS AND METHOD
3.1 The Dataset

Dermoscopy images provided by the International Skin Imaging Collaboration (ISIC) are used in this work. The dataset is a collection of 1800 benign and 1497 malignant images all of which have dimensions of 224×224 pixels [25]. It is randomly split into training and test sets with 70% and 30%, respectively. Some sample images of the dataset are given Fig. 1.
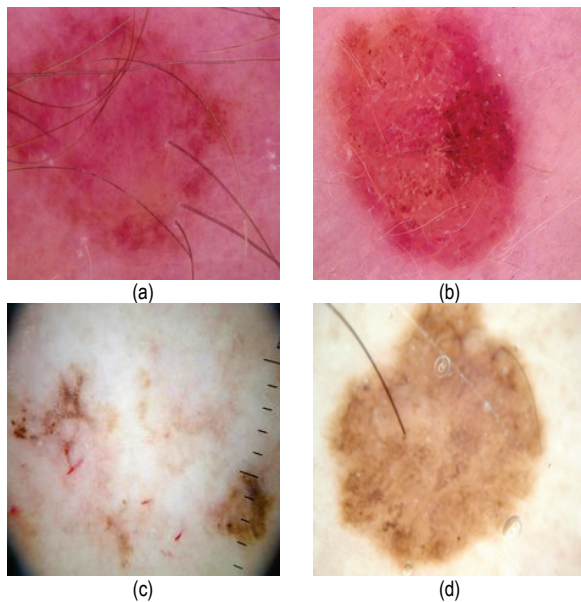
Figure 1 Benign (a, b) and malignant (c, d) samples from the dataset

3.2 Stacked Cross Validation with Deep Features

It is possible to divide the proposed SCV-DF method into three main levels of processing. The first level involves feature extraction from the images. The melanoma images in the dataset are structured data and the feature extraction from these images is an important task for an accurate classification. Deep learning methods allow for automatic extraction of the features from the images and there are state-of-the art CNN architectures to perform this task. Therefore, deep features are extracted from the images using three different CNN architectures. Features from these architectures are analyzed separately to understand the appropriateness of them. These features are used in the second level for training on the base models in SCV-DF method. The prediction outputs of the base models are stacked to be used in the third level. Together with the actual target values, the stack of the predictions is fed into a meta-model in the level three. The output of the meta-model is the final prediction that is used to evaluate the performance of the method.

3.2.1 Feature Extraction

Feature extraction is related to the first processing level of the proposed method. CNN architectures generally have two major parts. First one is feature extraction part in which there are convolutional layers together with activation, regularization and pooling operations. The second one is the classification part that contains several fully connected layers followed by a final decision layer.

In this work, the features used by the SCV-DF algorithm are extracted through convolutional layers of three different deep learning architectures that are ResNet50 [26], VGG16 [27] and Xception [28]. ResNet50 is a CNN architecture with a depth of 50 layers. The associated kernel size is 7×7 and 64 different kernels with a stride 2 is used for each layer.

VGG16 uses only 3×3 convolutions stacked on top of each other where max pooling is used to reduce the volume size. It consists of 16 weight layers in which 13 convolutional layers and three fully connected layers. Xception architecture contains linear stack of depths separable convolutions together with residual connections to eliminate the risk of vanishing gradient. Xception model has 36 convolutional layers in its feature extraction base.

Training of the deep learning models were performed with stochastic gradient descent optimizer and binary cross entropy was used as the loss function. The learning rate and the momentum parameters of the optimizer were set as 0.01 and 0.9, respectively.

3.2.2 Stacked Cross Validation Algorithm

The second and third levels of the SCV-DF method are involved in stacked CV algorithm that contains several base models and a meta-model that performs the final decision. In this algorithm, the base models are typically different and they are all trained on the same training set. The base models used in this work are SVM, KNN, ANN, and RF. Together with the expected outputs, the predictions made by the base models are fed into the meta-model to learn a relationship between the inputs and outputs. The most common meta-model is a logistic regression function which is used in this work as well. In order to include the cross-validation property, the dataset is divided into k folds and one fold is held out for testing, and the remaining $k–1$ folds are used for training for the base models. This procedure is repeated until all the folds are used as a test set. The prediction outputs of these models on the test sets of k folds are stacked to be used in the third level. In this algorithm, k is chosen as five. which is found through the experimentation to estimate with low bias a modest variance. All three levels of the proposed method are illustrated in Fig. 2.

3.3 Performance Evaluation Metrics

For the performance evaluation of this work, accuracy, sensitivity, *F1-score*, and AUC are computed. Correct calculation of these measures requires careful definition of the terms true positive (*TP*), true negative (*TN*), false positive (*FP*) and false negative (*FN*). Since detection of malignant type is the main concern, correct classification of an image containing malignant tissue is considered as a *TP* prediction. The other terms are defined accordingly and they are summarized in the confusion matrix given in Tab. 1.

Table 1 The Confusion Matrix

		Actual Class	
		Benign	Malignant
Predicted Class	Benign	*TN*	*FN*
	Malignant	*FP*	*TP*

The receiver operating characteristic curve (ROC curve) corresponds to the performance of the proposed model at all classification thresholds. It is the plot for true positive rate versus false positive rate. The area under the ROC curve

(AUC) provides the aggregate measure of all possible classification thresholds. The other three performance metrics are accuracy, sensitivity, and *F1-score* that are calculated using Eqs. (1), (2), and (3), respectively. *Accuracy* is a measure for rate of correct predictions among all samples in the test set. *Sensitivity*, also known as recall, is the ratio of correctly predicted malignant samples to the all actually malignant samples. On the other hand, *F1-score* is an important measure for imbalanced dataset.

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN}, \tag{1}$$

$$Sensitivity = \frac{TP}{TP + FN}, \tag{2}$$

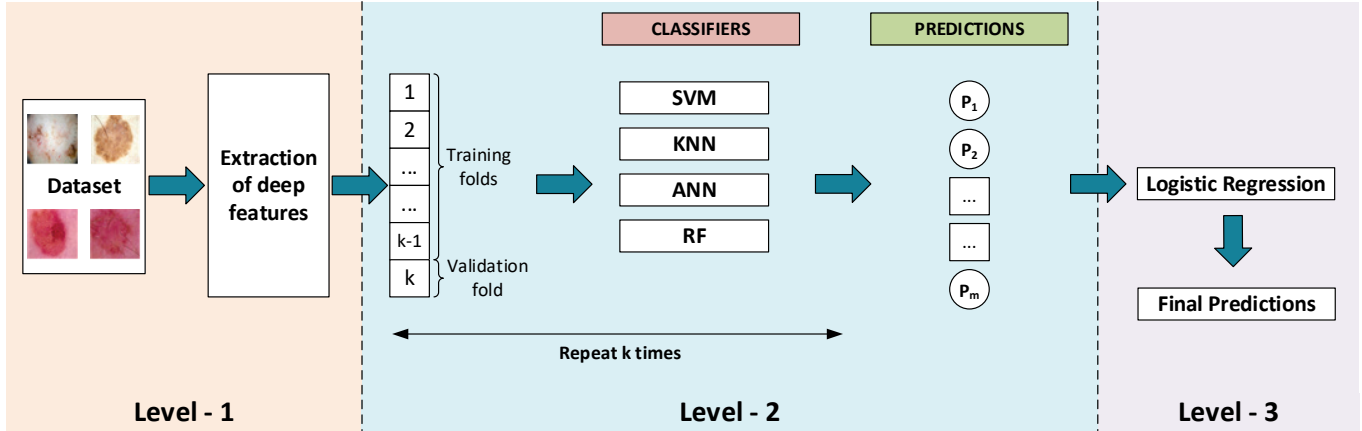$$F1\text{-}score = \frac{2TP}{2TP + FP + FN}. \tag{3}$$

Figure 2 The processing pipeline of the proposed SCV-DF method

4 RESULTS AND DISCUSSION
4.1 Evaluation of the Proposed Method

As indicated earlier, the first layer of SCV-DF involves utilization of deep learning methods for feature extraction from the images. In order to compare performances of different CNN architectures, three baseline models, namely, ResNet50, Xception, and VGG16, were used. Some of the feature maps generated with these models are given in Figs. 3 and 4 for samples of benign and malignant tissues, respectively. Since all these CNN models have high number of layers, each of which contains many filters, only some outputs of the filters are included in these figures. In order to illustrate how the frequency components of each layer change at different depths of processing, feature maps obtained at three different layers (2nd, 9th, and 13th) are provided in the corresponding columns. As can be seen from the figures that the feature maps belonging to initial layers resemble the input image more than those generated at the higher layers. In other words, as the image is processed at the deeper layers of the network, the meaningful features for the human eye are replaced by the features that are important for the classification model. Furthermore, the sizes of the feature maps are reduced by max-pooling operations at various layers. As a result, the feature maps obtained at higher layers have lower resolution and this situation is observable in Figs. 3 and 4, as well. Despite their low resolution, the number of such feature maps is typically high in CNN models and they are flattened into one single high dimensional feature vector which is the output of the first layer of processing the proposed method.
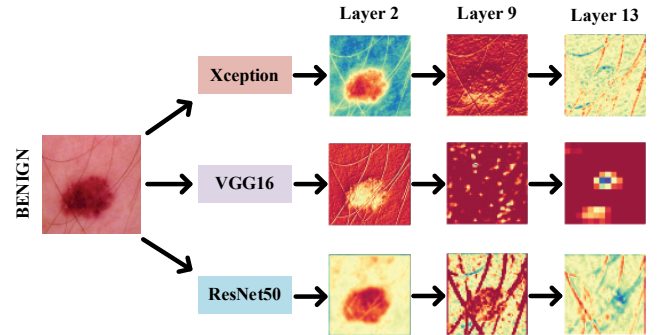

Figure 3 Feature maps generated by CNN architectures for a benign sample
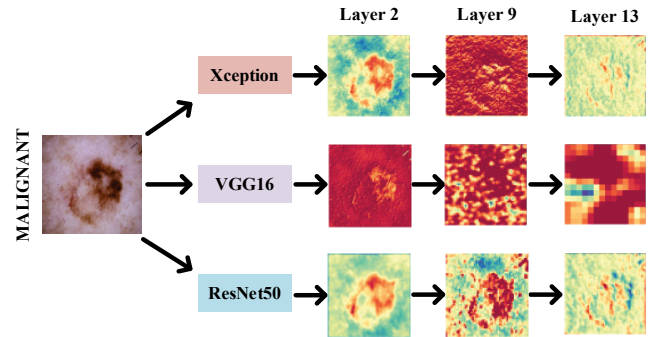

Figure 4 Feature maps generated by CNN architectures for a malignant sample

Next in the second layer, the extracted features were used for training of a stacked CV model for each of these architectures. To underline the appropriateness of stacked CV for this task, six different single benchmark classifiers were trained using these extracted features as well. These classifiers are SVM, KNN, ANN, RF, logistic regression, and

AdaBoost. The first five of them are the individual classifiers that are used in the second and third levels of the stacked CV method. Like stacked CV, AdaBoost is an ensemble learning method in which outputs of several weak learners are combined. The reason for selecting these benchmark methods is to underline the usefulness of stacked CV instead of using them individually. The details about the model parameters of single benchmark classifiers are provided in Tab. 2. When selecting the model parameters, their default values were used initially. Then the effects of slightly changing these values were observed to determine them.

Table 2 Properties and parameters of the benchmark models

Method	Properties
SVM	Kernel: Gaussian, C = 1, gamma = 0.001
KNN	K=5
ANN	# hidden units = 100, learning rate = 0.0001
RF	# trees = 100, split quality measure: Gini index
Logistic Regression	Penalization: L2-norm
AdaBoost	Base learner: Decision tree, # weak learners: 50

As can be seen from Tabs. 3-6 that the highest values for all of the four performance metrics are achieved by using the features extracted via Xception architecture in SCV-DF method. When compared to performances of individual benchmark models, SCV-DF with ResNet50 and VGG16 features improves the classification performance in general. In particular, *F1-score* and *AUC* values of SCV-DF with ResNet50 outperform all the individual models. On the other hand, the ensemble model, AdaBoost, is capable of achieving higher scores than SCV-DF model with ResNet50 features. However, this situation is not observable for all types of features. For example, with VGG16 features, the AdaBoost model has relatively lower accuracy, *F1-score*, and sensitivity values than those obtained via ResNet50 features. On the other hand, VGG16 features achieve higher *AUC* values with all benchmark models than ResNet50 features.

Table 3 Accuracy Values Obtained with SCV-DF and the Other Methods

	ResNet50	Xception	VGG16
SCV-DF	0.816	0.909	0.865
SVM	0.818	0.867	0.867
KNN	0.812	0.864	0.834
ANN	0.780	0.801	0.831
RF	0.787	0.803	0.840
Logistic Regression	0.806	0.863	0.875
AdaBoost	0.821	0.837	0.799

Table 4 F1-Score Values Obtained with SCV-DF and the Other Methods

	ResNet50	Xception	VGG16
SCV-DF	0.788	0.896	0.842
SVM	0.787	0.838	0.835
KNN	0.778	0.834	0.803
ANN	0.785	0.720	0.753
RF	0.735	0.739	0.805
Logistic Regression	0.762	0.837	0.847
AdaBoost	0.792	0.739	0.766

Even though it is not possible to tell a best deep feature extractor architecture that outperforms the other two in all metrics and for all classifiers, the highest scores are obtained by Xception architecture. As a result, it may be concluded that the SCV-DF method can improve the detection

performance when it is used together with appropriate CNN architecture for feature extraction. Bar graphs for the accuracy values are given in Fig. 5 for visual comparison.

Table 5 Sensitivity Values Obtained with SCV-DF and the Other Methods

	ResNet50	Xception	VGG16
SCV-DF	0.821	0.886	0.804
SVM	0.816	0.834	0.810
KNN	0.736	0.827	0.799
ANN	0.740	0.783	0.776
RF	0.715	0.678	0.798
Logistic Regression	0.752	0.853	0.844
AdaBoost	0.825	0.798	0.794

Table 6 AUC Values Obtained with SCV-DF and the Other Methods

	ResNet50	Xception	VGG16
SCV-DF	0.818	0.917	0.843
SVM	0.817	0.862	0.859
KNN	0.762	0.861	0.834
ANN	0.781	0.820	0.831
RF	0.777	0.784	0.834
Logistic Regression	0.798	0.862	0.870
AdaBoost	0.822	0.831	0.834
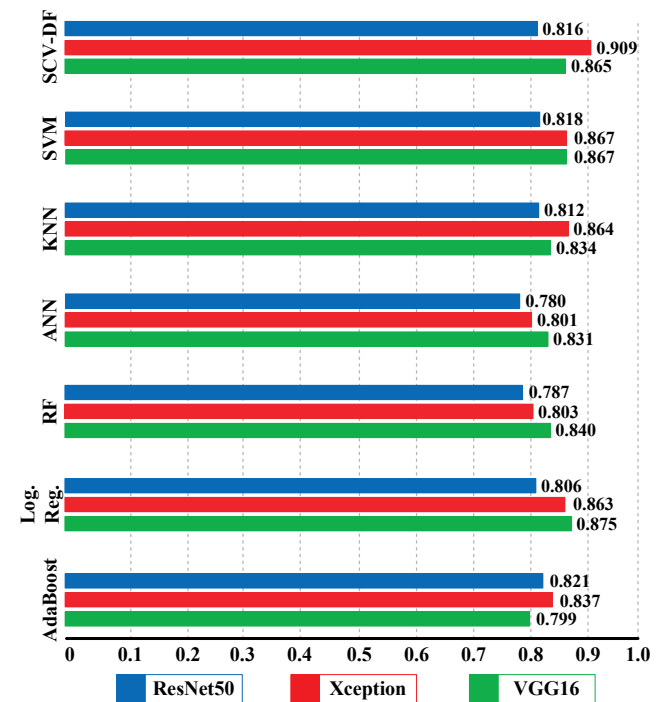
Figure 5 Percentage of accuracy values for visual comparison of the methods

The burden of false negative classifications is higher than false positives in this work because misclassification of actual unhealthy images may result in late diagnosis of the disease. As a result, it may cause catastrophic consequences for the patient. Sensitivity is measured is related to the rate of false negatives hence; extra emphasis needs to be put on this measure. Obviously, SCV-DF with Xception features achieves the highest sensitivity value as 0.886. It is also notable that SCV-DF with the other two deep learning based feature extraction methods can improve the sensitivity as well.

The AUC values are obtained by calculating the area under the ROC curves for each of the classifiers respectively.

The graphical representation of the related ROC curves is shown in Fig. 6.
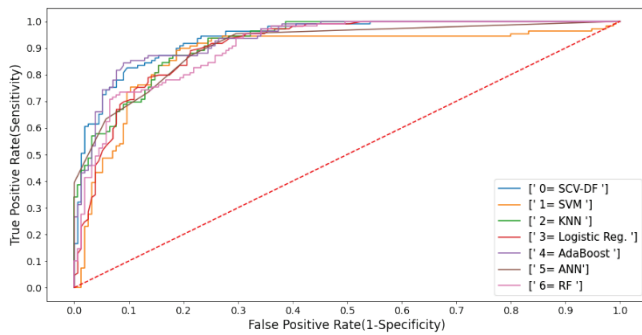

Figure 6 ROC curves of the classifiers

4.2 Comparison with the Existing Studies

In the literature, there are other studies in which the images of skin lesions are classified into different categories. In this section, the results obtained by SCV-DF are compared by those reported in five of the recent works where malignant and healthy lesions are detected.

In the majority of the other studies, the researchers generally utilize deep learning methods as they allow for automatic extraction of features. The obtained accuracy and AUC values, together with the utilized methods in these studies, are summarized in Tab. 7.

Both the accuracy and AUC scores achieved by the proposed method is higher than the other studies in the literature which supports the effectiveness of SCV-DF algorithm for detection of malignant skin tissue from dermoscopic images.

Table 7 Summary of the Existing Studies in the Literature

Reference No	Year	Method	*Accuracy*	*AUC*
[29]	2017	Sequential CNN	72.1%	0.94
[30]	2018	InceptionV4 + SVM	89%	0.773
		InceptionV4 + NN	89%	0.892
[31]	2018	ResNet50	72.1%	0.888
[32]	2021	AlexNet	81.8%	
		Sequential CNN	82.01%	-
		ResNet50	90.78%	
[33]	2021	VGG16	80%	-
		ResNet50	87%	-
Proposed method	2021	SCV-DF	90.9%	0.964

5 CONCLUSION

SCV-DF, a hybrid method for classification of dermoscopy images, is proposed in this work. The method includes extraction of deep features from the images using the convolutional layers of three deep learning architectures, which are ResNet50, Xception, and VGG16. These features are fed into a stacked-CV step where four different baseline classifiers are trained and their prediction results are merged. Together with the actual labels, these prediction results are then used as a training set for a meta-classifier. The baseline classifiers are SVM, KNN, ANN, and RF, and the meta-classifier is a logistic regression model.

The method is developed and tested using a dataset containing 1800 benign and 1497 malignant images. The performance of the proposed method is compared with the cases in which the baseline classifiers and the meta-classifier are trained individually on the deep features. Furthermore, as an alternative ensemble learning method, the performance of the AdaBoost method is evaluated to compare it with the stacked CV. According to the results, it has been shown that SCV-DF outperforms the benchmark models when deep features are extracted using the Xception network. Furthermore, all four of the calculated performance metrics for SCV-DF is higher than AdaBoost when VGG16 and Xception networks are used for feature extraction. In addition, the accuracy and *AUC* values of the proposed method were compared with the reported results in the relevant literature. It has been shown that SCV-DF model outperforms the other deep learning based methods. Therefore, it may be concluded that the proposed SCV-DF method is suitable for detection of malignant skin cancer lesions. In more general terms, this study has revealed that ensemble methods can increase the detection accuracy for this specific problem particularly when the features are extracted with the appropriate CNN architecture.

As a future work, sub-classes of the malignant and benign tissues is expected to be detected with an improved version of the method. In addition, other state-of-the-art CNN architectures are going to be included in the experiment to understand their suitability for this task.

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Salient Features Selection Techniques for Instruction Detection in Mobile Ad Hoc Networks

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Abstract: The development of wireless mobile ad hoc networks offers the promise of flexibility, low cost solution for the area where there is difficulties for infrastructure network. A key attraction of this mode of communication is their ease of deployment and operation. However, having a good and robust mobile ad hoc networking will depend entirely on security mechanism system in place. Traditional security mechanisms know as firewalls were used for defensive approach to oppose security obstacle. However, firewalls do not fully or completely defeat intrusions. To cope with this limitation, various intrusions detection systems (IDSs) have been proposed to detect such network intrusion activities. The problem encounter for this particular technique of instruction detections technique is that during network monitoring for data collection for anomaly detection, data that does not contribute to detection must be deleted before detection can be processed or application of learning algorithm for detection of abnormal attacks. In this paper we present a novel feature technique for feature selection before learning technique should be applied. The method has been applied into our own data set, and for the detection purpose we have used most of the well reputed three Machine Learning classifiers with the new selected features for performance evaluation and the experiment shows that higher accuracy results could be achieved with only all the 9 features extracted with our own algorithm with the data set created by using RandomForest classifier.

Keywords: AODV; IDS; Jammer Node; MANET; OPNET; Spoofing attack; Wormhole attack

1 INTRODUCTION

Today, more people use mobile phones than traditional fixed phones. Nevertheless, we are experiencing a huge growth rates in mobile wireless communication. For many countries, mobile wireless communication is the only solution of communication in some location due to the lack of an appropriate fixed communication infrastructure [1]. While traditional communication paradigms deal with fixed networks in which security can be managed, wireless communication raises a new set of questions such as due to the openness of the network appropriate security mechanism are hard to achieve. Especially in the case of Mobile ad hoc networking [2], which is the subject of our research studies, security mechanism is hard to imagine due to some design implementation issues that defined the network such as:

- Dynamic topology
- Limited Bandwidth
- Routing issues
- Lack of central authority
- Lack of association among nodes.

MANETsare more exposed to malicious attacks due to the openness of the network and the autonomous aspect of the connecting nodes. Any node can be able to join and or leave the network at any time.

Attacks in MANETS can be classified as one of the two forms: Horizontal attacks or Vertical Attacks.

The Horizontal attacks are the existing attacks such as: Dos attacks, Blackhole attacks, Malicious attacks, etc, and can be term as going from 1 to *n*. Whereas, vertical attacks means be able to detect news attacks term as going from 0 to 1. Vertical attack is hard to imagine because it require detecting an attack nobody else has ever detect.

To cope with design issues related to MANETs which are the causes of the vulnerabilities of the networks, various IDS (Intrusion Detection Techniques) have been implemented by the researchers in MANET community to have a suitable resources sharing, and communication with less vulnerabilities to malicious attacks.

Intrusion detection is the technique that strives to detect an instructor that attempted into computer system then initiate responses to the intrusion [3].

Various Axes involved in the intrusion detection techniques such as the time at which the detection occurs, the types of inputs examined to detect instructive activities, and the range of responses capabilities as the simple form of alerting an administrator of the potential intrusion. These axes included in the design space for detecting intrusion in the computer systems have yields a wide range of solution known as Intrusion-Detection Systems (IDS). These intrusion detection systems techniques come in two forms: Signature-base detection and anomaly detection.

In **signature-base detection technique**, the system inputs or network traffic are scrutinized for specific behaviour patterns (or signatures) that are known to indicate attacks. In this approach, only known attacks are identified. This issue is well known to virus-detection software vendors, who must release new signatures on a regular basis as new viruses are generated and detected manually. In the case of **anomaly detection**, the attempt or detection is to characterise normal (or non-dangerous) behaviours and detect them when something other than these behaviours occur. Anomaly system activity does not always imply an incursion, but the presumption is that intrusions often induce anomalous behavior in a system. In particular, anomaly detection can detect previous unknown networks of intrusions.

The aim of this research studies are the detection of the salient feature selections techniques used by various researchers to have a best implementation of IDS techniques to remove the node having malicious intent on MANET that constitute security threats. In addition, our feature recommended feature selection approach mechanism is elaborated and the application is performed on our own data generated and the results are applied to existing Machine learning Classifiers algorithms to check the detection accuracy of the proposed feature selection algorithm.

This study is very crucial because feature selection is very important in order to detect malicious behavior during network monitoring to extract various features contributing

to the data collected and the application of the learning algorithm to alert the system of the presence of malicious activities.

The paper's organizational structure is as follows: Section 2 is the description of the previous research work. The proposed method; simulation implementation and data collection is described in Section 3, illustration and results of proposed features extracted are given in Section 4, Experiments and results analysis of applied ML classifiers are given in section 5, and at last Section 6, is the Conclusions and future directions.
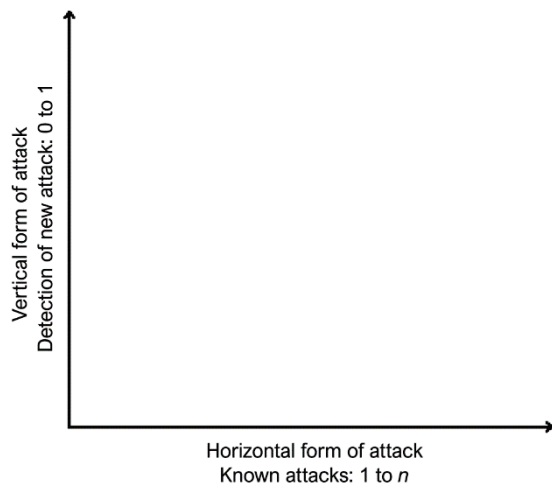
Figure 1 Horizontal and Vertical forms of attack

2 RELATED WORK

In the area of network intrusion detection techniques, relevant features are the main tool with which the detection technique is based on. However, the question arises as what constitute an important feature selection technique. The answer to this question depends entirely upon what constitute the researcher aims and the data generated or data at hand.

Various features solution techniques have been proposed in the literature in order to have a better detection rate in intrusion detection approaches. In [4], for feature selection, a trial-and-error method of deleting one feature at a time is proposed. Neural Network and Support Vector Machines were applied on the selected features for the importance of ranking of the input features. The set of important features was determined to be the reduced feature set that produced the highest detection rate in the experiments. Paper, [5] used a Naive Bayesian classifier to detect network intrusions. They used KDD'99 data with all 31 attributes from the data set and reported overall error rates of 5.1 %. In paper [6,] a feature selection algorithm based on information gain and SVM is developed (Support Vector machine). Its basic principle is to group all data features based on information gain, and then use the SVM algorithm to select the best features subset. In the first stage, Sangkatsance, Watlanapongsakorn, and CharnsriPinyo suggested a real-time intrusion detection system (RT-IDS) and retrieved 12 critical elements from the network packet instructions header. In the second stage, to evaluate the importance of the feature, information gain was used in detecting different forms of attacks. By using (RT-IDS) for detection of different forms of attacks, the rate detection was 98% for probing and denial of service attacks classes. In [8], for feature reduction, the authors developed a clustering conjunct information hybrid technique. Features Clustering was done based on similarity in an unsupervised manner. To increase similarity with response features providing class labels, a supervised learning approach was employed to find important features. Kabiri [9] in his work, DDoS attacks were simulated, and a classifier based on Principle Component Analysis (PCA) was used to select useful attributes from a set of 16 attributes. The three most important attributes he found are routing reply, the number of received packets and total RREP. In paper [8], the authors have elaborated two steps process feature algorithm for intrusion detection system in which redundant features are reduced using mutual information approach with (KDD-99) data set for experimentation. Highest accuracy and in processing speed was achieved by the proposed method. Bayesian networks were use in [10] for data classification as well as to select features with the help of Markov Blanket method on the target variables. Support vector machine and neural network were suggested by the authors in [11] for the classification procedure. In all attack classes, the detection accuracy was outstanding. Barmejo, P. Ossa, L. Gamez, J. A. & Puerta, J. M. [12] proposes a mechanism for dealing with subset selection in datasets with a large number of attributes. The goal of their research was to produce excellent results with a small number of wrapping strategies. To achieve the best results, the suggested approach alternates between filter ranking and wrapper feature subset selection. Furthermore, the approach was tested on 11 high-dimensional data sets using several classifiers.

3 PROPOSED FEATURE SELECTION ALGORITHM

Data is one of the main components in instruction detection techniques analysis. However, large data can occupy more recourse and may result in inefficient of intrusion detection. As a result, data that does not contribute to detection must be removed before processing or using a learning algorithm for atypical attack detection. This necessitates the employment of an appropriate feature reduction technique that cannot only aid minimize training time, but also provide higher detection accuracy and detect anonymous attacks.

Our recommended feature extraction technique is described as two-steps process. In the first step, data pre-pre-processing is elaborated and two algorithms, such as information gain and correlation, perform the second step feature selection or ranking.

3.1 Data Pre-Processing

In reality, due to multiple sources of origins, data used for experimentation are highly unclean, and susceptible to noise [13]. As a result, low-quality data will yield low-quality detection results. Hence, before any feature technique can be implemented it is necessary to check if the data to be use is clean and accurate. Various techniques of data pre-processing have been proposed in the literatures. The inconsistencies in data and removal of noisy data can be achieved using data cleaning technique. To merge data from

multiple sources into a coherent data or the storing of data in data wherehouse can be done with the method of data integration. The reduction of the size of data, or eliminating redundant features or clustering of data, can be achieved with the approach of data reduction. Finally, data transformation is applied to a data scaled within a smaller range related to 0.0 to 0.1. Therefore, the quality of data for experimentation has to satisfy the following requirements such as credibility, accuracy, interpretable, consistency and timeliness.

3.2 Feature Extraction

Data to be analyzedmay contain hundreds of features. Many of them may be unnecessary or redundant to the learning algorithm. Removing relevant features or keeping irrelevant features may be erroneous, and can lower the performance of the learning algorithm to be used. This can lead to the discovery of low-quality patterns. Furthermore, the addiction of an increasing volume of unnecessary or redundant features may gradually affect or slow down the learning process.

3.2.1 Information Gain

The information gain attribute selection technique is a research work approach done by Claude Shannon on information theory [13], by studying the value or "information content". The entropy of each feature is calculated using information gain. The higher the entropy, the more information it contains. The process of identification a given set of features vectors for which attributes is useful for learning process is done using information gain feature selection technique and the selected features will be used for classification in order to identify unknown instances and have a differentiation between types of attacks classes.

Let D be a set of training class-labeled tuples for the partition data. Let assume that the class label attribute has m different values that represent m different classes, for C_i for $(i = 1, …, m)$. Let $C_{i,D}$ be theset of tuples of the class C_i in D. Let $|D|$ and $|C_{i,D}|$ denote the number of tuples in D and $C_{i,D}$, respectively. The data required to classify a tuple in D is given by

$$Info(D) = -\sum_{i=1}^{m} p_i \log_2(p_i) \qquad (1)$$

Where p_i is the non-zero probability than an arbitrary tuple in D and part of class $C_i$and being estimated by $|C_{i,D}| / |D|$. A log function to the base 2 is used, because the information is encoded in bits. Therefore, the Info (D) is the average information needed to identify the class label of tuple D. If we were suppose to partition the tuples in D on some attributes A having v distinct values, $\{a_1, a_2, …, a_v\}$, as observe from the training data. If A is discrete-value, these correspond directly to the v outcomes of the test on A. Attribute A can be used to partition or subset D into v partitions or subsets, $\{D_1, D_2, …, D_v\}$, where D_j contains

those tuples in D that have outcome a_j of A. This split should, in theory, yield a precise classification of the tuples. That is, we want each division to be completely clean. The partitions, on the other hand, are very likely to be impure. How much more data would we require to arrive at a precise classification? This is determined by

$$Info_A(D) = -\sum_{j=1}^{v} \frac{|D_j|}{|D|} \times Info(D_j) \qquad (2)$$

The term $\frac{|D_j|}{|D|}$ acts as the weight of the jth partition. The

$Info(D)$ is the expected information needed to classify a tuple D based on the partition of A. Hence, the smaller the expected information required, the greatest the cleanness of the partitions. However, information gain is described as the difference between the initial information requirement and the new in requirement, obtain after partition of A. That is,

$$Gain(A) = Info(D) - Info_A(D) \qquad (3)$$

3.2.2 Correlation

To uncover features with greater utility values, we use a new mechanism that combines information gain with correlation-based features. Correlation is the second approach for ranking attributes. In a multiclass problem, the lower the correlation of a property in a feature vector, the more powerful it is to distinguish between distinct types of attacks. The pair-wise linear correlation coefficient between each pair of columns is returned by correlation as a matrix. Then, by taking the mean of each column, the correlation coefficient of each feature is computed.

Proposed feature selection Algorithms
Algorithm 1: Data Pre-processing
Input: Dataset with feature subset $f(N) = \{n_1, n_2, n_3, …, n_n\}$
Output: Compact and redundant dataset with feature subset $f(M) = \{m_1, m_2, m_3, …, m_m\}$
1. Removal of duplicate features
2. Replace Infinite values with zero
3. Replace missing values with zero
4. Return $f(M) = \{m_1, m_2, m_3, …, m_m\}$

Algorithm 2: Feature Selection
Input: Pre-processed dataset with feature subset $f(M) = \{m_1, m_2, m_3, …, m_m\}$
Output: Reduced features subset $f(R) = \{r_1, r_2, r_3, …, r_m\}$
1. for $f(M)$
a. Compute weight of IG_{mi}
b. if $IG_{mi} \geq 0.5$ then add into $f(IGFS_1)$
c. if $0.25 \geq IG_{mi} < 0.5$ then add into $f(IGFS_2)$
d. if $0.25 \geq IG_{mi}$ then remove IG_{mi}
2. for $f(M)$
a. Compute weight of CR_{mi}
b. if $CR_{mi} \geq 0.5$ then add into $f(CRFS_1)$

c. if $0.25 \geq CR_{mi} < 0.5$ then add into $f(CRFS_2)$
d. if $0.25 \geq CR_{mi}$ then remove CR_{mi}
End for
3. Compute $f(NMRFS) = f(IGFS_1) \cup f(IGCR_1)$
4. Compute $f(NRFS) = f(IGFS_2) \wedge f(IGCR_2)$
5. Compute $f(R) = f(NMRFS) \cup f(NRFS)$
6. Return $f(R)$

4 SIMULATION IMPLEMENTATION AND DATA COLLECTION

The implementation of our MANET model is design with OPNET modeler 14.5 with AODV as routing protocol and 2 types of attack have been implemented such as selfish nodes attacks and Dos attacks.

4.1 Ad Hoc on Demand Distance Vector Protocol (AODV)

The mechanism to identify routes path if only if there are needed is the functionality of Ad hoc On Demand Distance Vector Protocol [14]. Therefore a route need to be established first, and once a route is being identified, the paths is preserved until there is no needed for it and or once the message desired to the destination is completed the route can be discarded.

4.2 Attacks Implementation
4.2.1 Selfish Node Attack

Selfish node attacks are nodes that are presents in the network and due to lack of energy or in order to preserve their energy consumption for future use do behave maliciously in the network. Selfish node behavior can be categorized as a node that does not perform the packet forwarding after receiving the packet intended to the requested node, or purposely disable its routing protocol to avoid packet forwarding and receiving to preserve it energy, or a node that has power failure or power off during the communication [21].

In the case for our studies, the selfish node implemented is the one that has its routing protocol disabled: Disabling of AODV routing protocol is the configuration of selfishness nodes attacks for our studies.

4.2.2 DOS Attacks

Denial of Service Attack (DOS) floods the network with unnecessary network traffic. The attack traffic consumes network resources, preventing legatine traffic from reaching the destination, wasting nodes energy.

Pulse Jammer attack is simulated in our case. Jammer attack [14-19] floods the network with high wireless radio frequency to disturb the communication in place. Jammer node is different in structure as compared to MANET node. With its radio transmitter, it frequently generates noisy frequencies on wireless channel. Jammer node generates highest bandwidth (in kHz) during the transmission. Jammer transmitter power indicates the transmission power (in

Watts) allocated to packets transmitted through the channel. Lastly, the jammer node has a pulse width which point out the length of time (s) a pulse is transferred and a silence width specifies the interval in (s) between pulses [20].

4.2.3 Data Collection and Features Extraction

The recorded data set collected after the simulation was performed contains 15 features plus assigned classes label classifying each record as normal node, Selfish node attacks and dos attacks. The total number of instances that characterize each attack class is distributed in Tab. 3.

Table 1 MANET simulation parameter

Simulation parameters	Value
Network range	500×500 m
Routing Protocol	AODV
Number of nodes	80
Number of selfish nodes	5
Pulse jammer node	1
Packet size	512 packet/s
Simulation time	60s

Table 2 List of features extracted

Serial number	Features
1	Total Number of Hops per Route
2	Total Route Discovery Time
3	Total Routing Traffic Received
4	Total Routing Traffic Sent
5	Total Cached Replies Sent
6	Total Packets Dropped
7	Total Replies Sent from Destination
8	Total Route Errors Sent
9	Total Route Replies Sent
10	Total Route Requests Forwarded
11	Total Route Requests Sent
12	Radio transmitter queue size
13	Radio transmitter queuing delay
14	Radio transmitter throughput
15	Radio transmitter utilization

Table 3 Total number of instances for each attack class

Classes	Number of instances	Percentage of class occurrence, %
Normal	7575	92.60
Selfish Attacks	505	6.17
Dos Attacks	101	1.23
Total	8181	100

Table 4 Feature distributing ranking as per information gain

Ranking as per data distribution	Features	IGR
1	Total Number of Hops per Route	0.4291
2	Total Route Discovery Time	0.4291
6	Total Packets Dropped	0.4281
5	Total Cached Replies Sent	0.4281
9	Total Route Replies Sent	0.4281
7	Total Replies Sent from Destination	0.4281
8	Total Route Errors Sent	0.4281
10	Total Route Requests Forwarded	0.4281
11	Total Route Requests Sent	0.4281
3	Total Routing Traffic Received	0.1254
4	Total Routing Traffic Sent	0.1091
13	Radio transmitter queuing delay	0.0960
15	Radio transmitter utilization	0.0343
12	Radio transmitter queue size	0.0335
14	Radio transmitter throughput	0.0300

With the help of WEKA which is one of the powerful data analysis machine learning software, developed at the University of Waikato, New Zealand [15]. The information gain and correlation ratio is calculated with all the 15 features and the results are listed in the Tabs. 4 and 5.

Table 5 Feature distributing ranking as Correlation

Ranking as per data distribution	Features	CR
11	Total Route Requests Sent	0.636
10	Total Route Requests Forwarded	0.580
1	Number of Hops per Route	0.561
6	Total Packets Dropped	0.556
8	Total Route Errors Sent	0.536
2	Route Discovery Time	0.487
5	Total Cached Replies Sent	0.433
9	Total Route Replies Sent	0.417
7	Total Replies Sent from Destination	0.390
13	radio transmitter queuing delay	0.370
15	radio transmitter utilization	0.225
3	Routing Traffic Received	0.206
4	Routing Traffic Sent	0.205
12	Radio Transmitter Queue Size	0.205
14	Radio Transmitter Throughput	0.193

Base of the ranking of the information gain and correlation of collected features for our studies, the first stage of our recommended feature selection method results is summarized in Tab. 6.

Table 6 Summarized of First stage of proposed feature extraction algorithm

For Information Gain	
$IGFS_1$	{ θ }
$IGFS_2$	{ 1, 2, 6, 5, 9, 7, 8, 10, 11 }
Removed features	{ 3, 4, 13, 15, 12, 14 }
For correlation	
$CRFS_1$	{ 11, 10, 1, 6, 8 }
$CRFS_2$	{ 2, 5, 9, 7, 13 }
Removed features	{ 15, 3, 4, 12, 14 }

Table 7 Summarized of Second stage of proposed feature extraction algorithm

	Operations	Selected features
$NMRFS$	$(IGFS_1) \cup (IGCR1)$	{ 11, 10, 1, 6 , 8 }
$NRFS$	$(IGFS_2) \wedge (IGCR_2)$	{ 2, 5, 9, 7 }
R	$(NMRFS) \cup (NRFS)$	{ 11, 10, 1, 6 , 8, 2 , 5, 9 , 7}

Table 8 Reduced feature with our method

Features
Total Route Requests Sent
Total Route Requests Forwarded
Number of Hops per Route
Total Packets Dropped
Total Route Errors Sent
Route Discovery Time
Total Cached Replies Sent
Total Route Replies Sent
Total Replies Sent from Destination

The second stage of our recommended feature selection method proposed is the computation of the Union operation of $IGFS_1$ and $IGCR_1$ and the Interception operation of $IGFS_2$ and $IGCR_2$, which was store as $NMRFS$ and $NRFS$ respectively, and the best feature selection is the results of the Union operation of $NMRFS$ and $NRFS$.

The best-selected features using our proposed method are {11, 10, 1, 6, 8, 1, 5, 9, and 7}.

The importance of having a feature selection before any IDS methods can be implemented is that there are some features in the data set which can lead to the deterioration of the performance of the classifier learning method considered for anomaly detection. Therefore, any feature F is important if by removing it from the set of features affect the classifier performance. Having feature selection mechanisms in place will contribute to the predictive classifier model to be considered and helping choosing important features that will generate best accuracy and less complexity time when we acquired new data.

5 EXPERIMENTS AND RESULTS ANALYSIS

Experiment in this section used three most existing Machine Learning Classifiers such as NaiveBayes, RandomForest Decision tree and J48. The experiment has two phases: the first phase is the results of the performance using all 15 features applied to the Three ML classifiers. In the second phase, the evaluation is done with the 9 extracted features with all the three ML Classifiers. To measure the performance of the three ML classifiers, precision, recall, and F1 score evaluation measures were used, because they are the most use measurement for performance evaluation in anomaly detection detection techniques. Precision is the percentage of relevant instances found among the retrieved instances. The proportion of important retrieved instances in the total number of important instances is referred to as recall. The harmonic mean of precision and recall is used to calculate the F1 score. These three performance evaluation metrics depend entirely on the confusion matrix in which four possible situations can be defined, as shown in Tab. 9.

The experiment shows that 100% accuracy results is achieved with only all the 9 features extracted with our own algorithm with the data set created by using RandomForest classifier. However, we also have a higher accuracy for normal node and as well as DOS attack in case of NaiveBayes and higher accuracy for DoS Attack for J48 classifier.

Table 9 Evaluation metrics parameters

Measure	Explanation
True positive (TP)	Correctly classified instances as an anomaly
True negative (TN)	Instances that were accurately labelled as normal
False negative (FN)	Instances that were incorrectly classed as normal
False positive (FP)	Instances Anomaly incorrectly classified
Precision	$TP / (TP + FP)$
Recall	$TP \times (TP + FN)$
F1 score	2 ×precision × recall / precision + recall

Table 10 Phase 1: Results for all features (15)

| Classifiers	Accuracy, %	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area
NaiveBayes	99.99	1	0.002	1	1	1	0.999
RandomForest	100	1	0	1	1	1	1
J48	99.99	1	0.002	1	1	1	0.999

Table 11 Phase 2: Results for selected feature extracted (9)

Classifiers	Accuracy, %	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area
NaiveBayes	99.99	1	0.002	1	1	1	0.999
RandomForest	100	1	0	1	1	1	1
J48	99.97	1	0.002	1	1	1	1

Table 12 Accuracy detection for each individual class of attack

Classifiers	Classes	Phase 1, %	Phase 2, %
NaiveBayes	Normal	100	100
	Selfish Attack	99.80	99.80
	Dos Attack	100	100
RandomForest	Normal	100	100
	Selfish Attack	100	100
	Dos Attack	100	100
J48	Normal	100	99.98
	Selfish Attack	99.8	99.88
	Dos Attack	100	100

To sum up our feature selection technique performed well with RandomForest classifier.
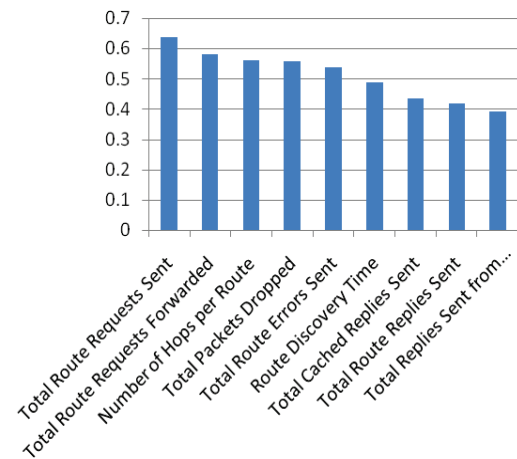
Figure 2 Selected features of dataset generated

Table 13 Comparisons of various feature selection and reduction techniques used in literature with their advantages and drawbacks with proposed feature selections proposed

Papers	Feature selection algorithms used	Types of feature selection categories	Advantages	Drawbacks
Akashdeep, IshfaqManzoor, Neeraj Kumar (2017)	Two algorithms were used: Information Gain and Correlation	Filter Method	The proposed approach detects 98.79 % of probing attacks	Performance for Normal class is low
Mukammala and Sung (2003)	SVM and neural networks were used to classify features.	Wrapper Method	After SVM was compared to neural networks, it was discovered that SVM has higher scalability, but that SVM may be utilized on huge datasets.	SVM can only perform binary classifications, and neural networks required more training time than SVM.
Ahmed Mahfouz, Abdullah Abuhussein, Deepak Venugopal, Sajjan Shiva (2020)	Applied the InfoGainAttributeEval algorithm with Ranker	Filter Method	The precision and recall rates is High, improvement of detection accuracy and improvement of TPR	Decreasing of FPR
Fleuret (2004)	A mutual information-based feature selection method is proposed.	Filter Method	Attain a high level of categorization efficacy.	For all classes, the results were insufficient.
Uguz (2011)	Two-stage feature extraction and selection algorithm has been proposed: Principal Component Analysis and Information Gain	Hybrid Method	Better performance with with naïve bayes than SVM	The focus is more on processing time.
Xiao et al. (2009)	Mutual information was used to eliminate redundant features.	Filter Method	Increased processing speed and accuracy	Just with DoS and Probing attacks only the Experiments showed good results
Karimi et al. (2013)	Information gain and symmetrical uncertainty are used to combine two feature sets.	Hybrid Method	Improvement in Detection rate	The precision of detection in U2R and R2L needs to be increased.
Al-Jarrah et al. (2014)	Random Forest-Forward Selection Ranking (RF-FSR) and Random Forest-Backward Elimination Ranking (RF-BER) are two new rankings that have been proposed (RF-BER)	Wrapper Method	0.01 % increase in detection rate and 0.01% decrease in false alarm.	Only Accurate format was used to generate the results.
Proposed Method	Combination of Information Gain and Correlation	Filter Method	100% accurate detection for Normal node, Selfish attack and Dos Attack With RandomForest algorithm	Not 100% accuracy for all Classifications algorithms used improvement need to be done

6 CONCLUSION AND FUTURE WORK

In this paper, we have presented a novel feature extraction technique to overcome the difficulties encounter during features selection techniques for networks intrusion detection techniques. The dataset generated for our study is completely labeled and 15 network traffic features have been extracted for intrusive flows detection. The feature selection technique proposed has extracted 9 important features. The selected features extracted has been use to compared the

performance of threemost well-known ML classifiers and the experiment shows that the higher accuracy results could be achieved by using RandomForest classifier. Our future work will be the use of Ensemble method for classification to improve the accuracy of detection rate. An Ensemble combines various ML classifiers (Base classifiers) for learning purpose and each base classifier is assigned a unique vote. Based on the votes of the base classifiers, the ensemble returns the prediction class for learning purposes.

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Influence of the Polymer Plate Thickness on the Plate Distortion Factor in Flexography

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Abstract: Flexographic printing plate is used for the transfer of image onto a printing substrate. The surface of printing plate is stretched lengthwise when the plate is mounted on plate cylinder. As a result, the print length on the impression is always longer than the actual length of the plate. Prepress must compensate for this difference in length. The result of wrong plate distortion is different print length in flexography compared to the processes that follow printing. The aim of this paper is to research the influence of repeat length in printing and polymer plate thickness on the factor distortion. The distortion factor values were calculated using the derived formulas. Regardless of the repeat length in printing, the value of the thickness factor for a particular printing plate is constant. However, the values of the distortion factor decrease with the increasing thickness of the polymer plate and the decreasing of the total plate cylinder circumference.

Keywords: factor distortion; flexography; polymer plate; print diameter; repeat length

1 INTRODUCTION

Flexographic printing has an advantage over other printing techniques, which can use a wider range of inks [1], and due to elastic printing plates, it is good for printing on various absorbent and non-absorbent printing substrates such as plastic foils and films, cardboard and paper, and other materials used in the production of packaging [2]. The quality of reproduction in flexographic printing is conditioned by a combination of different parameters related to the platemaking technology and type of polymer plates [3], specification of anilox rollers and pressure strength in printing [4] as well as characteristics of printing substrate [5]. The lightest pressure or "kiss impression" is ideal for printing [6]. Kiss impression is a clean print image created while applying the lowest value of pressure possible with the plate against the paper [7]. The gap value or the nip engagement between the plate and impression cylinder for lightest printing pressure is 3 thousand of an inch or 75 microns (0,0762 mm) [8]. It is not very often easy to print with the lightest pressure, primarily due to the characteristics of the printing substrate's surface, the uneven height of the printing elements or the type of work that is being printed. On the other hand, if the pressure is too high, the halftone dots will be more compressed leading to ink spreading and accumulation at the edges [9]. The entire process of flexography consists of a large number of influential parameters [10] that need to be standardized in accordance with the ISO 12647-6 standard [11].

Polymer plates are popular for products that do not require continuous printing on web materials, as plate gap appears at the joint of the plate when placed on the cylinder. Wrapping in elastic and relatively soft plate around the hard plate cylinder causes distortion in printing [12]. If this deformation is not predicted or calculated exactly, or if it is not applied to the original image, then the image in print will stretch and distort along the circumference of the cylinder, i.e. in the direction of the web movement. The text and images will appear elongated on the print. The elements printed in such manner will be misregistered with the other stages of the production process following the printing. It can

also happen that the plate cannot be completely mounted on the plate cylinder at all because it is too long.

To prevent this, such distortion needs to be anticipated and taken into account when doing the graphic preparation. The image on the polymer plate will not be in good ratio until it is placed on the plate cylinder. The process of calculating the distortion factor of a flexographic printing plate requires specific knowledge and data on the repeat length in print, basic circumference or number of plate cylinder gear teeth, plate thickness and sticky back thickness.

It is also important to know the technical characteristics of the printing press, and particularly the cylinder specification. The outer diameter of the plate cylinder includes the diameter of the cylinder, the thickness of the mounting tape and the polymer plate. The relationship between the plate and impression cylinder in combination with the printing substrate will determine if the printing is done in correct position. Otherwise, unless the surface of the plate is synchronous with the printing substrate, slurring occurs during the printing process [13]. Most parameters are determined by the configuration of the printing press, and the only parameter that needs to be controlled is the outside diameter of the plate cylinder, also called the print diameter.
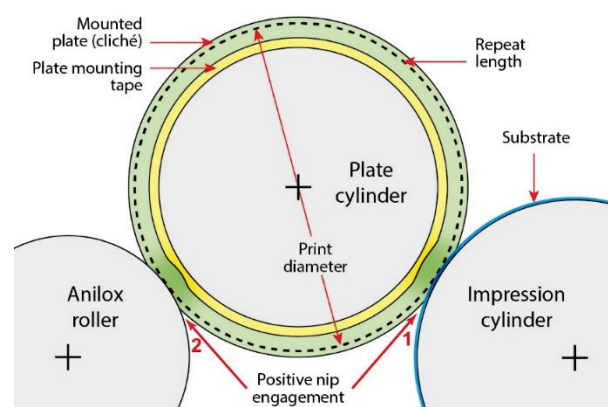

Figure 1 Positive engagement between the printing plate and the printing substrate

Although flexographic printing is called "kiss printing", minimal compression must exist in printing in order for

impression to occur (Fig. 1). Therefore, there is an interaction between the circumference of the outer surface of the plate towards the circumference of the anilox roller and the printing substrate. If this compression is too high (nip engagement > 150 μm), the surface of the plate will be outside the print diameter, so a slurring effect will occur at the places of contact between the plate and the printing substrate due to faster circumferential speed of the plate surface [14]. Otherwise, if the compression is too low (nip engagement < 20 μm) slurring also occurs due to lower circumferential speed of the plate surface [15].

Faulty printing process settings will affect the appearance of slurring, the accuracy of the repeat length, the print register in the direction of the web, the adjustment with the finishing stages (hot-stamping, die-cutting, screen-printing, numbering, printing of variable data), ink accumulation and tone value increase [16]. The inconsistency of the repeat length with the processes that follow after printing causes an error in the register between individual phases of operation. Print misregistration is constantly repeated and is visible within the printing format.

2 POLYMER PLATE DISTORTION

Nowadays, most polymeric plates are made of solid polymer, in sheeted form [17]. Single-layer photopolymer plates intended for CtP (Computer to Plate) production processes are mainly used [18]. The plate consists of LAMS (Laser Ablative Mask System) layer for laser processing, a photopolymer layer and a polyester backing that forms the basis of the printing plate and is dimensionally stable [19]. The polymer plate is placed on the plate cylinder using double-sided adhesive mounting tape.

The finished polymer plate transfers an identical but inverted copy of the image onto the printing substrate. However, if taken into account that the plate is wrapped around the plate cylinder, this image will not have the same length (Fig. 2).
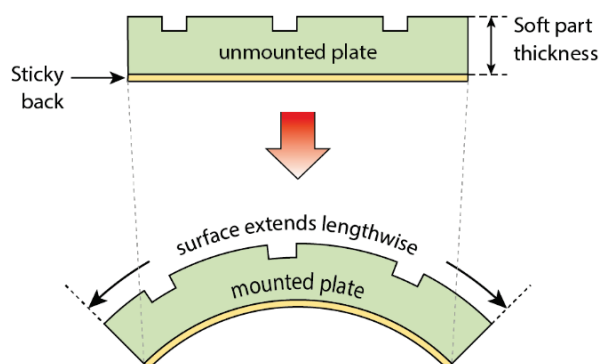

Figure 2 Distortion of the polymer plate when mounted on the plate cylinder

When mounted on the cylinder, the soft parts of the plate are extended in the direction of wrapping and an elongated image is obtained in the printing process. This effect is called distortion [20] and is shown in Fig. 3. The difference between the image on the polymer plate and the impression is predictable. It depends on the diameter of the plate cylinder

and the thickness of the polymer plate. The amount of distortion, or distortion factor, is defined in percentages. The correct distortion factor is applied in packaging prepress on imposition file, only for horizontal size of document, which represents the circumference of the plate cylinder. Therefore, the finished polymer plate is shorter in relation to the original image size. However, the print will be done in the real ratio. In this way, the elongation of the impression is already compensated when making the polymer plate.
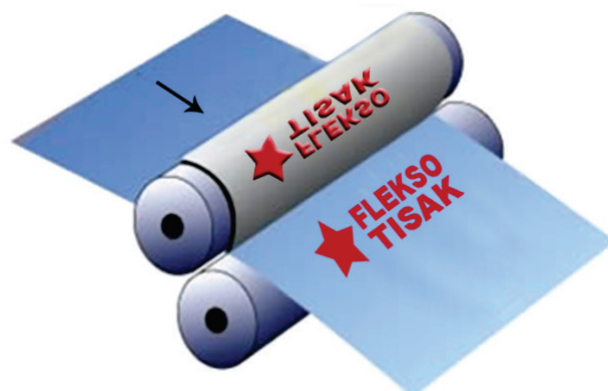

Figure 3 Display of "distortion effect" on the impression

The compensation of extending the polymer plates is usually done in prepress, before or during the screening phase. During the process of screening, scaling or distortion factor is applied. Therefore, any change in the polymer thickness, due to possible change in the printing press, requires re-screening. However, there are software solutions that allow the application of a distortion factor to a 1-bit data file created after screening, without affecting the middle tones. For plate making, this means that there is no need to create a new data file. Screening corrections are made to the existing one. The mounting tape is not a factor affecting the distortion of the polymer plate since it is used to place the polymer plate on a steel cylinder.

In order to calculate the distortion factor, it is necessary to know all the variables that affect the distortion of the image, i.e. the elongation of the impression, and these are the repeat length, print diameter and the thickness of the polymer plate and its backing [21].

Packaging converters typically have sets of plate cylinders for only ten most common repeat lengths. It is not uncommon for a customer to request a repeat length that is not available to them. There are three options in such cases: hope that the customer will accept a different repeat length, buy cylinders and gears for the required repeat length, or refuse a particular printing job. Very often, the customer simply cannot accept any compromise due to the precise packaging specifications.

Print diameter is the diameter of the plate cylinder together with the thickness of the polymer plate and the thickness of the adhesive mounting tape. The thickness of the adhesive mounting tape for narrow flexographic printing presses can be 0,25; 0,38 or 0,51 mm, depending on the configuration of the plate cylinder. It is through the interaction of plate cylinder rim (which is defined by the print

diameter) and the impression cylinder, and by applying a light "kiss" pressure in the printing process that the ink is transferred to the printing substrate.
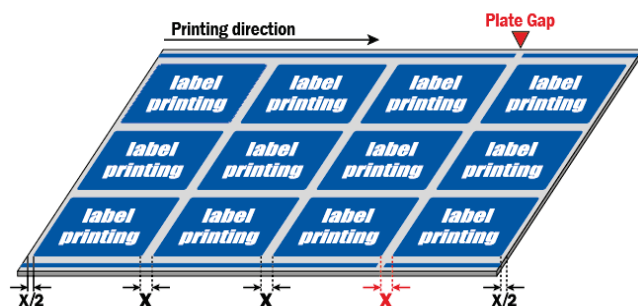

Figure 4 Placement of multiple labels by plate cylinder circumference and adjustment to the repeat length

The total thickness of the polymer plate consists of a soft polymer part and a hard polyester part. The hard polymer plate part is also called polyester adhesive or sticky back or mylar [22]. Polymer plates are usually available in thicknesses of 0,76 - 6,35 mm. The chosen plate thickness depends on the configuration of the printing press, the roll width, the print length, and the type of graphic product. The thickness of the polymer plate backing is usually 0,178 or 0,127 mm, and should not be thicker than half of the total plate thickness. Thin polymer plates, 0,76 - 3,94 mm thick, are reserved for narrow flexographic printing presses with the web width of up to 60 cm.

The K-factor (the name is derived from the word thic**K**), also known as the thickness factor, is directly related to the thickness of the soft polymer plate part. For a certain plate thickness and that of its backing, the K-factor is constant (e,g. for plate thickness of 1,7 mm and polyester backing thickness of 0,127 mm). Therefore, it is also called a distortion constant or a Plate Thickness Constant.

3 THEORETICAL APPROACH TO DETERMINING DISTORTION FACTOR

The aim of this paper is to theoretically determine the distortion factor depending on the repeat length and base thickness of the polymer plate in five most common thicknesses of polymer plates in narrow flexographic printing presses: 1,14; 1,70; 2,54; 2,84 and 3,94 mm. Two basic thicknesses of polyester backing used in the production of polymer plates in form of sheets are defined: 0,127 mm (0,005") and 0,178 mm (0,007"). Furthermore, five most common plate cylinder circumferences used in printing on narrow flexographic printing presses were selected: 127; 190,5; 254; 317,5 and 381 mm. These are actually repetitive lengths of printouts on web of paper, which are formed by one turn of the plate cylinder. By combining the selected values of the mentioned variables, the values of the distortion factor values in percentages are obtained, which can be in turn applied in scaling methods during graphic preparation.

The procedure of calculating the distortion factor can be represented by two strategies accompanied by the display of geometric models on the basis of which these formulas were created. The first strategy is based on the diameter values of the plate cylinder and the polymer plate thickness, while the second is based on the thickness of the soft polymer plate part. Both procedures will be explained in detail and presented using mathematical formulas.

3.1 Method 1: Calculation of distortion factor based on cylinder diameter and plate thickness

The applicability of this strategy is related to the fact that the total thickness of the polymer plate consists of a hard polyester backing and a soft polymer. By mounting or placing the polymer plate on the plate cylinder, the soft part of the polymer plate is stretched, which does not include the hard polyester backing. The soft part of the polymer plate participates 2 times in the total print diameter, both times at the ends of the diameter length. This makes the basis for obtaining the formula used for calculating the distortion factor. All the necessary elements for deriving the formula are shown in Fig. 5.
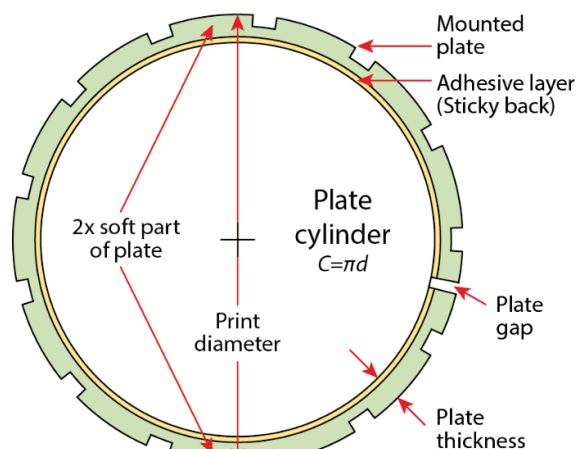

Figure 5 Cross section of a flexographic plate cylinder showing the variables involved in distortion

The distortion factor is the ratio of the print diameter reduced by double thickness of the "soft" polymer plate part (without the hard back thickness) and the total print diameter, and can be presented using the following formula:

$$distortion\ factor = \frac{print\ diameter - 2 \times soft\ thickness}{print\ diameter} \quad (1)$$

Print diameter can be obtained using the formula for circle circumference $C = \pi d$ as follows:

$$print\ diameter = \frac{C}{\pi} \quad (2)$$

The thickness (*THK*) of the soft polymer plate part is obtained based on the total thickness of the polymer plate and the thickness of the polyester backing:

$$soft\ THK = total\ plate\ THK - sticky\ back\ THK \quad (3)$$

For example, for printing process in which a plate cylinder with a repeat length of 381 mm and a polymer plate

of 1,7 mm thickness with 0,127 mm thick backing are used, the calculation of the distortion factor based on formulas (1), (2) and (3) is as following:

$$print\ diameter = \frac{381}{\pi} = 121,276\ mm$$

$$soft\ THK = 1,7 - 0,127 = 1,573\ mm$$

$$distortion\ factor = \frac{121,276 - 2 \times 1,573}{121,276} = 0,9741 = 97,41\ \%$$

3.2 Method 2: Calculation of distortion factor using plate thickness factor

Plate thickness factor or K-factor is a constant that is related to the thickness of the polymer plate, more precisely to the thickness of the soft polymer plate part.
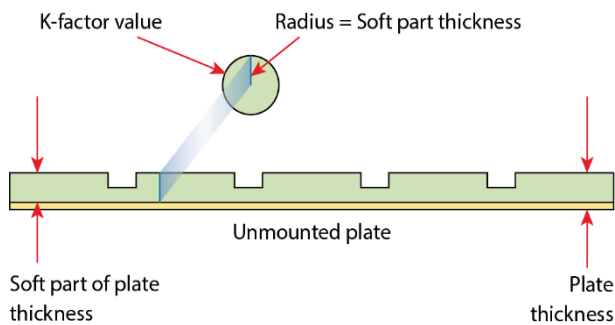
Figure 6 Schematic display of the polymer plate thickness factor derivation

This is actually the value of the circle circumference $C = 2\pi r$ where the value of the thickness of the soft polymer plate part is used for radius (Fig. 6). Accordingly, the K-factor is calculated using the formula:

$$K\_factor = 2\pi(total\ plate\ THK - sticky\ back\ THK)\ (4)$$

The repeat length is usually specified for each work printed. If the repeat length is unknown, it can be determined by measuring on the printed web. It can also be calculated based on the formula for circle circumference $C = 2\pi r$, where r it shows the total print radius including the radius of the plate cylinder and the thickness of the polymer plate together with the polyester backing:

$$printing\ repeat = 2\pi(cylinder\ radius - total\ plate\ THK)\ (5)$$

The distortion factor is the ratio of the repeat length in print minus the K-factor and total repeat length. Accordingly, the final formula for calculating the distortion factor based on plate thickness and repeat length factors in print is:

$$distortion\ factor = \frac{printing\ repeat - K\_factor}{printing\ repeat} \quad or \quad (6)$$

$$distortion\ factor = 1 - \frac{K\_factor}{printing\ repeat} \quad (7)$$

Calculation of distortion factor according to the data from the given example of printing process based on formulas (4), (5) and (6) is as following:

$$K\_factor = 2 \times 3,14 \times (1,7 - 0,127) = 9,883$$

$$distortion\ factor = \frac{381 - 9,888}{381} = 0,9741 = 97,41\%$$

It can be seen that both methods of distortion factor calculation had a completely identical result, which proves the credibility of the presented procedures.

4 RESULTS AND DISCUSSION

The final formulas (1) and (6) from both described methods were used for the calculation with the aim of determining the distortion factor for five most common thicknesses of polymer printing plates in narrow web flexo printing presses. The calculation also used five values of the total plate cylinder circumference (or print repeat length) according to the number of gear teeth, in a step consisting of 20 teeth (Tab. 1).

Table 1 Circumferences of the plate cylinder in relation to the number of gear teeth used for calculating the distortion factor

Number of gear teeth	Total cylinder circumference (mm)
40	127
60	190,5
80	254
100	317,5
120	381

The results obtained by applying both formulas are completely identical, which confirms the credibility of the results and the applicability of the described methods. The results of calculating the distortion factor in percentages for the two thicknesses of the polyester backing are shown in Tab. 2 and Tab. 3.

Table 2 The distortion factor (%) for all combinations of repeat length and plate thickness for 0,127 mm polyester backing

Sticky back 0,127 mm	Plate thickness (mm)				
	1,14	1,70	2,54	2,84	3,94
127	94,99	92,21	88,06	86,55	81,14
190,5	96,66	94,8	92,04	91,03	87,43
254	97,49	96,1	94,03	93,27	90,57
317,5	97,99	96,88	95,22	94,62	92,46
381	98,33	97,4	96,02	95,52	93,71

Repeat length (mm)

Table 3 The distortion factor (%) for all combinations of repeat length and plate thickness for 0,178 mm polyester backing

Sticky back 0,178 mm	Plate thickness (mm)				
	1,14	1,70	2,54	2,84	3,94
127	95,22	92,47	88,31	86,83	81,39
190,5	96,82	94,98	92,21	91,22	87,59
254	97,61	96,24	94,16	93,42	90,69
317,5	98,09	96,99	95,33	94,73	92,56
381	98,41	97,49	96,1	95,61	93,79

Repeat length (mm)

Results of the calculation show that the values of the distortion factor increase with the increasing thickness of the polymer plate and decrease of the total plate cylinder

circumference. The lower the percentage value of the distortion factor, the larger the print elongation compensation. In addition, the compensation is larger with a thinner polyester backing, which is understandable because the thickness of the soft part is greater in the same total thickness of the polymer plate.
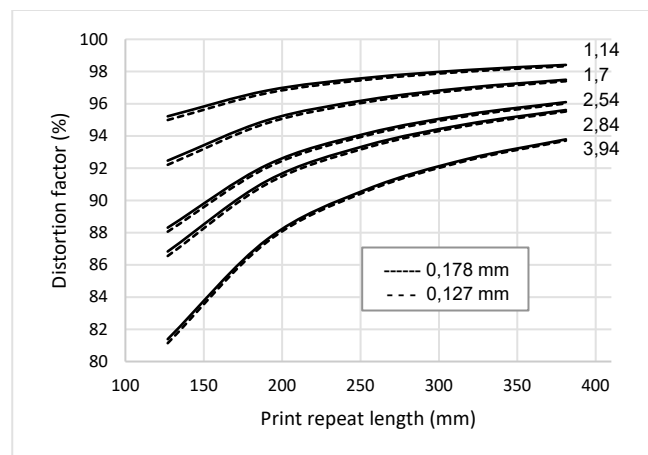

Figure 7 Dependence of distortion factor on repeat length for two polyester backing thicknesses

The difference between the results of distortion factor measurements for the two thicknesses of the polyester backing is an identical value for individual circumferences of the plate cylinder, regardless of the polymer plate thickness (Fig. 7). So, the difference is the greatest for 127 mm repeat length and it amounts to 0,25. By increasing the repeat length, the difference between the values for the two thicknesses of the polyester backing decreases, and at 381 mm it amounts to 0,08. However, this difference is not negligible because any deviation from the correct distortion factor value will not give good results in printing and will create problems in the working phases that follow printing; it will also create problems in application of such graphic product to the primary packaging product.

The thickness factor of polymer plate or K-factor increases as the plate thickness increases and as the thickness of the polyester backing decreases (Tab. 4). Since the K-factor is directly related to the thickness of the soft part in the polymer plate, its change is completely logical.

Table 4 K-factor for all combinations of plate thickness and polyester backing thickness

K-factor		Plate thickness (mm)				
		1,14	1,70	2,54	2,84	3,94
Sticky back (mm)	0,127	6,3649	9,8986	15,1672	17,083	23,9481
	0,178	6,0669	9,563	14,8409	16,7258	23,6373

The repeat length in printing has no effect on the change of K-factor because it is a constant for an individual type of polymer plate, and as such is used for calculating the distortion factor. The change of K-factor in relation to the thickness of the polymer plate is linear and can be shown in form of a straight line, which can be seen in Fig. 8.
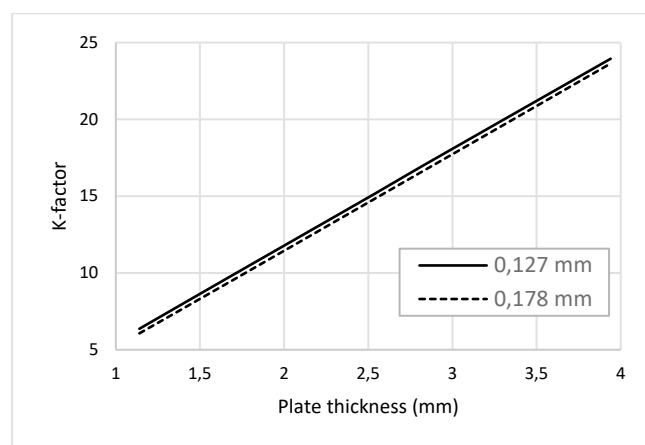

Figure 8 Dependence of K-factor on the change in the polymer plate thickness

5 CONCLUSION

This research was conducted to analyze the change in distortion factors depending on the variables that affect image distortion in printing process. When wrapping the polymer plate around the plate cylinder, the soft part of the polymer plate is stretched. This affects the elongation of the impression. This lengthening of the impression must be compensated in order to obtain the actual product size in print. The compensation procedure is performed during graphic preparation using distortion factor. The distortion factor is directly dependent on the total circumference of the plate cylinder and its print diameter as well as the thickness of the soft polymer plate part.

The calculation of the impression elongation compensation is shown using two formulas. Each formula is based on a different approach. They are both explained in detail based on the geometric models presented. Both formulas primarily take into account the thickness of the soft polymer plate part. The obtained results are identical, which confirms the applicability of the described methods.

Five most common thicknesses of polymer plates and five most common sizes of the plate cylinder in narrow flexographic printing presses were used to calculate the distortion factor. Results show that the value of the distortion factor decreases with the increasing thickness of the polymer plate and the decreasing of the total plate cylinder circumference. In addition, the largest change in the distortion factor was recorded at a polymer plate thickness of 3,94 mm (12,5%) and a plate cylinder circumference of 127 mm (13,8%). The difference between the values of the distortion factor for the two polyester backing thicknesses (0,127 and 0,178 mm), at the same polymer plate thickness, does not change regardless of the plate cylinder circumference. Therefore, this difference is constant; for polymer plate thickness of 1,14 mm it amounts to 0,25, and for thickness of 3,94 mm it amounts to 0,08. Further on, regardless of the repeat length in print, the value of the thickness factor for a particular printing plate is always constant.

It can be concluded that any deviation from the correct values of the distortion factor, for a particular combination of

plate cylinder circumference and polymer plate thickness, will affect the repeat length in printing and thus cause problems in printing or in the work phases following printing.

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Developing a Location-Based Recommender System Using Collaborative Filtering Technique in the Tourism Industry

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Abstract: The rapid growth of new information and products in the virtual environment has made it time consuming to acquire relevant information and knowledge amidst a vast amount of information. Therefore, an intelligent system that can offer the most appropriate and desirable among the large amount of information and products by following the conditions and features selected by each user should be essentially efficient. Systems that perform this task are called recommendation systems. Given the volume of social network data, challenges such as short-term processing and increased accuracy of recommendations are discussed in this type of system. Hence, it can perform processes faster with less error and can be effective in improving the performance of social recommending systems in improving the classification and clustering of information with the help of collaboration filtering methods. This study first develops an innovative conceptual model of a social network-based tourism recommendation system using Flicker network data. This model is based on 9 key components. The comparison show that the proposed method has an accuracy of 0.3% and a lower error rate.

Keywords: Collaborative Filtering Algorithm; DB Scan Clustering; Haversine; Multi-Factor Systems; Recommender Systems; Similarity Criteria; Tourism

1 INTRODUCTION

The recommender system is a necessity and a popular technology that, by collecting data from activities and inclinations, gains the interest of its customer from a set of data such as movies, hardware, clothing, etc. and makes offers to various customers. Currently, huge growth of content and the number of users in the internet world is undeniable. For this reason, mechanisms were created to filter the information available on the Internet. Collaboration filtering is one of the techniques used in this regard. Collaboration filtering came from the idea that people often get the best recommendations from people with the same taste. Collaboration filtering includes techniques for matching people with similar tastes and interests and providing recommendations based on that [1]. Recommendation systems have incorporated themselves into people's daily online activities and have been used successfully in a wide range of different fields. However, there is still work to be done to achieve great success in complex fields such as tourism. One reason is that properties of items in this field are not easily measurable and depend on a large number of factors. When you plan to travel, you ask friends or tour guides about attractive places or attractions, and then select the attractions you want. Recommending systems suggest the best and most accurate location based on your taste and characteristics to have a pleasant and satisfying experience [1]. Recently, recommending systems are increasingly used in the field of e-tourism. In this field, services such as travel advice, a list of points of interest that match the user's taste, and recommendations for tourist packages, etc. are provided. Recommendation systems available in the tourism industry offer the best to the user based on tourist destination, time limit and certain budget. The user typically expresses her needs, interests, and limitations based on selected parameters. Once the user makes her selection, the system links the list of specified destinations using the same parameter vector [2].

This study tends to develop a recommendation system using the pre-filtering approach by DBScan clustering and Haversine criterion and to improve accuracy of the proposed model using asymmetric similarity criterion in collaboration filtering approach. Using demographic information, this study tends to solve the problem of cold start. A hybrid approach used to tourism recommendation system based on background information, collaboration filtering and demographic information is another measure addressed in this study.

2 LITERATURE REVIEW

Currently, web users are faced with many options when surfing the web. Hence, recommendation systems (RS) and many web personalization tools provide web users with customized items. These systems are available on many websites that cover social networks, e-commerce, e-business, e-tourism, etc. [3]. In essence, RS compares users based on an appropriate similarity criterion, which is an important rule for success of the whole system. However, different similarity criteria often lead to different sets of neighbors for a particular active user. A good similarity criterion produces a close set of neighbors for a particular active user. In fact, many of the similarity criteria for collaboration recommender systems rely on overlap between users. However, the size of this overlap is not examined in detail, and most previous work has studied similarity criteria based on a predefined number of common items [3].

There are currently four types of recommendation systems:
- Content-based recommenders
- Recommenders based on collaboration filtering
- Hybrid systems
- Knowledge-based filtering.

These examples have different input data and each suggests different algorithms. Their input mainly includes user information (demographics), item (service content, description), content (location, time, activity) and feedback.

The collaborative filtering recommender system suffers from data shortages due to its reliance on numerical rankings to provide recommendations to users. This problem also makes the exact calculation of similar neighbors difficult for the system and reduces the quality of the offers. Existing methods are not able to process the missing new item ranking and cold start forecast for active users, which ultimately leads to poor quality recommendations. Therefore, quality of the results is prevented from declining by using the double-walled clustering algorithm to cluster the rating matrix of users and items, and the missing ranks in dual clusters are estimated and filled by using the Bi-Mean algorithm [4]. Chaudhary and Anupama developed a popularity model based on review and collaborative filtering by presenting an in-depth study and analyzing different algorithms. The proposed model is a straight forward model based on popularity that ranks the goods that the user rates. This model has recently become popular and has been used by companies such as Netflix, Amazon and Facebook [5]. Jin et al. [6] developed a new method of measuring similarity that effectively uses user textual information. Their method uses a unique factor to formulate a nonlinear equation and takes into account the user rating habits. This method can improve accuracy of predictions and is tested on a set of data and compared with other algorithms. The results indicate that their method can improve quality of the recommendation. Tohidi and Dadkhah [7] proposed a mobile recommender system called BomApettite to recommend a restaurant to a group based on tastes of all members of the group. They combined restaurant information from a well-known platform. By evaluating the system, it was found that reliability of the system was increased. Advantages of the systems are the use of collaborative filtering, which is one of the most widely used methods of the recommender system, to recommend a new item to the user.

3 METHODOLOGY

This study tends to predict the best attraction according to geographical location of the target user. For this purpose, a recommender system is proposed which suggests the best location by pre-filtering approach using DBScan clustering and the Haversine criterion, as well as improving the accuracy of the proposed model using the asymmetric similarity criterion in collaborative filtering approach. Currently, there is a wide range of information on the Internet; thus, the use of recommender systems will help users to find the most suitable location according to basic needs of the user. This can be done by analyzing the user's own profiles, previous searches, preferences, comments and user interactions with other services and users.

Tourism recommender systems mainly contain information such as user profile (tourist), item (tourist destination), time, user activities on social networks and weather conditions. The information used by the recommender system can be collected through feedback, ranking, social media or implicitly through data collection programs, user browsing history and agents. According to explanations provided in the field of the proposed algorithm and how DB Scan clustering works, different steps of this algorithm is shown in Fig. 1.
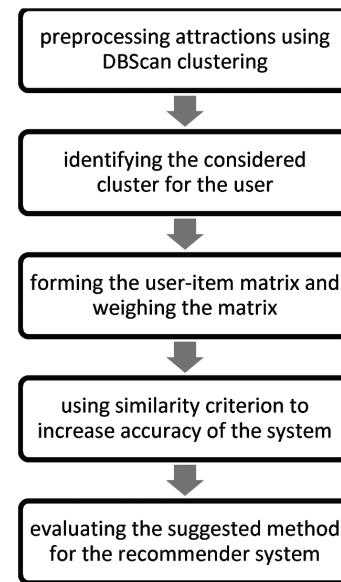

Figure 1 The suggested algorithm flowchart

User (Tourist)

There are two types of target users: domestic and foreigner. It includes individuals or groups with social and demographic information related to the tourist destination. This information is mainly used to model user ratings by date and preferences. The recommender system uses this user model to provide sufficient recommendations about the tourist destination. User information is defined by the following variables (as shown in Fig. 2):
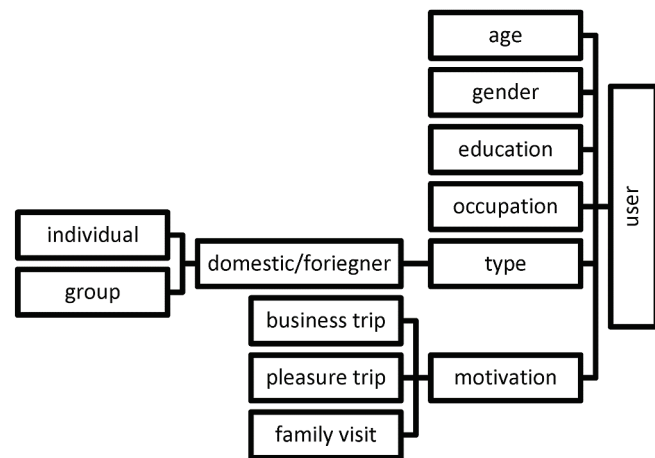

Figure 2 User variables

Item (Destination)

The location can be explicitly checked by visiting an account (such as Foursquare, Facebook) or geotags (Flickr), or implicitly, data can be collected from browsing history, agents, location-based services, location data collection programs or through a sensor in the form of mobile data from GPS, telecommunication towers, Wi-Fi, or telecom operators. Locations have many characteristics such as:

- Specific locations (user or item): any valuable information (geography, address)

- Geography may have value (continent, country, province, and city) or values such as tourist address, location, coverage and social network control.

Time

Time information is defined as calendar, day, period, and hour. Course attributes include period (morning, noon, evening, night), as well as other features such as calendar, day, and hour. This data is explicitly obtained by time tags (Facebook) or implicitly by browser history or collector program.

3.1 Inserting a Set of User Comments for Different Items in a Specific Field

At this stage, rates will be taken from the user in a specific field, such as time, geographical location, time, etc. In fact, at this stage, the user will assign a point to items from a specific field, which can indicate the importance of the item. This set of ratings will form an item matrix:

$$\boldsymbol{R}(User - Item) = \begin{bmatrix} d_{m_1 n_1} & \cdots & d_{m_1 n_n} \\ \vdots & \ddots & \vdots \\ d_{m_n n_1} & \cdots & d_{m_n n_n} \end{bmatrix} \tag{1}$$

Where, $\boldsymbol{R}$ is known as item-user matrix, m refers to the number of rows, which is the same number of users, and n refers to the number of columns, which are the same as the specific items in a particular field. $d_{i,j}$ also refers to the rate given by the ith user to the jth item.

3.2 Clustering User-Item Matrix Using the Proposed Algorithm

Once the matrix of ratings of different users in different items is formed, the users will be clustered using this matrix. It is very important in clustering algorithms to properly determine the number of clusters. In fact, the proper number of clusters will optimize the clustering algorithm process. In fact, to determine the number of clusters, we first enter the maximum number of C and then consider the maximum number of Cs from 1 to C. Suppose the data of a set is clustered by a method. For each data i, $a(i)$ is the average dissimilarity of data i to other data in the same cluster. Then we get the average of dissimilarity of data i with the data of other clusters. Of these numbers, we find the lowest number and call it $b(i)$.

To explain the algorithm, it is necessary to be familiar with the parameters ε and μ, which are explained:

- Each point in the data is apart from other points. Any point whose distance from a given point is less than ε (EPS) is considered as the neighbor of that point.
- Any assumed point (MinPoints) that has μ neighbors is a central point.

The relationship of points is divided into three categories based on their position (being central or not) in each cluster:

Connected points: A point is connected to a cluster that is first the central point, second adjacent to one of the points within the cluster.

Accessible points: A point is accessible to a cluster that is not the central point but is adjacent to one of the points within the cluster.

If the point does not have any of the above positions, noise is considered for that cluster. Moreover, if the point is noise relative to all clusters, it is placed in the noise cluster.

In the clustering algorithm, an initial population will be created. This population will be produced by Eq. (2):

$$X = Uniform\_Random\_Number\,(Lower, Upper) \tag{2}$$

Where, the *Uniform_Random_Number* function will generate a random number with a uniform distribution, X represents the population, and *Lower* and *Upper* will indicate the lower and upper limits, respectively, to generate normal random numbers.

Once the initial population is generated, as noted, the fitness function of the population will be calculated using DBScan algorithm. The distance of the target user's location from the centers of the cluster is calculated using the Haversine equation to identify the nearest cluster. The Haversine equation is used in the study of spherical geometry, especially in calculating the distance between two points distributed outside the sphere. Eq. (2) calculates the distance based on latitude and longitude. We considered points P1 and P2 as two points in space. φ_1 is latitude and λ_1 is longitude of point P1 and φ_2 is latitude and λ_2 is longitude of point P2. Radius of the earth is denoted by r. The function input is obtained from Eq. (3). Using the Haversine equation, the distance of the target user is identified based on geographical location with the center of the clusters and the nearest cluster.

$$d = 2r \cdot sin^{-1}\left(\sqrt{\begin{array}{l} haversin(\varphi_2 - \varphi_1) + \\ + cos(\varphi_1)cos(\varphi_2)haversin(\lambda_2 - \lambda_1) \end{array}}\right) \tag{3}$$

$$haversin(\theta) = sin^2\left(\frac{\theta}{2}\right) \tag{4}$$

Once the matrix of distance between the two vectors is calculated, the smallest distance will be selected as the best solution for this population. From the solutions obtained for different cases of algorithm iterations, the least distance will be selected as the best solution and the vector obtained from this least solution will be considered as the result of clustering.

3.3 Rating New Users

After clustering the users in the considered clusters, the new user rating will be estimated. To do this, it is first determined which cluster the user is in. Once the user cluster is determined, the number of k users with the highest similarity to the user will be identified, and then the new user

rating will be estimated based on average of ratings. Similarity criterion of two users will be calculated by Eq. (5).

$$D_r(a, b) = \sqrt{\sum_{i=1}^{r} (a_i - b_i)^2} \qquad (5)$$

Where, variables a_i and b_i refer to similar properties for two users, d indicates the dimension space of the problem, and r refers to the number of dimensions involved in calculating similarity.

3.4 Recommending Item to New User

Once the new user is placed in the considered cluster and the neighbors with high similarity to this user are found, first items of users with high similarity to the new user are sorted in descending order based on their rate and a new item is suggested to users. Then, based on the number of items recommended to the user, it is recommended to the new user from the beginning of the set of items. The similarity criterion is used to introduce users with high similarity through the Pearson criterion. Pearson correlation coefficient for two numerical variables is in the range of 1 to −1, 1 means complete agreement and −1 indicates complete disagreement. If the users are x and the new user is y, the Pearson criterion is defined as:

$$r = \sum_{i=0}^{n} (x_i - x)(- y) \Big/ \sqrt{\sum (x_i - x)} \sqrt{\sum (y_i - y)} \qquad (6)$$

4 RESULTS
4.1 Computer Specifications

Implementations of this study were done with a computer with following specifications: 3.8 GHz processor, 8 GB internal memory and Windows 7 operating system. To run the proposed algorithm, the programming language and MATLAB version 2018b were used. The Flickr website dataset was also used for the case study.

4.2 Dataset Descriptions

All tourist destinations in the UK in images of 10 thousand Flickr database, including 914 points from 24 different cities, were grouped in 7 clusters. The value of ε, which represents the radius of the neighborhood, was 999 meters, and value of the MinPts parameter was 30. The dataset contained 943 users who visited and rated at least one of the 914 points. In fact, considering the rates given to the locations by different users, an R matrix consisting of n users and m locations is formed that each cell of this matrix is the rate of the image given to it by the user. In fact, this matrix is formed using the rates that users gave to different places on the Flickr tourism social network.

4.3 Implementing the Proposed Algorithm

We must first run the proposed algorithm on the Flickr dataset and evaluate the results. Tab. 1 shows the input values for the proposed algorithm:

Table 1 Input values of the proposed algorithm

Parameter	Value
Number of clusters	7
Number of users	943
Number of locations	914
Neighborhood radius	999
Number of recommendations	20
Number of iterations	100
Population size	10

In fact, the data set is initially divided into 7 clusters. The number of users in this data set is 943 and the number of locations is 914. When a new user logs in and is categorized, the closest similarity for this new user is determined using the Haversine similarity criterion. The number of recommendations to the new user logged in is 20. The population size in the classification algorithm is equal to 10 and the number of iterations of this algorithm is equal to 100.

4.4 Evaluating the Proposed Algorithm

The following parameters are used to evaluate the proposed algorithm:

Mean Absolute Error (MAE): The mean of the measured error is equal to the rate that the system predicts that the user will give to the item minus the actual rate that the user has given to the item and is shown as Eq. (7).

$$MAE = \frac{\sum_{i=1}^{n} \left| value_{actual} - value_{predicted} \right|}{n} \qquad (7)$$

where, $value_{actual}$ shows the actual value of the user's rating for the item and $value_{predicted}$ represents the value suggested by the recommender system.

Accuracy: The number of favorable predictions divided by total predictions that will be calculated as Eq. (8).

$$Accuracy = 1 - \left[\frac{\sum_{i=1}^{n} \left| value_{actual} - value_{predicted} \right|}{n} \right] \qquad (8)$$

First, the mean error of the recommendations made by the proposed recommender system was calculated and then this error value was subtracted from one and accuracy was calculated.

Root Mean Square Error (RMSE): In Eq. (9), $R_{u,i}$, the value of r indicates whether item i has been rated by user u in the available data. The lower the *RMSE* value, the higher the accuracy of the recommender system results.

$$RMSE = \sqrt{\frac{\sum_{(u,i)|R_{u,i}}(\hat{r}_{u,i} - r_{u,i})^2}{N}} \qquad (9)$$

***Coverage* percentage**: Another evaluation criterion of the recommender system is "coverage percentage", the value of which represents the percentage of <item, user> pairs in the evaluated data for which the recommender system can predict a rating to total number of <item, user> pairs in the dataset evaluated.

$$Caverage = $$
$$= \frac{number\ of\ (u,i)\ pairs\ with\ solution}{total\ number\ of\ (u,i)\ pairs\ existing\ in\ the\ evaluated\ set} * 100 \qquad (10)$$

Precision: This criterion has values in the range [0, 1] and indicates the degree of error. A value of zero indicates an absolute error and a value of one indicates the absence of an error. Assuming that the output of the recommender system is an integer in the range [1, 5], the value of precision can be defined in the form of Eq. (11).

$$Precision = 1 - \frac{RMSE}{4} \qquad (11)$$

The number 4 in denominator of the fraction indicates maximum amount of error (4 = 5 − 1).

F-Measure: *F-Measure* is calculated to combine the coverage percentage and *RMSE* in the form of a criterion. To do this, *RMSE* must be converted to precision introduced above and displayed as a number in the range [0, 1]. Therefore, *F-Measure* equation is defined as Eq. (12):

$$F\text{-}Measure = \frac{2 * Coverage * Precision}{Coverage + Precision} \qquad (12)$$

4.5 Output Results

Once the classification program, the specifications of which are given in Tab. 2, is run, the classification operation is performed and the value of Best for each iteration of this algorithm is obtained as follows:

According to Fig. 3, the value of Best is shown in each iteration. In fact, this value indicates the within-class distance that decreases with each iteration, which will have optimal results for the proposed algorithm. The Mean vector also represents the median distances within the classes in each iteration of the proposed algorithm. Once the proposed algorithm is run, we need to calculate fit indices such as *Precision*, *Error*, *MAE*, and *RMSE* and evaluate the results. Tab. 2 evaluates the results.

Table 2 Output results from running the program

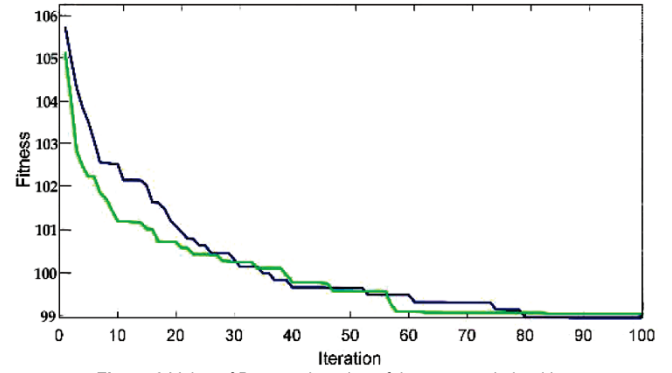| Parameter	Value
Precision	0.93414
Error	0.30512
MAE	1.1754
RMSE	1.5685

Figure 3 Value of Best per iteration of the proposed algorithm

To further explain the program outputs, assume the test data set in batches of 50, the results will be specified in the form of diagrams shown in Fig. 4.
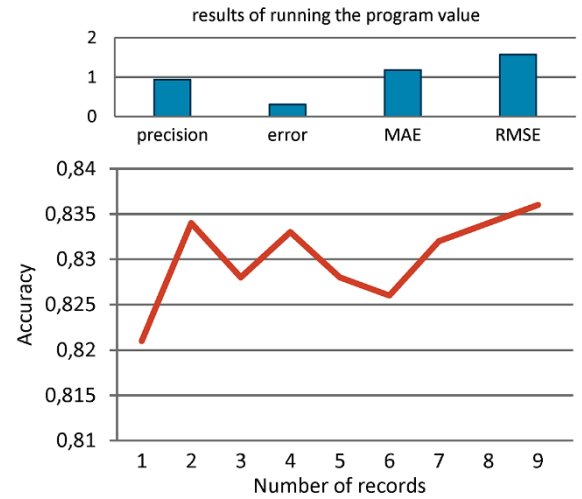

Figure 4 Diagram of precision for different number of test records

As shown in Fig. 4, precision ascends from the batch 6 and increases. In batches 1 and 3, the accuracy of recommendations to the user increases, and in batches 2, 4 and 5, this precision decreases. The reason for this decrease and increase can be attributed to similar neighbors to the new user, as well as location that these neighbors visited and suggested to the new user. Note that the horizontal axis shows the number of records in batches of 50.
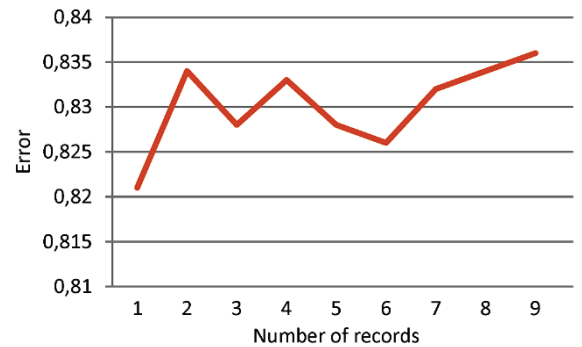

Figure 5 MAE for different number of records of the test dataset

As shown in Fig. 5, MAE of the proposed program is first increased and then decreased with the increase in the number of test data set records. This means that the location recommended to users in the first batches has an increasing error rate, and then the locations recommended to users in the last batches are more correct, which reduces the error. Fig. 6 properly shows RMSE.
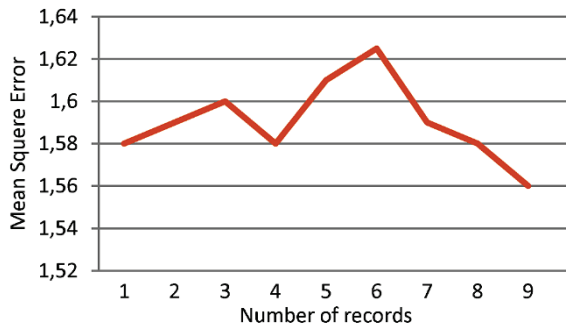

Figure 6 RMSE for different number of records of the test dataset

As shown in Fig. 6, RMSE first increases and then decreases as the number of test dataset records increases. The reason for this is that the locations recommended to the users in the first batches have a higher error rate and the locations recommended to the users in the last batches have a lower error rate.

Table 3 Results of running the proposed algorithm and other methods

Algorithm Parameter	Number of neighbours	DBCACF	Proposed
MAE (Neighbour)	10	0.71	0.716
	20	0.6402	0.6413
	30	0.7331	0.7352
	40	0.7544	0.7422
	50	0.7636	0.7683
	60	0.7836	0.7758
	70	0.7973	0.7945
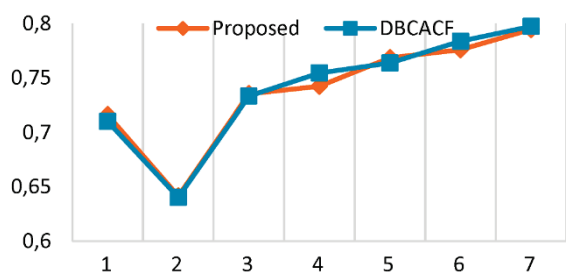
Figure 7 Results of running the proposed algorithm and the other method

Once the proposed algorithm is run on the dataset and the results are reviewed, in this step we must compare and analyze the results of running the proposed algorithm with the algorithm. Note that DBCACF algorithm is run on the dataset and the results are measured. Tab. 3 shows the results properly.

As shown in Tab. 3 and Fig. 7, MAE of the proposed method for different number of neighbors is less than the method presented in Tab. 3 and thus it is more optimal.

Tab. 4 and Fig. 8 compare RMSE of the proposed method and other methods, and shows that RMSE of the

proposed method is less than the method in Tab. 4 and is more optimal.

Table 4 Comparison of RMSE

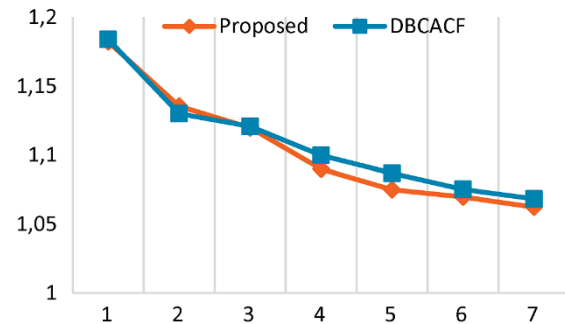| Algorithm parameter	Number of neighbours	DBCACF	Proposed
RMSE (Neighbour)	10	1.1839	1.1822
	20	1.13	1.1354
	30	1.1207	1.1197
	40	1.0998	1.0899
	50	1.0868	1.0749
	60	1.0752	1.0697
	70	1.0683	1.0623

Figure 8 comparison of RMSE

As shown in Tab. 5 and Fig. 9, precision of the proposed method for different number of neighbors is slightly higher and more optimal than the compared method.

Table 5 Comparison of precision for the proposed methods

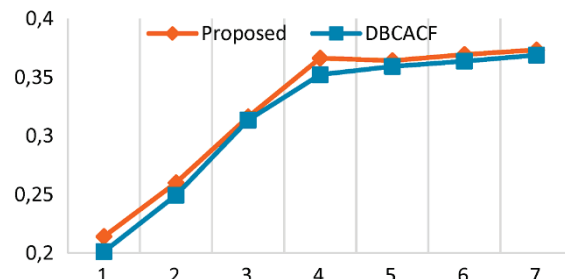| Algorithm parameter	Number of neighbours	DBCACF	Proposed
Precision (Neighbour)	10	0.2012	0.2141
	20	0.24945	0.2601
	30	0.31355	0.31628
	40	0.35235	0.3664
	50	0.35935	0.36425
	60	0.36378	0.36949
	70	0.36895	0.37345

Figure 9 Comparison of precision for different methods

5 CONCLUSION

This study tended to develop and implement a tourism recommender system in a completely dynamic and flexible manner. Because of that, it receives the interests and priorities of each tourism very personally, fix the cold start problem seen in these tourism systems by properly assessing the behavior of new users, and perform tourism planning according to the information obtained from each person. In

addition to its ability to recommend places of interest to users, this system allows tourists to manage their time and personal planning. One of the main goals of this study is to solve the problem of cold start of new users, of whom there is little information in the system. Collaborative filtering algorithm is run by forming a database of priorities of users for goods and services. This technology has been very successful in both research and implementation, as well as in information filtering applications. However, important research questions remain in the face of two fundamental challenges of collaborative filtering systems. As explained, user dataset and its items were first clustered by clustering with DBScan algorithm. Next, the degree of similarity of the appropriate items for the new user was determined using the Haversine similarity criterion. Depending on which class the new user is in, new items are recommended to the new user based on k users who are similar to that new user and which items are rated higher. The results of running the proposed algorithm and its comparison with other methods show that the proposed method outperforms in terms of defined fitness indices.

Given the proposed algorithm, advantages, and disadvantages of these methods, implications for future studies include:

- Using new interactive algorithms such as Gray Wolf, Dragonfly algorithms to increase clustering accuracy and running speed
- Using a neural network to respond faster to a new user in order to check the rates of previous users and analyze them for replacement with K nearest neighbor algorithm.

Using other methods for measuring similarity matrices to increase accuracy of recommender systems to determine similarity of new user to existing users in classes in order to increase accuracy of measurements in the considered class and consequently increase accuracy of recommendations to the new user

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Importance of Labelling Biodynamic Product Packaging in Croatia

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Abstract: A lot of research has been conducted on economic and consumer aspects of ecological food products. However, we are witnessing the appearance of food products produced according to the principles of biodynamic growth which can be seen as a higher standard in ecological production process. Similar to ecological cultivation the biodynamic one also has proscribed methods and processes of production, processing, distribution and labelling as well as control and certification processes. However, such products are still not being recognized be the consumers in Croatia. This paper provides, based on authentic empirical research, some basic background information on the importance of labelling packages of food products as well as their quality and traceability. These also present the first results of research on the importance of labelling biodynamic products packages in Croatia.

Keywords: biodynamic agriculture; biodynamic products; Demeter; organic farming; package labelling

1 INTRODUCTION

Awareness of people about the importance of sustainable and circular management, both in terms of environmental conservation, and in the direction of organic farming, together with the preservation of health and healthy life, has led to the creation of horizontal and vertical global eco-policies. Modern industry, to higher and lesser extent, has been continuously polluting the environment. All industrial branches, including food and packaging production, are beginning to recognize the importance of preserving the nature and natural resources. Therefore, they are increasingly trying to return to production that is environmentally friendly and sustainable [1-3], and follows the guidelines circular economy [4-6].

This concept includes the consumption of organically produced food that is packaged in environmentally friendly and recognizable packaging. The sale of organic food, i.e. food that has an eco/bio-label, is constantly increasing worldwide [7-9]. In last decades the world has been facing various social, political, economic and environmental challenges that are changing the classic dynamics of consumption towards sustainable practices, mainly in the field of food consumption (which includes environmentally friendly packaging). The mentioned values and trends are strongly linked and contribute to creation of an ecosystem in which sustainable processes can be promoted, especially in food production and packaging [10, 11]. The number of producers and consumers of organic and biodynamic food products is growing rapidly [12], despite the conflicting scientific opinions on the benefits of biodynamic food products [13]. Data on the share of organic agriculture in the world was presented in February 2021 by the Research Institute of Organic Agriculture (FiBL) and the International Federation of Organic Agriculture Movements IFOAM. According to the latest official data, 2019 was another record year for global organic farming. According to the latest research, organic agricultural land increased by 1.1 million hectares (1.6%) in one year, and amounts to 72.3 million hectares with 3.1 million organic producers. The global

ecological market continues to grow worldwide and has crossed the $ 106 billion threshold [9].

According to the data of the Central Bureau of Statistics of the Republic of Croatia, and related to organic production, in 2019 in Croatia the share of areas under organic production in the total used agricultural areas is 7.18%. The number of organic farmers is increasing each year [14].

European policies for labeling the quality of agricultural and food products are an important and useful tool in the hands of producers that guarantee competitiveness and profitability as well as a high level of product quality. The system of putting quality labels on product packaging is one of the most effective levers in product protection; for the manufacturer it means standing out among similar products on the market. Labels on product packaging represent more than just the product quality and safety - they create additional markets, new market niches and market opportunities [15, 16]. Research has shown that consumers are willing to pay more for biodynamic products, which makes it necessary to differentiate them on market from other products [16].

The making of packaging involves the design and manufacturing processes of the container that wraps the product. In recent times, many factors have contributed to making the packaging an important marketing tool. Traditionally, the primary function of packaging has been packaging and protection of products from external influences. Increased competition and crowded shelves of retail chains imply that packaging has a great influence on the purchase decision [16-18]. The advantage of a particular product in relation to the competition lies in the ability to keep the consumer's attention at the selling point during the short time in which the purchase decision is made. The most dominant sense used in this process is sight, and packaging becomes a key element in making a purchase decision [19].

Packaging is necessary for all manufactured goods and wraps. It promotes and protects the products we buy from the process of production, handling and storage, all the way to the end consumer - user. Without the use of packaging, handling most materials and products would be inefficient and unattractive, and the modern way of trading would be

impossible. Food packaging occupies an essential place in today's modern food industry [20]. All this brings us to the conclusion that packaging is "a silent" seller and means much more to the product than can be imagined at the first glance [16, 21]. Graphic presentation of packaging means providing the product with an IT, aesthetic and security code. Errors in the information part can lead to fatal consequences for the user or the whole environment. This is the reason why certain parts are prescribed by various laws and regulations. The overly expressive or weak communication characteristics of the packaging may exclude the product from the market line of similar products.

2 PAPCKAGE LABELLING OF ORGANIC AND BIODYNAMIC PRODUCTS

The Act on Agriculture (Official Gazette 118/18, Article 110) [22] and European legislation on organic production and labeling of organic products (EC 2018/848) [23] mention biodynamic production in terms of a sustainable agriculturally productive ecosystem. However, there is still no standardized labeling and marking of packaging of such products in Croatia, which would contribute to their diversification on the market. In the Republic of Croatia, biodynamic products are marked on their packaging only with the eco-product label, although according to their principles and methods of production they represent a completely different higher standard to the already defined eco-label (which is the standard). Without a specific mark on the biodynamic product packaging, both producers and consumers face the problem of recognizing such products on the market on daily basis [24]. Therefore, it is necessary to put forward a graphic solution in form of a label, which will

convey adequate information about the product to customers, in order to protect consumers and producers. In addition, it is important to establish a comprehensive standardization of biodynamic product package labelling.

In the Republic of Croatia, several labels are used in food production for their labeling. Each of these labels represents a certain standard and relies on different regulations and norms. Competent institutions are responsible for the correct standardization of labels; in the Republic of Croatia, it is the Croatian Standards Institute. The base law regulating organic production in the Republic of Croatia is the Agriculture Act (OG 118/18) [22], which is in line with Commission Regulation (EC 889/2008) laying down detailed rules for the implementation of Council Regulation (EC) No. 843/2007 on organic production and labeling of organic products with regard to organic production, labelling and control

The eco-label is primarily a communication instrument that guarantees the credibility of an organic product to a potential buyer. The perception of eco-label is closely related to consumer behavior, more precisely to the purchasing decision. Therefore, the effectiveness of eco/bio-labels has been the subject of numerous studies and research [24, 25]. In this context, there is a need to create a specific label on the packaging of biodynamic products in order to distinguish such products from similar products produced on ecological principles. One of the conditions for effective labeling of packaging, both organic and biodynamic products, is that customers are willing to pay added value for the product, which contributes to covering the increased costs of sustainable environmental management practices [26, 27].
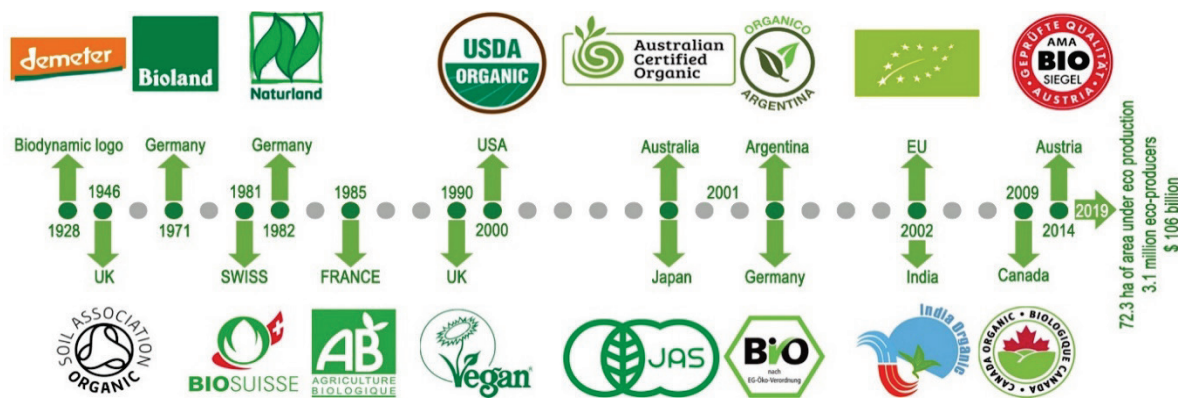

Figure 1 Timeline of eco/bio labels

The timeline shown in Fig. 1 shows that the labeling of biodynamic product packaging has existed in the world since 1928 and is recognizable by the Demeter label. Demeter is the only official certificate for biodynamic products, recognized internationally. Demeter-International prescribes a set of production and processing standards that are applied when using Demeter, Biodynamic® and related trademarks, as well as for marking the packaging of biodynamic products produced according to strictly specified methods and principles [25, 26]. Biodynamic and organic farming are

similar because both are ecologically oriented and do not use mineral fertilizers or pesticides. The main difference between biodynamic and organic production is that biodynamic farmers use eight biodynamic preparations - for soils, crops and composts. Interest in biodynamic agricultural practices and its methods is growing rapidly because it shows the potential to mitigate some of the adverse effects caused by conventional chemical-dependent agricultural practices [29].

According to research dealing with the so-called "green products", it was concluded that the products marked with the

eco/bio label symbolize a trustworthy product for the buyers. The goal of the eco-label is to reduce noise in the communication channel between the producer of the eco-product and the consumer, by providing credible information related to the environmental parameters of the product, as well as to suggest that the product stands out over a product without the label. Additionally, the aim of eco-labels is to provide simple and easy-to-understand information and encourage increased demand for products that are considered environmentally friendly [30]. Each label has its own development path, regardless of whether it is prescribed, standardized or originated as a producer's idea. When it is established that there is a need for a label, the procedure of its prescribing, i.e. standardization is initiated. The result of that process is a regulation or norm for handling the identified label. There are prescribed labels the use of which can be both obligatory and non-obligatory. The manufacturer decides whether and when to put any of the labels on its product and packaging. Regulations, Legal Acts and Ordinances on quality labels are prescribed at European and national level [31].

3 ECO/BIO LABEL AND PACKAGING AND ITS FUNCTION IN PRESERVING THE ENVIRONMENT

Current trends imply that consumers, especially in more industrialized countries, make purchasing decisions based on quality, price and availability, but also on environmental parameters. In doing so, it is necessary to monitor the environmental impact that may occur during the entire life cycle of the observed product. In this respect, the correct labeling of products and packaging is one of the ways to reduce the environmental threats that can occur in all areas of human activity. Therefore, attention should be given to all stages of product "life cycle" (from design, production, labeling of packaging, packaging, marketing, consumption, use to disposal of products and packaging) [32]. The impact of environmentally friendly packaging can be observed through increased civic awareness of self-responsibility, progress in the industrial sector, quantitative improvements in environmental protection and an increase in environmentally conscious consumer behavior [33]. The economic effects resulting from the application of environmental labeling can be seen through the analysis of market profit and impact on trade: a) market profit - different manufacturers state that they have achieved significant market profit by adopting some of the labeling of packaging standards; b) the impact of labeling on trade (sales) - the increase in sales of labeled products compared to similar (compatible) products without labeling represents a certain "power" of the standard for labeling packaging. The increasing sales of eco/bio-labeled products leads retailers to put appropriate pressure on producers so that they would supply them with eco/bio-labeled products. Some big retailers, such as ICA in Norway, commit in their statements that they will provide consumers with a certain share of eco/bio-labeled products in their range of products. Such trend directly affects the increase in requirements toward producers in terms of adapting their products to the requirements of different standards for packaging labeling [20, 30].

Package labelling for environmental protection will certainly in the future, taking into account the current development trends, retain the status of the main method for educating and encouraging environmentally responsible consumer behavior. It is also important that consumers continue to express the need for this type of information and that environmental protection remains important as a global issue, while continuing the trend of market and trade globalization [34]. Consumer requirements related to environmentally friendly packaging, which is safe when it comes to migration, easy and simple to handle, and preferably personalized, is one of the main growth and development drivers of the packaging market today. Packaging is omnipresent and concerns almost every person on the planet regardless of the shape it comes from or material it is made of. People need all these products directly or indirectly for living - mostly packaged in some form of packaging. As a result, packaging, along with labels, is one of the fastest growing areas within the printing industry due to the constant growth of overall needs. The latest Smithers Pira data, published in the study "The Future of Global Packaging to 2024", show that growth in the global packaging market will continue over the next five years, significantly influenced by technological and business evolution that drives global expansion [33].

4 RESEARCH AND RESULTS

For the purposes of this paper, an empirical research was conducted using the survey method, hat is an online survey questionnaire, for the purpose of which a specially structured questionnaire was made. The questionnaire was done using *Google* form and was conducted on *Facebook* social network. The survey was conducted in November 2020, after which the data were processed using Microsoft Excel, TIBCO Statistic and Flourish studio. The survey was conducted using the "snowball" method, a deliberate sample of subjects of both sexes aged 19 to 72, heterogeneous education levels ($N = 194$).

The obtained values were checked for distribution normality using Shapiro Wilks W test, the homogeneity of variance was tested using Levene's test, and after these checking the appropriate test was used to compare variables (t-test, Mann Whitney U test, ANOVA or Kruskal Wallis ANOVA). When the p value amounts to less than 0.05 it was considered to be a statistically significant difference among the respondents, 30.4% were male and 69.6% were female. The obtained distribution is not completely typical for the population image of Croatia because it represents a higher ratio in relation to the real situation of men/women, which amounts to 51.7% of women and 48.3% of men. According to the level of education of the respondents, 36.6% have completed only secondary school, while 28.9% have completed higher education with a degree in mag. ing. Number of respondents with high school or bacc. is represented in the survey with 19.1%, while 15.5% of respondents have a master's or doctorate degree.

Food quality is an important factor when choosing groceries; in the range of 1 to 10, 99% of respondents answered that it was important to them in the range of 6 to 10, which is an extremely high percentage (Fig. 2).
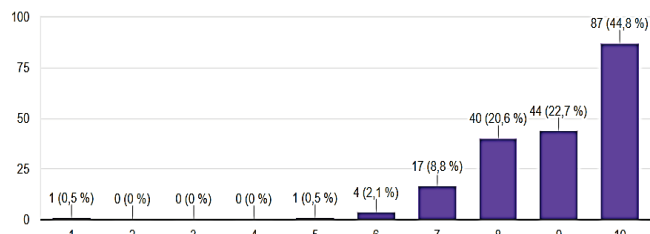

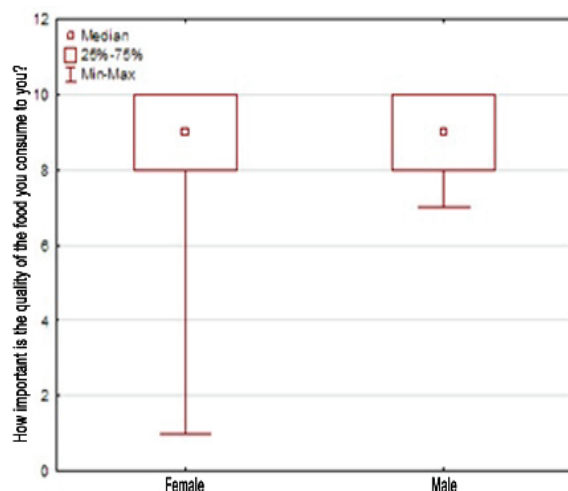**Figure 2** Importance of food quality consumed by the respondents

Figure 3 Relation between gender and importance of food quality

Importance of food quality consumed by the consumers (respondents) does not depend on gender. The medians are equal and the data distribution matches 75% data. Mann-Whitney U test confirmed that there is no statistically significant difference between the data distribution, which is evident form the p-value 0.95. Unlike for men, there is minimal value in women for whom the quality of the food they consume is extremely unimportant. Still, there is no statistically s difference (Fig. 3).
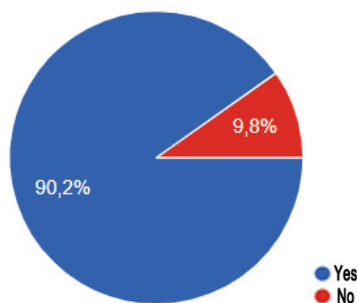
Figure 4 Perception of package labelling

The declaration is an "identity card" of each food that reveals its origin, purpose and composition. At the same time, it gives us proof of food health, that is it confirms its safety for consumption. Therefore, it is extremely important to pay attention to the declarations that are on products in stores. From 194 respondents, 90.2% of them read the declarations on product (Fig. 4). However, considering the age (median 36 years), generally speaking the middle-aged and older population reads the declarations on the packaging more than the younger population (median 21 years).
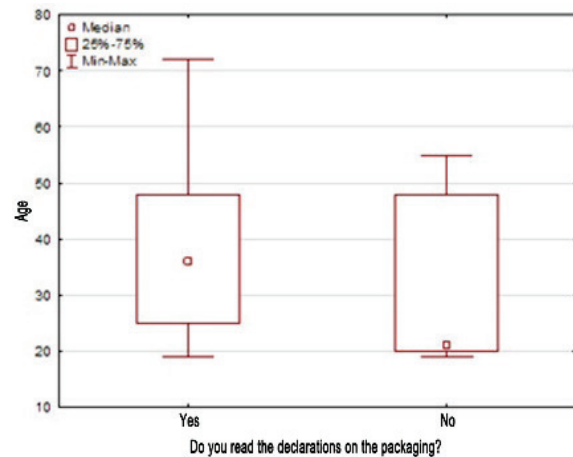

Figure 5 Relation between reading the package declaration and age

Data analysis leads to the conclusion that, regardless of the respondents' gender, the quality of the food consumed by the respondents is equally important. Have in mind that there is 63.4% of highly educated people in this population. This is further confirmed by the fact that those older than 25, who can already be considered highly educated, read the declarations on packaging (Fig. 5) [35, 36].
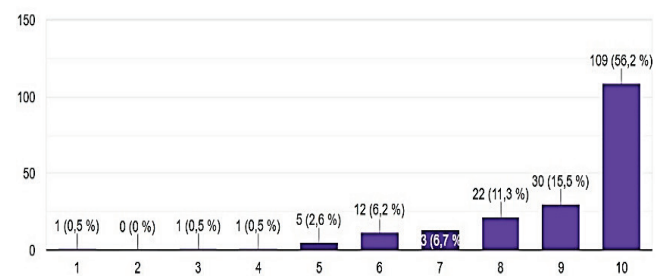

Figure 6 Importance of information on traceability of food production

Regarding the importance of information on the traceability of production from producers to consumers, in the offered range from 1 to 10, almost all respondents (98.5%) chose the answer on a scale of 5 to 10. This result indicates to consumer awareness about food product choices (Fig. 6). In the EU Commission report on factors influencing consumer purchasing decisions, consumer interest in origin labeling comes after the aspects of price, taste, date "use by/best used by" [34]. Although two-thirds to three-quarters of consumers express an interest in labeling the origin of unprocessed food. Consumers link information on origin to different aspects of products, such as quality, safety and environmental issues. Consumers also state that they would buy national products to support their country's economy, although there are important differences between Member States. They would prefer information on origin at country

level compared to the EU/non-EU level. They appear to be more interested in the place of production compared to the place of cultivation of the food [13].
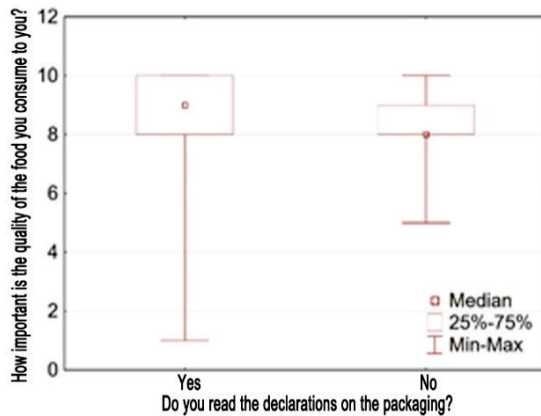

Figure 7 Relation of reading the package declaration and food quality

There is a statistically significant difference (p-value 0.01) in the distribution of data between the two groups; those who do not read the declarations on the packaging are generally less concerned about the food quality they consume (Fig. 7). While those who read the declarations on the packaging will pay attention to the labels and the appearance of the packaging itself in order to choose the best product for themselves. It is equally important for the respondents to have the data on product traceability (Fig. 8), which is shown by the statistical difference (p-value 0.01). From the above mentioned, it can be concluded that the middle and older population is more concerned about the quality of food and that they are the ones who read the declaration on the packaging. In doing so they pay attention to the traceability of products from producers to consumers.
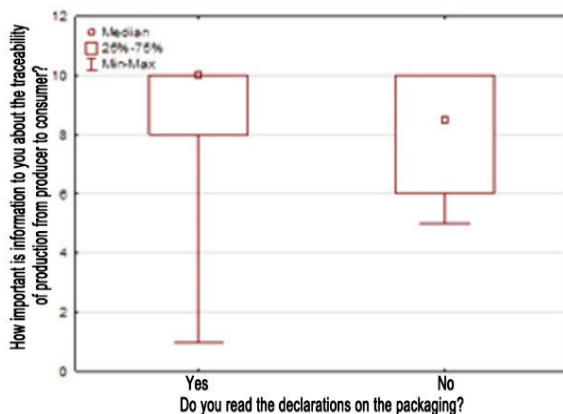

Figure 8 Relation of reading the package declaration

Food products produced according to biodynamic principles are above the ecological production standard, having their own standards in production and processing [37]. Although there are scientists who are asking for further research to confirm such claims [13]. In Croatia, there is a growing interest of agricultural producers who produce in compliance with the given biodynamic production guidelines, but still do not have a recognizable label on their product, on the packaging. On the other hand, there are almost no biodynamic products with the Demeter label on our market [38]. Nevertheless, 71.1% of respondents have heard of this type of product (Fig. 9) while 91.8% believe that the packaging of such products should be additionally marked (Fig. 10).
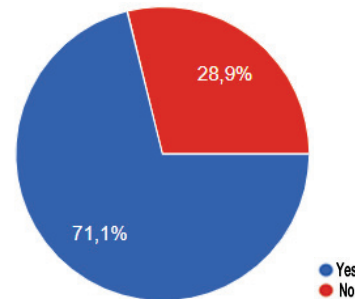

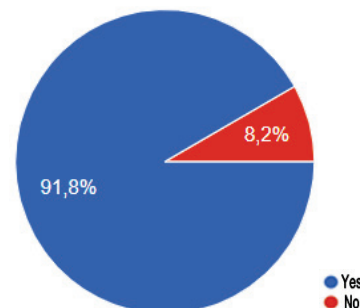**Figure 9** Result to the question: *Have you heard of the term biodynamic product?*

Figure 10 Result to the question *Do you think biodynamic products should be labelled additionally to be recognizable on the market?*
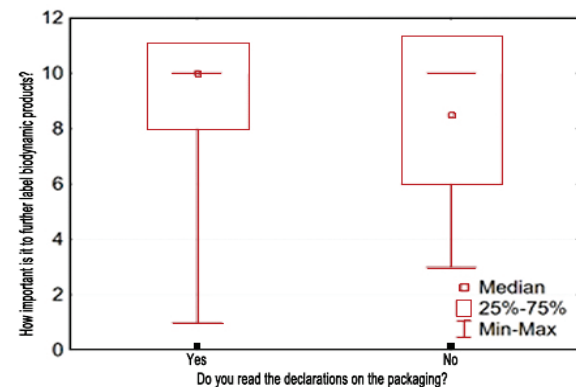

Figure 11 Relation of reading packaging declaration and additional labelling of biodynamic products

The results of the research show that consumers prefer products with an ecological and biodynamic certification label to identical products without a label. For almost all tested organic and biodynamic labels, consumers were on average willing to pay premium prices compared to similar organic products without a label. It can be seen from Fig. 11 that regardless of whether the respondents read the declarations on the packaging or not, both groups believe that biodynamic products' packaging should be additionally marked with a separate label. However, there is no

statistically significant difference (p-value 0.08) in the distribution between these data.

5 CONCLUSION

In this research we wanted to determine how important the quality of food that respondents consume is in relation to age and gender. Also, are respondents informed about the quality of food through packaging declarations, and how important is the information about the traceability of the product to them? The research found that there is a need to label the packaging of biodynamic products. The results of research on the importance of food quality consumed by respondents, with emphasis on the purposefulness of the declaration on the product packaging, and traceability of the product, show that respondents (consumers) are extremely interested in the quality of food they buy, and especially its traceability. This includes the information on its production, its origin as well as its environmental, ethical and health production aspects. Consumers are being more and more aware of their eating habits, and knowledge and consciousness as well as the need to have good quality groceries in on the increase. Also, research on biodynamic products has proven their recognizability in the market and the need for additional package labelling of such products. From this part of research, it can be concluded that most respondents are familiar with the methods and principles by which biodynamic food is grown, while a large percentage of respondents believe that biodynamic products should have package labelling so that the consumers could more easily recognize and notice them. Based on the results of this research, it is necessary to make additional research on how and in what way to effectively label the biodynamic products packaging.

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Recognition Model of Counterfeiting Digital Records of Biometric Photographic Image

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Abstract: Biometric portrait as one of the most important means of identifying requirements through strict definition of dimensional relationships, preservation of realistic information about all technical characteristics of the photographic image, so that all biometric values can be digitized and used in recognition. The great variety and accessibility of applications for digital processing of digital record of a photographic image has enabled a visually convincing display of a forged photograph that leaves a different impression on the viewer and transmits a different, that is, a forged message. Due to the need to prove the authenticity of the digital record of the photographic image, methods have been developed for the analysis of the record that can detect deviations from the real record even when there are no visual signs of processing the photographic image. Not all analysis techniques can detect certain methods of photo manipulation, so multiple digital photography detection and analysis techniques need to be applied. In order to prove its authenticity, the scientific paper deals with methods for analysis and detection of forgery of digital photography with respect to the digital record and the structure of JPEG format.

Keywords: biometrics; computer forensics; JPEG; manipulation; photographic image

1 INTRODUCTION

The daily use of digital photographic images for professional or amateur purposes opens the door to new and creative ways to forge a photographic image. With the advancement of technology and the possibility of installing a digital camera in almost any electronic device, including: laptop, tablets, mobile phone and broadband Internet access have enabled very fast sharing of photographic images and their publication on the Internet. With new technologies and trends, new, simpler computer programs for processing digital photographic images have emerged. Due to this problem, there is a need to prove the authenticity of the digital photographic image. The great variety and accessibility of computer applications for digital processing of digital photographic image has enabled a visually convincing display of a forged photographic image that leaves a different impression on the viewer and transmits a different, forged message. [1, 2] Each digital photographic image is a finite binary record made by a series of mathematical algorithms. Mathematical algorithms behave according to pre-known rules and each change affects the final record of the digital photographic image. This is why it is possible to analyze a digital photographic image in search of irregularities in the structure of the digital record and in the very structure of the digital photographic image. Each digital photographic image is considered unique and should be approached in this way during the analysis. Therefore, it is not possible to create a unique model for the analysis of digital photographic images, but it is necessary to apply a number of different techniques in order to detect potential errors or manipulations. This paper deals with methods for the analysis of digital records of biometric photographic images and the detection of their forgeries with respect to the digital record and the structure of JPEG formats. In order to prove the authenticity, the paper presents a method based on the observation and comparison of the basic characteristics of a biometric portrait photographic image and the characteristics of creating a digital JPEG record. Scientific research involves the analysis and authentication with a predefined model. For the analysis, manipulated photographic images made in laboratory conditions with targeted changes are used, and based on the results, the method of accurate interpretation of information is explained. In proving, a wide range of currently known methods of manipulating the addition or deletion of digital photographic image elements are analyzed.

Biometrics is one of the most important means of identification and authentication of individuals, and as a science, it speaks of automated procedures for uniquely recognizing people based on one or more innate bodily characteristics, or characteristics of human behavior. Biometrics has been used since ancient times and has developed in accordance with the development of human knowledge, that is, technology and science, whose dizzying development in recent decades opens up unimagined possibilities of their application in the fields of identification. Classical methods of identification in the new environment gain a new, additional quality, and completely new methods are established. Biometric authentication techniques are classified according to the type of characteristics being assessed: physiological properties or behavior. Physiological biometrics is based on classifying a person according to data obtained as part of the human body, such as fingerprints, faces, or the iris of the eye. The rapid development of technology has increased the need for reliable ways to identify people. Today, identification of persons is performed in two ways: Identification by means of identification documents, identification based on a security key. The use of biometrics, or specifically unique human characteristics, has existed for hundreds of years in one form or another, whether it is a physical description of a person or perhaps more recently a photographic image. Prior to biometric documents, the classic approach to portrait photographic image for documents based on the so-called Beautiful portrait of a face, in a European or American cut. Such an approach ensures an optimal range of shadows to display facial volume, which is not enough when it comes to portrait photographic images for a document, where properly defined facial geometries need to be ensured. In this case, since the introduction of

biometric portrait photographic images for documents, diffused lighting from the direction of the camera has been used. Such a biometric portrait for documents bears biometric data about the owner of the document, that is, the complete biometrics of the person. [1] Biometric portraits are taken under precisely defined conditions, such as high quality photographic image, format (width x height), about 2/3 of the image should be occupied by the head, which must be centered on the photographic image, satisfactory contrast and sharpness, uniform background without texture and shadows. [3] This means that the photographic image must be 35 mm wide and 45 mm high. The head (from the tip of the chin to the crown / parting) should occupy about 2/3 of the image, but should not be higher than 36 mm. Hair (high hairstyles) may protrude beyond the image. The distance between the eyes (from the middle of the left eye to the middle of the right eye) is a minimum of 8 mm (optimally 10 mm). The head should be centered on the photographic images. The face must be sharply painted in all areas, full of contrast and clear. The background must be monochromatic (ideally light gray) and with sufficient contrast to the face and hair. The photographic image should show the person with a neutral facial expression and closed mouth on the frontal shot. The person in the photographic image must look directly at the camera. The eyes must be open and clearly visible, and horizontal with the x axis. Eyes, nose and mouth should not be covered with hair as shown in (Fig. 1).
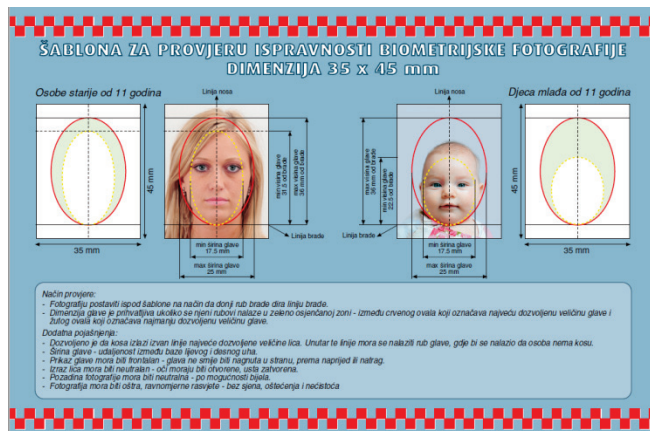

Figure 1 Biometric photographic image validation template

To ensure maximum iconicity, by recording a biometric portrait, the given conditions should be met. Shooting needs to be provided from a normal view, which means that the lens of the camera and the face of the model are in a plane-parallel position. Also, the light illuminating the model's face must be directed from the direction of the camera, to ensure that the model's face will be evenly illuminated over the entire surface without reflections and shadows with a solid background that will provide enough contrast to the face and hair. [3] As a rule, when shooting a biometric portrait photographic image for documents, general light is used, and a backlight can be used to illuminate the background, thus eliminating the possibility of shadows and increasing the brightness of the background. Since the light illuminating the model must be diffused, a softbox or white umbrella is

typically used as the transparent diffuser. The digital record of a photographic image is defined in the RGB color space, which, if necessary, depending on the output unit of the system, is usually compressed into a narrower, usually sRGB color space by rendering with perceptual intentions.

Digital photography is a set of binary values stored on a storage medium according to predefined rules and algorithms. Therefore, a digital file is mathematical in nature, not physical. Examination and analysis require a certain level of expertise and a thorough knowledge of the process of creating a photographic image in order to systematically start the process of proving authenticity. [4, 5] Each photograph is unique, and thus every case of proving authenticity. The conclusions of the examination are made by the investigator, and the techniques for analyzing the photographic image are only a tool used. [6, 7] With each technique of analysis, researchers get more and more information about photography, its origin and method of production. Although biometric analysis primarily involves the technical analysis of individual parameters of a photographic image, portrait photography also presupposes a visual assessment, and falsified images are recognized in this way.

2 EXPERIMENTAL PART

In the experimental part, for the purpose of creating a reference photographic image – the original, the pictures were taken with a digital Leica Canon 5DS R camera, with a maximum shooting resolution of 50 MP in Adobe RGB color space with the correct white balance for measured light temperature, the correct exposure determined by TTL camera system and standard recording saturation. A Canon RF 50 mm f / 1.2 L USM lens was used. All photographic images were taken with a sensitivity of 100/21 ISO and stored in the finest JPEG format and at a resolution of 300 dpi. Lighting for illumination used for the characteristic standard light source - Kaiser 1000 halogen reflector. The light was measured by the TTL system of the camera by segmental measurement of light to a standard color. The following exposure elements are specified for shooting: lens aperture 2.8, exposure time 1/60 s. The resulting digital recordings of photographic images were loaded into Adobe Photoshop 2020, to maintain differences in perception for all colors with perceptual rendering and transferred from Adobe RGB to sRGB color space, which is reproducible in various digital image printing techniques, monitors and other photo output units and stored in the highest fineness of JPEG records. Photographic images prepared in the format 3.5×4.5.

To form a falsified biometric photographic image, a 300 dpi resolution element in the sRGB color space was added to the original photographic record.

To examine the authenticity of the digital record of the photographic image, a model was made, which is divided into two parts, the first part which will deal with the analysis of the digital file structure and the second part which will deal with the structural analysis of the digital photographic image. File structure analysis deals with the study of data about the digital record and its origin. This aims to establish the format of the digital photographic image format. The EXIF record is

then analyzed for inconsistent information. This type of examination presupposes the possibility of establishing whether the data presented are accurate or false. If the data has changed it does not necessarily mean that the content of the photographic image has been falsified but can only be an indication that the computer application for processing the photographic image has interacted with the photograph. [8]

Figure 2 Sample of not manipulated image

Figure 3 Sample of manipulated image

Table 1 Test results of EXIF and hexadecimal values

Structural file analysis	Determine file type
	Hex values
	EXIF values
Structural analysis of digital photography	Luminance Gradient
	Quality Estimation
	Error Level Analysis
	Echo Edge Filter
	Copy – Move Forgery

After the analysis of the file structure, as visible in Tab. 1 the structural analysis of the digital photographic image is performed. In structural analysis, the investigation is conducted at the pixel level in search of manipulated areas and signs of copy paste manipulation methods are sought. The applied techniques are based on statistical analysis using specialized purpose algorithms. The next part of the analysis uses techniques based on the analysis of luminance gradient, intensity, tone, color, edge detection, quality estimation, JPEG error levels, and photo image compression. Light intensity, tone and color are the properties that affect the formation of a photographic image, and their processing in the camera creates the final digital photographic image. By changing these values with computer applications for photographic image processing, the manipulated areas of the photograph may have significantly different properties from the original environment. [9, 10] Therefore, an analysis of light intensity, tone, and color is performed. Human-computer interaction is necessary in this analysis, and the algorithms used in the analysis are just a tool. The conclusion is made by the investigator who, based on the obtained results and the presentation of the photograph, determines whether there are signs of manipulation. Algorithms with high-pass filters are used in this model to detect echo edges and search for tampering in photography for thorough analysis. Also, the result is carefully considered in the search for echo edges or small errors made during manipulation. At first glance, no differences can be seen in some of the obtained results, and it is necessary to further clarify the obtained display by increasing the contrast. Creating a counterfeit photo from two or more JPEG photos can cause discrepancies in the statistics. When a photographic image is forged, it can contain various pieces that are reduced, cut, inverted to make the display as realistic as possible. In addition, parts of the photo are not compressed by the same quality factor. All these factors affect the creation of minor anomalies in digital recording. Therefore, the JPEG compression analysis technique is applied, which divides the photo into segments, and by analyzing each block of the photographic image, it looks for statistical anomalies. The examination analyzes the authenticity of the biometric portrait previously described and shown in (Fig. 2). The initial photographic image defined as the original (Fig. 2) was manipulated by inserting the chin element shown in (Fig. 3). Through the analysis with the pre-proposed model, testing is performed with all techniques and a conclusion is made depending on the overall test result.

Assumptions of the analysis of these techniques can provide sufficient evidence and signs of manipulation of the photographic image. In the first part of the analysis, open source computer applications JPGsnoop, file and stat are used, and in the second part of the analysis, due to specific needs and analysis techniques, the program code written in the programming language Python is used. Applying this model, several scenarios and the process of research and analysis of digital photographic image are presented. For recording the results, a table was made in which all the analysis techniques of that category are listed, where the success of individual analyzes is indicated. The proposed model primarily focuses on the analysis of counterfeits created by the copy paste technique. Photographic images that contain parts that are not the original part of the scene can be said with certainty to be forged. The best way to prove authenticity is to use tests using as many different analysis techniques as possible. The quality of photographic image manipulation depends mostly on the author of the manipulation, and the detection of superior manipulations requires a lot of time and patience in analysis and monitoring

of new techniques, methods and models for analysis and testing of digital photographic images for the purpose of proving authenticity.

3 REASERSCH RESULTS WITH DISCUSSION

The scientific research was conducted using a model to examine the authenticity of the digital record of a photographic image, a biometric portrait, which should be approached with great care for noticing details. The effectiveness of this model and individual techniques is presented in this chapter.

The first step in researching a digital photographic image is to examine the structure of the digital image to determine if the file complies with the JPEG recording rules at all. This test is performed because the computer does not know the difference in naming files, so it is possible to arbitrarily name any file and extension. The result shows that the JPEG record is correct. The test was performed with the computer application file and stat, and the obtained results are JPEG image data, JFIF standard 1.02. Also, the obtained results show the standard used in the recording of JPEG photographic image. The results are shown in Tab. 2.

Table 2 Results of digital record format testing

Case	Insufficient signs for manipulation	Possible signs of manipulation	Certain signs of manipulation
Biometric portrait	×		

For analysis and review of EXIF and hexadecimal values, the computer application JPEGsnoop was used, which displays the parameters of the photographic image in detail. In Tab. 3, the obtained results are shown. With the JPEGsnoop computer application, it is possible to see all the parameters of the photographic image, from the camera model to each individual element of exposure when creating a digital photo image. The results show possible signs of manipulation, as a record of the interaction of the computer application and the examined photographic image was found among the EXIF data. Part of the EXIF data contains information about the manufacturer and model of the camera and the time of creation, that is, the last time of interaction between the computer application and the photographic image. However, the EXIF record only recorded the interaction of the photographic image and the computer program, but not the actual change in the photographic image itself. In these cases, there is only the possibility that the digital photo image has been resized.

Table 3 Results of EXIF and hexadecimal values

Case	Insufficient signs for manipulation	Possible signs of manipulation	Certain signs of manipulation
Biometric portrait		×	

Light intensity analysis is used to detect manipulation of the copy paste technique from several different photographic images. Namely, if two photographic images are recorded with two different cameras under different lighting conditions, a difference will be created that is, not visible to the naked eye. Analysis of light gradient will reveal the difference in areas that have different degrees of illumination at the same optical distance. Tab. 4 shows the results obtained by this analysis, and shows the deviations of luminance gradient, which is why there is a suspicion that it occurred in different light conditions, which indicates the first signs of manipulation of the copy paste technique.

Table 4 Results of luminance gradient analysis

Case	Insufficient signs for manipulation	Possible signs of manipulation	Certain signs of manipulation
Biometric portrait		×	

By quality estimation analyzing, quantization tables are used to estimate last saved JPEG quality. Manipulated areas pasted on the original photo may have different JPEG quality. Therefore, this technique is applied, and the results are shown in Tab. 5.

Table 5 Results of Quality Estimation analysis

Case	Insufficient signs for manipulation	Possible signs of manipulation	Certain signs of manipulation
Biometric portrait	×		

Applying error level analysis looks for areas of photography that differ in JPEG compression quality. In this analysis, it is necessary to determine the contrast threshold of block recognition due to the existence of noise in the photographic image. The value of the threshold can be between 0% and 100%, and it is best to start with a threshold level of 50%, depending on the need to increase or decrease the threshold by 5%. The results of this analysis (shown in Tab. 6 and Fig. 4) show that there is an area that stands out significantly from the surrounding and it is possible to conclude that there is an area of manipulation.

Table 6 Results of error level analysis

Case	Insufficient signs for manipulation	Possible signs of manipulation	Certain signs of manipulation
Biometric portrait		×	

Table 7 Results of echo edge filters

Case	Insufficient signs for manipulation	Possible signs of manipulation	Certain signs of manipulation
Biometric portrait			×

Echo edges or JPEG are created when pasting objects of lower compression quality to the original photo. This method has proven most effective in searching for manipulated areas. [11, 12] Tab. 7 shows the obtained results, which show that the JPEG echo edge was observed, that is, it is suspected that the original photographic image was subsequently simulated and processed by inserting the chin element (Figs. 4 and 5). In addition to the analysis of luminance gradient and error level with which there was a possibility of photo manipulation in the same area, this analysis provides even stronger evidence for the existence of manipulation.
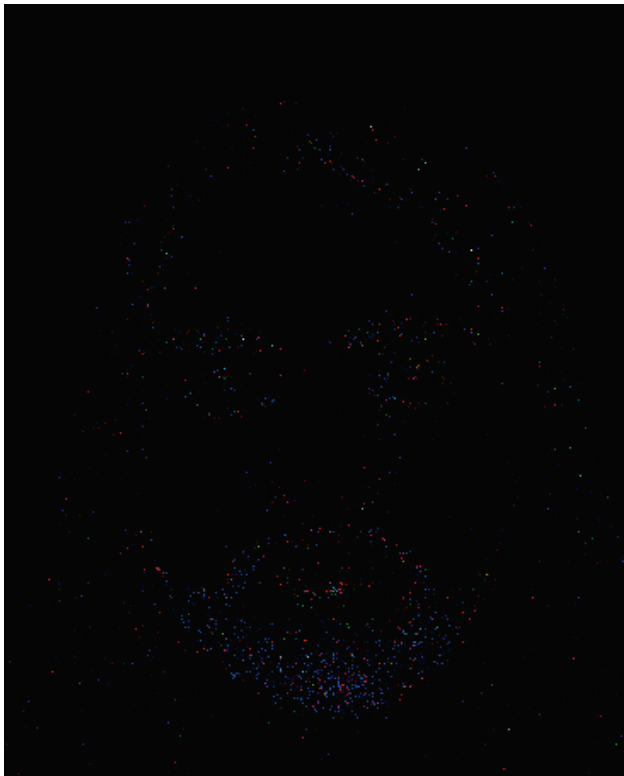
Figure 4 Results of error level analysis

Figure 5 Results of echo edge filters

Adding new elements to an existing photo image changes the JPEG statistics. By analyzing and detecting echo edges with high-pass filters, the result obtained shows the area of manipulation, a large inconsistency of data in the

facial area is noticed, which, among other evidence, indicates that the photographic image is forged. The results are shown in Tab. 8.

Table 8 Results of echo edge filters

Case	Insufficient signs for manipulation	Possible signs of manipulation	Certain signs of manipulation
Biometric portrait			×

Applying copy paste analysis looks for cloned area detection of photography. In this analysis, it is necessary to determine the response rate, matching rate, distance rate and clusters for the BRISK type detector. The value of the rates can be between 0% and 100%. The results of this analysis (shown in Tab. 9 and Fig. 6.) show that there is an area with possibility of copy paste elements and it is possible to conclude that there is an area of manipulation.

Table 9 Results of error level analysis

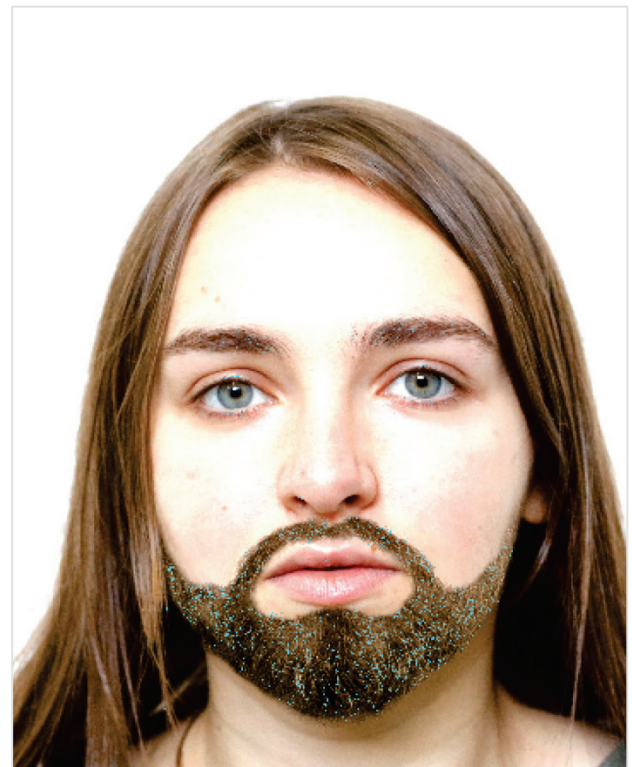| Case	Insufficient signs for manipulation	Possible signs of manipulation	Certain signs of manipulation
Biometric portrait			×

Figure 6 Results of Copy move forgery

After a detailed investigation and application of the proposed model, the final result is determined by the investigator. The application of analysis techniques from the proposed model serves only as a tool that makes it easier for the researcher to display certain information about the photographic image, and thus draw conclusions. The results of scientific research are shown in Tab. 10.

Table 10 Final results of scientific research

Case	Insufficient signs for manipulation	Possible signs of manipulation	Certain signs of manipulation
Biometric portrait			×

The model used to investigate was divided into two parts. The task of the first part of the investigation was to determine the integrity of the digital record, and from the EXIF data it was possible to decide on the further course of the research. In the example where the analysis was performed, advanced manipulation techniques were not used, so the record structure and EXIF data were not changed in order to conceal traces of the use of computer applications for digital processing of photographic images. When concealing traces of manipulation in the record structure, it is necessary to have a lot of knowledge and skills in manipulation and to know the structure of the file record itself. In the second part of the research, all techniques and methods were intended to search for subsequently pasted or erased elements of photography. Most photographic image manipulations occur because one wants to conceal something or add it to the original scene, so analysis techniques that are an integral part of the proposed model are chosen. The techniques of luminance gradient and quality estimation analysis belong to simple analyzes due to simple and fast algorithms. In certain cases, by applying only these analysis techniques, possible manipulation can be sensed. In other techniques, the applied algorithms are much more complex, and the analysis itself requires much more time, which increases proportionally to the resolution of the photographic image.

4 CONCLUSION

This paper describes and applies techniques that can be used for forensic analysis of digital records of photographic images, with the aim of proving the authenticity and integrity of digital records of photographic images. After describing and explaining the techniques in the theoretical part of the paper, a model was developed according to which the analysis of the structure of the digital file record and the analysis of the structure of the digital photographic image were performed. The results of application of the proposed model and techniques for analysis and proving the authenticity of digital photographic image record show the possibility of successful detection of manipulations on digital photographic images. Forensics of the digital record of a photographic image makes it possible to prove the authenticity of the photographic image and the origin of its origin. Proof of authenticity does not depend only on the applied analysis techniques but is a major factor in the whole process of examination by the investigator. The researcher is a person who should be very well acquainted with the process of digital photographic image creation, familiar with the analysis techniques applied, able to distinguish the obtained results and draw the conclusion of each examination. In the proposed model for testing digital photographic images, techniques are applied that cover the area of structural analysis of the digital file and structural analysis of the digital photographic image itself. The speed of analysis increases in proportion to the resolution of the digital photographic image, and this was taken into account when creating this model. The goal was to create an efficient model that does not require much time for the overall analysis of a digital photographic image. The developed model proved to be very efficient and quickly met all expectations in the analysis. The test was based on the authentication of JPEG records with an emphasis on the detection of copy paste manipulation techniques. This manipulation technique is currently the most widely used method of manipulation with a very convincing result and is mostly imperceptible to the human eye.

Structural analysis of the digital file record examines the file that contains the information that represents the digital record of the photographic image. Each file type has a different structure and stores information differently. By checking the integrity of the file, it is possible to determine whether the structure of the JPEG photo image format is correct, and this can lead to the conclusion of how the digital photo image was created. By checking the EXIF record, it is possible to obtain the first signs of possible manipulation of the digital photographic image because computer programs can leave traces if they were in interaction with the examined photographic image. Techniques applied in the structural analysis of digital photographic image record have proven to be very successful in the search for manipulated areas. The most successful technique in searching for manipulated areas in a digital photographic image is the analysis of JPEG echo edge filter and copy-move detection that identified a suspicious area while other techniques hinted at the possible existence of manipulation. Systematic examination of the digital record of the photographic image according to the proposed model has successfully revealed manipulations on the photographic images.

This model can be extended to make the analysis even more detailed by applying other techniques described in this paper. Extending this model of analysis should also take into account the time required to examine digital photographic images.

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A New Framework for Evaluation Sustainable Green Service Supply Chain Management in Oil and Gas Industries

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Abstract: Oil and gas industries are among the industries involved in the international service supply chain, which include domestic and international transportation, import and export, and technology information. By creating utility and satisfaction from environmental perspective throughout the service supply chain, the supply chain managers of leading companies have recently tried to use green logistics and improve environmental performance in the entire of their service supply chain as a valuable resource for sustainable competitive advantage. Thus, the main reasons for investment in creating a sustainable green service supply chain includes management of unwanted environmental, social, and economic risks and creating sustainable services by increasing revenue and enhancing cooperation. Given the purpose of this article which is to provide a framework to assess sustainable green SSCM dimensions. Organizational factors, environmental factors were obtained. In this study, structural equation modelling (SEM) was used to test the hypotheses.

Keywords: green management; oil and gas; supply chain management; sustainability

1 INTRODUCTION

Due to intense competition in global markets, products with short life cycle, and increased customer expectations, businesses pay more attention to investment and supply chain. This combined with continuing improvements in communication and transportation technologies have created incentives for continuous development of supply chain and its management practices. Oil and gas industries are among the industries involved in the international supply chain which include domestic and international transportation, ordering and inventory control, storage of materials and equipment, import and export, and technology information. In a supply chain, a company is related with its upstream, middle and downstream sections through information exchange, liquidity and raw materials. Tendency to SCM in industries has markedly increased in recent years. Various factors have contributed to this. Many companies have lowered their production costs as far as possible. In addition, they found that they can achieve significant savings through effective planning and supply chain management. Finally, one can point to technological change in the transportation industry which led to various forms of transportation methods and its reduced cost. But the logistics systems have been significantly more complex. Thus, it is not surprising that many companies are analysing their supply chain. In most cases, this analysis is based on experience and intuition, and analytical models and design tools are less used in the process.

2 RESEARCH PROBLEM STATEMENT AND LITERATURE REVIEW

Changes in customers, technological requirements, international obligations, globalization, volatile markets and global sourcing have created new challenges in SCM [1]. In addition, today competition is not only between companies, but also between their supply chains. In the competition between different supply chains, the success of companies producing the final products more depends on their ability in the integration management of their business relations networks with suppliers, distributors, partners, etc. in the supply chain. The Integration of business processes, that will create value for customers, is seen as key to the success of companies [2].

In recent decades, the world has experienced an astonishing economic growth because of access to new technologies, globalization of economy and the financial and credit resources, open world markets, accelerated movement of production factors. Unfortunately, serious environmental problems threaten the quality of human life such as thinning of the ozone layer, rapid destruction of rainforests, water and air pollution, global warming, and acid rain. Therefore, ensuring and continuation of sustainable development in any country are subject to the conservation and efficient use of limited and often irreplaceable natural resources [3].

Supply chain which covers all activities related to the goods conversion flow from raw material delivery to end-users, as well as information flow throughout the supply chain [4] has a potentially important impact on the environment. Supply chain managers look for faster delivery of goods and services, reduced latency, lower costs and increased quality. [5]

By creating utility and satisfaction from environmental perspective throughout the supply chain especially among end-users, the supply chain managers of leading companies have recently tried to use green logistics and improve environmental performance in the entire of their supply chain as a valuable resource for sustainable competitive advantage. Organizations that are using the strategic weapon of customer value are trying to maximize customer satisfaction by recognition of the key dimensions of customer value and responding to them. Naturally, this customer satisfaction will be followed by customer loyalty and repurchase and ultimately, maintaining competitive advantage [6].

Since the demand for natural resources, especially fossil fuels, is increasing and the capacity of the world's resources does not meet the demand of consumers now and in the future, this difference leads to the early termination of natural resources, higher energy prices and lack of access to affordable energy sources [6].

2.1 Sustainable Green SCM

The term sustainable development was first formally proposed by Brantland in 1987 in the "Our Common Future" report. The word means "correct and efficient management and utilization of basic resources, natural resources, financial resources and human resources to achieve optimal consumption pattern with the use of technical facilities, and suitable organization and structure to meet the needs of present and future generations continually and satisfactorily." Supply chains are the key rings that connect the organizational input to output. In fact, a network is created which covers supplier(s) to consumer(s). Challenges this network faces are about lower costs, ensuring timely delivery and reduced shipping time in order to better respond to business environment. On the other hand, due to increased environmental costs in this network and growing consumer pressure for offering environmentally standard products, increased awareness of community and staff on social issues related to organizations and the creation of groups in support of community and individuals and increased social responsibilities of organizations and companies, many organizations move towards supply chain stability and consider new criteria (key factors) in their operations [7].

However, long-term trends imposed challenges on supply chain managers and created the need for expertise in the SCM areas in today's companies and factories. These trends include globalization, increased competitive intensity, more need for security, lack of resources, and finally a reliable, flexible and cost-effective business system in order to support different categories of customers. Moreover, the supply chain managers deal with more complex and dynamic supply chains than in the past, which will reduce their forecasting capability [8]. Clearly, SCM is extraordinary more complex than management of an organization. The supply chain managers need to understand more the sustainability issues in their business environment and this, especially on the global scale and fragmented supply chain, not only needs more efficient supply chain operations, but also networking skills, (and knowledge of key factors) so that they can permanently meet the sustainable development requirements to create a customer-centric supply chain [9].

Today, control of natural resources has increased in order to realize sustainable development, minimize environmental sustainability and negative impacts on the environment. Focusing more on the use of green technologies in materials supply, this belief has strengthened that all industrial activities affect the environment. These industrial activities include the development and use of products, equipment, systems and natural resources, which can reduce the negative effects of human [10, 11].

Finally, those organizations involved in the oil and gas industries are looking for sustainable development and with a deep understanding of all aspects of key factors in the deployment of sustainable green supply chain in their decisions, they consider a new dimension called "social costs" in addition to considering the common costs and benefits and measure the environmental dimensions of their decisions. This way, they obtain the benefits of sustainable green supply chain and take steps to protect the environment and minimize negative impacts on environment due to supply chain decisions. The main reasons for investment to create a sustainable green supply chain are as follows:

- Management of unwanted environmental, social and economic risk
- Reputation and shareholder expectations management
- Reducing costs and improving efficiency
- Development of sustainable products by increasing income and improving cooperation [12].
- In fact, the sustainable SCM can create value and success for business and society [13].

2.2 Components Identified in Connection with the Proposed Framework

Given the purpose of this article, which is to provide a framework to assess sustainable green SCM dimensions, the following components are identified and extracted after extensive review of research literature. After several refining, organizational factors, environmental factors, economic factors, social factors, and political factors were obtained.

3 RESEARCH METHOD
3.1 Descriptive Study of Demographic Characteristics

Descriptive statistics refer to a set of criteria that can provide an overview of collected data for the researcher. Note that in descriptive statistics, the results cannot be generalized to the general conditions but the criteria just provide an overview of the study. This study descriptively examines observations by providing related charts and tables. Tab. 1 shows the descriptive results of demographic characteristics of respondents.

Table 1 Descriptive results of the respondents' demographic characteristics

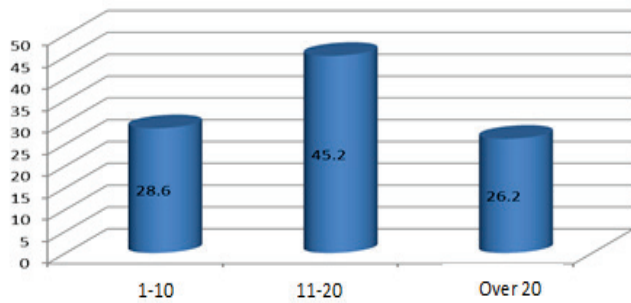| Description		Frequency	Percent
Gender	Female	72	28.6
	Male	180	71.4
	Total	252	100.0
Education	Associate	6	2.4
	License	66	26.2
	MA	180	71.4
	Total	252	100.0
Experience in the industry	1-10 years	72	28.6
	11-20 years	114	45.2
	Over 20 years	66	26.2
	Total	252	100.0
Education field	Humanities	42	16.7
	Basic sciences	36	14.3
	Engineering	144	57.1
	Other	30	11.9
	Total	**252**	**100.0**

Figure 1 Experience of respondents

According to the above table and exhibit, 28.6% of respondents have less than 10 years of experience, 45.2% between 11 and 20 years and 26.2% over 20 years. Figs. 2 and 3 show the education and field of respondents, respectively.
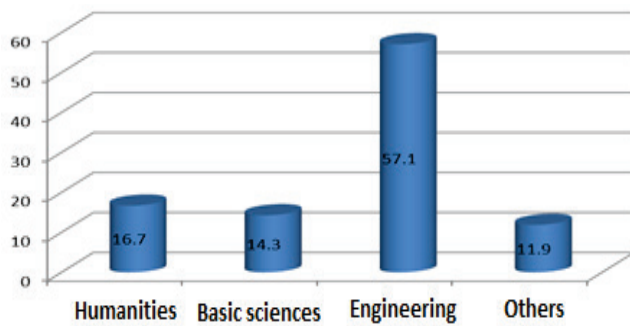

Figure 2 Education field of respondents

In terms of age, the highest percentage of participation (16.7%) are educated in the humanities, 14.3% basic sciences%, 57.1% engineering and 11.9% other disciplines.
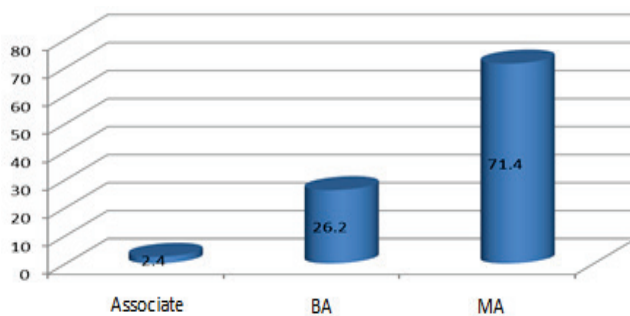

Figure 3 Education of respondents

In terms of education, 71.4% have MA, 26.2% BA and 2.4% associate degree.

3.2 Inferential Analysis of Results

In inferential statistics, the following tests were used:
- Confirmatory factor analysis (CFA)
- Structural equation modelling (SEM).

Since the simultaneous multivariate analysis, instead of bivariate analysis (each time one independent variable is examined with the dependent variable) needs specific methods, it is one of the strongest and most appropriate methods of analysis in behavioural and social science research. In this study, structural equation modelling (SEM) was used for hypothesis testing. One of the new concepts in structural equation topics is latent variables and manifest variables. Latent variables (LVs) refer to variables that cannot be directly measured and are qualitative. To resolve this problem in structural equation, variables called manifest variables (MVs) or indicators were defined that are easily measurable. Another point is that latent variables are divided into two types: endogenous and endogenous. In the first group, models are divided into two types: structural (inner) and measurement (outer). Structural or inner models are composed of relationships between latent variables. In fact, these relationships have been derived through literature and theoretical support. For each latent variable in structural model, an outer model should be defined. In fact, these models consist of the relationships between the latent variable and its measurement indicators, i.e. manifest variables. The interesting point is that each measurement model is drawn based on the theoretical framework and the existing theories, because scientists believe that if measurement models lack theoretical support, the structural model will be unclear and the empirical review of theories will be impossible [14].

This study used structural equation modelling with partial least squares (PLS) method using SMARTPLS for studying independent variables and multi collinearity to confirm the model and respond to hypotheses. The PLS estimation method determines coefficients in a way that the resulted model has the highest power to interpret and explain. This means that the model can predict the final dependent variable with highest accuracy. The partial least squares method (or PLS in regression modelling discussions) is a multivariate statistical methods. Despite some limitations such as the uncertainty of the response variable distribution, the low number of observations or the existence of a serious autocorrelation between independent variables, one or more response variables can be modelled simultaneously on several independent variables.

3.3 Validation of Measurement Models

Before getting into hypothesis testing and the conceptual model, we must confirm the validity of exogenous and endogenous measurement variables. This is done through confirmatory factor analysis. The confirmatory factor analysis is one of the oldest statistical methods to investigate the association between latent variables (main variables) and the observed variables (questionnaire statements) and represents the measurement model [15].

This technique which estimates parameters and tests hypotheses according to the basic factors of the markers, is based on a strong theoretical and empirical foundation that specifies which variable is correlated with which factor (dimensions of that factor) and which factor is correlated with which factor(s). The validation criteria of the measurement models are summarized in Tab. 2.

Table 2 Validation criteria of measurement models

Type of validation	Indicator	Interpretation of the indicator	Reference
Internal consistency reliability	Cronbach's alpha (CA)	This indicator measures the simultaneous loading of structure or latent variables when a manifest variable increases. The value of this indicator ranges from 0 to 1. The value of this indicator should not be less than 0.6.	[16]
Internal consistency reliability	Composite reliability (CR)	This indicator is the sum of factor loadings of latent variables divided by the sum of factor loadings plus error variance. Its value is between 0 and 1 and it is an alternative to Cronbach's alpha. The value of this indicator should not be less than 0.6. This indicator is also called Dillon-Goldstein's (or Jöreskog's) rho.	[17]
Indicator reliability	Factor loadings of indicators	This shows that what extent of the variances of indicators is explained by the latent variable. The value of this indicator should be greater than 0.6 and be significant at the 5% confidence interval. The significance of this indicator is derived by the bootstrapping or jack-knifing.	[18]
Convergent validity	Average variance extracted (AVE)	It measures the amount of variance a latent variable takes from its indicators. The value of this indicator should be greater than 0.5.	[19]
Separated validity	Fornell-Larcker Criterion	According to this indicator, the variance of each latent variable for its own indicators must be greater than any other indicator. To identify this, we first calculate the square root of the AVE of the latent variable and then compare the result with the correlation values this latent variable has with other latent variables. The AVE square root must be greater than correlation values. We repeat this for other latent variables.	[20]

3.4 The research Diagrams and the Results of Confirmatory Factor Analysis

Fig. 4 shows the model when estimating standard coefficients. The green sustainable SCM is endogenous (dependent) and the organizational factors, environmental factors, economic factors, social factors, political factors and cultural factors are exogenous (independent). In this diagram, numbers or coefficients are divided into two categories. The first category is called measurement equations, which explain the relationship between latent variables (oval) and manifest variables (rectangle). These equations are called factor loadings. The second category is called structural equations that explain the relationships between latent variables and are used for hypothesis testing. These coefficients are called path coefficients. All factor loadings less than 5.0 must be excluded from the model, and the model must be estimated and modified regardless of these indicators. All factor loadings in the model had the necessary validity because their factor loadings were greater than 0.5 [21].
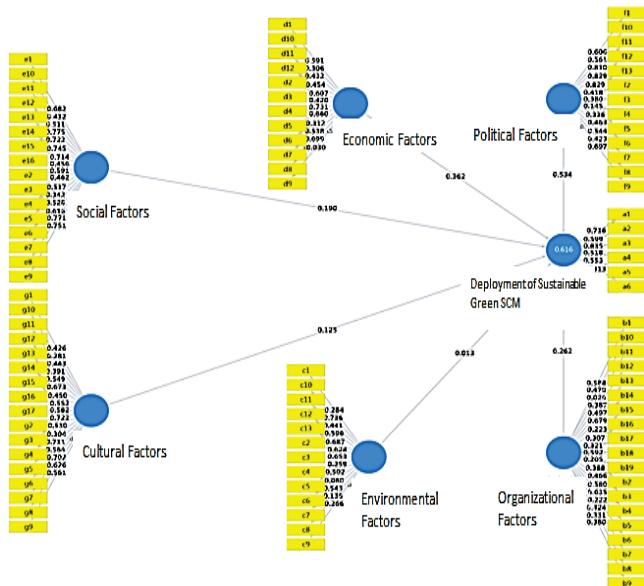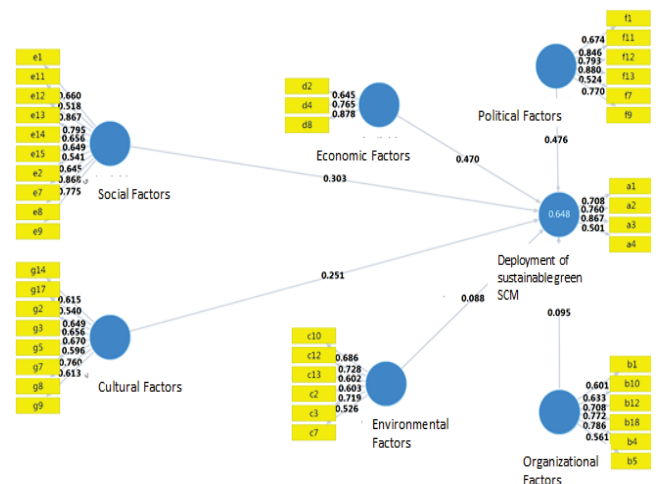

Figure 5 Modified models (removal of questions with factor loadings less than 0.5) in the estimation of standard coefficients

Fig. 5 shows the confirmatory factor analysis and structural equation model in the t-value mode. This model tests all measurement and structural equations using t-statistic. According to this model, path coefficient is significant at the 95% confidence level if the t-statistic value is greater than 1.96.

Figure 4 Initial model when estimating standard coefficients

Figure 6 Model in the significance absolute value (|T-Value|)

Studies show that the highest factor loading value for each indicator is related to the structure of that indicator; for other structures, less factor loading reflects that each structure or latent variable accepts the highest factor loadings from its own indicators. As a result, we can say that the latent variables of the model are distinct enough from each other.

Table 3 Validity, reliability indicators

Latent variables	AVE	Composite reliability	Coefficient of determination	Cronbach's alpha	Average response	$\sqrt{\overline{AVE}}$	$\sqrt{\overline{R^2}}$	GOF
Deployment of sustainable Green SCM	0.561	0.808	0.648	0.676	4.025	0.751	0.805	0.605
Organizational Factors	0.565	0.837		0.776	3.975			
Environmental Factors	0.520	0.811		0.771	3.891			
Economic Factors	0.591	0.810		0.749	4.043			
Social Factors	0.600	0.907		0.899	3.761			
Political Factors	0.573	0.887		0.848	3.804			
Cultural Factors	0.540	0.846		0.810	3.900			

Tab. 3 shows the validity and reliability indicators for all the research variables. In addition to the structure validity, which is used to investigate the importance of selected markers for measuring structures, discriminant validity is used in this study. This means that the markers of each structure finally provide a good separation in terms of measurement for other structures of the model. To put it simply, each marker measures only its own structure and their combination is in such a way that all structures are well separated. With the help of the average variance extracted indicator, it was found that all the studied structures have an average variance extracted higher than 0.5. The composite reliability (CR) and Cronbach's alpha indicators are used to check the questionnaire reliability. This indicator must be higher than 0.7 to approve reliability. All of these factors are above 0.7, so the measurement tool is reliable. A column of Table 3 shows the average responses. Given that the 5-option Likert scale was selected for the questions composing the research variables, the values resulted from respondents' views should be examined to know that whether the average of their responses is different from 3 (the middle number of the Likert scale)? As you can see in this column, all the research variables were assessed above average (the response average was greater than 3) which the variable situation is satisfactory. Social factors have the weakest evaluation and economic factors have the most favourable assessment [22].

3.5 Goodness of Fit Indicator (GOF)

This indicator shows the compromise between the quality of the structural model and the measured model and is equal to:

$$GOF = \sqrt{\overline{AVE}} \times \sqrt{\overline{R^2}} \tag{1}$$

Where $\overline{AVE}$ and $\overline{R^2}$ are the averages of AVE and R. A GOF value higher than 5.0 shows the model goodness. The GOF value is 0.605 (> 0.5), so the model has a proper fit. In simpler words, the data of this study has a good fit with factor structure and the research theoretical basis, which indicates that the questions are consistent with theoretical structures [23, 24].

Table 4 Correlation coefficients and separated validity indicator

Latent variables	(1) SGS	(2) OF	(3) EF	(4) EF	(5) SF	(6) PF	(7) CF
(1) Deployment of sustainable green SCM	0.749						
(2) Organizational factors	0.524	0.752					
(3) Environmental factors	0.444	0.325	0.721				
(4) Economic factors	0.644	0.436	0.507	0.769			
(5) Social factors	0.340	0.531	0.494	0.340	0.775		
(6) Political factors	0.631	0.566	0.476	0.350	0.620	0.757	
(7) Cultural factors	0.549	0.576	0.741	0.452	0.727	0.664	0.735

** Main diagonal represents the square root of average variance explained (*AVE*).

Tab. 4 examines correlation coefficient and separated validity. The main diagonal of the matrix shows the square root of the average variance explained (AVE). Separated validity is confirmed if the square root of AVE is greater than all correlation coefficients of the related variable with other variables. For example, the square root of AVE for the sustainable green SCM deployment variable (74.9%) which is greater than the correlation value of this variable with other variables. As the table suggests, the square root of the AVE indicator for all variables is greater than the correlation of that variable with other variables. The lower part of diagonal represents Pearson correlation coefficients. A positive coefficient indicates a direct positive relationship between the two variables and a negative coefficient indicates a negative reverse relationship. All coefficients are significant at the error level less than 0.05.

3.6 Validation of Structural Model

After validation of measurement models, the structural or inner model must be studied. In this part, the validation criteria of structural models are given in Tab. 5.

Table 5 Validation criteria of structural model

Type of validation	Indicator	Indicator interpretation	Source
Model validity	Coefficient of determination (R^2)	It measures the explanation variance of an endogenous variable versus its total variance by exogenous variables. For this indicator, values greater than 0.670 are considered strong, greater than 0.333 intermediate, and less than 0.190 weak.	[25, 26]
Model validity	Path coefficients	Path coefficients between latent variables must show the relationship between two variables based on algebraic signs, value and significance. A negative coefficient shows a reverse relationship and a positive variable shows a direct relationship between the two variables.	[27]

Table 6 Results of structural equation to evaluate sub-hypotheses

Research hypothesis	Beta	t	R^2	Hypothesis result	Relationship direction
Organizational factors ≥ Deployment of sustainable green *SCM*	0.095	1.215		Rejected	Non-significant
Environmental factors ≥ Deployment of sustainable green *SCM*	0.088	2.804		Confirmed	Direct
Economic factors ≥ Deployment of sustainable green *SCM*	0.470	5.806	0.648	Confirmed	Direct
Social factors ≥ Deployment of sustainable green *SCM*	0.303	2.221		Confirmed	Direct
Political factors ≥ Deployment of sustainable green *SCM*	0.476	5.138		Confirmed	Direct
Cultural factors ≥ Deployment of sustainable green *SCM*	0.251	1.952		Confirmed	Direct

$|T| > 1.96$ Significant at $P < 0.05$, $|t| > 2.58$ Significant at $P < 0.01$

Table 7 Framework for the Deployment of Sustainable Green *SCM* in Oil and Gas Industries

Organizational factors	Expertise and loyalty of employees
	Attention to specialization, professional orientation, division of labor
	Senior management commitment, employee engagement and teamwork
	Continuous monitoring of how to shorten delivery times to customers
	Effective communication within and outside the organization
	Needs identification and customer focus (increasing flexibility)
Environmental factors	Owners of technology and the level of technological competence
	Political, economic, social and cultural conditions
	Environmental legislation
	Senior officials of the Ministry of Oil, partner organizations and companies
	Communication between stakeholders
	Environmental considerations and focus on the use of clean technology, environmental liabilities, energy consumption
Economic factors	Interest rate
	Inflation rate
	Exchange rate and a stable value of money
Social factors	Individual features of employees
	Social structure of employees
	Improving social infrastructure and cooperation in the shaping of social morality
	Development of working relationships in order to respect human rights
	Observance of the principle of equality and transparency in the relations between suppliers and contractors
	Supporting sports and healthy lifestyle and supporting charitable organizations
	Respect for civil rights and developing equal opportunities
	Respect for human dignity and socioeconomic rules and regulations
	Amount and distribution of income
	Individual culture, entrepreneurial spirit and creativity of employees
Political factors	Government tax policy-making
	Setting restrictions on the advertisement of companies, new business planning
	Laying down laws for protecting the environment, people's health, customer support, social equality and economic development
	Legal framework for contract enforcement
	Protection and support of intellectual capitals
	Business rules and regulations (business, environment, trade restrictions, freight)
	A basic model of assumptions, values and basic beliefs, practices and behaviors, and signs and symbols
	Power structures and control systems
	Tendency to loyalty, commitment to the organization and maintaining morale
	Willingness to learn, grow and strengthen the scientific character and respect for rules
	Working based on cooperation and innovation
	Stability
	Conflict between people based on struggle for survival
	Resonance and cooperation between people

4 CONCLUSIONS

According to the surveys made, Tab. 6 shows the results obtained in this study:

- The calculated effect of organizational factors on the deployment of sustainable green SCM is 0.095. Because the t-statistic value is within the critical range (between –1.96 and +1.96), the researcher's claim that "there is a significant relationship between organizational factors and the deployment of sustainable green *SCM*" is rejected with a probability of 0.95.
- The calculated effect of environmental factors on the deployment of sustainable green *SCM* is –0.088. Because the t-statistic value is not within the critical

range (between −1.96 and +1.96), the researcher's claim that "there is a significant relationship between environmental factors and the deployment of sustainable green *SCM*" is accepted with a probability of 0.95. Considering the positive beta coefficient, there is a direct and positive relationship between the two variables.

- The calculated effect of economic factors on the deployment of sustainable green *SCM* is 0.047. Because the t-statistic value is not within the critical range (between −1.96 and +1.96), the researcher's claim that "there is a significant relationship between economic factors and the deployment of sustainable green *SCM*" is accepted with a probability of 0.95. Considering the positive beta coefficient, there is a direct and positive relationship between the two variables.
- The calculated effect of social factors on the deployment of sustainable green *SCM* is 0.303. Because the t-statistic value is not within the critical range (between −1.96 and +1.96), the researcher's claim that "there is a significant relationship between social factors and the deployment of sustainable green *SCM*" is accepted with a probability of 0.95. Considering the positive beta coefficient, there is a direct and positive relationship between the two variables.
- The calculated effect of political factors on the deployment of sustainable green *SCM* is 0.476. Because the t-statistic value is not within the critical range (between −1.96 and +1.96), the researcher's claim that "there is a significant relationship between political factors and the deployment of sustainable green *SCM*" is accepted with a probability of 0.95. Considering the positive beta coefficient, there is a direct and positive relationship between the two variables.
- The calculated effect of cultural factors on the deployment of sustainable green *SCM* is 0.251. Because the t-statistic value is not within the critical range (between −1.96 and +1.96), the researcher's claim that "there is a significant relationship between cultural factors and the deployment of sustainable green *SCM*" is accepted with a probability of 0.95. Considering the positive beta coefficient, there is a direct and positive relationship between the two variables.
- The coefficient of determination is 0.648. Thus, all the variables (organizational factors, environmental factors, economic factors, social factors, political factors, cultural factors) together explained 64.8% of the changes of the deployment of sustainable green *SCM* variable. Considering the beta value, it can be said that political factors have the greatest impact (highest beta value) and cultural factors have the least impact (lowest beta value).

Given the study results, Tab. 7 shows the proposed evaluation framework for the deployment of green sustainable SCM in oil and gas industries.

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Increasing Productivity of Furniture Factory with Lean Manufacturing Techniques (Case Study)

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Abstract: Lean manufacturing techniques are mostly applied in large enterprises and companies that produce more technological products. In this study, productivity has been increased by the application of lean production techniques in SMEs that produces simpler products and has a lower education level of employees. For this, as the first step, Pareto analysis is performed on the sales and production data of the previous year, and the target product family is selected for improvement. In the next step of the study, improvement projects are determined with the Value Stream Mapping (VSM) method, and then productivity increases are achieved by using Kaizen, 5S, standard work, layout plan, and single-piece flow techniques. As a result of the applications, a decrease was achieved in the production process times and the number of quality defects, and at the end of one year, a 29% reduction in total workmanship is observed.

Keywords: flow manufacturing; 5S; lean manufacturing; spaghetti diagram; standard work; Value Stream Mapping (VSM)

1 INTRODUCTION

In Turkey, like other countries in the world, SMEs have a great role in the growth of the economy. There are different methods used to increase productivity, but the most used and more widespread among them is lean production applications. The application of lean production techniques has not been applied in detail in SMEs due to reasons such as financial and human resources constraints. When we ask the owners and top managers of companies that do not apply lean production techniques, they think that these methods are not suitable for their scale and work. Womack et al. claim the applicability of lean manufacturing practices despite the size of the firm [1]. When we search the publications, there are very few articles that describe lean manufacturing practices in SMEs in detail. Therefore, this study has been prepared for the purpose of generalizing lean production in SMEs and to show that it is not dependent on the scale and the work done. As a result, it answers the question "Do lean manufacturing practices increase productivity in SMEs?" This study consists of 3 main parts: the first part includes the definition of lean manufacturing, the second part includes application methods, and the third part includes application and results.

2 LITERATURE REVIEW
2.1 Lean Production

To understand what lean production means in a simple and detailed way, it is necessary to know the definitions of lean production and some basic lean concepts in these definitions. Lean manufacturing constantly focuses on eliminating non-value-added activities and maximizing value-added activities by reducing production costs and improving the quality of an organizational process. In general, non-value-added activities add costs to operations without increasing the value of products. Non-value-added activities are defined as waste in lean production. Any activity that the customer is not willing to pay for is determined as non-value-added and wasteful [2]. Non-value-added activities can be classified into seven wastes: excess

production waste, unnecessary waiting, unnecessary transportation, over-processing, excess stock, unnecessary movement, and defects. Cost reduction and increase in efficiency in operations are realized by eliminating the waste in the process. To eliminate these wastes, techniques such as visual control, 5S, VSM and Kaizen are applied from various lean production tools [3].

2.1.1 Lean Production Principles

The lean production system aims at low cost, fast delivery, and a high-quality-oriented foundation. To achieve this basis, the lean production system has 5 principles. Lean production principles consist of identifying value, Mapping the value stream, creating flow, establishing pull, Perfection seeking.

2.1.1.1 Value

A lean manufacturing system requires a change in the usual system and supports the distinction of "value" from "waste", providing studies that will affect the transformation of existing resources into products and/or products. Value is the basic concept in the lean production system. If we define the value briefly, it is the whole of all processes that will meet the expectations and requirements of the customer in the product and/or service formation process. The period starting from the customer's request in the formation process of a finished product, from the raw material entry to the product formation and delivery to the customer, consists of 5 steps [4]: Processing Time, Control Time, Handling Time, Waiting Time, and Storage Time. When we look from the perspective of the customer, the questions of why he wants the product, what he needs, what the product qualities are, how much it is priced and when it can be delivered help to find value criteria. Process steps other than these transactions are products that the customer does not want to pay and do not add value to them. It will be possible to manage customer value with the steps in Fig. 1.

Figure 1 Managing customer value

All transactions that do not add value in the process of product and/or service formation, that is, do not contribute to the transformation process of the product and/ or service, are called waste. Taiichi Ohno (1988) defined waste as "a resource-consuming activity that does not create value. In other words, it is an activity that does not add value but creates costs. The list of wastes is: Faulty Production, Overproduction, Excess inventory, Waiting, Overprocessing, Unnecessary Transport, Extreme Movements, Unused Knowledge/ Talent.

2.1.1.2 Value Stream

The value stream is the concrete set of actions required to achieve a particular product and is achieved through the three critical management functions found in every business. The value stream includes all the stages from one producer to another producer and the end user in the process of transforming the raw material into the final product, and it contains an incredible amount of waste. There are three types of activities in production:

- "Value-creating" activities (such as dyeing, assembly, weaving) that transform in the direction desired by the customer
- "Mandatory" jobs that do not create value but are necessary for the customer to do the job (such as molding, adjustment, transportation)
- "Non-value and avoidable" tasks such as waiting, counting, sorting, error, repair

When value streams are examined, it is seen that activities that do not create value, that is, waste, consume most of the time and resources. Elimination of these wastes will bring radical improvements in time and cost. Once value is fully defined, the value stream map for a given product is fully drawn by the lean business, and the wasteful steps are eliminated, it's time for lean thinking to take the next step. What remains is to ensure a continuous flow of value-creating steps [5].

2.1.1.3 Continuous Flow

It is the uninterrupted flow of processes in the product and/or service formation process that the customer wants to buy. The continuous flow principle in lean manufacturing

systems is subject to flow interruptions with usual systems and wrong practices in most organizations. The continuous flow aims to keep everything working and to progress continuously.

2.1.1.4 Pull System

The pull principle, which relates to creating flow, is the process of starting production with customer demand and triggering the previous process from the product to the raw material, instead of the thought of producing and selling in traditional production. With the pull system, fluctuations in demand can be transferred to previous operations, intermediate stocks can be reduced, and simpler production can be achieved by eliminating waste [6].

2.1.1.5 Search for Perfection

It is a process that does not have a waste type, is free from all waste and creates value as defined by the customer. By changing the culture of organizations mostly, it enables them to be directed towards continuous improvement and to develop the organization. One of the most important tools for this is Kaizen. Kaizen makes employees seek improvement opportunities. They also contribute to the pursuit of excellence by supporting the organization's change and development. The pursuit of perfection comes from an effort to achieve more perfect, in a continuous cycle, by thinking that it can be continuously improved. The stages of organizations seeking excellence are accepting the change and starting within their body, showing their stakeholders where they have reached with the change and finally making improvements [7].

2.2 Lean Manufacturing Techniques
2.2.1 VSM

The value stream is the set of value-added and non-value-added activities needed to produce a product along the main streams essential to each product. The main flows applicable to each product are (l) the production flow from raw materials to the customer, (2) the design flow from concept to installation (product development process) [8]. We usually connect this flow with lean manufacturing, and this is the zone that lean techniques are tried to be implemented. The value stream viewpoint means working on the big picture, not just one activity, and improving all processes, not just parts. If you really look at the whole and follow all the paths from the raw material to the customer, you will need to survive a value stream through many companies and factories. However, mapping a flow of this bigness is too much and difficult to begin with. The first thing that appears in the production flow is the material movement flow in the factory. But there is another flow that tells each process what to do next: the information flow. In lean production, information flow is as important as material flow. You need to map both. The question you have to ask yourself is, "How should we flow information so that one process only produces what the next process wants, when it wants to?

VSM follows the steps shown in Fig. 2. Note that the "Future State Map" is highlighted because your goal is to design a lean value stream. The current state map is useless without the future state. The future state map is the most important thing. The first step is to draw the current situation by collecting information from the production area. This provides the information you need to design the future state. Also, if you notice, the flows between the current and future situation go both ways. This shows that current and future developments are studies that affect each other. Ideas about the future situation will be formed while drawing the current situation map. Similarly, the future state plot will reveal important previously overlooked information about the current state. The final step is the preparation of an implementation plan and start to application it. A one-page implementation plan defines how we will achieve the future state. Then, when the future state is reached, a new future state map should be drawn [9].
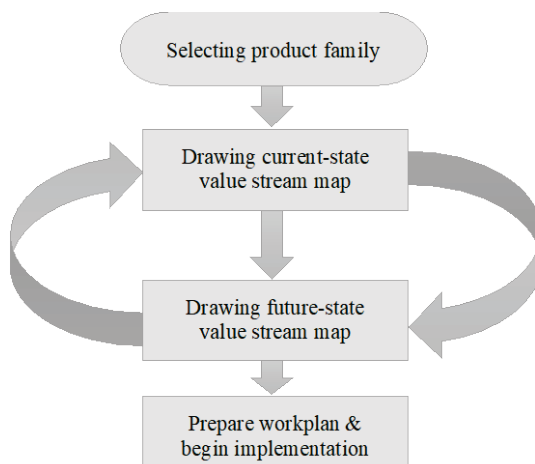
Figure 2 Value stream mapping steps

2.2.2 Spaghetti Diagram

The spaghetti diagram is an easy yet strong instrument for imagining motion and transportation [10]. Such as diagrams are a well-established tool that seeks more effective layouts [11]. When the transportation routes are sketched, it is often simple to spot potentials to reduce waste in movement. The spaghetti diagram was used to follow and draw worker movements to try to find unnecessary motions that could be eliminated. Furthermore, analyzing the current state may be useful for comparing it with recommended improvements. [12].

2.2.3 5S Method

The 5S is a Japanese technique of organizing the workshop, in a clean, efficient, and safe mode, to gain a productive workspace [13]. The 5S is the starting point for companies that want to be recognized in the world class [14]. The 5S technique consists of five steps: **a**. Sort: Separation of necessary and unnecessary items and elimination of unnecessary items; **b.** Set in Order: Systematic arrangement of necessary items and so that they can quickly be taken and

returned in the original place after use [15, 16, 17]; **c.** Shine: Cleaning the workplace and equipment regularly. The source of indiscipline, inefficiency, faulty production, and work accidents is dust and dirt [15, 18]; **d.** Standardize: Standardization and documentation of methods, use of standard procedures. Standards should be fluent, clear, and easy to understand [15, 18, 19]; **e.** Sustain: Maintaining the continuity of the established procedures, regularly auditing the working methods, making the 5S method a habit and integrating it into the culture. In general, the first three steps are easily applied in the enterprises, but because the fourth and fifth steps are not implemented, it returns to the old situation after a short time. The simple yet powerful 5S technique helps identify and eliminate workplace problems [20]. It also helps to have an efficient and high-quality workplace. [21].

2.2.4 Kaizen

Kaizen consists of two words, Kai (development) and Zen (continuous), expressing improvement and continuous improvement [22]. Kaizen predicts awareness of problems and gives clues to identify these problems, it is an important management support covering many management practices used in organizations [23].

2.2.5 Standardized Work

Berger et al. identified the Standard Work as an important tool for continuous improvement [24]. One of the safest and most effective ways to use resources such as people, machines, and materials efficiently and to make operations sustainable is to apply a standard operating method. Work Standardization can be defined as a set of analysis tools that results in a set of standard operation procedures (SOPs). SOPs show which work steps are followed by the activities performed within the target time. SOPs helps us to eliminate the take-time fluctuation problems. With the increase in demand, we can gradually add workers. If the amount of demand decreases, it can gradually remove workers from the production line [24, 25]. Standardization is to determine the lower and upper limits of quality in the organization and to ensure that products and services are produced above the determined level [26].

2.2.6 U-Line Manufacturing System

In its overview, the entrance and exit of the U line should be in the same place [27]. With both ends of the line on one side, a narrow U shape is formed. The advantages of U-shaped lines are reducing the number of workstations, balancing the line, visibility, and flexibility. Guerriero et al. Stochastic simply described the flexibility of the U-Line layout and suggested that flexibility makes it easier for this line to increase or decrease the number of workers when demand is experienced. As for the installation results of the U-Line, minimum workstation, minimum labor, and a workflow can be determined [28].

2.2.7 Flow Manufacturing

The principle of flow production is to produce an element at a time at a rate equal to the cycle time. The successful implementation of flow manufacturing requires U-line layout, multi-skilled workers, standardized cycle time, designing operator work as standing and walking way. Miltenburg et al. recommended that the pull through or over long process flow can be balanced by introducing the customized operation in the workstation in order to balance the operation with the workstation cycle time [29, 30]. Mixed flow model is made smooth by designing workstation with quick change and small batch size.

3   METHODOLOGIES

There are various methods for current state analysis and increasing productivity in companies. In this study, we follow 5 steps as shown below:
1) Drawing current state VSM for identifying wastes
2) Selection of improvement projects by brainstorming with department workers
3) Using lean manufacturing techniques for applying in improvement projects:
a) 5S and Kaizen method used for general settings in workshops
b) Spaghetti diagram used for analyzing and improvement walking distances in a frame workshop layout
c) Standardization Work used for decreasing cycle time in upholstery process
d) Standardization Work used for decreasing paint faults in paint shop
e) U-Line Manufacturing System used for cycle time improvement in upholstery process
f) Flow Manufacturing (One piece flow) used for fabric sewing process.
4) Comparison of productivity criteria before and after application in production processes.

4   DATA ANALYSIS AND RESULTS
4.1 Furniture Manufacturing Current State Value Stream Map

For drawing the current state map in this factory based on methodology, at first, we select a product family by using Pareto analysis method. In this case, we collect one-year sale data and after that, by drawing Pareto graphics, find the products that were most sold last one year as shown in Fig. 3.

The below steps have been followed for drawing the GST current state value stream map:
1) Collection of customer order information (Monthly customer demand, weekly working days and daily working hours)
2) Determination of information flow from customer order to shipment
3) Determining planning strategy in the current state
4) Identify manufacturing steps and all data related to them (cycle time, changeover time, number of employees, working rate,)

5) Determining work in process parts numbers
6) Calculating of total production time and lead time
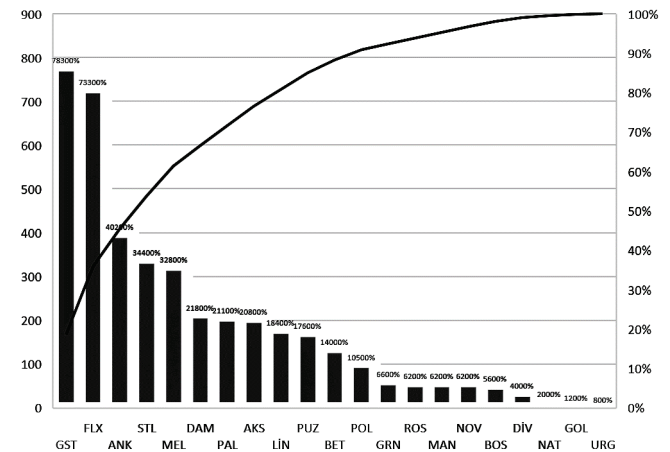7) Drawing the timeline of the current state map.

Figure 3 Pareto analysis of one-year sofa group sales data

As shown in Fig. 4, the current state value stream was complete by the following steps. At the end of calculations and analysis in the value stream, problems were identified, and improvements projects determinate on a departmental basis.

4.2 Current State VSM Analysis Results

According to the results obtained from the analysis of the current state value stream map, the following problems have been identified in the production processes as shown in Tab. 1.

Table 1 Process Based problems

Production Process	Problems
Frame manufacturing	Unnecessary transportation, Unnecessary movements, Unorganized workplace
Painting	Painting mistakes, Faulty products, Unorganized workplace
Fabric Sewing	Waiting, Unbalanced operations, Unorganized workplace
Upholstering	Waiting, Unbalanced operations, Production without flow, Non-standard operations, Unorganized workplace

4.2.1 Frame Workshop Layout Improvement Applications

When the workflows of the top-selling GST, FLX, STL product families are examined, the frame section is the first stage of the production process. As determined in the current situation value stream map analysis, unnecessary transportation, unnecessary movements, waiting, excess stock, and excess production wastes were determined in this section considering the wastes above, a project to improve the frame workshop layout has emerged. The following steps have been applied to realize this project:
1) Examining prescriptions and routes,
2) Determining the parts and machine groups by considering all the alternative machines that the parts in the production can be processed,

3) Creation of the part-machine matrix,
4) Using clustering method according to operation similarities in part-machine matrices,
5) If there is an exceptional situation in the operations, separate clustering (orienting to one-piece flow with clustering),
6) Holistic analysis of the clustering method,
7) Designing different options for the frame workshop layout to minimize the delays in the value stream according to the clusters made,

8) Selecting the most beneficial option from the different machine layout options evaluated according to the rules below:
I   Material flows are in such a way as to prevent returns,
II   Develop machine competencies,
III Choose the one with the maximum total profit according to the selected product/products.
9) If the distance and time obtained from the comparison of the existing and new settlement is useful, apply that option. The clustering result is shown in Tabs. 2, 3 and 4.
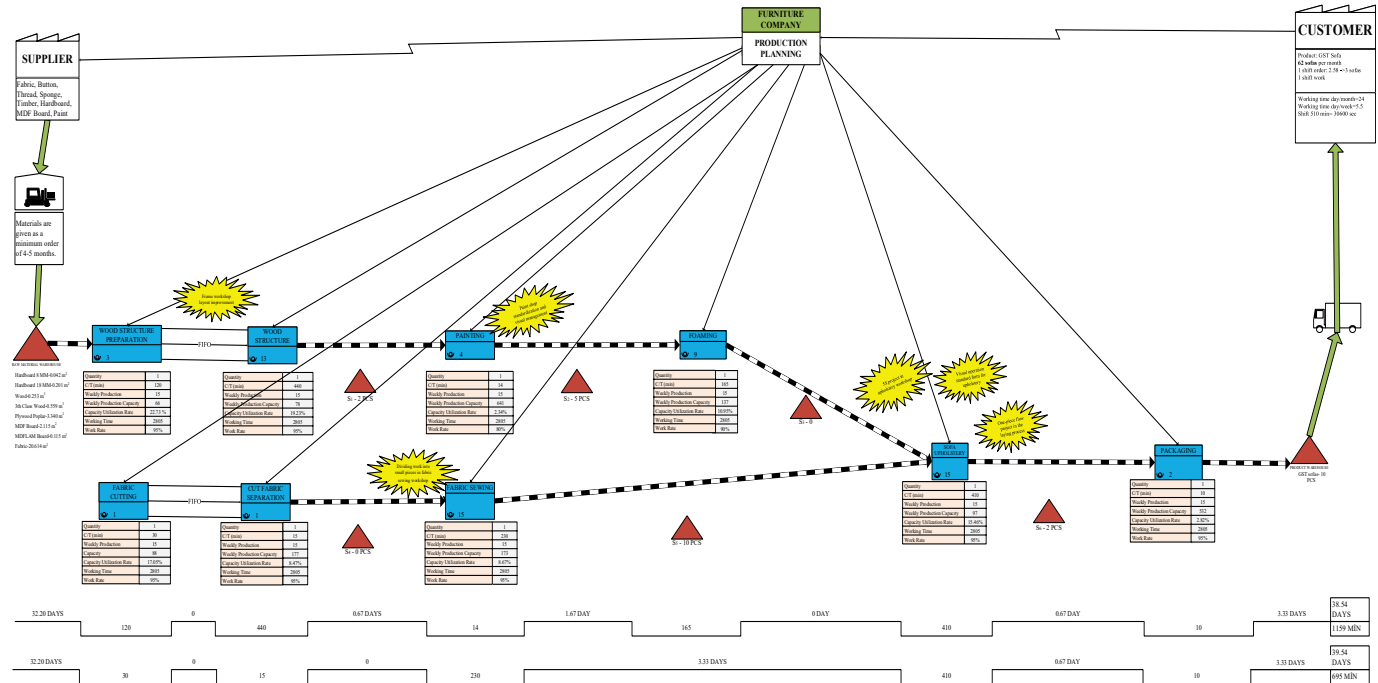
Figure 4 GST current state value stream map

In the next step, the number of parts made on the machines for each product was determined. The total number of parts processed in the 10 machines was determined to be 200 in the GST sofa, 166 in the FLX sofa and 126 in the STL sofa (Tab. 5).

According to Table 5, rules have been created for the machine layouts of the products. These rules are:
I   According to the clustering method, in the new layout, the M2 machine and the M1 machine should be close to each other.
II   The M5 – M6 – M7 machines should be close to each other.
III The M8 – M9 machines should be close to each other.

As the next step, the spaghetti diagram method was used for the benefit analysis of the current situation and the designed future situation layout plan. Spaghetti diagrams of the products were drawn for current state, and distance was calculated based on the movements of the 3 main raw materials (Hardboard, Wood, MDF hardboard). Then the layout established based on constraints and distance was calculated again for comparing current state and future

layout. Detail of spaghetti diagrams shown on Fig 5 (see Appendix).

To calculate the effect of the study on the company, the improvement amounts were multiplied by the annual sales amounts and added together. As a result, 868.67 km less walking of the employees and at the same time 14477.79 minutes, that is, 241.30 hours (approximately 30 working days), were gained to the company (Tabs. 6 – see Appendix and Tab. 7).

4.2.2 Paint Workshop Standardization and Visual Management

When we list the problems in the paint workshop in the current situation value stream map, the color tone difference in the products has been determined as the biggest and most common problem. To eliminate the problem, root cause analysis was performed and as a solution, standardization and visual management from lean production techniques were applied. For standardization, a paint mixture recipe was created for each color and placed on the worktables in the paint shop with a painted sample (Tab. 8).

Table 2 GST sofa clustering matrix

PART / MACHINE	QUANTITY	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
P1	2			1							
P2	2			1							
P3	4		1								
P4	2	1	1					1			
P5	3	1	1								
P6	4	1	1								
P7	2	1	1								
P8	2	1	1								
P9	6	1	1								
P10	1	1	1					1			
P11	1	1	1					1			
P12	2	1	1					1			
P13	2		1								
P14	1	1	1								
P15	2	1	1								
P16	1		1								
P17	4	1	1								
P18	2		1								
P19	2		1								
P20	2		1								
P21	4	1	1			1	1	1			
P22	1	1	1								
P23	2	1	1			1	1	1			
P24	2	1	1			1	1	1			
P25	1	1	1					1			
P26	2		1			1	1				
P27	1		1			1	1				
P28	4		1								
P29	2				1						
P30	2				1						
P31	2				1						
P32	4			1	1						
P33	2			1	1						
P34	2			1	1						
P35	4			1	1				1		
P36	1			1	1				1		
P37	5			1	1						
P38	1			1	1						
P39	2			1	1						
P40	2			1	1						
P41	2			1	1						
P42	2			1	1						
P43	4				1						

Table 3 FLX sofa clustering matrix

PART / MACHINE	QUANTITY	M1	M3	M2	M5	M4	M6	M7	M8	M9	M10
FP1	2			1						1	
FP2	2	1		1							
FP3	2	1		1							
FP4	4	1		1	1						
FP5	2	1		1							
FP6	2	1		1							
FP7	1	1		1							
FP8	4	1		1							
FP9	4	1		1	1						
FP10	2	1		1							
FP11	4	1		1	1		1	1			
FP12	2			1	1		1				
FP13	4			1	1		1				
FP14	2		1								
FP15	2		1								
FP16	4		1								
FP17	2		1								
FP18	4		1								
FP19	4		1								
FP20	1		1								
FP21	1		1								
FP22	2		1								
FP23	6		1			1					
FP24	2		1								
FP25	6		1			1		1			
FP26	8		1			1					
FP27	8		1			1					
FP28	1		1			1					

Table 4 STL sofa clustering matrix

PART / MACHINE	QUANTITY	M1	M2	M5	M6	M7	M10	M3	M8	M9	M4
SP1	1							1			
SP2	1							1			
SP3	1							1			
SP4	1							1			
SP5	2							1			
SP6	2							1	1		
SP7	1							1			
SP8	4			1				1			
SP9	2							1		1	
SP10	2							1			
SP11	2							1			
SP12	2							1			
SP13	1			1				1			
SP14	2	1	1								
SP15	1	1	1								
SP16	2	1	1								
SP17	8	1	1								
SP18	2	1	1								
SP19	4	1	1								
SP20	2	1	1	1	1	1	1				
SP21	2	1	1	1	1	1	1				
SP22	1	1	1								
SP23	4		1		1	1					
SP24	2		1		1	1					
SP25	7	1	1								
SP26	2	1	1								
SP27	1										

Table 5 Number of parts made on each machine based on product

Machines	Total number of parts (GST)	Total number of parts (FLX)	Total number of parts (STL)
M1	40	21	31
M2	60	33	38
M3	29	53	22
M4	37	21	0
M5	11	16	14
M6	7	10	9
M7	11	4	4
M8	5	6	2
M9	0	2	2
M10	0	0	4

Table 7 One-year total improvement

Product Name/ Improvement Type	Improvement By Annual Sales Amount			
	GST	FLX	STL	Total
Total Part - Steps Number	665550	284404	135880	1085834
Total Distance (m)	532440	227523,2	108704	868667,2
Total Time (min)	8874,00	3792,05	1811,73	14477,79

Table 8 PLM Product Paint Recipe

X Color	Quantity (grams)
A	8000
B	1500
C	500
D	250
E	200
F	250
G	20

At the same time, model-color charts were prepared to ensure control by comparing the dyed products with the standard product color (Fig. 6).

As a result of the improvements, the number of malfunctions due to wrong color painting before the project decreased from 10 in April and 7 in June to 2 in July (Fig. 7).
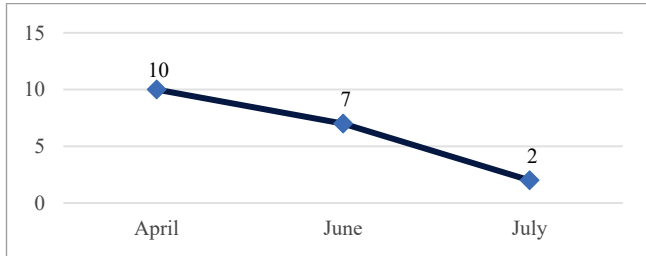
Figure 6 Model-color charts

Figure 7 Number of Failures Due to Color Mismatch (Monthly)

4.2.3 Dividing Work into Small Pieces in Fabric Sewing Workshop

In the current situation, the set (2 sofas and 2 bergère) belonging to the order in the sewing workshop are all made by a single employee. When this working method is applied, problems arise due to the long duration of the sewing process, waiting in the next processes and backlogs after cutting. At the same time, in cases where the employee is off, the work done by that employee is stopped and, due to this reason, delays occur in the next workflow. In this improvement, a set consisting of 4 parts was distributed to separate personnel, and a one-piece flow was ensured. In this way, the waiting time of the upholstery section has changed from the sewing time of 1 set to the sewing time of 1 piece. In addition, when we analyzed employee-based product sewing times, it was determined that there were great differences between them. To solve this problem and increase the productivity of the total employees, each employee was given the fastest job in the work distribution. As the first result of the improvement project, while the average processing time of 3 employees (BK-RG-UY) was 620 minutes before the project, it decreased to 508 minutes after the project implementation (Fig. 8).
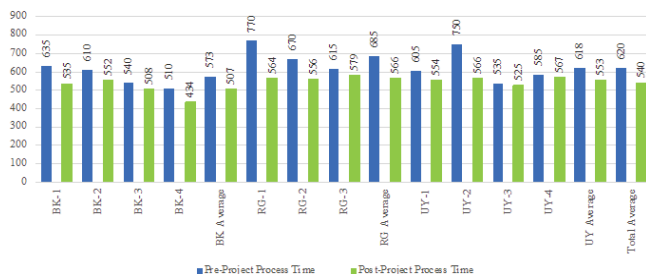
Figure 8 Employee based sewing processing time (Min)

At the same time, since we have divided the work into small parts (4 parts), the waiting time for the next process (Upholstery) from sewing has decreased from 508 minutes to 180 minutes on average (Fig. 9).
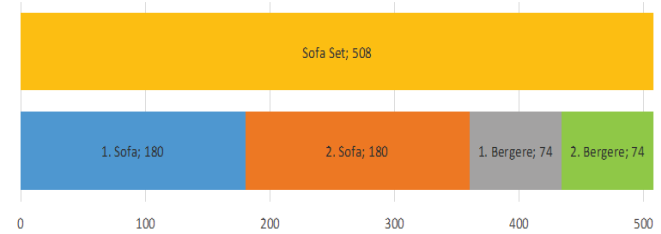
Figure 9 Work division chart in sewing process

4.2.4 Implementation Lean Techniques in Upholstery Workshop

As a result of the evaluation of the current situation value stream map, it was determined that there were delays in delivery. When we went to the cause of this problem, it was determined that the reason for the delays was the long duration of the upholstery process. For the continuation of the steady-state analysis, historical data were collected and analyzed. The processing time consists of four parts: 1. Material preparation time, 2. Search for tools, 3. Upholstery process time, 4. Waiting time for semi-finished products from previous processes. Another result obtained in the analysis of the times is that different employees complete the same job at very different times. Finally, to solve the problem 5S, one-piece flow and Kaizen from lean manufacturing techniques were used.

Figure 10 5S implementation in workbench

4.2.4.1 5S Project in Upholstery Workshop

As seen in Fig. 10, raw materials and work tools were placed next to the worktable in a mixed state and in an undefined state. For this reason, it seemed that the search for materials and tools took a long time during the work. To eliminate the waste of searching for materials and tools, 5S and Kaizen application was used. First, the necessary and unnecessary materials were separated, and the unused

materials were transferred to the warehouse, then a unique workbench was designed by brainstorming with the employees for the necessary materials. In this workbench, places for all materials to be used have been reserved and arranged. After the implementation of the 5S project, a 50% improvement was achieved in the time of searching for materials and vehicles.

4.2.4.2 Visual Operation Standard Form for Upholstery

When the same product is made by different personnel, it has been determined that there are differences in production times. To find the root cause of this problem, work and time-study analyzes of the product-based upholstery process were made on different employees. As a result of the work study analysis, it was determined that different employees made process in different order of operations. As the first step of this improvement, the standard work steps of the process were defined with the employees. In the next step, the operations to be done in each step are visualized and added to the form to make the operation standard form easy and understandable (Fig. 11 – see Appendix). To measure the post-implementation effects of the project, the monthly average processing times of the GST seat were compared before and after the improvement. The average of GST sofa upholstery time before the project was 488 minutes and after the project to 420 minutes, 13,94% improvement was achieved in the process time (Fig. 12).
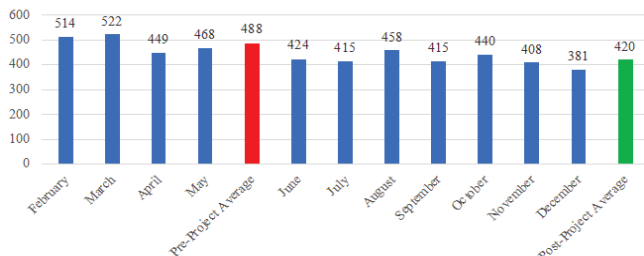
Figure 12 Upholstery process mean time before and after project implementation

4.2.4.3 U-Line and Flow Manufacturing System Project in the Upholstery Process

In the review of the current working method, it has been determined that all activities of the upholstery process are carried out by a single employee. Therefore, unbalanced work occurs in the packaging process, and the delivery time is extended. At the same time, when we look at the operation steps of the upholstery process in the work study, it has been determined that the process consists of four main parts. Since the back upholstery process was a bottleneck, eliminated unnecessary work with the Kaizen method, and the processing time was 130 minutes. Process steps and related time shown in Tab. 9.

After examining the time and operation data in Tab. 9, it was determined that the process took a short time to be done in small pieces, and, therefore, it was decided to break up the process and establish the assembly line. One of the most important issues that we should pay attention to in the design

of the assembly line is that the processing times are balanced. For this reason, 2 people have been allocated for the back upholstery operation, and the operations of cushion, assembly and throw pillows have been combined. As a result of this work distribution, the longest processing time was determined as 65 minutes. As the next step, the operations are sequenced to ensure one-piece flow and forward movement of materials (Fig. 13).

Table 9 GST sofa upholstery operations and work times

Process No	Process description	Process time(min)
GST-OP1	Sofa base upholstery	69
GST-OP2	Sofa case upholstery	59
GST-OP3	Sofa back upholstery	130
GST-OP4	Sofa cushion upholstery	23
GST-OP5	Sofa assembly	24
GST-OP6	Sofa throw pillow upholstery	9
Total		314
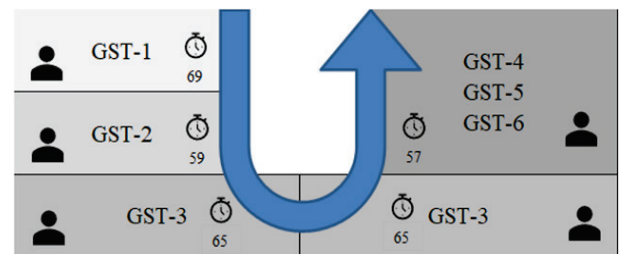
Figure 13 GST sofa new upholstery process layout and operation steps

When we apply the new working method, 5 workers produce a sofa every 65 minutes, so the total time spent on upholstery will be 330 minutes, and when we compare it with the old method, the following benefits are provided:
1) Reduced operation time by 90 minutes,
2) Quick adaptation of new workers to jobs as the process is broken down into smaller pieces,
3) Elimination of waiting and stockpile problems in downstream processes,
4) Reducing the number of semi-finished products and increasing the number of finished products in daily production,

5 CONCLUSION

The question of lean production practices in SMEs will lead to an increase in productivity was answered by implementing lean production techniques in the sofa manufacturing company. The current situation analysis was carried out by establishing a value stream mapping system and past data monitoring system in the sofa production factory. Lean manufacturing techniques were applied in bottleneck operations (Frame, Paint, Sewing and Upholstery) on the most produced and sold product. Reduction in time and erroneous transactions are prevented. In the next step, the work was divided into small lots to achieve the main goal of lean production, and a one-piece flow was achieved. As a result of the one-piece flow application, an improvement of 65% was achieved in waiting times. When we look at the general results, lean production practices were implemented, and annual labor times were improved by 29%. As for the

limitations of the research, data collection difficulties are obtaining correct data from employees and employees' opposition to change. In this study, all techniques of lean manufacturing were not used. In future studies, the effect of lean production on productivity can be investigated by realizing other applications in different sectors.

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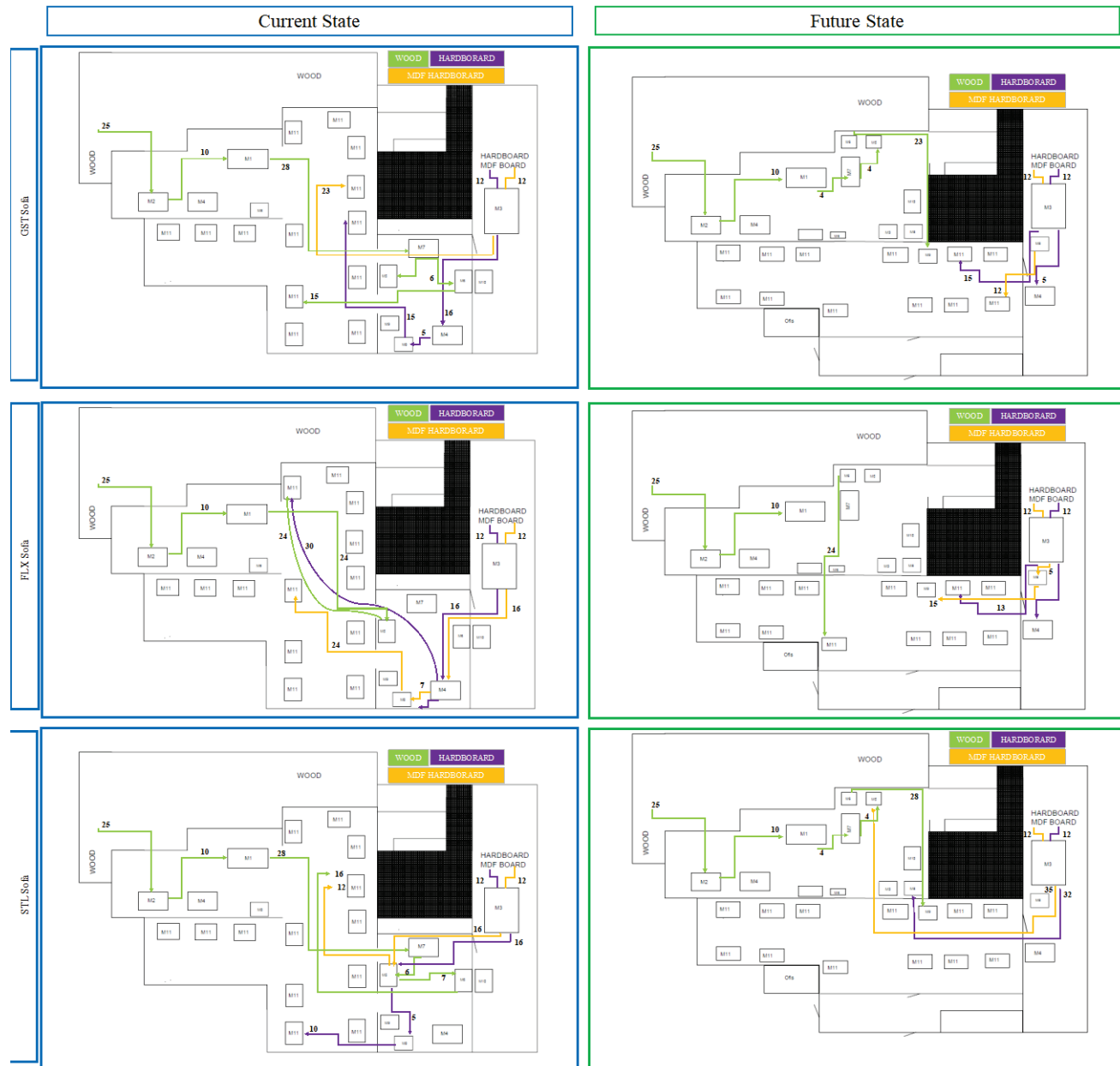E-mail: alireza.shahbazpourasiabi14@ogr.atauni.edu.tr

Appendix

Figure 5 Comparing future state and current state spaghetti diagram

Table 6 Distance improvement calculation and results

	Old Settlement Plan			New Settlement Plan			Old Settlement Plan			New Settlement Plan			Old Settlement Plan			New Settlement Plan		
	Total Part - Steps Number	Total Distance (m)	Total Time (min)	Total Part - Steps Number	Total Distance (m)	Total Time (min)	Total Part - Steps Number	Total Distance (m)	Total Time (min)	Total Part - Steps Number	Total Distance (m)	Total Time (min)	Total Part - Steps Number	Total Distance (m)	Total Time (min)	Total Part - Steps Number	Total Distance (m)	Total Time (min)
	GST Sofa						**FLX Sofa**						**STL Sofa**					
Wood	2370	1896	31,6	1554	1243,2	20,7	771	616,8	10,3	688	550,4	9,2	1284	1027,2	17,1	930	744	12,4
Hardboard	322	257,6	4,3	328	262,4	4,4	390	312	5,2	232	185,6	3,1	212	169,6	2,8	196	156,8	2,6
MDF Board	104	83,2	1,4	64	51,2	0,9	386	308,8	5,1	239	191,2	3,2	104	83,2	1,4	79	63,2	1,1
Total	2796	2236,8	37,28	1946	1556,8	25,95	1547	1237,6	20,63	1159	927,2	15,45	1600	1280,0	21,33	1205	964,0	16,07
Gain	**Total Part - Steps Number**			**850**			**Total Part - Steps Number**			**388**			**Total Part - Steps Number**			**395**		
	Total Distance (m)			**680,00**			**Total Distance (m)**			**310,40**			**Total Distance (m)**			**316,00**		
	Total Time (min)			**11,33**			**Total Time (min)**			**5,17**			**Total Time (min)**			**5,27**		
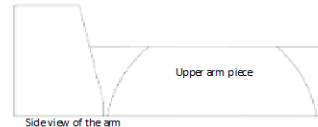
No.	Process	Durations		Steps		Figure	Document Date	
			Product Name:	**GST Sofa**	Workshop **Upholstery**	Revisin No		1
					Total Time 1 Hour	Page No.		**1/1**
1	Sofa Upholstery	1 Hour	1	Cut fiber for sofa arms and glue all arm fiber.				
			2	Glue fiber to the upper arm piece. Then staple the fabric from the bottom and cut the leftover fabric.				
			3	Thread the sewn fabric over the entire base piece. Check the fabric.				
			4	Glue the fabric on the lower back of the base to the whitened skeleton with glue.				
			5	Staple the bottom of the base indicated by the dashed line shown in the figure, then the mounting location of the upper arm piece shown in figure 2 to the frame.				
			6	Drill screw holes where the upper arm piece in the 2nd image will be mounted. Screw the upper arm piece to the arm.				
			7	Staple the bottom of the arm piece of the whitened skeleton.				

Figure 11 Visual operation standard form of upholstery process (GST sofa)

The Impact of a Web Banner Position on the Webpage User Experience

Snježana Ivančić Valenko*, Damira Keček, Marko Čačić, Katarina Slanec

Abstract: Visual perception of a web banner depends on different parameters. Webpage template configuration and web banner position are important parameters that can affect the banner visibility. This paper aims to determine the impact of a web banner position on the banner visibility and webpage experience. Research was conducted by using an eye tracking technology. Four webpage templates were created for two groups of respondents. Webpage templates were based on a news portal wireframe and six different banners. Each respondent was exposed to the same set of four different web banners on left and right positions, but their placement on the webpage was changed for each group of respondents, while template complexity remained the same. Two other banners placed on the top position remained the same for both groups, since the emphasis is on evaluation of left and right web banner positions. Research results indicate that the web banner on the left position is noticed before the web banner on the right position. Although the web banner on the left position is noticed before, the web banner on the right position is on average viewed for a longer time. The analysis of a different web banner positions provides guidelines for web designers to improve web banner visibility and overall webpage user experience.

Keywords: banner position; banner visibility; eye tracking; user experience; web banner; webpage

1 INTRODUCTION

Websites are very important advertising outlets in the modern world since World Wide Web is the most popular media of today's information society. Advertisements are most often incorporated into websites as web banners, which can be static or even animated. Visual perception of a web banner depends on different parameters. According to Cho and Cheon [1], if visitors perceive banners as obstacles to achieving a certain goal, they are more likely to ignore them.

Graphic design of a web banner, webpage template configuration and banner's position on a webpage layout are important parameters that can greatly affect the webpage user experience. Most users tend to view webpage areas that are known as banner positions, such as top, left, and right side of the webpage. This paper aims to determine the impact of a web banner position on the banner visibility and webpage user experience. More precisely, banners on the left and right side of the webpage layout were observed. Some of the presented methods and results are based on work completed as part of the student final thesis entitled *The impact of graphic elements of web user interface on the user experience* [2].

2 PREVIOUS RESEARCH OVERVIEW

Effectiveness of a static banner placed on different positions on the screen was explored by Muñoz-Leiva et al. [3]. Four templates and four groups of participants were analysed. Each version of a template had static banner on different position: bottom-right, bottom-left, top-left and top-right of the webpage. Authors concluded that banners placed on the bottom-right and bottom-left positions are less visible and receive less attention. They also note that top-right is the best position on the screen, and banner on that side will be longer viewed. Different results that indicate participants are focused more on top and left of the page than other positions were obtained by Güner and İnal [4]. Calisir and Karaali [5] based their research on top-left, top-center and top-right positions on the webpage layout.

John and Sathiyaseelan [6] concluded that the position of an online banner affects its effectiveness. They observed four web banner positions – at right and left side, top and bottom of the webpage. Authors concluded that banner placed on the top of the webpage is noticed better than banner on the right position. There was no significant difference between left and right web banner positions. The same results were obtained by Goodrich [7].

The impact of banner format and animation on banner effectiveness is investigated by Li et al. [8]. Two banner formats (vertical banner on the side of the webpage and horizontal banner at the top of the webpage), and three types of animation (high, low, and static) were used. Horizontal banners were attracting more interactions than vertical banners, but vertical banners held user's attention longer than horizontal. Animated banners attracted more attention than static banners. Opposite results indicating that static banner attracted more attention were obtained by Lee and Ahn [9].

3 RESEARCH OBJECTIVES AND METHODOLOGY

The purpose of research in this paper was to examine the impact of left and right web banner positions on the banner visibility and webpage user experience.

In this research each respondent was exposed to the same set of web banners, but their placement on the webpage was changed for each group of respondents, while template complexity remained the same. The main hypothesis is that the banner positioned on the left side of the webpage will be noticed before the one positioned on the right side. That prediction is based on the conclusions made by Nielsen [10]. He discovered that web content is being read in F-shaped pattern, so we expect that the same observations are appliable to the web banners used in this research. Besides testing the beforementioned hypothesis, aim is to determine how long will respondents look on certain web banner position and then draw usable conclusions from study results.

Research in this paper was conducted by using a customized webpage templates that were based on a news portal wireframe and six different banners. Research involved first-year students of the Multimedia, design and

application undergraduate professional study at the University North in Varaždin, Croatia. Students were divided into two groups of respondents. Their task was to observe prepared templates while being recorded by the eye-tracking device. First group of respondents had to observe two webpage templates that displayed the news and three banners, one placed on the left and other on the right side of the webpage's main container, while third was placed on the top position, under navigation bar. Second group of respondents observed other two webpage templates that had news sections identical to the ones displayed on the templates for the first group, but left and right banners switched positions, while top banner remained intact. Banners that previously were on the left side of the webpage's main container now were placed on the right side, and vice versa.

Templates were prepared and displayed to the respondents as 1905×915px webpage layout pictures, without scaling, on a 21.5" Samsung LCD screen, model S22A350H. Screen aspect ratio was 16:9 and display resolution was set to the 1920×1080px. Relevant measurements were performed by the Gazepoint GP3 Desktop eye tracking device and processed by the Gazepoint Analysis 3.5.0 software.

In order to get precise and accurate measurements, eye-tracking device was recalibrated for every respondent. For some respondents recalibration could not be successfully performed, so they did not participate in this research. The respondent's distance from the screen was in the range of 60 to 80 cm and their face was parallel to the screen. Two webpage templates were shown to the respondents, each for 10 seconds.

3.1 Webpage Template Design

Webpage templates were designed to inspect web banner visibility and relevant parameters of the webpage user experience. Visual appearance of banners is based on randomly selected parameters since the emphasis of this research is on web banner position, not design elements.

One of the potentially most influential visual parameters is banner's background colour. Its impact was analysed by Lapa [11], also with eye-tracking device. Author observed banners that had either a white background with black text or white text on a coloured background. Research results showed that the banner background colour does not affect user behaviour [11].

According to the literature review, complexity of the webpage is more important parameter for this kind of research. Liu et al. [12] note that complexity of the webpage is very important as it affects the first fixation on the banner.

Four webpage templates were created for two groups of respondents. Webpage templates were based on a news portal wireframe and six different banners. Each respondent was exposed to the same set of four different web banners on left and right positions, but their placement on the webpage was changed for each group of respondents, while template complexity remained the same. Two other banners placed on the top position remained the same for both groups, since the emphasis is on evaluation of left and right web banner positions.

3.1.1 Webpage Templates for the First Group of Respondents

Fig. 1 shows the first webpage template for the first group of respondents. The template displays the main news, several other accompanying news on the page, and three different web banners, one positioned on the left, second on the right side of the webpage's main container, while third is placed on the top position. Left banner is named Banner_A, right banner is Banner_B, and top banner is Banner_E.
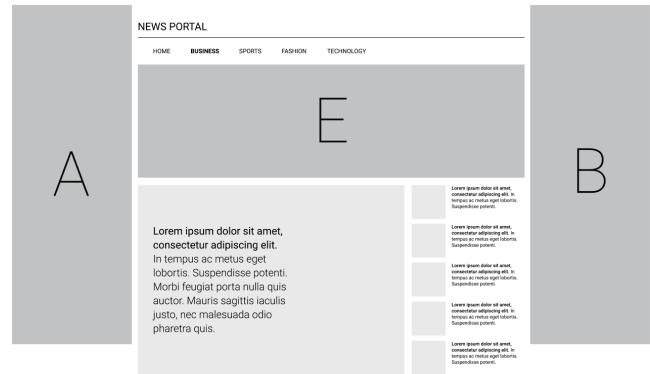
Figure 1 First webpage template for the first group of respondents

Second webpage template for the first group of respondents is shown in Fig. 2. The template structure is identical to the previous one, but content is different. As first webpage template, it shows the main news, several other accompanying news on the page, and three different web banners – one positioned on the left, second on the right side of the webpage's main container, and third is placed on the top position. Left banner is named Banner_C, right banner is Banner_D, and top banner is Banner_F.

Figure 2 Second webpage template for the first group of respondents

3.1.2 Webpage Templates for the Second Group of Respondents

Webpage templates for the second group of respondents are based on the same concept as the ones for the first group. Content of each template is same as previous, but banners switched positions. Left and right banners were swapped to determine if the web banner position affects its visibility, while top banner remained intact. Fig. 3 shows the first webpage template for the second group of respondents.
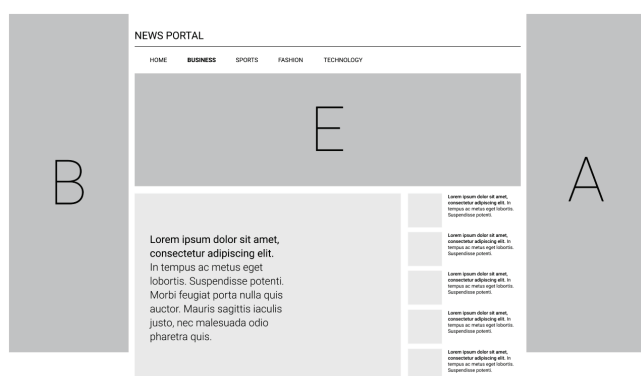
Figure 3 First webpage template for the second group of respondents

Similarly, Fig. 4 shows the second webpage template for the second group of respondents.

Figure 4 Second webpage template for the second group of respondents

4 STATISTICAL ANALYSIS AND RESULTS

In order to determine statistically significant differences in the time that each banner was viewed with regard to its position, a t-test for independent samples was applied. Before testing the hypothesis that the means of two groups are equal,

homogeneity of variances of the populations from which the samples were selected was tested using the Levene test. According to the results of the Levene test, in all analysed cases the variances are homogeneous. The differences confirmed at $p < 0.05$ were considered statistically significant.

Descriptive statistics, Levene and t-test results for the time that Banner_A and Banner_B were viewed regarding to their position are shown in Tab. 1. On average, the Banner_A on the right position was viewed longer than when it was placed on the left position, but difference in the recorded view times was not confirmed as statistically significant ($p > 0.05$). The same conclusion can be drawn for the Banner_B.

Tab. 2 shows descriptive statistics, Levene and t-test results for the time that Banner_C and Banner_D were viewed regarding to their position on the webpage. Banner_C on the left position was on average viewed longer than the same banner on the right position. Banner_D on the right position was on average slightly longer viewed than the same banner on the left position. According to the t-test results, significant difference in arithmetic means in both banners was not confirmed ($p > 0.05$).

According to the research results presented in Tab. 3, the time to first view of the Banner_B on the right position is on average twice as long as the same banner on the left position, and this difference is statistically significant ($p < 0.05$). The time to first view of the Banner_A on the left position is on average slightly longer than the same banner on the right position, but the significant difference in arithmetic means in this case has not been confirmed ($p > 0.05$).

The results show that the time to first view of Banner_C and Banner_D on the right position is on average longer than on the left position (Tab. 4). Differences in the time to first view of both banners with respect to their position on the webpage are statistically significant ($p < 0.05$).

Table 1 Descriptive statistics, Levene and t-test results for the time that Banner_A and Banner_B were viewed regarding to their position

| Time viewed (s) | Banner position | | | | | | Levene test | | t-test | |
| | Left | | | Right | | | | | | |
	N	Mean (s)	Standard deviation (s)	N	Mean (s)	Standard deviation (s)	F	p	t	p
Banner_A	29	1.09	1.15	25	1.21	0.89	0.161	0.689	−0.438	0.663
Banner_B	27	0.92	0.64	22	1.16	0.94	2.444	0.125	1.063	0.293

Table 2 Descriptive statistics, Levene and t-test results for the time that Banner_C and Banner_D were viewed regarding to their position

| Time viewed (s) | Banner position | | | | | | Levene test | | t-test | |
| | Left | | | Right | | | | | | |
	N	Mean (s)	Standard deviation (s)	N	Mean (s)	Standard deviation (s)	F	p	t	p
Banner_C	28	1.18	1.06	31	1.04	0.75	0.746	0.391	0.598	0.552
Banner_D	29	1.23	0.71	21	1.38	0.88	1.476	0.230	0.674	0.504

Table 3 Descriptive statistics, Levene and t-test results for the time to first fixation on the Banner_A and Banner_B regarding to their position

| Time to first fixation (s) | Banner position | | | | | | Levene test | | t-test | |
| | Left | | | Right | | | | | | |
	N	Mean (s)	Standard deviation (s)	N	Mean (s)	Standard deviation (s)	F	p	t	p
Banner_A	29	3.88	2.57	25	3.60	2.16	0.547	0.463	0.631	0.531
Banner_B	27	2.96	2.10	22	5.90	2.13	0.104	0.748	−4.688	0.000

Table 4 Descriptive statistics, Levene and t-test results for the time to first fixation on the Banner_C and Banner_D regarding to their position

| Time to first fixation (s) | Banner position | | | | | | Levene test | | t-test | |
| | Left | | | Right | | | | | | |
	N	Mean (s)	Standard deviation (s)	N	Mean (s)	Standard deviation (s)	F	p	t	p
Banner_C	28	3.23	2.84	31	4.92	3.19	0.697	0.407	−2.141	0.037
Banner_D	29	2.76	2.62	21	5.63	3.01	0.971	0.329	3.594	0.001

5 HEAT MAP ANALYSIS

Fig. 5, 6, 7 and 8 present heat maps generated by first and second group of respondents. Heat maps are showing visual attention of respondents and illustrate differences in perception between observed webpage templates and implemented banners.

By comparing Fig. 5 and Fig. 6, it can be concluded that the banner on the left side of the webpage is noticed first, while banner on the right is viewed in more detail.

Fig. 5 contains the overall average of what the first group of respondents observed in the first template. The red and orange colour on the heat map indicates that the respondents did not only watch, but also read the content of the main news. The content above the main news was also viewed and read but less than main news. The content of the left banner was viewed slightly more than the right banner, but the top part of the right banner was read more.
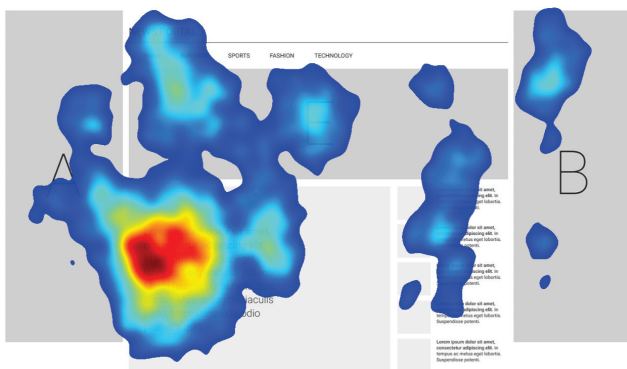
Figure 5 Heat map generated by first respondent group observing first webpage template
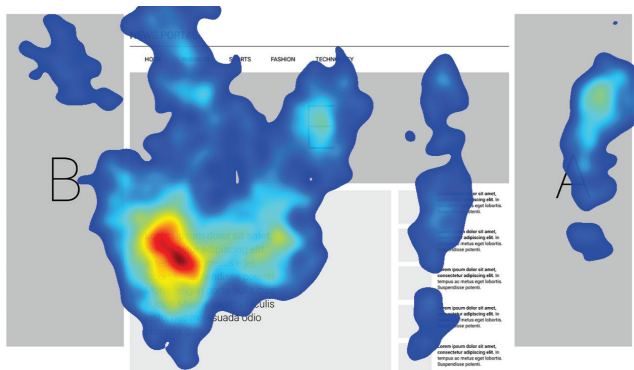
Figure 6 Heat map generated by second respondent group observing first webpage template

Fig. 6 contains the overall average of what was observed by the second group of respondents in the first template. This group of respondents observed Banner_A longer than previous group. It is obvious that the same banner was longer viewed when it was placed on the right position, than when it was on the left side of the webpage.

Fig. 7 contains the overall average of what the first group of respondents observed in the second template. The content of the left banner is viewed to the same extent as the right, but part the right banner was noticed much more.
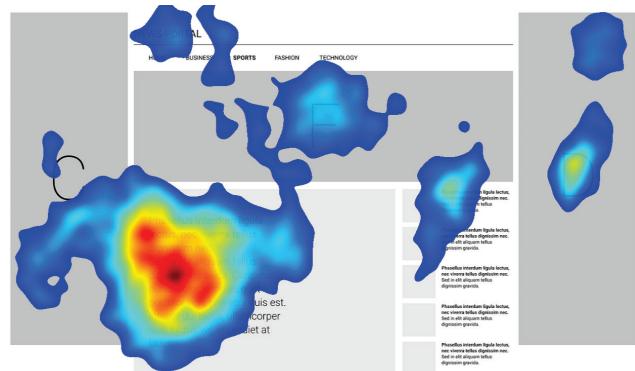
Figure 7 Heat map generated by first respondent group observing second webpage template

Fig. 8 contains the overall average of what the second group of respondents observed in the second template.

Figure 8 Heat map generated by second respondent group observing second webpage template

This group of respondents, unlike the previous one, equally noticed banners on the left and right side of the webpage. If we compare heatmap of Banner_C placed on the right position (Fig. 7) with the heatmap of the same banner placed on the left position (Fig. 8) it is obvious that it is much less viewed when placed on the left position.

In the Fig. 8, there was a deviation in that the left banner was viewed longer than the right, which was not the case in the previous three examples. This is attributed to the content of the banner itself. Incorporated graphic design components attracted the attention of the respondents, so it can be said

that with carefully selected graphic elements the area of interest can be redirected to another area.

Respondents first noticed the upper left side of the web banner, and later the right. Observation is in line with Nielsen's F-shape theory [10] which predicts that web content is being read from top to bottom and from left to right.

6 CONCLUSIONS

The aim of research in this paper was to determine the impact of left and right web banner positions on the banner visibility and webpage user experience. Research was conducted by using an eye tracking technology and customized webpage templates with integrated set of banners.

Four webpage templates were created for two groups of respondents. Webpage templates were based on a news portal wireframe and six different banners. Each respondent was exposed to the same set of four different web banners on left and right positions, but their placement on the webpage was changed for each group of respondents, while template complexity remained the same. Two other banners placed on the top position remained the same for both groups, since the emphasis is on evaluation of left and right web banner positions.

According to the research results, respondents in the first seconds of the conducted experiment mostly noticed the central part of the webpage, which was expected due to the layout configuration. The banner on top of the webpage was noticed before the main news.

Research results indicate that the web banner on the left position is noticed before the web banner on the right position. Although the web banner on the left position is noticed before, the web banner on the right position is on average viewed for a longer time and in more detail. Respondents first noticed the upper left side of the web banner, and later the right. Since the banner positioned on the left side of the webpage is noticed before the one positioned on the right side, the main hypothesis is confirmed.

Observations are in line with Nielsen's study [10] which states that web content is being read in F-shaped pattern, from top to bottom and from left to right. Future research could involve additional control survey that will question what respondents saw on the certain web banner. That additional information could be used in the process of web banner position efficiency determination and provide additional insights for advertising optimization.

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Analysis of Solar Chimney Power Plants Based on the Bam's Climate

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Abstract: One of the ways to generate power from the solar energy is to use the solar chimney technology. In the present study, by examining the weather map of Iran and using GIS software for selecting the appropriate area for the power plant site, the four physical models proposed studied for the solar chimney. This study is a numerical simulation (by MATLAB) regarding four physical models of solar chimneys in the city of Bam site, in Kerman province. The difference between the four mentioned models of the solar chimney is in storage system and the use of air diffuser. The behaviors of all four models were examined according to the valid meteorological information on a specific day from the target site. According to the results of the simulation, which includes airflow speed in several internal parts of the chimney and the production capacity of each of the mentioned models, the best and most proper model of solar chimney can be selected for the studies site and a proper estimation of the final production can be obtained.

Keywords: GIS software; numerical simulation; production capacity; solar chimney power plant; wind speed

1 INTRODUCTION

The quantity of energy consumption has significantly increased with the advancement of technology and industrialization of countries. Increasing the capacity of power grids depends on the investment and production of new power plant units. Due to declining fossil fuel reserves and increasing air pollution and global warming, researchers are trying to replace production units based on new and renewable energy instead of conventional units. The use of solar energy as a green and sustainable energy has always attracted the attention of researchers. Solar Chimney Power Plant is one of the new projects that will always be a place for innovation and research, and so far, general research has been done on this type of technology in Iran, but unfortunately, so far, no detailed study has been done due to the weather conditions in a specific place in Iran. The first example of this power plant was established in the Manzanares region of Spain, where researchers, after conducting research on the unit and other units, have reached better and more complete results about this technology. The effective parameters in the design of the solar chimney have been studied in [1]. These studies include changing the outlet and inlet radius of the chimney [2], types of heat storage systems and its effect on the solar chimney [3] and [4], the effect of collector surface on output power [5] and the effect of collector radius and the intensity of solar radiation [6] and the study of variables to increase the outlet of the solar chimney. Research(s) has also been conducted on the cost estimate for this project in India [7, 8 and 9]. Regarding the climatic conditions of Iran, which has desired areas for the construction of this type of power plant, such new and high-yield projects can be used as alternative infrastructure projects and other advantages of using this type of power plant can be applied. With a brief review of Iran's climate maps, especially in the central and eastern regions, it will be founded out that this new and clean technology is applicable there. We also consider the country's climate maps to find an ideal site over a 25-year period in terms of cloudiness, temperature, sunlight and wind intensity for establishing a site for Solar Chimney Power Plant [10]. Unfortunately, studies on this case have rarely been done in the Iranian climate. In the present study, by examining the four physical models [11] of the solar chimney and simulating the results of the existence of each and finally the output power of each model [12], a proper result can be obtained regarding the operation of the appropriate model for the site.

2 INVESTIGATION OF IRAN's WEATHER CONDITIONS

With reference to the necessary factors to study the mentioned plan, it is essential to study the whole area of Iran in terms of the rate of sunlight, the duration of sunlight, the rate of cloudiness and wind conditions in the studied areas. Iran, with an area of about 1,648,591 square kilometers, is located between 25 degrees and 3 minutes to 39 degrees and 47 minutes north latitude and 44 degrees and 5 minutes to 63 degrees and 18 minutes east longitude, so in terms of receiving Solar energy is among the highest in the world. Due to this feature, it has great potential for exploiting natural resources and energies. In order to reach the best and most proper place in Iran to establish the Solar Chimney Power Plant site, we need to study the desired parameters, such as the amount of sunlight, the amount of cloudiness in the area and the intensity of the wind.

2.1 Zoning of Iran's Regions in Terms of Solar Radiation

Iran has a four-season climate. As observed in the Fig. 1, Iran is divided into four climatic zones on the map. The Northern Belt (Region1) has a humid and rainy climate. The western region (Region2) has a temperate and cool climate, the central and southeastern regions (Region3) have hot and dry climates and the southern belt (Region4) has a warm and humid climate.

This division can also be considered based on the intensity of the sun's radiation. Fig. 2 indicates the hourly average of solar radiation through the years 1981-2007. As shown in Fig. 2, the most sunlight radiated areas of Iran are in Region 3.

Fig. 3 indicates the average hours of solar radiation through the months of the years (1986-2005) that the region

(3) is marked in red, which is higher than other highly sunlight radiated areas, including areas 2 and 4 which are the highest ones.
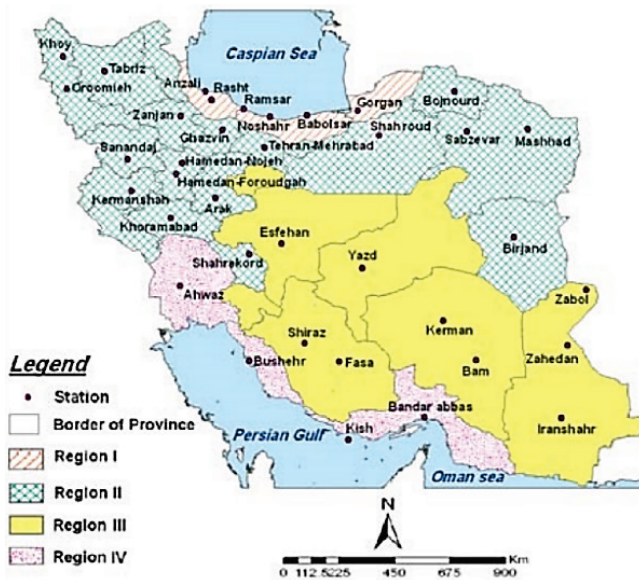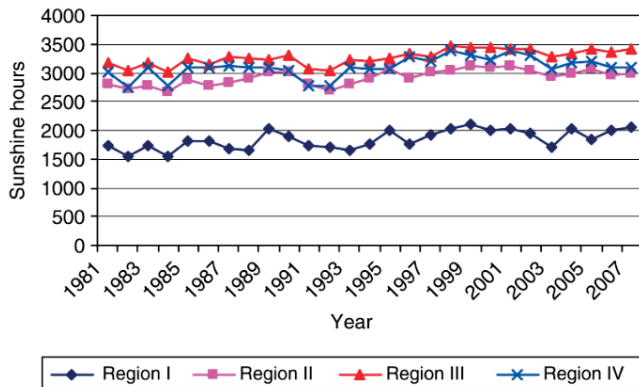

Figure 1 Climate map of Iran

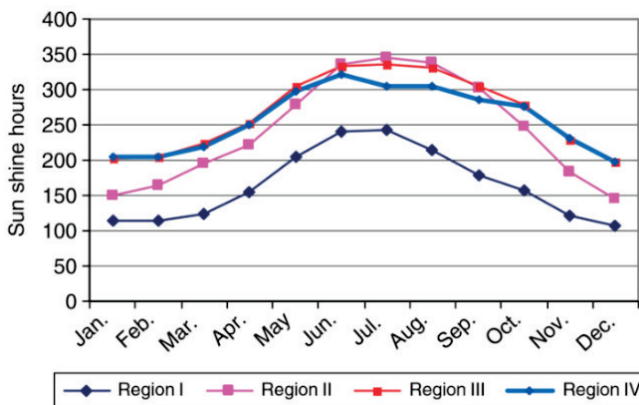**Figure 2** The average hourly sunlight through the years 1981-2007

Figure 3 The average hours of solar radiation in the months of the year

2.2 Zoning of Iran's Regions in Terms of Cloudiness

One of the main factors in choosing the right site to establish Solar Chimney Power Plant is the low cloudiness of the region. Fig. 4 indicates the annual zoning of Iran in terms of the number of days with the least amount of cloudiness. As observed, parts of Kerman province and South Khorasan province are the most sunlight radiated regions of Iran based on the least cloudy days.
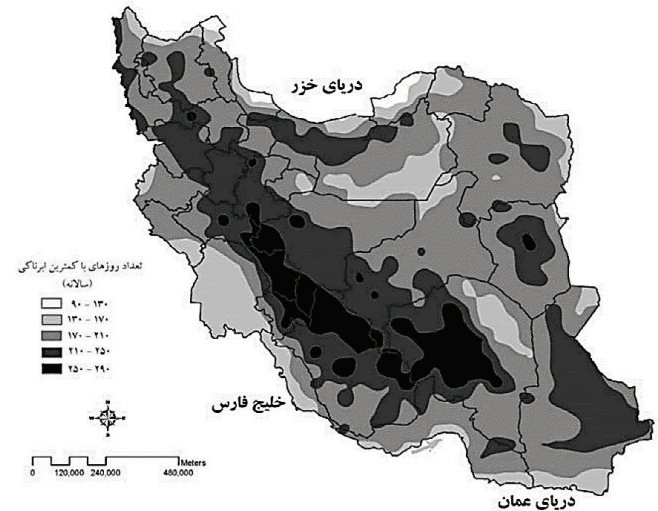
Figure 4 Annual zoning of Iran in terms of the number of days with the least amount of cloudiness

2.3 Zoning Regions in Terms of Temperature

Fig. 5 indicates the average temperature map of all regions of Iran. It is observed that the maximum temperature is related to the southern belt and southeastern region of Iran [16].
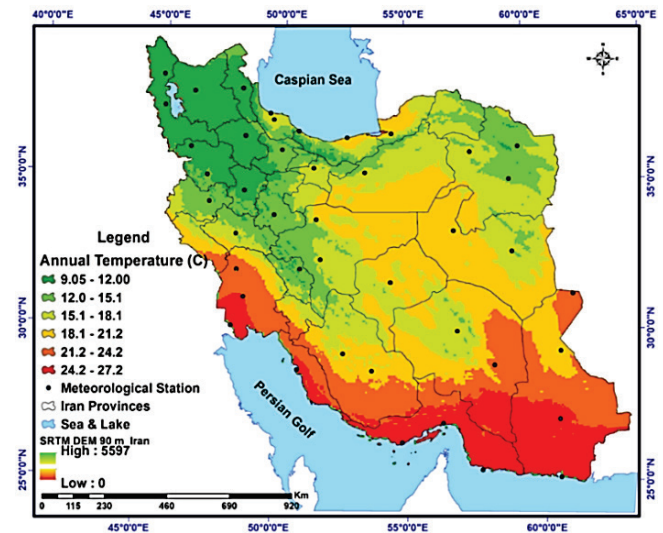
Figure 5 Average temperature map of regions in Iran

2.4 Zoning Regions in Terms of Wind Intensity

Toward using solar chimney technology, in addition to high solar radiation, high temperature and a dry, cloudless area, a low wind area without sandstorms is needed. The lower the wind, the more proper the site will be. Fig. 6 indicates a map of Iran in terms of average wind speed [17].
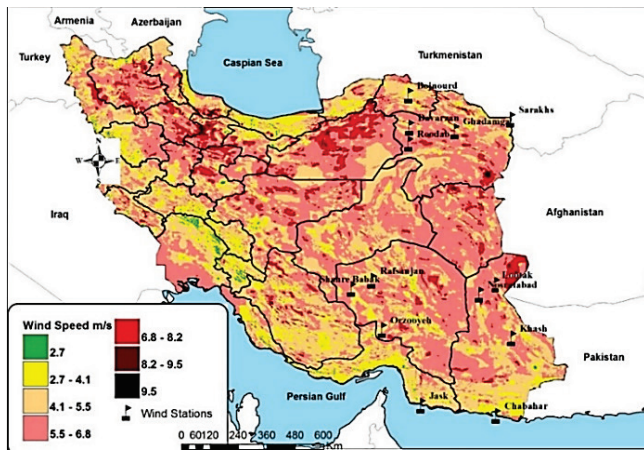
Figure 6 Average wind speed map of regions in Iran

2.5 The Average Amount of Solar Radiation in Four Climatic Zones

As observed in Fig. 1, four climatic regions have been identified for Iran, and Fig. 2 compares these areas based on the hours of solar radiation. Tab. 1 lists the cities in each area, and for each of these cities, the average hours of solar radiation in the seasons of spring, summer, autumn, and winter, as well as the average annual hours of solar radiation through the years of 1981 and 2007, are listed. Tab. 1 indicates that the city of Bam in Kerman province has the highest amount of radiation and Ramsar has the lowest amount of solar radiation.

Table 1 The average hours of solar radiation in spring, summer, autumn and winter, as well as the average annual hours of solar radiation through the years 1981 and 2007 for the Iranian cities

Region	Station	Spring	Summer	Autumn	Winter	Annual
I	Anzali	593.1	636.8	308.6[a]	291.1[a]	1829.7
	Babolsar	616.6	640.0	388.2	356.1	2000.9
	Gorgan	598.4	655.1	488.8	407.6	2150.9
	Noshahr	531.5	525.5	388.7	350.7	1796.4
	Ramsar	473.7[b]	481.9[a]	321.4	298.1	1575.1[a]
	Rasht	521.3	556.7	310.1	295.8	1684.0
	Avg.	555.8	582.7	367.6	333.2	1839.5
II	Arak	859.1	971.5	586.7	537.7	2955.0
	Birjand	891.2	1027.5	698.1	610.4	3236.5
	Bojnourd	782.1	937.4	556.5	451.2	2727.2
	Ghazvin	857.3	1010.4	563.2	518.7	2949.5
	Hamedan- Foroudgah	862.7	1001.3	562.4	507.3	2933.7
	Hamedan-Nojeh	811.8	973.5	561.7	487.8	2834.8
	Kermanshah	837.4	997.7	568.2	494.3	2897.6
	Khoramabad	847.5	995.7	612.6	539.3	2995.1
	Khoy	764.3	961.7	473.6	433.6	2633.2
	Mashhad	832.6	1036.1[b]	571.8	446.6	2887.2
	Oroomieh	842.8	1020.7	530.9	481.2	2875.7
	Sabzevar	863.9	1003.9	639.0	542.8	3049.6
	Sanandaj	837.0	969.2	557.1	487.3	2850.6
	Shahrekord	896.3	987.1	672.3	626.6	3182.3
	Shahroud	852.3	967.7	602.1	562.7	2984.8
	Tabriz	805.8	990.8	529.9	462.1	2788.6
	Tehran-Mehrabad	856.5	989.4	584.7	546.2	2976.8
	Zanjan	827.9	993.3	543.3	492.4	2857.0
	Avg.	840.5	990.8	578.6	512.7	2923.1
III	Bam	906.2	990.9	791.3	698.7	3387.0[b]
	Esfehan	911.5	1014.2	692.7	658.8	3277.2
	Fasa	949.0[b]	971.2	760.2	678.4	3358.9
	Iranshahr	887.6	853.1	810.6[b]	711.0[b]	3262.4
	Kerman	850.8	998.9	624.8	547.4	3022.0
	Shiraz	943.2	992.3	747.7	671.4	3354.7
	Yazd	899.8	1014.7	711.9	634.1	3260.5
	Zabol	894.3	923.9	720.4	628.7	3167.4
	Zahedan	900.5	987.1	761.4	663.0	3311.9
	Avg.	904.8	971.8	735.7	654.6	3266.9
IV	Ahwaz	859.6	983.6	645.9	596.6	3085.7
	Bandar Abbas	870.6	800.4	745.0	651.8	3060.9
	Bushehr	844.9	923.3	681.5	601.3	3051.0
	Kish	906.8	881.7	755.5	657.4	3201.5
	Average	870.5	897.3	707.0	626.8	3099.8

[a] Lowest value in the season/annual. [b] Highest value in the season/annual.

3 SELECTING THE PROPER AREA FOR THE SITE

Through observing the weather map of Iran and estimations in terms of temperature, solar radiation, cloudy days, the lowest amount of wind and data analyze with GIS software, one may select the most proper place for Solar Chimney Power Plant site. In keeping with the mentioned information, Region 3 is the best area in terms of solar radiation and according to Fig. 4, Kerman and Fars Provinces have the fewest cloudy days. In line with Fig. 5, the provinces of Kerman and Sistan and Baluchestan have all the required conditions based on the above results. Tab. 1 indicates that the highest hours of annual solar radiation relate to the city of Bam, which is located in Kerman province. Therefore, it can be stipulated that the city of Bam is a proper choice for the power plant site. Bam is located in the eastern part of Kerman province. The city has latitude of 29 degrees and 9 minutes north and a longitude of 58 degrees and 21 minutes east, which is 1067 meters above sea level. Fig. 7 indicates the average annual temperature in Bam. The maximum temperature of this city is 39 degrees Celsius, which is practically a proper temperature for exploiting this technology. Fig. 7 indicates the difference between the maximum and minimum temperatures of the city, which is very important and practical. The highest temperature will be on 3rd day of July, according to which Fig. 12 and Fig. 13 will be extracted [18].
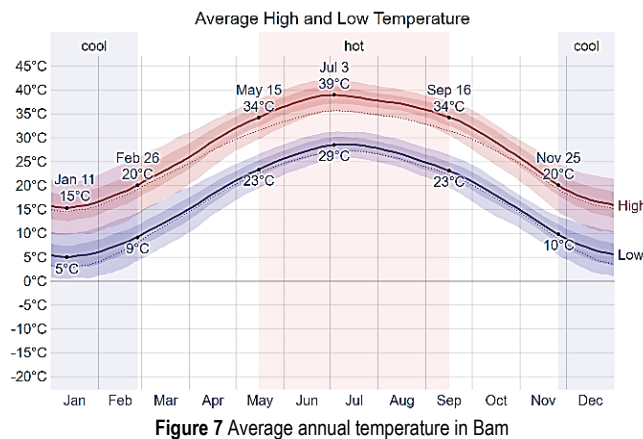
Figure 7 Average annual temperature in Bam

4 THE STUDIED SOLAR CHIMNEY MODELS

Four physical models of solar chimneys are examined in this study. For the ease of review and the same results, the collector surface and its material and the height of the chimney and its material are considered the same in all four models. The height of the chimney of all four models is 200 meters with a diameter of 10 meters. The collector has the same material and specifications, 245 meters in diameter and 2 meters above the ground. Fig. 8 indicates the first model of a solar chimney, in which water and soil are used as storage systems. In addition to using soil as a proper storage, it is covered with water to a height of 10 cm. The water is covered with a transparent coating to prevent surface evaporation of water.
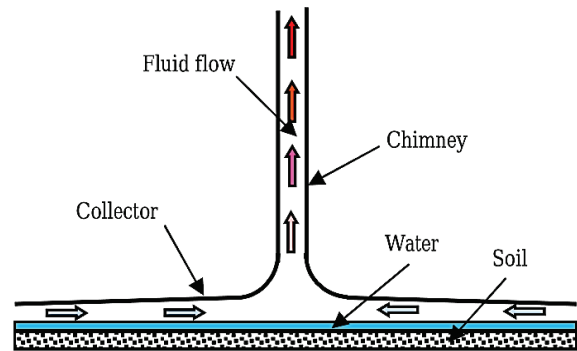
Figure 8 The first model of the solar chimney
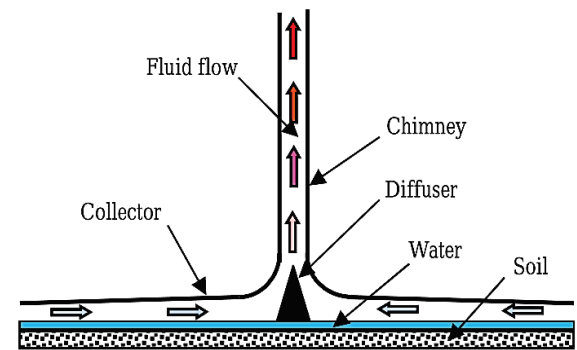
Figure 9 The second model of the solar chimney
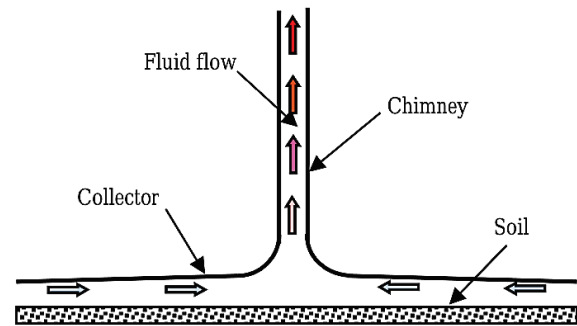
Figure 10 The third model of the solar chimney
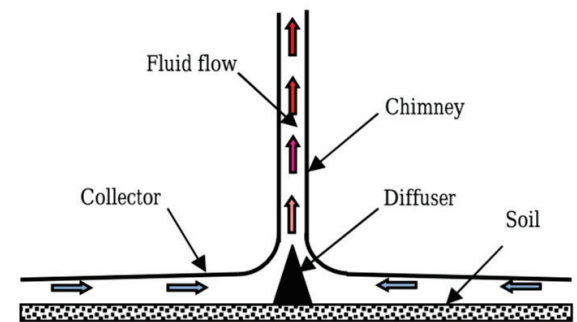
Figure 11 The fourth model of the solar chimney

Fig. 9 indicates the second model of the solar chimney that uses a diffuser at the entrance to the chimney.

Fig. 10 indicates the third model with soil storage. Fig. 11 indicates the latest model of solar chimney, having a soil storage system and a distributor at the entrance to the chimney.

5 EQUATIONS GOVERNING THE SOLAR CHIMNEY

Eq. (1) shows the efficiency of the solar chimney. In Eq. (1), Q is the power inlet from solar radiation based on w, p_{elec} is also the electric power of the solar chimney based on w, η_t is the efficiency of the turbine based on kg/m^3. $\rho_{a,o}$ is the density on kg/m^3. A_t and u_t respectively are area and velocity based on m^2 and m/s. G is the intensity of the solar radiation is based on w/m^2 and A_{coll} is the collector surface in m^2.

$$\eta = \frac{p_{out}}{p_{in}} = \frac{p_{elec}}{Q} = \frac{\frac{1}{3}\eta_t \rho_{a,o} A_t u_t^3}{G A_{coll}} \tag{1}$$

The maximum efficiency can be obtained from the Eq. (2). R_{coll} is the radius of collector based on meter.

$$\eta_{max} = \frac{p_{max}}{Q} = \frac{p_{max}}{G A_{coll}} = \frac{p_{max}}{G \pi R_{coll}^2} \tag{2}$$

But the maximum power can be obtained from the Eq. (3).

$$p_{max} = \frac{p_o}{p_i} \cdot \frac{\pi g}{c_p T_o} H R_{coll}^2 G \tag{3}$$

In Eq. (3), p_o and p_i is the static pressure outside and inside of the chimney based on w, c_p is the specific heat capacity of the air based on J·kg^{-1}k^{-1}; T_o is ambient temperature based on k and g is gravitational acceleration based on m/s^2. The electric power can be obtained Eq. (4). η_g is the efficiency of the generator.

$$p_{elec} = \eta_g p \tag{4}$$

Eq. (4) can be expressed in another way [13].

$$p_{elec} = \frac{2}{3}\left(\eta \frac{gH}{c_p T_o} A_{coll} G\right) \tag{5}$$

In Eq. (5), H is the height of the chimney tower in meters. Regarding our specifications and information about the environment and the solar chimney, it is possible to obtain maximum electrical power using Eq. (6). Using Eqs. (7), and (8), the efficiency of other parts of the chimney can be obtained [14, 15].

$$\eta_{coll} = \frac{\dot{m}\Delta h}{G A_{coll}} \tag{6}$$

$$\eta_{ch} = \frac{gH}{c_p T_o} \tag{7}$$

$$\eta_{scpp} = \eta_{coll} \eta_{ch} \eta_T \eta_{gen} \tag{8}$$

In Eq. (6), $\dot{m}$ is the mass flow rate based on kg/s and Δh is the airflow enthalpy J/kg. based on meter. In Eq. (8), the efficiency of the solar chimney power plant is obtained with the multiplication of the whole efficiency where η_{ch} is the efficiency of the chimney, η_T is the efficiency of the turbine and η_g is the efficiency of the generator.

6 RESULTS FROM THE SIMULATION

In order to perform this simulation and simplify the assumptive computations that have considered through this study, the relative input pressure of the collector is considered zero (0) and the temperature of the storage system is considered constant. The chimney tower also has insulating walls. The studies were carried out based on the weather conditions in the central region of Iran, Kerman province, the city of Bam and according to the temperature and the amount of solar radiation on the third day of July. In Fig. 12, the temperature of Bam was given for the 24 hours of the third day of July [18].
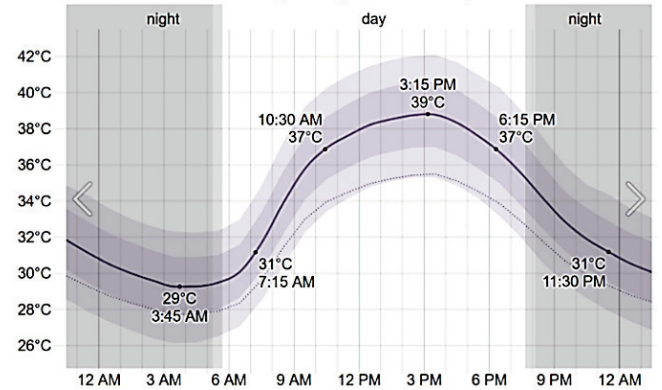
Figure 12 The city of Bam temperature during the 24 hours of the third day of July

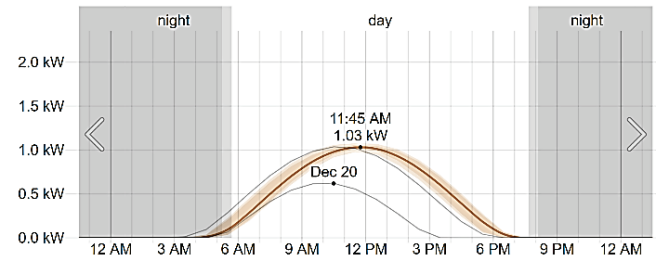Fig. 13 indicates the amount of solar radiation for 24 hours based on kW on the third day of July [18].

Figure 13 The amount of solar radiation during the third day of July

Depending on the temperature and the amount of radiation in the studied site, the necessary results can be extracted. Fig. 14 indicates the average airflow speed at the collector outlet.

Fig. 15 also indicates the average airflow speed at the chimney inlet at a height of 2 meters.

Fig. 16 indicates the average speed of airflow at the chimney inlet at a height of 6 m inside the chimney.

Fig. 16 indicates the average speed of airflow at the chimney inlet at a height of 6 m inside the chimney. Fig. 17

indicates the airflow speed at eight meters' height of chimney.
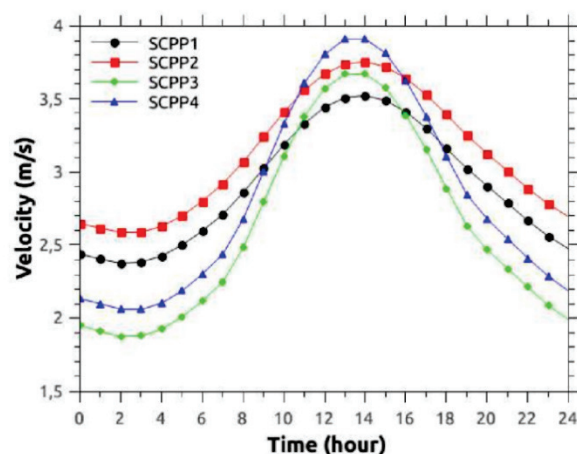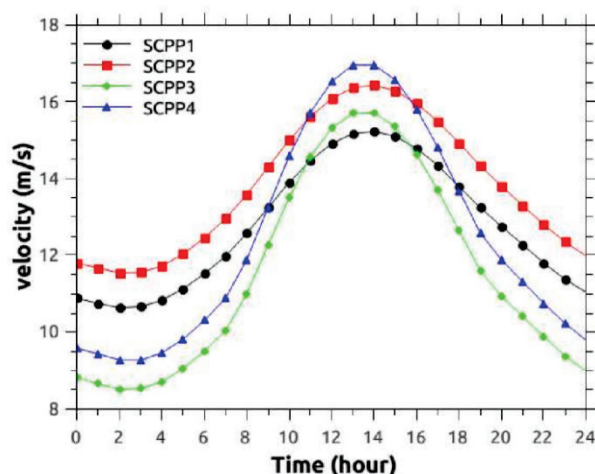

Figure 14 Airflow speed at collector outlet

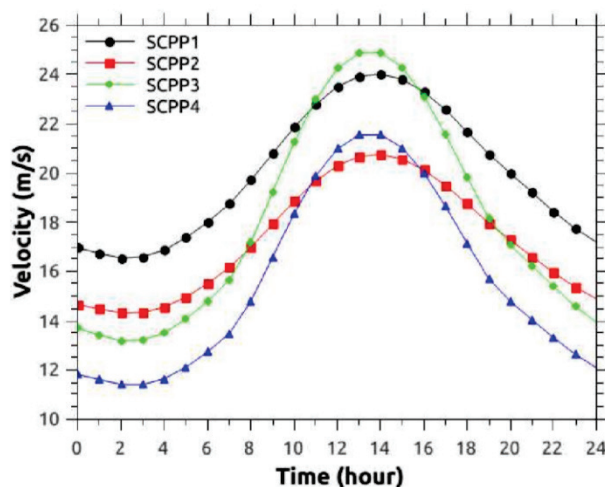**Figure 15** The airflow speed at a height of two meters in the collector

Figure 16 Airflow speed at six meters' height of collector

The results of the above figures are significant. It is obvious that the highest airflow speed occurs during solar radiation times. In models (1) and (2) where the storage is used, the average rate of airflow at sunset is much higher than in models without storage. In the case of the diffuser, which is in models 2 and 3 at the collector outlet, it increases the airflow speed at the collector outlet and the 2 meters height of the chimney. But at a height of 6 and 8 meters, the chimney has the opposite effect and reduces the speed of airflow. Another point is that during the hours when we have the highest amount of solar radiation, between 11:00 and 16:00 o'clock, in models that have a storage system (models 2 and 4), the average air speed decreases compared to similar models without a storage system.
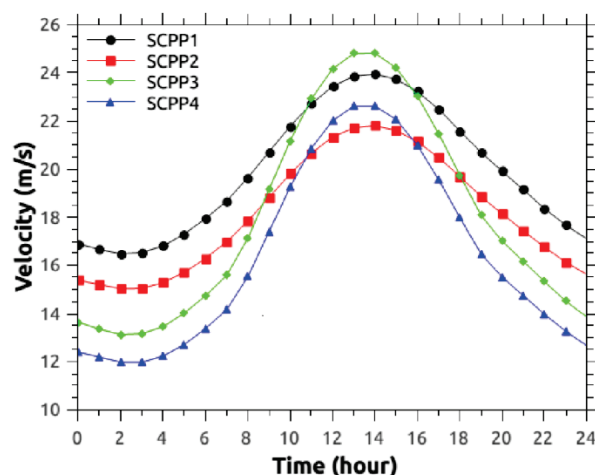
Figure 17 Airflow speed at eight meters' height of collector
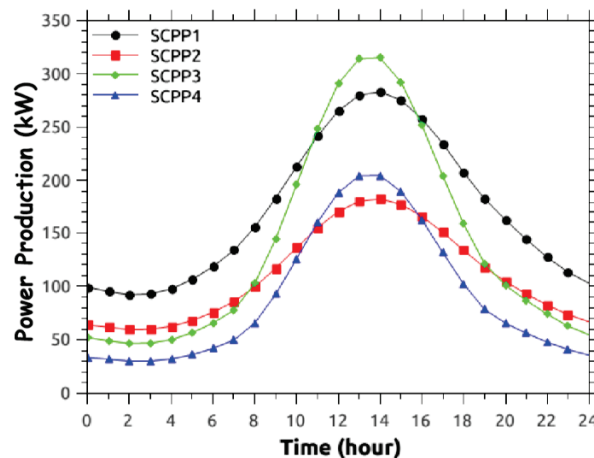
Figure 18 The average production capacity of a solar chimney in terms of kW

Fig. 18 indicates the average production capacity in kW, based on the 24 hours of the third day of July. The maximum power output is 300 kW, which is produced by Model 3. The second production of 260 kW is related to model 1. The fourth model has about 200 kW in maximum production mode and 170 kW is the share of the fourth model. Figure 18 indicates that at sunset, models 2 and 4 that have a storage system with more production capacity than similar models without storage. It is important to note the effect of the diffuser that models without distributors (models 1 and 3) have far more power production, having more significant power than models with diffusers (models 2 and 4). The

reason for this could be a decrease in the level of the inlet section as well as an increase in the chimney inlet, which reduces the production capacity. The use of airflow diffuser at the collector outlet at a height of 6 meters and higher heights will be efficient and will increase the airflow speed. However, at lower heights, it will have the reverse effect.

7 CONCLUSIONS

Numerical analysis of airflow in the case of four models of solar chimney and production capacity of each model on a specific day (July 3rd) based on annual meteorological patterns was performed on the site of the city of Bam of Kerman province. Comparing the results, it was found that models that have a heat storage system (water and soil) without an air diffuser will be more efficient and effective. The use of solar chimneys in Iran can be a proper solution to increase the capacity of the network and the use of clean and new technologies. Taking into consideration the results of the study of four models of solar chimneys, a good viewpoint is available about the use of the optimal model in the desired site. Taking into account this technology of energy production and investment in renewable energy issue, the most sunlight radiated areas can be considered as a hub for the use of this type of technology, which will not only benefit from the energy produced, but also the target site may be the research site for this technology. Many other articles have discussed the use of other benefits, including the greenhouse space under the collector, which can also be used on the site. Due to the novelty of the mentioned technology, several additional research can be done on the production costs of this technology based on the generated electric power, the study of other materials that can be used in the construction of chimneys and collectors and estimating the costs of the project implementation in terms of affordability.

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Constructive Improvements in the In-Ladle Treatments - A Comparative Industrial Study

Imre Kiss

Abstract: Nodular gray cast iron having properties superior to conventional gray cast iron can be produced by treating the molten iron so that, when cast, the graphite will be compacted rather than in flake form. One such treatment involves the introduction of magnesium (Mg) into a molten iron bath of such composition. It is the principal object of the present industrial experiments to provide an improved process for the ductile cast iron production. Another object is to provide a process which permits the efficient use of the nodulizing agents, which results in the efficient production of an improved homogeneous nodular cast iron. Essentially such treatments result in the retention by the cast iron of small amounts of nodulizing agents, for example magnesium (Mg). Conventionally these agents are added to cast iron, usually in the form of pre-alloys and the efficiency of the process is illustrated by the high assimilation of the added nodulizer's constituents. Another object of this technological practice is to provide an improved method for introducing the nodulizing agents, using constructive improvements to the in-ladle equipment. Finding magnesium (Mg) using novel techniques is the first step to advance the understanding of the role of magnesium (Mg) in the formation of the nodular graphite, the mechanism behind nodular graphite formation due to the addition of Magnesium (Mg) being still relative unclear at present time. Moreover, this may advance new methods to improve the nodulizing treatment process. This study take into account the flexibility of the used technique, which describes the elasticity of the treatment process, by improvement or alternative to the existing one. As nodulizing agents magnesium-ferrosilicon (Fe-Si-Mg type) and cerium-magnesium-ferrosilicon (Nodulin type) are examples of materials containing nodulizing agents that have given excellent results in the mixture. This experiments relates to a process for the production of ductile iron (nodular gray cast iron) and particularly to a process for adding magnesium (Mg) to the melted iron.

Keywords: assimilation degrees; constructive improvements; ductile cast iron (nodular graphite iron); in-ladle treatments; magnesium (Mg); nodulizing agents; silicon-based pre-alloys

1 INTRODUCTION

Nodulization in cast irons is a process of controlling the structure and properties by changing the graphite shape from flakes to spheroidal, during the solidification process [1-6]. The nodularizers are added into the liquid iron to promote the formation of spheroidal (or compacted) form of graphite, specific for the ductile irons. Therefore, a certain quantity of nodularizing agent is necessary to obtain the spheroidal (or compacted) form of graphite [1-9]. So, production of ductile iron with consistent properties is generally accomplished by the addition of nodulizing elements in the iron alloys [1-9]. Nodulizers such as magnesium (Mg), cerium (Ce) and rare earth elements, alone or as pre-alloys, promote the formation of spheroidal graphite in iron. Among these, magnesium (Mg) is the most commonly used in the production of ductile iron [1-9].

Depending on the characteristics of each pre-alloy used as nodulizing agent, different treatment techniques are used. Among these, the most widely used are the in-ladle, the in-mould, and the flow-through methods, the first being the most used [3-9]. Most in-ladle treatments involve the use of pre-alloys (usually magnesium-ferrosilicon) in a specially prepared ladles, as in the open ladle (sandwich) and covered ladle (tundish) processes. In the practice of nodulization it is demonstrated that, compared to open ladle techniques, the use of a covered ladle gives better magnesium (Mg) assimilation with much less fume [4-9].

Nodular cast iron is made by adding to the cast iron under the proper conditions a quantity of a nodulizing agent and inoculating the cast iron [1-9]. The treatment results in a cast iron in which free graphite appears in compacted or nodular form rather than as flakes [1-4, 10-11]. Recent discoveries have established that certain advantages accrue when the elements necessary to nodulizing the cast iron's graphite are used by in-ladle treatment [4-9].

Over the years, in the history of nodular graphite irons, numerous and different treatment processes have developed. Some, the best performing, were accepted, others were rejected a long time ago. The first procedures used spear injection and ladle shaking to achieve the nodulization, and many of these can no longer be seen in the modern foundries, being out dated. Currently, the most widespread processes are those with in-ladle treatment, with ordinary bottom, or those with special construction, which use, in particular, silicon-based nodulizers (class of Fe-Si-Mg) [3-13].

Figure 1 Silicon-based (light) master alloys as nodulizer
(a) magnesium-ferrosilicon lump; (b) magnesium-ferrosilicon granular;
(c) magnesium-ferrosilicon briquette; (d) magnesium-ferrosilicon powder

The properties of cast iron can be improved by the addition to it of nodulizing elements, commonly cerium (Ce), magnesium (Mg) or both, added, suitably, by various technological techniques [1-9].

In nodulizing of cast iron with the treating agent and according to the nodulizing process, the sulphur (S) content of the iron needs to be treated as an important factor [1-5, 9-13]. In general if a substantial amount of nodulization is to be obtained efficiently the sulphur (S) content of the iron prior to the adding of the treating agent should not exceed about 0.02%. For best results the sulphur (S) content should not exceed 0.01% [1-5, 9-13]. The reduction of the sulphur (S) content of cast iron to the indicated low values may be accomplished conveniently by the adding of nodulizing agent into the melted iron.

In view of the above–described problems, it is one objective to provide a method for producing nodular cast iron by using a nodulizer and a spheroidizing device that effectively solves problems of violent reaction and low adsorption rate of effective nodulizing elements [1-5, 9]. The treatment method need to be capable of accurately controlling the reaction time of the spheroidizing, improving the product quality, lowering the production cost, effectively using the resource, and obviously improving the manufacturing process of the nodulizer and the environment of the spheroidizing process [1-5, 9, 13].

Since the start of ductile iron production the simple ladle treatment has undergone various developments, all of them trying to improve the consistency of the nodulizing process and thus favouring adding as lesser magnesium (Mg) as possible [1-5, 9]. Thus have evolved the treatment procedures, from simply immersion with the plunging bell, to the in-ladle treatments, with a pocket or pockets [3, 4, 9]. These processes (i.e. Plunging, Sandwich/Over pouring, Trigger) are joined by those that introduce a cap on top of the treatment ladle into the nodulization technology. In this category of in-ladle treatments with cover, significant is the Tundish-Cover process. During cast iron treatment, such technique would ensure recovery of magnesium (Mg) reaction thanks to the pressure generated inside the ladle and to the contact of the magnesium (Mg) with the metal bath.
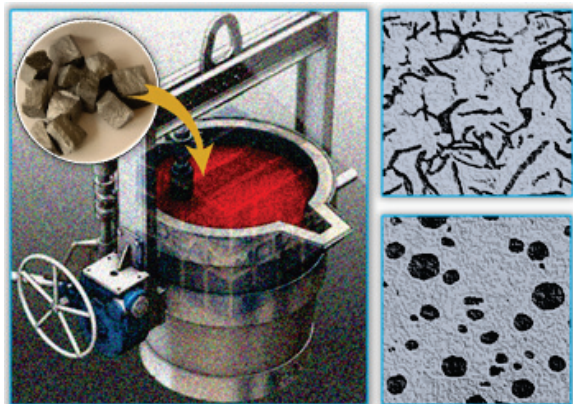
Figure 2 In-ladle treatment

The Trigger process can be improved in order to increase the magnesium (Mg) assimilation. Thus, a proposed solution consists in the arrangement at the ladle bottom of two or more pockets, arranged equidistantly, in which the nodulizers (same nature or of different sorts) are introduced. The nodulizers can be protected with calcium carbide layers like in the conventional technologies (Sandwich or Trigger). This layers will be perforate, successively, triggering a series of change reactions, time–appropriated, lasting only a few tens of seconds [1-5, 9]. Theoretically, the nodulizing effect increases. And practically this has been experimented under foundry conditions, in special ladle with two or four pockets, arranged equidistantly and symmetrically.

2 IN-LADLE TREATMENT METHODS

A number of in–ladle treatment techniques have been developed to prepare ductile iron over the years [1-5, 9]. The most common treatment techniques in use today are the immersion (plunging) process, the open ladle process, the sandwich process (with special pocket), and covered ladle (tundish) process [1-5, 9]. Today, the majority of ductile iron castings made throughout the world are produced using ladle-metallurgy practices with Fe-Si-Mg alloys [1-5, 9].

In-ladle treatment is one of the most common technology used in foundries due to its simplicity. For in-ladle treatment, the magnesium-ferrosilicon is introduced into a pocket built into the bottom of the ladle and is then covered with either steel punching [1-5, 9, 13]. As a way of increasing the assimilation of magnesium (Mg) from the pre-alloy, in order to achieve the nodulization of the graphite of cast iron, changes made constructively to the treatment ladle were used [1-5, 9]:

- The classic Trigger method (Fig. 3) uses a ladle with a pocket, in which the agent is placed. This method is an improved variant of the open ladle process. In this process, the magnesium-ferrosilicon is introduced into pocket built into the bottom of ladle [1-5, 9].
- The Trigger method with covered pocket (Fig. 4) uses a ladle with a pocket, in which the nodulizer is placed, over which a layer of calcium carbide is placed [1-5, 9]. The liquid iron causes a layer of slag over the nodulizing alloy, which prevents, for the time being, direct contact between the iron and the nodulizer. After filling the treatment ladle, the slag layer is perforated with a steel bar, thus making contact between the iron and the nodulizing agent [1-5, 9].
- The Trigger method with 2 covered pockets (Fig. 5) uses a treatment ladle with two symmetrical pockets, in which the nodulizer is placed [1-5, 9]. After the nodulizing in two steps, the slag formed on the surface of the metal bath is removed, the cast iron is discharged into another ladle and before pouring into the mould, a post–nodulizing with FeSi75 is made.
- The Trigger method with 4 covered pockets (Fig. 6) uses a treatment ladle with four symmetrical pockets, in which the nodulizer is placed [1-5, 9]. After the nodulizing in four steps, the slag is removed and a post–nodulizing is made (with FeSi75).
- The Tundish-Cover process, based on Trigger classics (Fig. 7), is a further improvement of an open ladle by applying a special cover [1-5, 9].
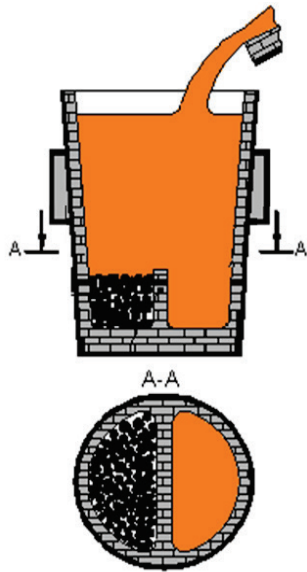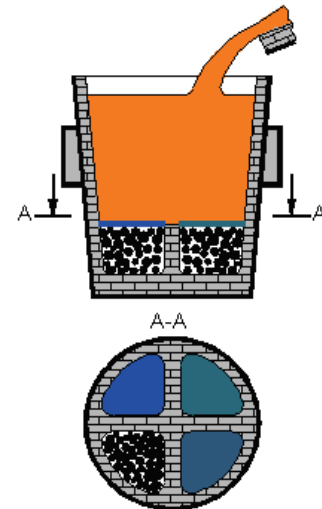
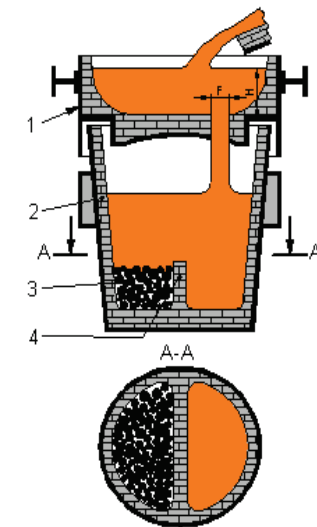**Figure 3** The Trigger method (classic, uncovered pocket) - Trigger I
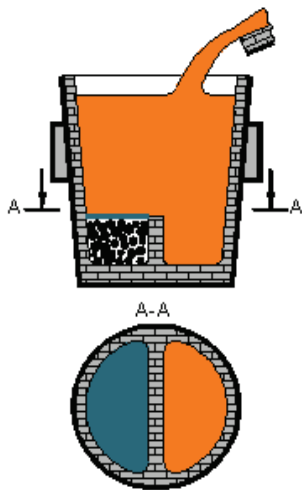
Figure 4 The Trigger method with 1 covered pocket - Trigger II
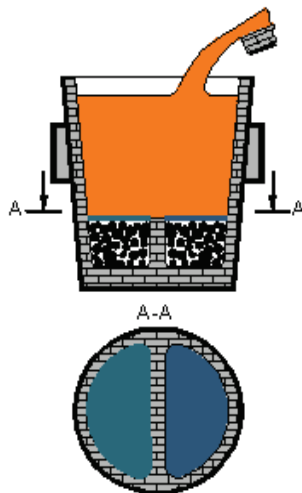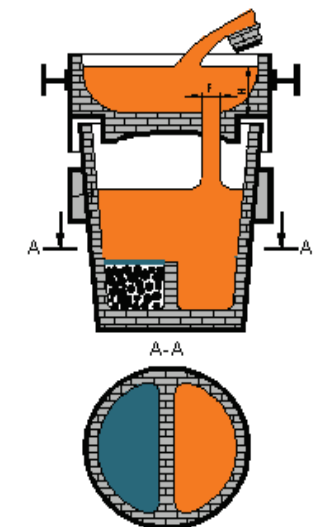

Figure 5 The Trigger method with 2 covered pockets - Trigger III

Figure 6 The Trigger method with 4 covered pockets - Trigger IV

Figure 7 The Tundish process based on Trigger classics (uncovered pocket) – Tundish-Cover I

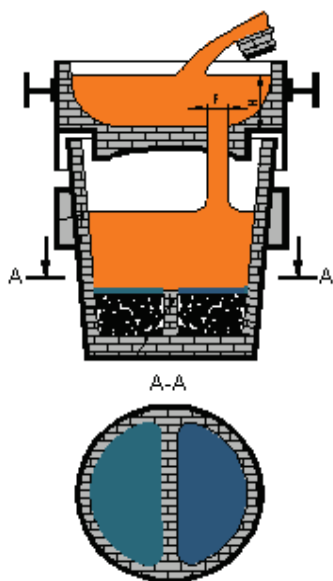**Figure 8** The Tundish process based on Trigger method with 1 covered pocket - Tundish-Cover II

Figure 9 The Tundish process based on the Trigger method with 2 covered pockets - Tundish–Cover III
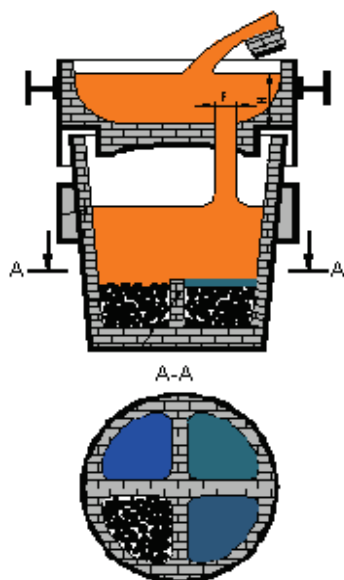
Figure 10 The Tundish process based on the Trigger method with 4 covered pockets – Tundish-Cover IV

- A covering material is also possible in Tundish-Cover II (Fig. 8), though generally in lesser quantities than used in the classic technique. The classic version is also used, but the nodulizer is covered before the cast iron is fully discharged into the treatment ladle.
- In Tundish-Cover III (Fig. 9) the improved method of the Trigger process is used, with a special nodulizing ladle, having two pockets in the bottom, making a first step nodulizing, with two reactions, at small intervals.
- In Tundish-Cover IV (Fig. 10) another improved method of the Trigger process is used, with a nodulizing ladle with four pockets, making a step-by-step time-response nodulization at small intervals. In the modification ladle, four pockets were allocated in the bottom of it, in which the pre-alloy is deposited.

The foundries production capacity in ductile iron can determine the type of treatment or type of agent. Whereas numerous nodulizers are known, alloys based on magnesium (Mg) are usually preferred because of their effectiveness, availability and relatively low cost. Nowadays, most foundries use Fe-Si-Mg alloys for the treatment. The treating agent is defined as an essentially homogeneous solid cast block preferably containing alloying ingredients to treat the graphite's form. In order to treat these irons, developed in electric induction ovens (with the chemical compositions according to [14]), classical techniques - the Trigger and Tundish-Cover methods, and their variants described above - were used.

3 METHODOLOGY & MATERIALS

The iron melting is performed in induction electric furnace (12.5 t capacity, 2800 kW installed power) and is carried out with the maximum possibilities of the furnace, in order to reduce the duration of the charge [13]. Immediately after melting, the liquid iron contains a large quantity of coarse inclusions and remaining graphite, mainly from raw cast iron and from the carburizing process of cast iron with petroleum coke. In order to eliminate the coarse inclusions and the dissolution of the remaining large graphite, it is necessary to overheat the liquid iron in the temperature range of 1450-1550 °C, the higher the temperature being when the cast iron contains a greater amount of inclusions [9, 13]. Using an overheating between 1530-1550 °C, an advanced purification of liquid iron is obtained, overheating which will positively influence the mechanical properties. Keeping at overheating temperature is about 15 minutes [9, 13].

In the case of cast irons with nodular graphite, after de–charging, the nodulizing operation is followed, using a special ladle (Fig. 11). The treatment ladle must be clean, without scraps of slag or metal from the previous charges. The required amount of nodulizing alloy is placed in a special pocket. The nodulizing alloy has been placed as compactly as possible and then covered with a coating material, placed in such a way that the nodulizing reactions will begin only when the entire amount of iron has been filled in the ladle.


Figure 11 Treatment ladles

In all cases, the same amount of iron, melted in electric induction ovens (12.5 t capacity), using one method or another, or one pre-alloy or another, has been modified. As

nodulisers Fe-Si-Mg pre-alloys were used, with different percentages of magnesium (Mg) (5, 6 and 10%), but also a special silicon based pre-alloy, considered "light pre–alloy" (Nodulin type), with composition given by Tab. 1 (according to [9, 15]).

Table 1 Silicon based pre–alloys – Chemical composition [9, 15]

Used pre–alloys	Chemical composition (%)					
	Mg	Si	Ca	Al	Ce	Ba
Fe-Si-Mg 5	5	42	0.5	1.0	1.5	0.5
Fe-Si-Mg 6	6	42	0.5	1.0	1.2	0.5
Fe-Si-Mg 10	10	42	0.5	1.0	1.2	0.5
Nodulin 5.8	5.8	48	1.5	1.0	2.0	1.2
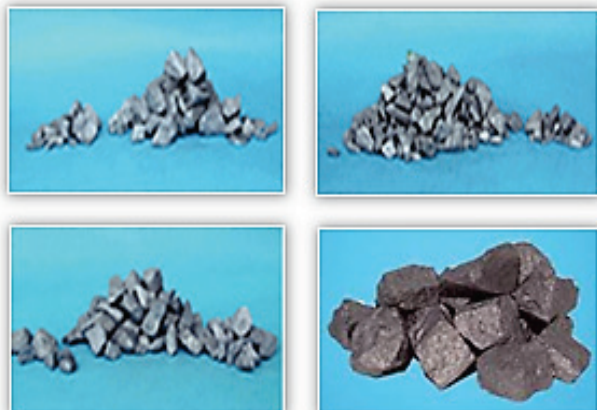
Figure 12 Nodulizing pre-alloys
(a) Fe-Si-Mg 5; (b) Fe-Si-Mg 6; (c) Fe-Si-Mg 10; (d) Nodulin 5.8

The amount of pre-alloy used is between 1.2-1.8% of the quantity of treated iron, so that the remaining magnesium (Mg) must be between 0.03 and 0.06% [9, 13]. The most used in practice are those that use as a modifier metallic magnesium (Mg), in powder form, in the form of magnesium (Mg) pre-alloys, or magnesium (Mg) lighters. Once more, it is shown that magnesium remains the most common modifier. An increase in its efficiency can be done by using the magnesium (Mg) pre-alloy, with given and precise compositions in magnesium (Mg), or by using special construction of the nodulizing ladle. The treatment effect lasts between 5-30 min, during which time the casting of iron must be carried out at 1400-1450 °C [9, 13].

4 RESULTS & DISCUSSIONS

Different degrees of assimilation of magnesium into the iron were obtained, depending on the method and the type of nodulizing pre-alloy used in the experiments, rendered in a synthesized way in Tab. 2.

The experiments start from a given capacity of liquid iron (1000 kg), which has a temperature between 1350 and 1450 °C [9]. The pre–alloy are inserted in the ladle (granulation 20-40 mm), preheated in advance, to increase the degree of magnesium (Mg) assimilation.

Table 2 Summary table on experiments

Nodulizing technique/ method	Used Pre-alloys (-)	Quantity of nodulizer (%)	Treatment temperature (°C)	Degree of magnesium assimilation (%)
Trigger (I)	Fe-Si-Mg 5	1.8	1480	42
	Fe-Si-Mg 6	1.8	1480	43
	Fe-Si-Mg 10	1.8	1480	45
	Nodulin 5.8	1.8	1480	50
Trigger (II)	Fe-Si-Mg 5	1.8	1480	45
	Fe-Si-Mg 6	1.8	1480	48
	Fe-Si-Mg 10	1.8	1480	52
	Nodulin 5.8	1.8	1480	58
Trigger (III)	Fe-Si-Mg 5	1.8	1480	49
	Fe-Si-Mg 6	1.8	1480	53
	Fe-Si-Mg 10	1.8	1480	57
	Nodulin 5.8	1.8	1480	62
Trigger (IV)	Fe-Si-Mg 5	1.8	1480	51
	Fe-Si-Mg 6	1.8	1480	54
	Fe-Si-Mg 10	1.8	1480	60
	Nodulin 5.8	1.8	1480	64
Tundish–Cover (I)	Fe-Si-Mg 5	1.8	1480	45
	Fe-Si-Mg 6	1.8	1480	47
	Fe-Si-Mg 10	1.8	1480	51
	Nodulin 5.8	1.8	1480	58
Tundish–Cover (II)	Fe-Si-Mg 5	1.8	1480	49
	Fe-Si-Mg 6	1.8	1480	53
	Fe-Si-Mg 10	1.8	1480	56
	Nodulin 5.8	1.8	1480	64
Tundish–Cover (III)	Fe-Si-Mg 5	1.8	1480	52
	Fe-Si-Mg 6	1.8	1480	56
	Fe-Si-Mg 10	1.8	1480	60
	Nodulin 5.8	1.8	1480	72
Tundish–Cover (IV)	Fe-Si-Mg 5	1.8	1480	58
	Fe-Si-Mg 6	1.8	1480	61
	Fe-Si-Mg 10	1.8	1480	65
	Nodulin 5.8	1.8	1480	82

The Trigger method, in its improved variants, by increasing the number of pockets in the ladle bottom and by applying a cover to the surface of the treatment ladle, has, in conclusion, a number of advantages. The following advantages have been observed as a result of these practical experiments:

- In the case of the use of the same pre–alloy, regarding to the nodulizing of cast iron graphite, however, to different methods, the degree of assimilation differs, depending on how the modification takes place, by casting the iron over the pre–existing nodulizer at the bottom of the ladle. Under the same method, the assimilation increases, with the increase of the reaction surface, following the application of the treatment in several consecutive steps;
- A saving of nodulizing agent is made, the nodulizing effect increasing if the same quantity of nodulizer is inserted in two or more pockets. Therefore, at the same effect, the consumption of the nodulizer decreases;
- Increased the effect of assimilation because the distribution of the nodulizer over a larger area leads to the shortening of the diffusion distances;
- It is observed an increase of the degree of the treated cast iron's homogenisation;
- If the treatment ladle is covered, like the Cover process, the assimilation is even higher, resulting in an optimal, favourable and economical process, to any medium technological foundry. By applying a cover to the

nodulizing ladle related to the Trigger process, it becomes a more efficient and economical process (Tundish-Cover). Therefore, applying the cover will significantly improve the process. Without a cover, smoke and flame emission results during the change reaction;

- The classical modification procedures provide relatively low degrees of assimilation of magnesium (Mg) embedded in the pre-alloys. For the purposes of increasing assimilation, practice shows that the Tundish–Cover process, based on the increased Trigger ladle with 2 and 4 pockets can be used at higher performance as alternatives to the classic techniques;

- The both basic methods (Trigger and Tundish-Cover) and their variants show good and conclusive results (Fig. 13, Fig. 14), and their application in practice, appreciably raises the degree of assimilation of magnesium (Mg), by a few percentage points, moreover, are always open to any subsequent perfections.
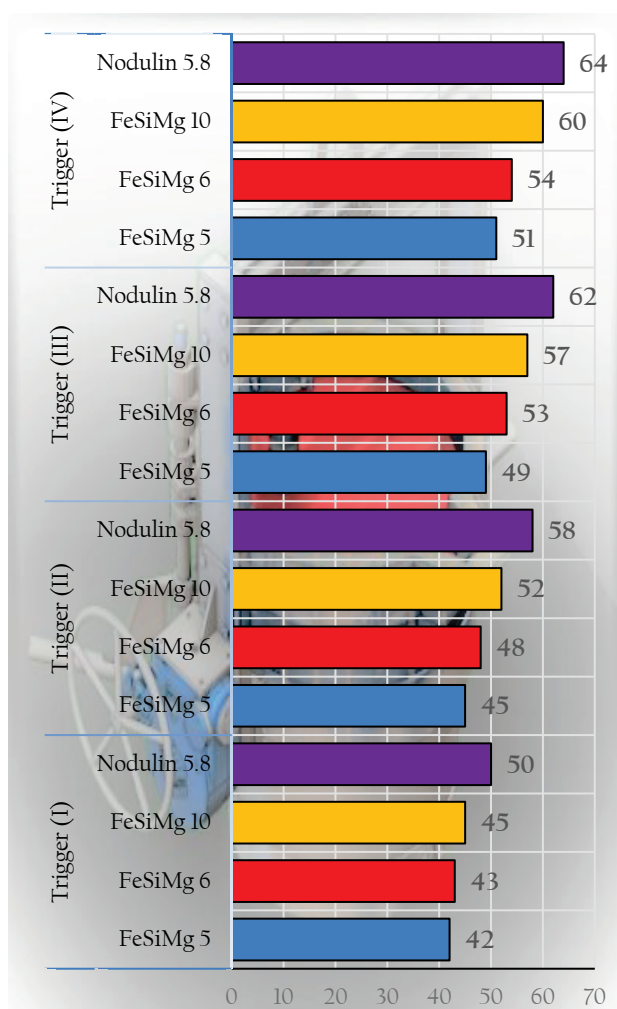
Figure 13 Magnesium (Mg) assimilation in the Trigger methods (%)

For the purposes of the above, the Trigger method may undergo some improvements, which are worth stating, especially since during the experiments carried out, these methods have demonstrated their effectiveness. The purpose

of the proposed process is to increase the efficiency of the nodulization process of the cast irons and is to make treatment ladles, of a special construction, with two or more pockets, in which the chosen nodulizer is then inserted. Thus, the nodulization is carried out in stages, practically achieving an increase in the degree of magnesium (Mg) assimilation.
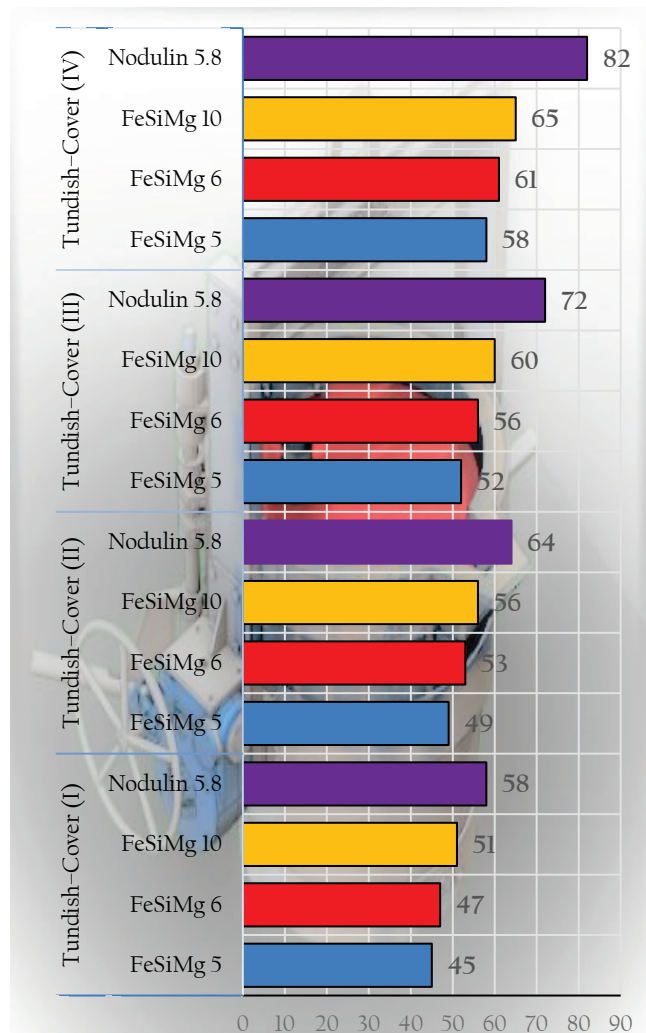
Figure 14 Magnesium (Mg) assimilation in the Tundish-Cover methods (based on the Trigger methods) (%)

5 CONCLUSIONS

This study take into account the flexibility of the process, by improvement or alternative to the existing one. Some of most important variables, in the ladle treatment of irons, are:

- the nodulizer, which indicates the proper pre–alloy when several categories of agents (Fe-Si-Mg and Nodulin) are available;
- the nodulizing treatment temperature, which indicates the optimal range of temperature;
- magnesium (Mg) vapour steering in the ladle, which depends on whether the ladle is covered or uncovered;

These main factors should be taken into account when the method of introducing the pre-alloy into the treatment

ladle is chosen. Also, the nature of the pre-alloy used according to the parameters of the process is a key-factor, having in view the risk of the silicon (Si) growth when the Fe-Si-Mg range is used. Magnesium (Mg) may be added directly to the ladle as nickel-magnesium, iron-silicon-magnesium or nickel-silicon-magnesium alloys. Higher magnesium (Mg) assimilation is obtained using the latter, as light pre-alloy.

If the treatment takes place at a temperature higher than 1480 °C, a Fe-Si-Mg pre-alloy with a high content of calcium (Ca) (1-2%) should be used, which will increase assimilation and calm the reaction. At lower temperatures, the reaction is less violent. Thus, if the temperature is below 1480 °C, pre-alloys with low calcium (Ca) (< 1%) content will be used.

One of the most advantageous methods of modifying the shape of cast iron graphite, applicable, without too much investment and in any foundry, is the Trigger method, and the improvements made to this method, only increase its industrial applicability.

It can be concluded that the effect of the nodulizing is high when number of pockets increases, increasing the reaction area between the nodulizer and the treated iron, thus ensuring all of the advantages outlined above. Above all, a nodulizer economy is achieved, a particularly important fact in a market economy, where production is always sought. It seeks the application in the foundries, in all ways, of the technologies that best ensure the savings of materials, increase productivity, efficiency of the production of ductile irons and alignment to a high standard. A simple nodulizing ladle shall be considered as a basis, plus the costs of adapting the technologies. Everyone can choose the system according to the facilities, possibilities and needs of this foundry sector.

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Performance Management in Czech Construction: Public Investors' Perspective

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Abstract: Performance management belongs to crucial managerial activities. This study aims to address how performance management in construction is applied among Czech public organizations on the project level. In order to address this issue, qualitative data has been collected by semi-structured interviews of experienced experts representing organizations owning/operating important facilities and infrastructure (road and rail infrastructure, water and sewage systems, education facilities and collectors). Findings revealed that the level of performance management adoption is rather low, organizations mostly focus on supplier performance evaluation as a response to the ISO 9001 requirements. The practical use of BIM or life-cycle costing is rather in the reflection and preparation phase, on the other hand, a progressive approach is applied in terms of deployment of modern equipment for monitoring of structural defects or the use of robots for maintenance and repairs.

Keywords: construction industry; facility; investor; performance management; project management

1 INTRODUCTION

Achieving high performance is the subject of attention of both researchers and practitioners for decades. In the construction industry, the core of the performance inextricably relates to the so-called "iron triangle" taking into account cost, time and quality components [1]. Nevertheless, many authors argue that the iron triangle model of three constraints is not enough to capture all relevant aspects resulting from the complexity and specificity of construction projects and to determine the level of project success [2,3].

Since the construction is often criticized for its lower performance when compared to other industries (e.g. due to the high number of stakeholders involved and different sub-processes [4], various innovative approaches have been adopted. In this sense, performance management in construction (PMiC) is often based on one of the following frameworks: Balanced Scorecard (BSC), European Foundation for Quality Management (EFQM) model and Key Performance Indicators (KPI) based models [5–7]. As each framework has its own pros and cons, the key question of what to actually measure still remains open especially if we follow the premise that PMiC can be seen from various perspectives. The need to use appropriate metrics is essential in order to cover all relevant areas of measurement as well as from the fact, that it affects the overall efficiency of the performance management system.

The issue of finding meaningful metrics is only one side of the matter, in addition, there is a need to look for causes that affect the achievement of the required performance, and to follow recent trends related e.g. to Construction 4.0 and Construction 5.0 initiatives. Despite the fact that a broad body of knowledge exists on construction performance management, this paper aims to contribute to available literature by addressing how Czech public investors perceive the current attitude to PMiC and its potential development in future.

The paper is organised as follows. Firstly, an overview of common performance management areas is provided, in the next section, mainstream initiatives in the construction industry are presented in the light of PMiC. Then, the data

and methods are provided. After the analysis of findings and discussion, the conclusions drawn from this study are given in the final section.

2 OVERVIEW OF COMMON PERFORMANCE MANAGEMENT AREAS IN CONSTRUCTION

Yang et al. [6] have pointed out that performance management studies can be assigned to three levels: project, organizational and stakeholder. However, in practice, the stakeholder's aspect cannot be separated from the project perspective. It has been argued, that the objectives of all stakeholders have to be considered when measuring project success [2] as the project's performance depends, among others, also on the effective coordination of multiple actors [8]. Accordingly, more appropriate structuring of the main areas should be just among the project and organizational level, when organizations can basically be considered as main stakeholders involved in the project.

On the project level, no consensus is reached on the range of metrics that should be monitored. E.g., a set of six highly significant indicators has been proposed for reporting performance [9], whereas it is suggested to supplement these key indicators with additional depending on the type of works or experience level. As it can be seen in Tab. 1, the stakeholder's perspective is omitted among the top six indicators. In another approach [4], the stakeholder aspect is already included as client satisfaction is considered a component of project performance. The stakeholder's point of view is crucial as individual objectives might be different or even conflicting. As highlighted in the example of the PPP project [10], three major stakeholders have significantly different views on performance goals; while the public sector highlights whole life cycle efficiency, building long-term relationships and safety are in the focus of private sectors and users respectively. A more comprehensive approach defining 27 indicators added additional measurement areas such as environment, risk or security [11]. From these defect frequencies, cost efficiency and construction schedule predictability were evaluated as the top three most important. These findings suggest that the scope of the performance

measurement should be quite extensive in terms of the number of monitored areas, but still based on the iron triangle approach.

Table 1 Examples of PMiC on project level metrics

Ref.	Recommended performance areas/metrics
[9]	Quality Control, On-Time Completion, Cost, Safety, $/Unit, and Units/MHR
[4]	Time, cost, quality, safety, client satisfaction
[2]	Budget performance, schedule performance, client satisfaction, functionality, contractor satisfaction, project manager/team satisfaction
[11]	Cost, time, quality, safety, environment, productivity, risk containment, security
[12]	Cost deviation, schedule deviation, accident frequency, accident gravity, planning effectiveness, constraint release, quality, productivity, contract bid change
[13]	Construction cost, construction time, predictability of cost and time and client satisfaction
[14]	Integration, scope, time, cost, quality, human resource, communications, risk, procurement, stakeholder, safety, environmental, financial, and claim management

Much of the traditional construction management literature recognizes the importance of cost and time overruns. In this relation, the predictability of cost and time as proposed by [13] becomes crucial and therefore this aspect should be considered within the performance. The predictability can be viewed as a challenging issue due to the fact that time/cost overruns might be caused by numerous variables such as inadequate planning, design changes, an increase of material costs, poor supervision, lack of skilled professionals, unforeseen ground conditions or poor contract administration [15–17]. Obviously, more precise cost estimations (in terms of the bill of costs) are at disposal when detailed project documentation is available [18], whereas preliminary estimations in the design phase are quite inaccurate if no advanced approach tools are used [19–21]. Furthermore, costs issues related to the project can be improved by the use of cost-optimal construction scheduling approaches [22].

On the organizational level, the focus does not lie on individual projects, but the company/institution as a whole. Apart from profit, iron triangle organizational performance metrics have been proposed [23], assessing e.g. percentage of the projects being delivered on/under budget in a given period. Performance management framework based on Balance Scorecard perspectives (financial, customer, internal business process and learning and growth) has been proposed by [24] with an accent to the periodical estimation of the performance score. This approach has been further developed into particular indicators [25]. While [13] reports safety, profitability and productivity being company performance indicators, a more comprehensive set of 20 performance attributes and related measurement methods was designed [26]. The authors of this study argue that the rapidly changing environment of the construction industry requires the use of non-traditional performance criteria because high financial performance alone is not enough to achieve the required overall organizational performance.

Generally used performance management frameworks, such as EFQM Excellence Model (EFQM) and Balance Scorecard (BSC) cannot be overlooked, of course. Despite their wide use, such frameworks have significant limitations resulting from their basic concepts. A critique of their deficiencies has been presented by [5, 27, 28] and in this line [5] proposed integrated BSC with EFQM to be applied in an advanced way.

Table 2 Examples of PMiC on organizational level metrics

Ref.	Recommended performance areas/metrics
[23]	Schedule performance, cost performance, safety performance, customer satisfaction, profit
[24]	Financial, customer, internal business process and learning and growth
[26]	Set of 20 performance attributes (time, satisfaction, cot performance, health and safety, …)
[5]	BCS integrated with EFQM

3 PMiC: GOING BEYOND ITS TRADITIONAL CAPABILITIES

Implementation of construction projects faces several risks. Eight risk classes have been identified in relation to large-scale projects, namely sponsorship/development, market, social acceptability, regulatory and political, financial, execution, and operation classes [29]. The problem with the successful use of risk management lies in the fact that while some risks can be foreseen in the early stages of the project, other risks are hard to predict [30]. Expected risk can be well managed and allocated among the project stakeholders (to the one who can handle it best, e.g. in the case of natural risks such as flood or windstorm, that is insurance company [31]), for other risks it is advisable to use the proposed risk models/registers. The general methodology enabling the development of risk register has been suggested by [32], on the other hand, models designed directly for specific types of buildings are also available, e.g. for wastewater treatment plants [33] or offshore wind power facilities [34].

Accordingly, [35] argue that performance management systems should be related to risk factors with the aim to estimate their influence on the project. For this purpose, risk performance indexes have been developed. However, such an approach might be applicable for mega (large-scale) projects), for smaller projects usually there is not enough ability or willingness to apply such a time and knowledge demanding approach. Therefore, it can be suggested to apply key performance indicators in such a way that they will measure relative deviations from set targets.

Furthermore, risks may vary across the entire project life-cycle. In the early stages, projects face the problem of not being able to pinpoint the future costs not only of the execution stage but also operational costs. This significantly affects the achievement of the required financial performance of investors. Many studies in recent years have focused on the development of models that will help to predict future construction costs or overhead costs [21, 35–38], however, their application by construction practitioners is highly limited. Preliminary cost estimations may also be based on the use of technical-economic indicators that may provide users misleading economic information [39].

As highlighted by [40], each stage of the project is equally important; that is why cost and time overruns, improper design and/or construction might be caused by carelessness during any stage. Therefore, performance management should not focus solely on the construction phase but should be involved in the project earlier, e.g. in order to monitor the ability to predict cost or time issues [11] on the required level.

The importance of the early stages of the project can be demonstrated e.g. on the procurement stage, as highlighted by [14]. This stage aims to award the contract to a capable contractor at favourable conditions inclusive of the award price. To select a capable contractor, prequalification plays an important role, however, also other aspects should be considered such as the procurement method to foster achieving project goals [41–44]. Achieving the financial performance of the project can be supported in the procurement stage by promoting the level of competition in the tender [45] as well as by considerations to use electronic reverse auctions [46–48].

Improving the ability to work better with data and make better predictions closely relates to the Construction 4.0 initiative. Applying Construction 4.0 visions to a full extent requires a significant transformation of the industry and its essence includes revolutionary approaches of digitalization and automation [49]. In this line, the development, adoption and application of Building Information Modelling (BIM) technology represent practical achievements for the industry. It should be stressed that the level of BIM adoption varies across the world, e.g. report on the UK construction industry from 2017 shows an increasing rate of 4D BIM adoption for planning projects while pointing out a time lag of 2.38-3.00 years between awareness and first use [50].

The comparison of BIM adoption rates among ten selected countries has been provided by [51] indicating that while the rate of adoption in the US, Canada and the UK is relatively high (79%, 78% and 74% respectively), for other countries such as the Czech Republic or Poland the rate of adoption is lagging behind (25% and 23% respectively). Such a smaller rate of adoption might be caused by various factors, e.g. by higher resistance to change caused by the use of national classification/cost estimation systems/software that are not fully compatible with the software used worldwide. As pointed by [52], BIM adoption is often driven by government or public agencies mandating its use. If adopted, users may benefit most from better cost estimation and control, efficient construction planning and management, and improvement in design and project quality [53].

Performance improvement should also be viewed in terms of a new concept called the Internet of Things (IoT); based on connecting devices, acquiring data and performing computational processes [54]. As an example of improvement, Aste et al. [54] state bridging the gap between predicted and measured energy performance. It is believed that the application of IoT will bring several benefits, not just time and money savings, but also improved safety and security and enhanced waste management [55]. Recent trends also push performance management systems to cope with the

Construction 5.0 dimension by adding social aspects and commitment to sustainable development goals [56].

The aspect of sustainability is recently also accented by the Covid-19 crisis in terms of ensuring sustainable supply chains providing uninterrupted supplies of construction materials to avoid unnecessary material price escalations [57]. It should be stressed that the Covid-19 pandemic has affected the construction industry to a considerable extent in many directions (e.g. immobility of the workforce, demanding requirements related to work safety, etc.) and therefore increased the uncertainty during the execution of construction projects [58, 59].

4 DATA AND METHODS

In order to achieve the objectives of this paper, it was necessary to collect viewpoints of public investors on the PMiC topic regarding their opinions, practical experiences, current knowledge and future visions and expectations. Semi-structured interviews with experienced personnel of relevant public organizations in the Czech Republic have been conducted to achieve that. The semi-structured design of the interview has been judged as the most effective one because it allows to address core areas relating to the PMiC as well as to investigate prospective issues based on the experience of interviewees and the development of every single interview. In order to guide the interview properly, a set of predetermined basic questions has been created.

In total, five interviews were realized during autumn 2021, the interviewees are representing organizations operating important facilities/infrastructure such as road constructions, educational facilities, water and sewage systems, collectors and rail infrastructure. The details about respondents and organizations are given in Tab. 3.

Table 3 Description of respondents

Organization	Position	Years of experience	Main agenda
Technical networks	Head of department	8	Management of collectors
Road infrastructure	Administrative director	15	Road management and maintenance
Waterworks and sewerage	Technical director	13	Water supply and sewerage networks
Public transport company	Deputy technical director	16	Rail infrastructure
University	Head of investment department	8	Educational facilities

Careful selection of appropriate respondents with long-term experience in the field (see data in Tab. 3) creates the necessary precondition for obtaining valid and representative qualitative data, its consequent analysis and finally drawing adequate conclusions. The years of interviewees' experience varies between 8 and 16 years. Furthermore, respondents represent organizations with a varied spectrum of different types of facilities/structures which makes it possible to reveal their possible specifics and on the other hand look for matching points across them.

5   RESULTS AND DISCUSSION

5.1 General View on Performance Management, Procurement and Project Success

With regard to the general view on the performance, all of the respondents reported that no comprehensive performance management system is used in their organizations. More specifically, there are no strict requirements how to evaluate the performance of particular projects. Therefore, if a project is completed approximately within the set targets, there is no action from the investor's side. Only if a project fails in terms of its predefined targets, a more detailed response to such a case is required. As an exception, one organization applies KPIs to estimate the performance of the labour force.

The only issue that enjoys more attention is supplier evaluation usually performed due to the ISO 9001 requirements. Accordingly, metrics such as satisfaction with the delivered quality or the number of claims is evaluated. In this way, suppliers can be classified into predefined classes according to their performance. This activity usually aims to stabilize the number of suppliers and establish long-term buyer-supplier relationships, if applicable.

One respondent mentioned, that informal sharing of information and experience exists within the organization among persons responsible for construction project management. Similar sharing of information about project outputs and experiences with suppliers has been stated at the level of the association of municipal transport companies. Such informal sharing of information, experience, problem-solving and best practices represents a significant contribution to the performance improvements, however is not applied in an organized or official mode.

Regarding the awarding the contract within tenders, investors strive to ensure the selection of a capable supplier by sound qualification requirements, e.g. having licence or authorization for specific works such as mining licence, traffic construction and surveying authorization, list of reference projects or professional level of the supplier's employees (e.g. site manager or responsible project manager). Interviewees emphasized proper check of compliance with a qualification in order to exclude ineligible suppliers.

The evaluation process is based just on the lowest bid price criterion or as a combination of the lowest bid price and the duration of works (i.e. multicriteria evaluation [60]). For certain types of contracts investors prefer fast delivery, for example in the case of water supply or transport infrastructure, as longer construction time ensures related costs, e.g., for water supply replacement or ensuring and implementation of detours and alternative public transportation services). In such cases, contractors with faster delivery might be preferred even with a bit higher bid price (the weight of duration of works criterion is usually about 20% - 30%).

One investor has adopted an innovative and proliferating procurement method of Best Value Approach (BVA), highlighting the price/value ratio [61]. Supplier is selected based on performance and price, furthermore, BVA minimizes the level of risk during the execution of the project. This investor noted time-consuming tender preparation within BVA and weight of price criterion being about 30% while the quality aspect is evaluated with the total weight 70% (price criterion weight is in contrast with traditional public procurement). Such an approach appears to be highly suitable from a performance management perspective, in addition, it enables to filter inexperienced tenderers well.

Regarding the project success, provided answers suggest that no consensus is reached in terms of what determines the success. While one respondent considers "all internal processes related to the project were well managed" is crucial for project success, others emphasize "no occurrence of complications during the project execution", "meeting the deadlines", "shortening the delivery period and well managed and realized coordination with other investors", "smooth handover of the executed works", and "satisfaction of the final owner or user". The list of project success criteria contains a wide spectrum of diverse items, sometimes very poorly defined, which seems to be, among other things, one of the reasons why organizations did not establish a clear performance management system.

5.2 Specifics to Construction Projects, LCC & BIM

As for the actual execution of construction works, experts stress the importance of quality tender documentation. Fewer errors in the documentation will subsequently have a positive effect on reducing the number and severity of problems during the implementation of works. Accordingly, some investors apply detailed consultation and comment on the documentation already in the phase of its creation. Such an approach contributes to the achievement of project targets both in terms of costs and time, e.g. by reducing the extent of extra-works, and thus consequently to better performance. All of the experts pointed out the need for proper supervision in order to observe the delivered quality during the execution of works (extremely important for structures to be hidden, e.g. groundworks or foundations) as well as during the takeover of the work.

Specific problems can be attributed to particular types of structures. For example, in the case of collectors, extra-works are common, as despite the thorough exploration in the form of test wells the actual condition of the subsoil is not exactly known. It is therefore essential for performance management that accurate records of the purchase and actual consumption of grouting are provided. Another challenging issue is the efficient coordination with other investors, e.g. when repairing the water supply network, it is necessary to coordinate the works, for example, with the road administrator or with the municipal transport company.

One interviewee has also mentioned the issue of slow response to changes in the project and an insufficient level of communication from the supplier's side. As such issues might negatively affect the meeting the deadline, also these kinds of "soft" aspects should be observed and evaluated. The

site supervision is carried out by own experienced employees and/or external experts or as a combination.

The interviewed organizations are aware of the Life-Cycle Cost (LLC) importance. However, the real application of LCC approach is very limited. Generally speaking, accurate LCC values are not estimated/monitored. One interviewee mentioned, that LCC could be indirectly positively affected by BVA (higher quality of the delivery will positively result in lower repair and maintenance costs), another stated that selected technical elements with a specific service life are required when preparing tender documentation. The most comprehensive approach applies to Waterworks and Sewerage Company, as the financing plan for the renewal of this infrastructure is required by law. In this case, LCC planning is facilitated as the legislation indicates recommended values of service life of particular materials. The company applies the strategy to use materials with long service life (in order to minimize future repairs and related excavation works), that is e.g., the use of chemically resistant earthenware or concrete pipes with basalt lining in the case of sewage system.

For road infrastructure, it should be mentioned that LCC planning is well applicable in rural areas, while in urban areas is aggravated by objective facts, such as emergency interventions into the road structure in the event of a failure of the networks stored under them. Road operators set repair plans; however, these plans are usually based on limited financial conditions rather than on objective needs or LCC view. This results from the long-term underfunding of not only road infrastructure but also water infrastructure.

The attitude to the performance of completed and operated facilities/infrastructure varies according to its basic features. In the case of collectors, real-time monitoring of the conditions in the underground is needed, therefore, a system of dispatching, sensors (temperature, humidity, motion and end sensors) and regular inspections have been established. Advanced repair and maintenance services are applied by Waterworks and Sewerage Company, e.g., by the use of modern monitoring kits with satellite cameras, revision cycle every 12 years (around 100 km annually) or sewer robots. Trenchless technology allows detection of minor defects on time, therefore, repairs made by sewer robots has the character of preventing emergencies and will bring a more significant economic effect later.

The road administrator also uses modern technologies, such as identification of road defects using CCTV vehicles with systems for precise positioning or mobile application "Brňáci pro Brno", an effective tool for online reporting local defects on devices, objects and communication areas by its users. As mentioned by one interviewee, "it is not important how we get the information on road defects, it is just important to have such importation in time to create efficient repair plan". The potential for maintenance planning and evaluation is certainly not fully exploited. In the case of rail infrastructure, it applies to the frequency of grinding vehicle wheels, which is more based on financial limitations rather than economic analysis.

BIM technology is considered to be a necessity in the future, nevertheless, the current approach of individual organizations varies. One organization already have trained employees, another organization currently performs an analysis from which the concept of BIM implementation should be derived. Most of the respondents consider providing trained staff as the main challenge and at the same time expect that BIM will help them not only during the implementation of projects but especially during subsequent operation of facilities/infrastructure. Operators of the critical infrastructure tend to interconnect BIM with their current platforms, such as GIS data or dispatching visualization in future.

Sustainability issues are addressed by all the respondents at a different level with respect to their main agenda. Typically, these involve recycling requirements of the waste, ecological disposal, use of environmentally friendly materials or noise reduction. Sustainable agenda predominantly relates to the ISO 14001 adoption which can be considered and major motivating factor for environmental considerations in analyzed organizations.

6 CONCLUSIONS

This study has addressed various issues related to performance management in the Czech construction industry. In particular, it analysed the public investor's point of view and revealed to which extent the performance management is actually adopted. In-depth semi-structured interviews with representatives of five important owners/operators of municipal facilities/infrastructure (water and sewage systems, collector infrastructure, road and rail network and educational facilities) have pointed to the relatively low level of performance management.

Notwithstanding the organizations making certain efforts to increase the performance, these activities are rather locally focused on the particular specifics of particular project and lack a more comprehensive and holistic approach. A positive finding resulting from this study is the use of modern equipment for monitoring structural defects or the use of robots for maintenance and repairs, however significant progress is needed especially in the LCC and BIM perspectives. Czech legislative requirements demanding the adoption of LCC for the above-the-threshold public contracts in near future as well as BIM pilot studies realization will certainly contribute to their forthcoming expansion in practice.

The main limitation of this study relates to the low number of interviewees. In order to allow the generalization of presented findings and conclusions relating to the Czech construction sector, a larger dataset is required. Further research might also extend this study to compare the level of performance management adoption and use at an international level in order to reveal progress in this area from a wider geographical perspective.

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Methodology of Reverse Engineering Implemented in the Process of Digitalization and Conservation of Wooden Carvings

Atanas Kochov*, Lidija Stoleska

Abstract: The purpose of this paper is to present the benefits of reverse engineering when applied to cultural heritage i.e. digitalizing and duplicating an artwork in lack of original documentation, drawings, or computer models; Usage of different methods for 3D scanning, reverse engineering softwares with a smart combination of history-based CAD with 3D scan data processing, for preparing the obtained 3D model for future production use; Describing tools and machines for rapid prototyping, materials used and the feasibility of its completion; Set of tools that provide opportunities for new projects and innovations but are also of cultural and historical significance.

Keywords: 3D scanning; digitalizing; preservation; rapid prototyping; reverse engineering

1 INTRODUCTION

The rapid development of science and technology, the application of new modern technologies, in every scientific and applied field, leads to the setting of new higher requirements related to the application of advanced technologies in designing production processes i.e. new approaches in new product development processes. The essence is to place a high quality product on the market. In such conditions, new technologies such as: rapid prototype technology (RP), rapid tool making technology (RT), reversible engineering (RE), and appropriate 3D scanning, 3D printing, are new and efficient technologies that provide companies with the opportunity to significantly reduce the time of product development and its placement on the market. [1] But, what is very important is that these new techniques and technologies are increasingly being used in the processes of protection of cultural heritage. Namely, Reversible Engineering is the process of replicating an existing object, assembly or product without having original drawings, documentation or computer models. [2] In this thesis, the focus is on the importance of reversible engineering and consequently on the appropriate tools, programs and machines in order to collect data on works of art, cultural heritage and wood carvings that have not been software stored, digitalized and stored in databases, and then be able to be rebuilt into physical models. We are witnessing frequent weather disasters, destruction by various factors, which can permanently destroy an object. Handmade woodwork becomes timeless if digitilized. When the necessary methodologies and methods are studied, an opportunity is created for making copies of them. The topic of scanning works of art is not current in Macedonia, so it leaves a lot of room for further upgrading. The aim of the research is to create a methodology of reversible engineering for digitalization of cultural heritage and new works in the field of wood carving art, as well as a practical part of the application of reversible engineering and visualization techniques through specific examples. All technologies that can lead to digitalization and reprocessing in 3D model have been developed. The aim is to specify the steps for obtaining a digitalized database and ways to create copies of wood carvings.

2 DEFINING

Art creators convert their ideas into physical models with different materials – like clay, wood, plaster, or foam – but a CAD model is necessary if the part needs to be manufactured. 3D scanners capture the basis of artistically inspired and man-made figures and precise records of original pieces for archiving or creating reproductions by using combining technologies. Another option to 3D scanning is by camera through photography (photogrammetry). Smartphones and smart technologies can easily and simply help preserve world heritage by digitalizing pre-built works of art and placing them in a database. Smart technologies are widely used across various industries, because they offer quality services in a short period of time. Its usage in cultural activities it's still not that developed and has space for improvement. The concept is shown in Fig. 1.
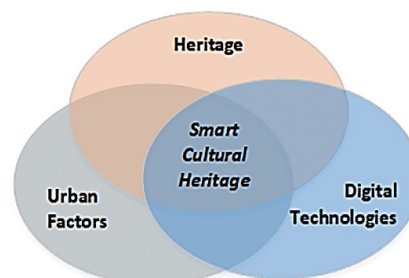

Figure 1 Smart cultural heritage concept [3]

Quick, free and inexpensive smartphone applications can help you efficiently create digitalized objects [6] that can be stored on a server for later use.

For this purpose, except the objects to be scanned, the 3D scanner or camera, we need a professional reverse engineering software with a smart combination of history-based CAD with 3D scan data processing, for preparing the obtained 3D model for future production use. In the current case, the Geomagic Design X and Autodesk Recap programs were used.

Another programs that should be taken into consideration are Virtual CNC simulations of machining

processes, so that an object can be manufactured or duplicated (carving, for current case study) with minimum mistakes, so no additional costs happen and sustainability is kept on a high level. Powerful numerical controls are required for complex machine technologies. Programming part of the machine is hard and time consuming. However, with the usage of simulation and virtual commissioning there are possibilities available that support the manufacturer in ways that can reduce time and costs. Such methods are nowadays recognized under the term "Digital Twin".

There are no end to the usage and purposes of the 3D scanners, smartphone applications and CAD/CAM programs which everyday are getting better and more useful in different areas. The promotion of cultural heritage can be developed through implementation of certain knowledges, technologies and social inclusion. As result, with participation and promotion of each, smart cultural heritage can be built.

Steps of producing a prototype of a previously digitalized wooden carving will be presented through practical example. Prototyping with CNC machines (CNC wood routers) and 3D printing will be explained.

3 TECHNOLOGIES AND METHODS APPLIED

The steps that can be taken to reproduce an object will be briefly explained as well as comparing the needed technologies and their limitations.

3.1 3D Scanning

3D scanning is a technique of using a 3D scanner to capture shapes of objects. After 3D scanning, 3-dimensional files are made. With the help of 3D printers, those 3D files can be saved, edited and printed. There are different methods of 3D scanning based on different principles. Each of these methods have their own advantages, disadvantages and cost differences. 3D scans are compatible with CAD (Computer Aided Design) softwares and with 3D printing. When analysing reverse-engineering processes, 3D scans are the primary step for getting information about the object's design. One of the biggest obstacles to encounter when converting physical objects to digital is a major incompatibility between two different types of 3D models: meshes and solids. A 3D scanner outputs a mesh, rather than a constructive "solid" model. Meshes need to be reverse engineered to be made editable.

There are different types of 3D scanning methods: Laser pulse-based 3D scanning technology, Laser triangulation 3D scanning technology, Structured light 3D scanning technology, Photogrammetry, Contact-based 3D scanning technology.

3.2 Scan to Model Programs
3.2.1 Geomagic for SolidWorks

The most complete integrated model solution (Scan-to-SolidWorks). It reduces the time required to build complex 3D models of objects by directly scanning or importing scan data into SolidWorks. Automated and advanced wizards quickly and easily create precise sketches, surfaces or feature-based editable solid parts inside SolidWorks. Geomagic for SolidWorks is a software toolset that plugs directly into a SolidWorks environment giving advanced capabilities to make tools point clouds and polygons more usable in the design process. This software supports a range of popular 3D scanners as well as the import of standard point and polygon file formats. Data can be imported or scanned directly in SolidWorks and the feature extraction wizards can be used to extract CAD sketches, surfaces and solids.

3.2.2 Autodesk's ReCap Software

This software allows direct point cloud opening. The technology lends itself readily to mechanical and manufacturing industries. Reality captures can be done of desired objects, for which design parameters aren't known. With this technology, you can overlay your new part to match the size, bolt-hole placement, etc. with exacting tolerances, in short period of time.

3.3 Rapid Prototyping

The process of creating prototypes quickly to visually and functionally evaluate an engineering product design.

When explaining fast prototyping, it is the rapid creation of a product that will be representative of the technology used and the precision of the desired design. Confirms the way of manufacturing, how the system works in reality. Multiple technologies can be used. When discussing the creation of a new product or design on the market, one cannot fail to include rapid prototyping as an integral part of the process. Rapid prototyping can be used at any stage of the product development cycle or for any component or sub-component and can be repeated numerous times along the new product design process. [4]
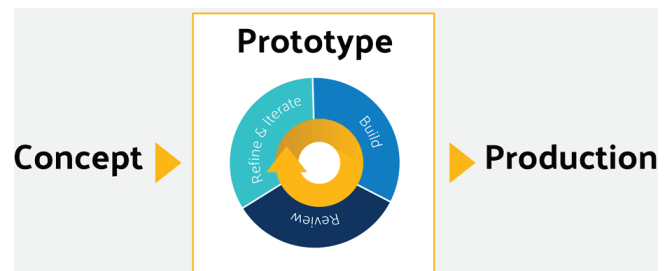
Fig. 2 shows the rapid prototyping process.

Figure 2 The rapid prototype process [5]

Rapid prototyping is not limited to one process. Many manufacturing techniques can be used to assemble a prototype.

Following are some of the types of rapid prototyping technologies divided in two groups:
- Additive manufacturing:
- Direct metal laser sintering(DMLS)
- Fused Deposition Modelling (FDM)
- Stereolithography (SLA)

- Selective laser sintering (SLS)
- Other techniques:
- CNC Machining Prototyping
- Vacuum casting
- Investment casting.

3.4 Comparison between Additive Manufacturing and CNC Machining Prototyping

If we compare the two groups of technologies, we will quickly and easily see the difference. Namely, fast prototyping can be divided into subtraction technology and addition technology. The first group, subtraction prototyping, is designing the desired object from a certain material by machine engraving (taking off of block material). [6]

Additive manufacturing is opposite process. Structures are made by the addition of thousands of minuscule layers which combine to create an object. The process must be supported by a special CAD software which relays messages to the printer so it "prints" in the previously drawn or scanned figures. Suitable for use with a range of different materials, the cartridge is loaded with the filament for different purposes and later it's "printed" into the shape, layer by layer, fused together until the shape is done.

There are machines with different axis manipulation for manufacturing but the focus will be put on 5-axis machining because of the complexity of the wooden carvings if it were to be reproduced. 5-axis machining involves using a CNC to move a part or cutting tool along five different axes simultaneously. Five axes machines are complex. Therefore, trained staff is needed to manage them, accompanied by appropriate CAD/CAM software for effective, efficient machine use, and error minimization.
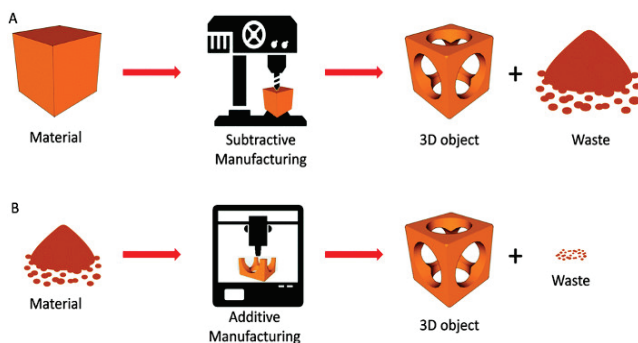
Figure 3 Visual difference between additive and subtractive manufacturing [6]

Fig. 3 graphically shows the difference between the technologies. The controller in the machine has to be able to process the data fast enough so the toolpath is a nice, smooth, uniform motion. For minimizing errors CNC simulation is the best tool. It is used to visualize virtual production sequences in machine tools in a realistic way. By mapping the complete working area of the machine (including all fixtures, tools and workpieces) and the movements of the machine (including visualization of the tool path and material loading and unloading) in 3D, to the user can evaluate and optimize the process before the CNC programs are transferred to the machine. Predator Virtual CNC is an example of that kind of software designed to simulate and verify operation of your CNC machines on your PC.

For the current case study wood router ought to be used for production. It is controlled in the same way as a metal mill, but the CAD/CAM programs are more specific, such as Artcam, Mastercam, Bobcad, and AlphaCam. Wood routers are frequently used to machine other soft materials such as plastics. The advantages of CNC wood router (compared to general machine) as follows:

- High degree of automation
- Consistent quality
- High productivity
- Processing complex shapes
- Easy to implement CAD/CAM.

3.5 Limitations of Technologies

Each of the 3D scanning technologies has its advantages and disadvantages. The laser triangulation technology has advantage of accuracy and high resolution while the disadvantage is it is sensitive to the properties of the surface that it scans. Laser-pulse based technology is great for scanning large objects and environments, on the contrary, the main disadvantage with structured lighting 3D scanning is its sensibility to lighting conditions and therefore it's difficult to work outside. About photogrammetry, its main advantages are precision, acquisition speed and its capability of reconstructing subjects of various scales that are photographed from different perspectives.

When comparing the rapid prototyping technologies a few things are taken into consideration such as: used materials, precision, speed, waste and price. CNC mills can work on a huge variety of materials: metal alloys (e.g. aluminium, steel alloys, copper, and brass), hardwoods and softwoods, thermoplastics, acrylic, modelling foams etc. Variety of cutting tools for different materials are required, but tool-to-machine interfaces are commonly standardized – so the tools can easily be exchanged. CNC mills/routers can be utilized to manufacture prototypes in the same material that will be used for the final product. Desktop 3D printers are usually restricted to a few materials, typically thermoplastics (PLA, ABS, sometimes nylon) or resins. Thermoplastics can be mixed with other materials such as ceramics, wood, metal, but the workpieces produced on a 3D printer are not as durable as produced on a CNC machine, and are brittle when subjected to higher pressures.

Thermoplastics and resin 3D printers use completely different methods, a resin printer cannot handle thermoplastics – and vice versa. CNC mills offer positioning accuracies of around 0.025 mm and tolerances of 0.0127 mm. There are 3D printers supporting resolutions of 0.025 mm and 0.02 mm. Comparing speed is difficult as CNC mills and 3D printers are typically used for different workpieces and materials. Different rapid prototyping technologies are used for different purposes. It is therefore difficult to compare specifications, such as processing speed. Roughly speaking, for larger objects the 3D printer takes many hours while the CNC machine can process an object in up to an hour. CNC mills are typically faster when chipping away material from

a solid block than 3D printers that build objects layer by layer and occasionally have to slow down to avoid printing problems. The result: But, because it is a subtractive technology, CNC definitely produces more waste than 3D printing.

4 MATERIALS

Now that technologies were explained, next point would be implementing them into the subject of reproducing wooden carvings. It is known that wood is processed on CNC machines, but the first question when combining wood with additive manufacturing is: "How can you 3D print wood?" It is possible in a way, by printing with wood filament.

The material is mainly PLA that contains wood fiber. Tissue comparison of natural and printed wood is shown in Fig. 4. Objects printed with wood filament look wood-like. There are different versions of wood filament, depending on the manufacturer. There are potential difficulties when printing with wood filament. It is considered a "temperamental" material. Typically, wood filament is composed of around 70% PLA and 30% wood fiber. [7] Because of the added wood, it tends to be more delicate than regular PLA, breaking more easily. Early wood filaments were made with sawdust, but the final prints looked more like cardboard than wood. The advantage is its greater flexibility, but with today's wood fiber filaments, 3D printed objects can look, feel, and smell very much like carved wood. In combination with 3D printing these materials can help with preserving handmade wood designs.
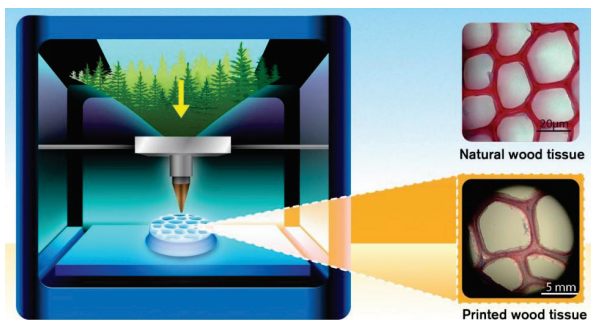
Figure 4 Comparison of natural wood tissue and printed wood tissue [7]

5 PRACTICAL EXAMPLES

The first carving chosen to be digitalized is part of a Bishop's throne. It has a vase shape, symbolically suggesting a crown worn by bishops in Byzantine style. [8] Second carving is a bird on a leaf, which is a part of an iconostasis as decoration. The third carving is head of a pillar also serving as a decoration on the top of an iconostasis. They represent an idea for the restoration of one of the first such cultivations that date back to the 5-6th century. Wood as a material for the processing of such works has a limited durability, is subject to aging, pest attacks unlike those made in stone and marble that have a much longer lifespan. The historical events of the last few years, the loss of certain buildings of cultural and historical significance such as the fire in Bigorski Monastery

or the Officer's Home in Skopje and the development of digital and machine technology, all indicated the need to think about how digital records of valuable artwork can be provided that could then be used for restoration. The number of craftsmen and artists making such works is diminishing and the technical aids and knowledge of those used at the time are diminishing. Therefore, helping machine-made copy of a work of art (or a whole) is invaluable to the collective memory of national wealth and the preservation of world cultural heritage. The objects are displayed in Fig. 5, Fig. 6 and Fig. 7.

Figure 5 Small vase-like pedestal

Figure 6 Bird on a leaf

A 3D scanner was used on the principle of structured light 3D scanning technology to digitalize the first object, along with the GeoMagic program. For the other two carvings, a camera will be used on the principle of photogrammetry together with the AutoDesk Recap program. The NextEngine Scanner is a desktop 3D scanner that uses an array of lasers to scan objects at resolutions of 0.127 mm, [9] shown in Fig. 8.

Figure 7 Head of pillar

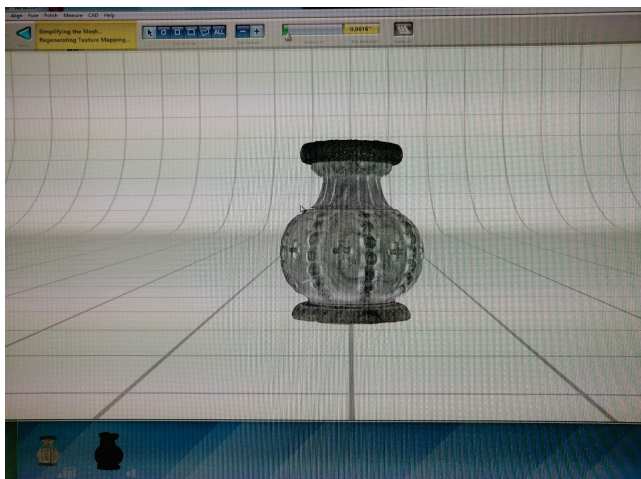**Figure 8** Obligatory parts for the scanning process

Figure 9 Finished scan of the carving

In Fig. 9 below, the finished scanning process of the vase-looking pedestal can be seen. This chosen carving needs little bit of cleaning after scanning. The software itself gives that option but the part still needs to be cleaned again in another program so that it can be used in future processing

like 3D printing or CNC machining. It can easily be imported in SolidWorks or directly in 3D printer as STL file.

Fig. 10 shows the digitalized carving mesh cleaning, transferred in SolidWorks.
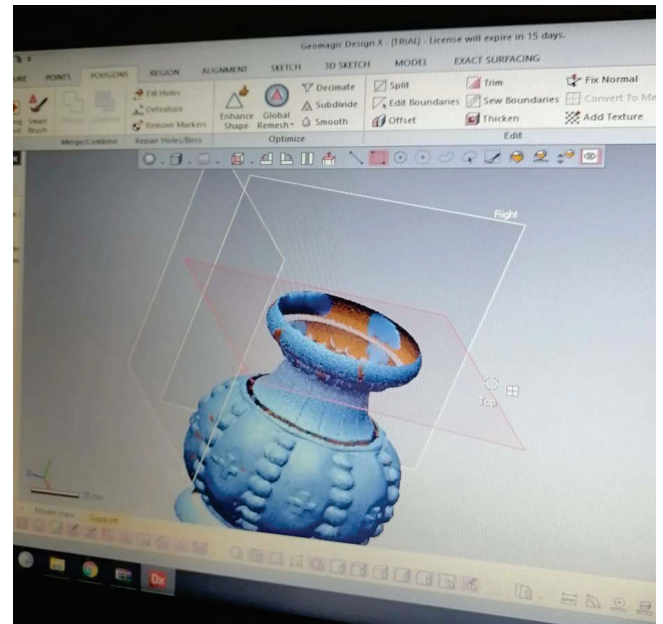
Figure 10 Mesh cleaning in GeoMagic

The following Figs. (11)-(16) show the use of photogrammetry for digitalizing the previously mentioned carvings. The digitalization process is as follows: Get the necessary camera images, clean the objects in AutoDesk Recap and import them as STL files. The STL file format has become the Rapid Prototyping industry's defacto standard data transmission format. [10]
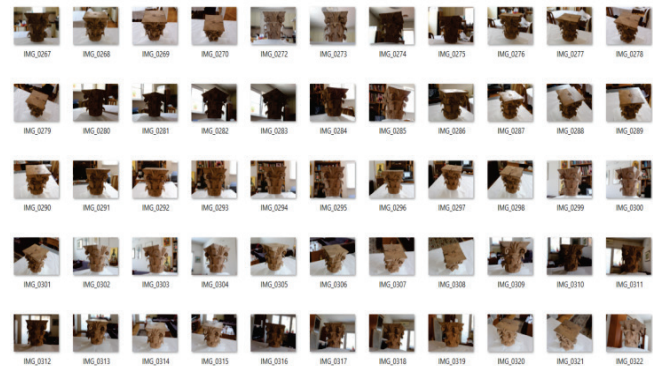
Figure 11 Required photos for photogrammetry completion

Fig. 12 shows the final product of AutoDesk Recap's photogrammetry.

Fig. 13 shows another possibility of AutoDesk Recap – video of scanned object rotation.

Fig. 14 is a triangulate representation of the mesh (carving) and Fig. 15 is the object transferred in SolidWorks as solid body.
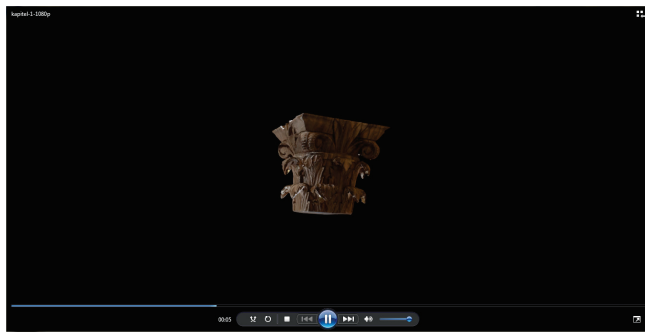
Figure 12 Head of pillar in RCM file

Figure 13 Video screenshot of the head of the pillar – Autodesk Recap possibilities

Figure 14 Triangulate representation of the mesh (carving)

research is needed than just buying the latest machine. Precise programming and good familiarity with tool tolerances are required.

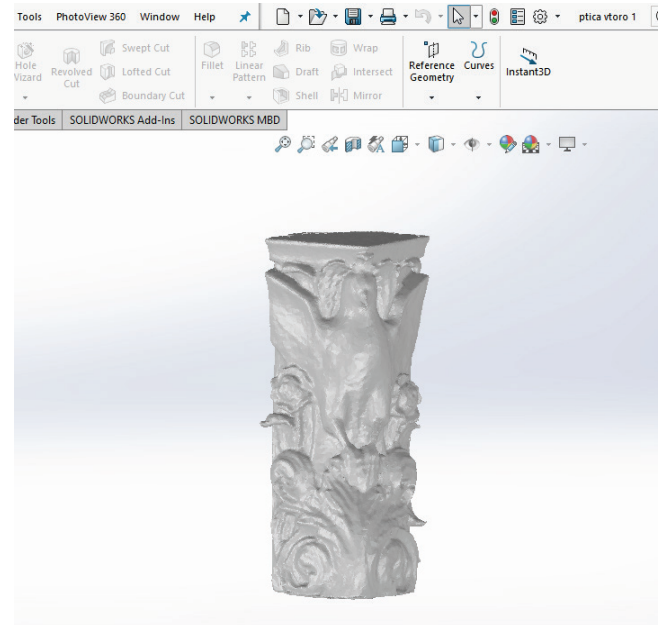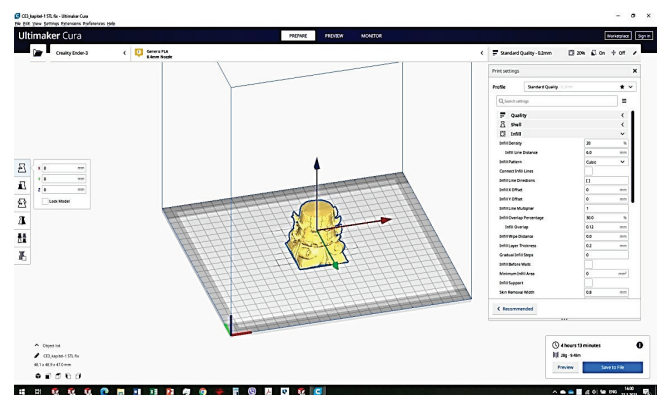**Figure 15** Solid body of the bird carving in SolidWorks

Figure 16 Initial setting of head of pillar

Physical representation of the head of pillar was made (Fig. 17) on an Ender3 3D printer. Using Ultimaker Cura which is one of the most popular 3D printing softwares, the print was prepared with a few clicks. The software is integrated with CAD software for an easier workflow. Fig.16 below, shows the setting up of the head of pillar before printing.

Printed with PLA (as the conditions allowed), but serving as proof of a possible reproducing when having the right printer and filament. Printing PLA is closest to wood filament.

Because of lack of suitable 5-axis machine, physical representation of a carving produced by wood router won't be shown. Manufacturing carvings on a CNC machine has many advantages, but it is very important to know that more
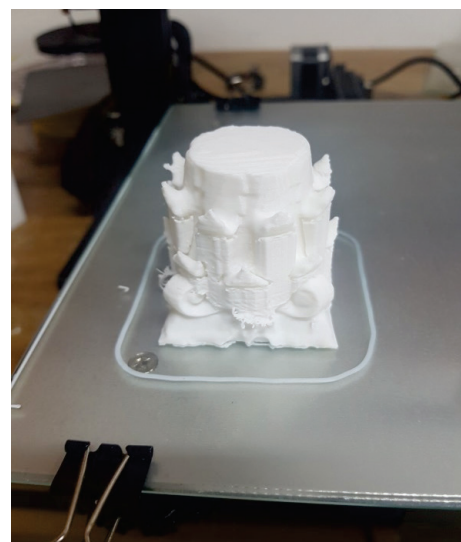

Figure 17 Final 3D print of the head of pillar

Last but not least, smartphone usage for scanning is presented. The Qlone application was used for the purpose of this thesis. [11] A compatible mat is required to put an object on (carved cup-holder, Fig. 18), scanning can be continued. Pieces can be put horizontally or vertically.
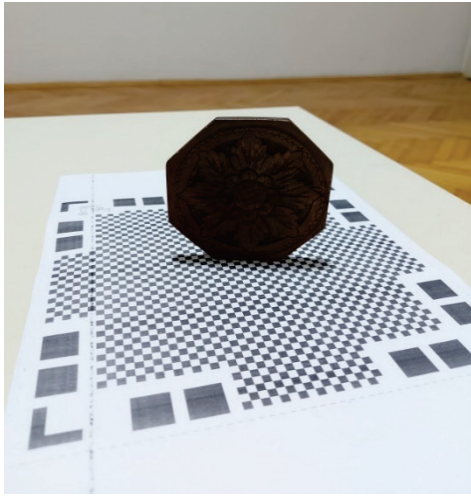

Figure 18 Carved cup holder on mat

Scanning of the carving will be complete after rotating with the smartphone's camera around it until every blue part of the hemisphere is gone (Fig. 19). In Fig. 20 the finished scan of the carver cup holder can be seen.
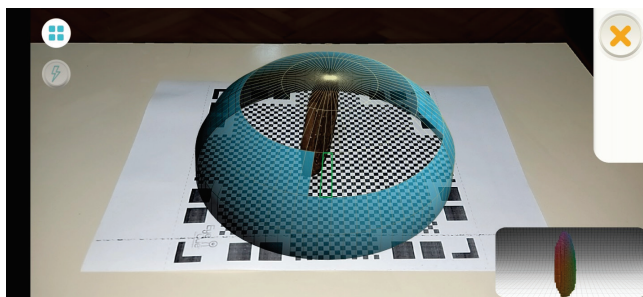

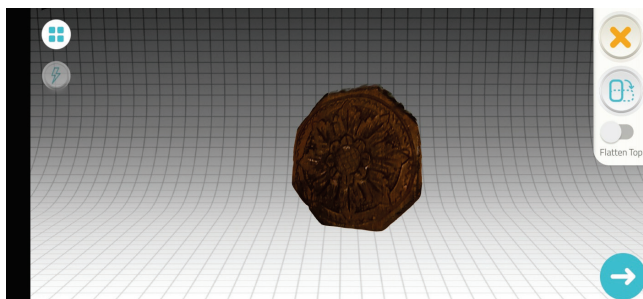**Figure 19** Blue hemisphere around carved cup holder

Figure 20 3D scanned carved cup holder

6 COST OF INNOVATION

So, how feasible is making business out of preserving works of art? You need the right equipment, machines and programs as well as a trained person for each of them to implement it. The basic and most important thing is to have a suitable scanner or camera so that we can digitalize carvings. Then, appropriate licensed programs are needed that will generate the required file and where an object can be 'cleaned'. Next, a 3D printer is needed or a CNC machine to get a physical model. But within all, there are a lot of additional costs, such as material, cleaning of excess material, space, electricity, maintenance, etc. You need to calculate the time and effort put to do the work, as well as to return your investment for equipment.

According to The Williamstown Art Conservation Centre, "Conservation cost is based on time and materials required, not on the value of the object". It is important to note that you are paying for a professional's time and expertise, so the rates for conservation range broadly based on the work's medium, age, cultural or historical significance, as well the methods required for conservation. [12]

6.1 Cost of Equipment and Material

3D printer materials and operating costs usually tend to be lower than those encountered when using traditional methods. The first thought that might come across mind is that printing an extremely detailed 3D model is very expensive – but that is not the case. It is shown that the biggest contributor to the price is the amount of material used and not its particular features.

CNC routers have many advantages over traditional hand tools with speed and automation being the greatest. This means work can be accomplished in a much faster pace, with a lot less employees - which on the other hand, saves money and time.

Depending on the complexity of the machine and what can be achieved with it, price ranges are as follows:
- $5,000-$10,000 for the most basic of three-axis
- $25,000-$50,000 for mid-range machines (used for panel processing and signage)
- %50,000-$150,000 for high end machines.

Aside from machine costs, there are several other costs that need to be considered:
- Purchasing a computer aided (CAD) software package - used for creating the design. Several option are available with prices anywhere from $2,500 - $10,000.
- Training, depending on the familiarity level of staff, anywhere from $500-$1,000
- Machine installation, $500-$1,000/day
- Shipping, anywhere from several hundred dollars to $3,000.
- 3D printer.

Prices for 3D printers can vary, with the cheapest being around $200, average consumer type – around $700 to several thousand dollars for high-end consumer printers. [13] It is fair to say that the cost for 3D printers has significantly dropped over the past few years with several high-quality options available from $1000.

Three factors were considered when ranking the best 3D scanners:

- Scan quality, price-performance ratio and customer feedback on the scanners. They can be grouped into three price ranges: cheap.
- Under $1,000, medium priced – under $10,000 and industrial – over $10,000.

7 CONCLUSIONS

Set of knowledge, methods, methodologies, technologies and interests are assets to mechanical engineering as an assembly in helping to preserve a piece of art. It is important to note that the objects used throughout the case study, were not damaged. If all the possibilities offered by different professions are taken into consideration for conservation and restoration of art objects, we would have permanently preserved wealth. We leave that synergy to future projects. Each of those assets represent different areas of implementation, depending on the condition, form, function and intended use of the cultural item. Scientific methodologies engaged in the analysis of materials and ways of digitalization and processing are combined with humanistic concerns around authenticity, value and significance in the negotiation of sustainable preservation outcomes. This corpus of knowledge contributes to specialized and non-specialized publications, promoting an overall understanding and appreciation of the cultural significance of heritage. The possibilities after digitalization are numerous. The only obstacle in this project are the conditions. Much more complicated parts can be scanned and processed if the appropriate equipment is available. But the initial goal has been achieved. Develop a methodology that is an example of reversible engineering for wood carvings. What were the steps of this methodology? Find a carving you think should be 'saved', digitalize it with the tools mentioned above, 'clean' the carving in one of the mentioned programs (although there are more on the market, another can be used), transfer the section to appropriate CAD/CAM programs and 'leave' the 3D printer and/or CNC machine to do the 'magic'. Although this methodology can be seen as type of business, it is also of great historical and cultural importance, a fusion of engineering with art.

Notice

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Application of Data Envelopment Analysis (DEA) in Information and Communication Technologies

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Abstract: The consistent improvements and fast-growing trend of information and communication technology (ICT) have impacted all areas of society and the economy. In 2020, with the sudden pandemic of COVID-19, businesses worldwide faced great challenges and had to transform and become digital-native enterprises by using data analytics, digital business platforms and personalized customer approaches. In such a digital era, innovation, entrepreneurial dynamism and ICT are the key ingredients for business' success and sustainability. Furthermore, it has become very clear that the influence of the ICT industry on economic growth is immense. Therefore, it should not come as a surprise that the interest in research of the ICT industry is great. Data Envelopment Analysis (DEA) is the leading non-parametric mathematical technique for assessing performance and measuring efficiency of complex entities called Decision-Making-Units (DMUs), by conversion of multiple input variables to multiple output variables. DEA has experienced rapid growth in use in many areas ever since its introduction by Charnes, Cooper and Rhodes in 1978. The purpose of this paper is to present and describe Data Envelopment Analysis as the leading mathematical programming technique for data analysis and to provide an extensive literature review, to identify the studies implementing the DEA methodology in Information and Communication Technologies (ICT) and to present its findings. Furthermore, this study's goal is to inspire and encourage researchers to employ this methodology in the fields of ICT and to give guidance for future research in this area.

Keywords: Data Envelopment Analysis application; DEA; efficiency evaluation; ICT; Information and Communication Technologies; non-parametric method; relative efficiency

1 INTRODUCTION

Information and communication technologies (ICT) are involved in all aspects of life. The emergence and development of the ICT industry in the past two decades has altered the economic landscape and the technological advancement has increased the use of sophisticated hardware and software in all areas of life and business. Namely, ICT have transformed the way in which we communicate and interact with each other, the way we seek and find information, the way we work, do business and operate, and the way we manage our social lives [1-3].

As a basic economic need, every business operating in the ICT industry (as well as any business in general) needs to be efficient and to perform. DEA (data envelopment analysis) is a mathematical programming technique that helps evaluate and assess efficiency of peer units concerning multiple performance and efficiency measures. In DEA, the units that are evaluated are known as decision making units (DMUs) and the measures of performance are grouped into input variables and output variables. This methodology is very convenient in cases when the relationships between the input and output variables are unknown [4].

DEA is becoming a globally acknowledged and commonly used technique for assessing efficiencies and performance of decision making units (DMUs). Due to its simplicity and successful application in different research areas, DEA has gained considerable attention and is extensively used by business and academy researchers from all over the world [5].

The remainder of the paper is structured as follows: Section 2 gives an introduction and an overview of the DEA methodology, a short theoretical background and its basic models; Section 3 presents the most important application of the DEA methodology in efficiency measurement in ICT worldwide. Section 4 offers a discussion on the benefits and limitations of this methodology and Section 5 presents concluding remarks and guidance for future research.

2 DATA ENVELOPMENT ANALYSIS (DEA): THEORETICAL BACKGROUND AND BASIC MODELS

The reason why performance and efficiency are being measured is to compare behaviour (i.e. efficiency) of organizations consistently. Efficiency is one of the key indicators of performance, thus being a vital element for business viability and a precondition for business improvement. These "benchmarking comparisons" (i.e. efficiency comparisons) can be divisional or cross-divisional, national or supranational etc. [6].

When analysing performance and efficiency of entities, there are two existing approaches at hand: the parametric and the non-parametric approach [7]. According to De Borger, B. et al. [6], the main assumption in the parametric approach is that "the boundary of the production possibility set can be represented by a particular functional form with constant parameters", whereas the non-parametric approach "does not impose regularity axioms on the production possibility set and directly constructs a piecewise technology on the sample".

Data Envelopment Analysis (DEA) is the leading non-parametric methodology that has gained a lot of popularity and interest from researchers since its introduction in the literature of the operational research (OR) discipline in 1978 by Charnes, A. et al. [8]. However, Farrell, M. [9] is the one who developed the concept of best-practice frontiers and introduced the first measurement scheme and efficiency concept [6].

The Data Envelopment Analysis (DEA) is a linear mathematical programming methodology whose purpose is to evaluate the performance (i.e. the relative efficiencies) of a group of complex entities referred to as Decision Making

Units (DMUs) [10]. The evaluation is based on the implemented inputs and on the produced outputs. One of the main strengths of this approach (unlike the parametric approaches) is the possibility to include more than one output and to not set assumptions for the production function [11].

What is crucial in DEA is the decision-making units (DMUs) to be homogeneous entities, which means they should use the same resources (known as inputs) to produce the same results (known as outputs) [7]. DMUs can be banks, hospitals, supermarkets, shops, police stations, tax offices, defence bases, schools, restaurants, insurance companies, libraries and even university departments. According to Samoilenko, S. & Osei-Bryson, K. M. [12], DMUs can be people, companies, or countries.

In other words, DEA is one of the existing frontier methods, and represents a convex non-parametric frontier. Frontier methods are methods in which an efficiency frontier (which is based on real observations) is used to classify the different DMUs. Thus, Data Envelopment Analysis is a non-parametric approach that implements a linear programming to discover the efficiency frontier for a company or DMU. The relative efficient DMUs form the efficient frontier that presents an envelope for the analysed DMUs [11]. This way, DEA is used to solve an individual linear programming problem for each analysed organization or DMU, considering the organization's "input and output data are assigned a set of weights to maximize the ratio of inputs and outputs" [13]. The DMUs that are on the frontier (i.e. the cases of best practices) are considered relative efficient, whereas DMUs that are not on the frontier are considered relative inefficient [10, 6].

The first DEA model, introduced by Charnes, A. et al. [8] was named DEA-CCR in honour of their authors. The DEA CCR model has an input orientation and the main assumption is the existence of constant returns to scale (CRS), i.e. all firms are working at an optimal scale [13, 14]. Banker, R. D. et al. [15] have made alterations to the CCR model to incorporate variable returns to scale (VRS) and to estimate the pure technical efficiency of DMUs, thus developing the BCC model (named in honour of its authors as well). The BCC model also recognizes whether a DMU is "operating in increasing, decreasing or constant returns to scale". So it is safe to assume that CCR models are a specific type of the BCC models [5].

Furthermore, DEA models can be performed in the following common orientations: an input-orientation, an output orientation or a non-orientation. In an input orientation, the DEA model should determine the proportion of inputs' reduction that would achieve the same given level of output, with the main assumption that outputs are fixed. In an output orientation, it is not outputs that are fixed, but rather inputs. When using this model orientation, the model determines proportional increase of outputs that would lead to maximization of outputs for a given level of inputs. The non-oriented DEA model is a model in which the input variables are simultaneously reduced and the output variables are increased in order for the DMUs to become efficient [16-19].

DEA has been gaining a lot of popularity in different areas of research and in different industries. Namely, in the last four decades, there are 10.300 published journal articles since the original DEA paper published in 1978 [20]. However, this was not the case in the beginning. Originally, DEA methodology was used to evaluate and measure the efficiency of non-profit organizations, due to the inability to assess them on the basis of conventional economic and financial indicators, which were used for commercial (profit) organizations [21]. In the past decade, DEA has been employed in different areas. For example, Gardijan, M. & Škrinjarić, T. [22] have used the DEA-based investment strategy to conclude the efficiency of the Croatian stock market; Rabar, D. [23] has measured the socio-economic performance of OECD countries, many scholars have evaluated the efficiency and performance of the banking sectors in different countries (Jemrić, I. & Vujčić, B. [24] for Croatia, Fotova Čiković, K. & Cvetkoska, V. [25] for North Macedonia, Sufian, F. et al. [26] for Malaysian banks etc); it has been used in ecological research of maintenance of forestry mechanisation [27], in the process of selection of Energy-Saving Projects [28], in measuring the productivity of chain restaurants [29], in assessing the efficiency of Brazilian electricity distributors [30], in measuring the technical efficiency of primary public health care centres [31], to examining the efficiency of Formula 1 drivers and teams [32]. But, according to Emrouznejad, A. & Yang, G. [20], there are five areas of research where the DEA methodology is mostly used, and these are the following: agriculture, banking, supply chain, transportation, and public policy. Emrouznejad A. et al. [13] found "banking and finance, education, health care and hospital efficiency, energy and utilities, and transportation" to be the most popular application areas of DEA.

In the next Section, the focus shifts on DEA's application in ICT in ten different studies (with ten different perspectives).

3 APPLICATION OF DATA ENVELOPMENT ANALYSIS (DEA) IN INFORMATION AND COMMUNICATION TECHNOLOGIES

The ICT industry has not been on the radar for implementation of DEA models very often. Even though the ICT industry has been largely researched and has attracted significant attention in the recent literature, the DEA methodology is not widely accepted by academics and researchers in this area. In this paper the focus is on the application of DEA in information and communication technologies by analyzing 10 studies published in the past two decades, i.e. from 2006 to 2021.

The applications of DEA in the context of information and communication technologies are presented in Tab. 1.

Chen, Y. et al. [4] have presented how the non-linear programming approach DEA can be handled as a parametric approach and thus, they emphasize the need for a more inclusive and thorough approach that takes into consideration wider economic and strategic IT effects on productivity. They have developed and implemented a new two-stage

DEA model to evaluate the impact IT has on a company performance when intermediate measures are at hand. Their model uses an outline from a previous study and they have selected fixed assets, employees, IT investment as inputs in the first stage, deposit as an input (intermediate measure) in the second stage, and profit and loan recovered as outputs.

Table 1 The applications of DEA in information and communication technologies

Author/s and year of publication	Application
Chen, Liang, Yang & Zhu, (2006) [4]	Evaluation of information technology investment and the impact of IT on multiple stages
Anderson, Daim & Kim (2008) [33]	Predicting the future wireless communications technologies
Asosheh, Nalchigar & Jamporazmey (2010) [5]	Information technology project evaluation
Emrouznejad, Cabanda & Gholami (2010) [34]	Measuring information and communication technology (ICT)
Goto (2010) [35]	Evaluation of the financial performance analysis of US and world telecommunications companies
Paço & Pérez (2013) [14]	Evaluation of the impact of ICT on productivity in the hotel sector
Martinez-Nunez & Perez-Aguiar (2014) [36]	Evaluation of the productive efficiency and online-social-networks (OSN) in telecommunications firms from Spain
Efendi, Syahputra & Muchtar, (2018) [37]	Measuring efficiencies of ICT development in Indonesia region
Guccio, Martorana, Mazza & Rizzo (2019) [38]	Evaluation of the impact of the use of ICT on the performance of public historical archives
Mimbi (2021) [18]	Public value framework to evaluate ICT public value creation

Anderson, R. T. et al. [33] have developed and presented a framework for characterization, assessment and forecast of the wireless communication technologies. They have employed a DEA-based methodology for forecast of the "state of the art in future wireless communications technologies". Namely, they have implemented the Technology Forecasting using Data Envelopment Analysis (TFDEA), which was created in 2001 as an „alternative quantitative approach for technology forecasting". Their study is very influential from both theoretical and practical perspective. From a theoretical point of view, the study stretches the use of DEA in technology forecasting, whereas from a practical perspective, it offers a specific methodology that has been thus far used to microprocessors, fighter jets, enterprise data systems and USB drives.

Asosheh, A. et al. [5] have implemented the DEA methodology together with the Balanced Scorecard approach to evaluate IT projects. They specifically focus on the critical aspect of IT management of deciding upon the best set of IT project from numerous competing proposals. Their study implements Balanced Scorecard (BSC) as a framework to define the criteria for IT projects' evaluation, whereas DEA helps them rank the IT projects. Their paper offers great scientific and practical contribution, due to the fact it combines two popular managerial methodologies: the DEA and the Balanced Scorecard (BSC), and furthermore give a proposal of how to approach new IT project selection processes.

Emrouznejad, A. et al. [34] have implemented an alternative approach for assessing information and communication technology (ICT), with the application of the Data Envelopment Analysis (DEA), on a sample of 183 economies. They have drawn the data from the International Telecommunications Union and have made a comparison of the existing ICT-Opportunity Index (ICT-OI) with their developed DEA-Opportunity Index (DEA-OI), and found a high correlation between the two indexes. The developed DEA-OI consists of 10 ICT indicators, similar to the ICT-OI. The authors suggest that DEA-OI can be considered as "an alternative measurement approach for benchmarking and measuring progress toward the information society".

Goto, M. [35] explores the financial performance of the global telecommunications industry by implementing the DEA–DA (Data Envelopment Analysis – Discriminant Analysis), whose model has a relation with the Altman's Z score. The sample consists of 44 world telecommunications companies, which were ranked according to their performance, which provides crucial information for investors, corporate management, the public and anyone who is interested in the financial performance of companies in the telecommunications sector. Additionally, this article gives a commentary to the financial performance of AT&T (American Telephone & Telegraph) and NTT (Nippon Telegraph and Telephone) after their divestment and found that AT&T outperformed NTT due to its evolvement in an IT company.

Paço, C. L. & Pérez, J. M. C. [14] demonstrate ways in which applications of information and communication technologies (ICT) can bring competitive advantages in hotel firms, with an application of the DEA (CRS) methodology. Their sample consists of 184 hotel establishments, and the analyzed period is from 2008 to 2011. The inputs used were human, financial and material factors and their relative costs, whereas the outputs were the total number of stays in the establishment from 2007-2010 and the number of stays in this period resulting from Internet bookings. They claim the DEA method allows them to diagnose the limitations and blind spots and possible ways to increase efficiency in hotels.

Martinez-Nunez, M. & Perez-Aguiar, W. S. [36] have implemented the DEA methodology together with various indicators of business "social media" activities and thereafter carried out the super-efficiency analysis together with the bootstrapping techniques to improve the model's robustness and accuracy. In their study, they examine the relationship between the productive efficiency and online-social-networks (OSN) on a sample of Spanish telecommunications firms. They chose the DEA model due to its flexibility and non-existent requirements to pre-determine any functional form for the production function. They employed the input-oriented DEA model and developed four models with combinations of the selected input (employees, assets, equity, tweets, following tweets, posts) and output (sales, profits, followers, fans, comment received) variables. This study is valuable to researchers and businesses because it presents divergent factors that present the performance in the use and management of Web 2.0 technologies and OSNs. Their

findings imply that the company's capacity to absorb and utilise OSNs are the most significant factor in efficiency improvement.

Efendi, S. et al. [37] implement the DEA BCC method to find the index of efficiencies for all regions in Indonesia and to evaluate the level of readiness of each district and city in each province (DMUs) for the ongoing digital economy era. Their findings show that the readiness of each of the analysed province was not enough, but a level of efficiency is required from each province, in a way that the local government could be able to recognize the weaknesses and inefficiencies of each province.

Guccio, C. et al. [38] explore one rather rarely verified area of research: the impact of ICT (represented by the existence and usage of a website) on the efficiency of public services (in their case the public historical archives - PHAs). They employ a two-stage approach including the DEA and the Window DEA together with the Mann–Whitney and Kolmogorov–Smirnov tests. The selected inputs are the total surface area in square meters; the total shelf dimension in linear meters; the number of personnel; and current PHA expenditure excluding labour costs. Output variables include: the number of visitors; the total number of requests processed by PHA; and the total number of documents inspected. The obtained results imply that the distribution and implementation of ICT does improve efficiency and in the case of their study, Italian PHAs with a website appear to be generally more efficient than others. They focus on the public sector due to the lack of studies in the literature that focus exclusively on efficiency in the public sector.

Mimbi, L. [18] has adopted a "public value framework to interrogate ICT public value creation", which is quite an interesting study. In this study, he implemented the DEA together with a cluster analysis to analyse data for 53 African countries in the period from 2010 to 2019. The clusters were formed using the human development index (HDI). In his study, Main telephone line, Internet users and Mobile cellular subscribers were used as input variables, whereas Accountability, Government effectiveness, Press freedom and Rule of law as output variables. His findings show that ICT has "efficiently transformed public values in Africa" by 14%, 35%, and 63% in countries of clusters 1, 2, and 3, respectively. Moreover, his findings are in line with the public value theory, which forecasts doing more with less. Namely, the clusters that showed highest efficiency of ICT are the ones noting low human development.

4 DISCUSSION

The presented review of the DEA literature in ICT shows the application of DEA in different aspects of efficiency evaluation, and highlights the broad use of this methodology. In this paper, we have adopted a pragmatic perspective and we seek to objectively point to some of its strengths as well as its limitations.

There has been open criticism and rebuttals on a number of methodological and substantive grounds regarding the DEA methodology [23, 39, 40]. Nevertheless, Stolp, C. [41]

claims DEA should be considered as an informative and useful tool for systematic sensitivity analysis.

In Tab. 2 the most stated strengths, limitations and setbacks of the DEA are presented.

Table 2 The strengths and limitations of DEA
(Source: Authors' construction, based on [10, 24, 39, 41, 42, 43])

Strengths	Limitations
No required knowledge of the explicit functional form linking input variables and output variables nor a priori determination of the weights for these variables	The basic assumption that random errors do not exist can lead to frontier sensitivity to extreme observations and measurement errors
Characterization of each DMU by a single result of relative efficiency	Ignores the effect of exogenous variables on the calculation and operation
Simultaneous analysis of inputs and outputs	Does not offer possibilities and ways for efficiency improvement
Use of multiple input variables/output variables without imposing any functional form on data or making assumptions of efficiency/ inefficiency or certain relations	Performing statistical tests with the findings could be quite challenging
Provides a comparison of each inefficient unit with its "peer group"	The results can be sensitive to the selection of input variables and output variables, so an analysis of their relative importance is essential prior to the calculation

The biggest and most important issue in DEA is the validated selection of the RTS (return-to-scale) assumption. Furthermore, the selection of the output or the input orientation has been an important issue of DEA, since Emrouznejad, A. et al. [44] report that "there can be significant differences" between the results of the CCR and BCC model variants [40]. Therefore, it should be advised that DEA results need to be interpreted with much caution so that wrong signals and inappropriate recommendations could not be laid out.

5 CONCLUSION

The constantly changing environment that we live in requires the ICT industry to be not only innovative, alert and responsive, but also productive and efficient. As Martinez-Nunez, M. et al. [36] state regarding the ICT use in companies, "the key point is not how good a technology is, but how well it is used by members of an organization". This statement highlights the reason why DEA methodology should be more commonly used and implemented for performance and efficiency measurement in the ICT industry by business analysts and academic researchers.

Data Envelopment Analysis is an econometric mathematical programming technique that has gained large interest in different areas, but has not been often used in the ICT industry. In this paper a theoretical background of the data envelopment analysis (DEA) is given and its application in information and communication technologies is presented according to ten published studies in this area in the period from 2006 to 2021. These studies have explored very different perspectives of the ICT industry and have all implemented the DEA methodology, starting with the

evaluation of IT investment [4], prediction of the future wireless communications technologies [33], IT project evaluation [5], measuring ICT [34] and ICT development in Indonesia region [37], evaluation of financial performance of US and world telecommunications companies [35], evaluation of the productive efficiency and online-social-networks (OSN) in telecommunications firms from Spain [36], evaluation of the impact of the use of ICT on the performance of public historical archives [38] to the use of the public value framework to evaluate ICT public value creation [18]. This paper highlights all the possible ways to implement and benefit from the DEA methodology in ICT.

As any other methodology, DEA has strengths and limitations. Its limitations and pitfalls could present ample opportunities for some alternative approaches in dealing with these issues, but also for improvement of DEA implementation by researchers as well [13]. Other than that, DEA is a significant diagnostic tool that is relatively easy to implement and that gives new insights to stakeholders in different types of companies and different industries.

The main objective of this paper is to present the studies published thus far implementing DEA in information and communication technologies as well as to encourage other scholars and researchers to implement this methodology in ICT, to use the benefits of this approach and to give new insights to academic researchers, business analysts and the public.

6 REFERENCES

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Extension of Intersection Method for Multi-Objective Optimization in Case of Interval Number and its Application

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Abstract: This paper aims to develop the extension of intersection method for multi-objective optimization under condition of interval number. Based on the linear correlation of partial favourable probability and the corresponding performance indicator, and the assumption of uniform distribution of the actual value of performance indicator within the range of its lower and upper limits in case of interval number, it derives that the actual partial favourable probability of a performance indicator is the arithmetic mean value of the partial favourable probabilities of the arithmetic mean value and the variation value of the interval index of the corresponding performance indicator for each candidate, or their desired sum. Furthermore, according to the rule of algorithm for the total favourable probability quantitatively, all candidates are ranked according to their total favourable probabilities to complete the multi- objective optimization in case of interval number. As applications, the quantitative assessments of multi-criteria selections for effective dwelling house walls, project managers and contractor for construction works are given in detail, satisfied results are obtained.

Keywords: arithmetic mean; favourable probability; intersection method; interval number; multi-objective optimization

1 INTRODUCTION

Multi-objective optimization (MOO) is the process of specifying the optimal solution from all feasible alternatives. The category of MOO is to conduct the selection from a limited number of alternatives by assessing the performances of multiple objects in beneficial or non - beneficial manners comparatively. A MOO technique determines how the performance information to be assessed and to get the appropriate selection. Given the proper decision matrix and decision-making procedures, the decision maker could conduct the best alternative and /or rank to complete the selection.

In traditional multi - objective optimizations, the performance indexes and attributes are assumed to be well determined without any uncertainty. However, in some cases, the responses of alternatives to attribute are not always possessing exact values. Especially, decision makers' judgment is often vague, which may not present their preferences with exact numerical values. In order to deal with such uncertain elements of a decision problem, several approaches are proposed. In interval COPRAS-G, complex steps are included involving artificial parameters and personality [1]. Hafezalkotob et al. extended the MULTIMOORA method to include interval number by using fuzzy logic theory and a novel comparison technique [2], by introducing a preferences of $A \geq B$ or $B \geq A$, and each coordinate of the comparison matrix of P_{qr} being a one – to - one comparison between intervals, as well as specific value of 0.5 for diagonal preferences, i.e., $\{P_{11}, P_{22}, \ldots, P_{vv}\}$. Jahanshahloo et al. proposed an extension of the technique for order preference by similarity to ideal solution (TOPSIS) to deal with decision making problems with interval numbers [3]. Sayadi et al. extended the VIse Kriterijumska Optimizacija i kompromisno Resenje (VIKOR) technique by considering interval value [4]. Pan et al. formulated an interval multi attribute decision making (MADM) approach by using the linear additive utility function and composite utility variance [5]. Chen et al. developed a unique interval MADM method with loss aversion [6]. Cao and Wu extended

the continuous ordered weighted geometric (COWG) operators to solve multiple attributive group decision making (MAGDM) problems with interval numbers [7]. Brauers et al. employed the fuzzy numbers to extend the crisp MULTIMOORA method [8]. Liu et al. utilized fuzzy numbers to determine the risk of failure modes by extending MULTIMOORA method [9]. Mandal and Sarkar used the fuzzy MOORA methodology to perform the selection of an optimal intelligent manufacturing system [10].

Recently, a new "intersection" method for MOO was proposed in the viewpoints of probability theory and set theory [11], which aims to solve the inherent problems of personal and subjective factors in previous multi – object optimizations. In the new MOO method, a novel concept of favourable probability was developed, which reflects the favourable degree of the candidate in the optimization; each performance utility indicator of the candidate contributes to a partial favourable probability quantitatively; the total favourable probability of a candidate is the product of all partial favourable probabilities in the viewpoint of probability theory, which is the overall and unique decisive index in the competitive selection process. The new MOO method was applied in materials selection and multi - objective orthogonal test design (MOOTD) and multi - objective uniform test design (MOUTD) successfully [11].

As a further study on the newly proposed "intersection" method for MOO, here in this paper, an extension of the intersection method for MOO under condition of interval indexes is developed so as to include this case in the evaluations.

2 EXTENSION OF THE "INTERSECTION" METHOD FOR MOO IN CASE OF INTERVAL NUMBER

In traditional MOO, the performance indexes and attributes are assumed to be well determined without any uncertainty. However, in some cases, the performance indexes and attributes are often vague, which results in un-exact numerical values instead of well determined data. In

order to deal with such decision problem with uncertain elements, proper approach is in need.

In general, the decision-making matrix X is with the form of Eq. (1) in case of interval numbers,

$$X = \begin{bmatrix} [w_{11}; b_{11}][w_{12}; b_{12}] \cdots [w_{1m}; b_{1m}] \\ [w_{21}; b_{21}][w_{22}; b_{22}] \cdots [w_{2m}; b_{2m}] \\ \cdots [w_{ij}; b_{ij}] \cdots \\ [w_{n1}; bn1][w_{n2}; b_{n2}] \cdots [w_{nm}; b_{nm}] \end{bmatrix} \quad (1)$$

$i = 1, 2, ..., n;\ j = 1, 2, ..., m.$

In Eq. (1), w_{ij} represents the lower limit, and b_{ij} is the upper limit of the performance index.

The main feature of the new "intersection" method for MOO is that there is no necessary to make normalization for the decision-making matrix [11], the partial favourable probability can be obtained from the decision-making matrix directly for the performance index with exact value, and the total favourable probability is the overall representative in the viewpoint of probability theory, which is the unique decisive index in the competitive selection process.

However, in some cases there gives the interval value instead of exact value for the performance index, i.e., the lower limit and upper limit of the performance indicator.

In cases of interval values, it is no doubt that the value of the performance index is within the range of the lower and upper limits of the performance indicator. Thus the lower and upper limits of the performance indicator may lead to uncertainty of the partial favorable probability of the performance index.

In [11], it assumed that the partial favourable probability is correlative to the corresponding performance index linearly from the principle of simplicity, if we further assume that the actual value of the performance indicator under condition of interval number is uniformly distributed within the range of its lower and upper limits, then the actual partial favourable probability of a performance index is the arithmetic mean value of the partial favourable probabilities of the arithmetic mean value $m_{ij} = (w_{ij} + b_{ij})/2$ and the variation value $v_{ij} = (b_{ij} - w_{ij})/2$ of the interval index, i.e. or their desired sum,

$$P_{ij} = \frac{\left[P(m_{ij}) + P(v_{ij}) \right]}{2}, \text{ or}$$

$$P_{ij} = a_j * P(m_{ij}) + (1 - a_j) * P(v_{ij}). \quad (2)$$

In Eq. (2), $P(m_{ij})$ and $P(v_{ij})$ represent the partial favorable probabilities of the arithmetic mean value and variation value of the interval index, respectively. The assessments of $P(m_{ij})$ and $P(v_{ij})$ are in accordance with Ref. [11], individually; in general, $P(v_{ij})$ is attributed to non-beneficial type; a_j is the adjust parameter for desired sum.

In this operation, the interval index is divided into two parts, i.e., m_{ij} and v_{ij}, which represent the various properties of interval index in different aspects. This operation opens a new treatment to interval index, which breaks away from the

persecution of comparison of interval indexes, while the comparison of interval indexes is continuously an unsolvable problem.

Afterwards, the assessment of the intersection method for MOO under condition of interval number will be as usual as that in [11].

Till now, the extension of intersection method for multi - objective optimization under condition of interval number is completed.

3 APPLICATIONS OF THE EXTENSION OF INTERSECTION METHOD FOR MULTI-OBJECTIVE OPTIMIZATION

In this section, the extended intersection method for MOO in case of interval number is applied to deal with the following multi-criteria decision-making problems.

3.1 Selection for Effective Dwelling House Walls

Zavadskas et al. once developed a "specific method of multiple criteria decision-making combining with grey relations" to deal with the problem of attribute values within intervals [1]. Tab. 1 shows the initial decision-making index for effective dwelling house walls with values expressed in intervals, which is cited from [1].

Table 1 Initial decision-making matrix with values expressed in intervals

Alternate No.	Durability		Thermal transmit.		Cost		Weight of wall		Human expenditure	
Weight q	0.21		0.33		0.26		0.09		0.11	
Index	X_1		X_2		X_3		X_4		X_5	
Optimum	max		min		min		min		min	
Alternat.	w_1	b_1	w_2	b_2	w_3	b_3	w_4	b_4	w_5	b_5
A_1	75	100	0.22	0.25	72.08	94.71	590	652	4.60	4.60
A_2	75	100	0.22	0.25	89.01	100.93	596	625	4.60	4.60
A_3	75	100	0.21	0.25	80.32	96.42	581	604	4.60	4.60
A_4	25	25	0.24	0.27	67.76	98.10	455	479	4.55	5.01

Table 2 Evaluated results for actual partial favourable probability, total favourable probability and ranking

Probability	P_{X1}	P_{X2}	P_{X3}	P_{X4}	P_{X5}	P_t	Rank
1	0.1522	0.2602	0.2420	0.1702	0.2929	0.2225	4
2	0.1522	0.2602	0.2869	0.2545	0.2929	0.2411	2
3	0.1522	0.2294	0.2722	0.2737	0.2929	0.2230	3
4	0.5435	0.2501	0.1989	0.3017	0.1214	0.2605	1

In Tab. 1, b_{ij} means the upper limit of the j performance indicator in the i alternative of a solution, w_{ij} means the lower limit of the j performance indicator in the i alternative of a solution; the word "max" in Tab. 1 means "the higher the better", i.e., beneficial performance index, and the word "min" means "the lower the better", i.e., unbeneficial performance index in the multi-objective optimization evaluation for the arithmetic mean value of the interval index.

The partial favourable probabilities of $P(m_{ij})$ and $P(r_{ij})$ are assessed from the performance data of the interval indexes shown in Tab. 1. According to Eq. (2), the arithmetic mean value of the partial favourable probabilities of

performance indexes of the candidates of mean value and variation represents the actual partial favourable probabilities of performance indicators, which is shown in Tab. 2.

The evaluated results for total favourable probability together the ranking results are given in Tab. 2 as well.

The sequence in Tab. 2 is "$A_4 > A_2 > A_3 > A_1$", which is not the same as the ranking of Zavadskas [1], however one may use the formula of desired sum with adjust parameter α_j to improve the consequence for one's aim; the expression "$A_4 > A_2$" here means that A_4 is prior to A_2.

3.2 Multi-Criteria Selection of Project Managers

In addition, in Ref. [12], Zavadskas et al. applied the "specific method of multiple criteria decision-making combining with grey relations" to deal with a project manager problem.

Tab. 3 shows the initial decision-making index for project manager problem, which is cited from [12].

Table 3 Initial decision-making index with the criterion values described in intervals and normalized weighted matrix

Index	X_1		X_2		X_3		X_4		X_5		X_6	
Optimum	max		max		max		max		max		min	
Weight q	0.25		0.15		0.12		0.20		0.13		0.15	
Manager	$\underline{x_1}$	$\overline{x_1}$	$\underline{x_2}$	$\overline{x_2}$	$\underline{x_3}$	$\overline{x_3}$	$\underline{x_4}$	$\overline{x_4}$	$\underline{x_5}$	$\overline{x_5}$	$\underline{x_6}$	$\overline{x_6}$
1	50	60	40	55	10	20	50	70	45	50	30	40
2	70	80	60	70	40	45	60	75	70	80	60	70
3	60	70	55	70	30	40	70	80	55	65	40	50

In Tab. 3, $\overline{x}_{ij}$ means the upper limit of the j attribute in the i alternative of a solution, $\underline{x}_{ij}$ means the lower limit of the j attribute in the i alternative of a solution.

Again, let's using Eq. (2) to conduct the assessment of the actual partial favourable probabilities for the performance indicators, the results are shown in Tab. 4.

Tab. 4 shows evaluated results for total favourable probability and ranking as well.

Table 4 Evaluated results for partial favourable probability, total favourable probability and ranking for project manager selection

Probability	P_{X1}	P_{X2}	P_{X3}	P_{X4}	P_{X5}	P_{X6}	P_t	Rank
1	0.3077	0.2784	0.2061	0.2593	0.3801	0.3763	0.2958	3
2	0.3590	0.4000	0.4797	0.3333	0.3305	0.2796	0.3547	1
3	0.3333	0.3214	0.3142	0.4074	0.2894	0.3441	0.3380	2

The sequence in Tab. 4 is "project manager 2 > project manager 3 > project manager 1", which is the same as the ranking in [12] fortuitously.

3.3 Multi-Criteria Selection of Contractor for Construction Works

Beside, in Ref. [13], Zavadskas et al. studied contractor selection problem for construction works by applying saw-g and TOPSIS grey techniques.

Tab. 5 shows the initial decision-making index values of contractor selection for construction works problem, which is cited from [13].

Table 5 Initial decision-making index values of contractor selection for construction works problem

Index	X_1		X_2		X_3		X_4		X_5		X_6	
Optimum	max		max		max		min		max		max	
Alternative	w_1	b_1	w_2	b_2	w_3	b_3	w_4	b_4	w_5	b_5	w_6	b_6
A_1	11	15	10	15	3.30	4.5	35	48	0.152	0.203	1	2
A_2	10	14	7	13	2.54	3.68	40	58	0.111	0.162	1	2
A_3	14	18	5	9	1.95	2.46	42	53	0.079	0.121	1	3
A_4	12	16	1	4	0.42	1.73	15	63	0.01	0.054	1	2
A_5	6	10	2	9	0.62	2.67	10	46	0.012	0.122	1	2

Once more, Eq. (2) is used to conduct the assessment of the actual partial favourable probabilities for the performance indicators, the results are shown in Tab. 6.

Tab. 6 shows evaluated results for total favourable probability and ranking of each candidate as well.

Table 6 Evaluated results for partial favorable probability, total favorable probability and ranking of contractor selection for construction works problem

Probability	P_{X1}	P_{X2}	P_{X3}	P_{X4}	P_{X5}	P_{X6}	$P_t \times 10^5$	Rank
1	0.2032	0.2667	0.2666	0.2347	0.2823	0.2049	19.6047	1
2	0.1952	0.2133	0.2380	0.1991	0.2424	0.2049	9.7989	3
3	0.2270	0.2133	0.2479	0.2240	0.2165	0.1806	10.5103	2
4	0.2111	0.1733	0.1399	0.1381	0.1481	0.2049	2.1442	4
5	0.1635	0.1333	0.1076	0.2042	0.1108	0.2049	1.0866	5

The sequence in Tab. 6 is "$A_1 > A_3 > A_2 > A_4 > A_5$", which is not the same as the ranking in [13].

The applications of the extension of new method for MOO under condition of interval number by above cases indicate its validity.

4 CONCLUSION

From above discussion, the extension of the new method for multi-objective optimization in case of interval number is an appropriate approach. The arithmetic mean value of the partial favourable probabilities of arithmetic mean value and variation value of the interval index or their desired sum gives the actual value of the partial favourable probabilities of the corresponding performance indexes. The total favourable probability is the overall and unique indicator to decide the final result of the assessment comprehensively. The approach is full probability theory based, which is categorical and simple without any artificial and personal factors.

Conflict Statement

There is no conflict of interest.

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The Third Mission of the University: The Response of GRAFOS' Students to the Consequences of Natural Disasters in Croatia 2020

Sanja Lončar-Vicković, Marija Krajnović*, Martina Kamenarić

Abstract: The universities of the 21st century are dedicated to three missions - education, science and advancement of the community. The impact of two major earthquakes in Croatia in 2020 as well as the impact of the COVID 19 pandemic, led to the integration of these topics into the educational process at the Faculty of Civil Engineering and Architecture Osijek (GRAFOS), Croatia. In this example, GRAFOS architecture students designed shelters for people left homeless following natural disasters. The paper presents the process of creating innovative and bold shelter proposals, simultaneously developing students' skills like critical thinking, team work, communication and interpersonal skills.

Keywords: GRAFOS; natural disasters; shelter architecture; students' design; third mission of the university

1 INTRODUCTION

Universities in Europe, first emerging nearly a thousand years ago, were focused on two basic objectives - education and scientific research. The importance and significance of those objectives changed through centuries depending on the political, economic and social environment surrounding academia. However, in the last few decades, a deeper involvement and cooperation between academia and the society started to develop.

The term *third mission of universities* describes the orientation of universities towards connecting education (the first mission) and science (the second mission with the needs of their socio-economic surrounding.

The Faculty of Civil Engineering and Architecture Osijek (GRAFOS), a faculty within the University of Josip Juraj Strossmayer of Osijek, Croatia, defined its third mission in official documents as "socially responsible involvement within the community". In recent years this mission has been noticeable in engagement of GRAFOS' teachers and students with respect to eliminating the consequences of 2014 floods in eastern Croatia and the 2020 earthquakes in Croatia's capital Zagreb and around Petrinja in central Croatia.

This paper presents analytical and graphical overview of GRAFOS' students' residential shelter designs for communities affected by natural disasters within the study course *Architectural design.*

2 THE THIRD MISSION OF THE UNIVERSITY

Most definitions of the term university describe the university as a place for teaching and providing scientific and artistic services.

A definition by the Croatian Encyclopedia states: university (Ger. Universität, from Lat. universitas, Genitive case universitatis: association, community) is a community of faculties and other institutions of higher education founded to promote educational, scientific or artistic activities. [1]

According to the Croatian Law on higher education and science (Official Gazette 131/17) "academic freedom, academic self-administration and university autonomy entail

responsibility on the part of academic community towards social community it operates in" [2].

The third mission of the university is a concept where universities are "the carriers of positive changes that contribute to social and economic development on local, regional and national level" [3].

Majority of modern universities incorporate all three missions while envisioning their development. The University of Zagreb defines its mission and vision through the engagement "in public activities that generate technological, economic and social development consistent with the strategic needs of the Republic of Croatia". [4]

The University of Josip Juraj Strossmayer in Osijek cites that "higher education is of exceptional importance for the community because it contributes to regional development as well as national societal development". [5]
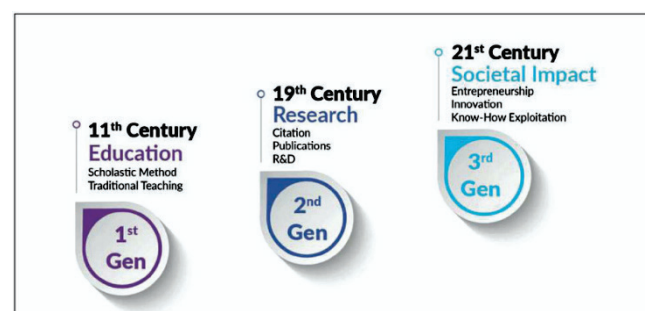

Figure 1 The university development model though three developmental phases (from the 11th till 21st century)

A model of university development, starting in the 11th century and divided in three phases or generations following up to the 21st century, is presented in Fig. 1.

According to this graphic model, first generation of universities arose with the founding of "modern" universities in Europe in the 11th century and the most important aspect of their engagement was education (the first mission) by means of traditional scholastic methods. Previous periods and civilizations are not to be disregarded, but contemporary universities can be viewed as successors of universities

established in the Middle Ages in cities like Bologna, Paris and Krakow.

The second generation of universities, formed in the 19th century, was oriented towards science and development (Research & Development), emphasizing research authenticity, transparency and publishing research results (the second mission).

The universities of the third generation emerged in the 21st century and are orientated towards social impact of university activities, innovations and transforming knowledge into socially useful products (the third mission). Subsequently, the universities of the third generation are currently undergoing a change from the *transfer of knowledge* paradigm to the process of *co-creation. Transfer of knowledge* is a model in which the researcher "generates" the knowledge at the university and transfers it by means of patent or some other way into technologically advanced products. Co-creation is a model in which the university researcher and partners from economy collaborate from the beginning of the research. Co-creation model positions the university as a proactive place for connecting people and ideas through education and research - students, teachers, businessmen, public sector and the civil society. [6]

3 THE THIRD MISSION OF THE FACULTY OF CIVIL ENGINEERING AND ARCHITECTURE OSIJEK (GRAFOS)

The Faculty of Civil Engineering and Architecture Osijek (GRAFOS) accentuated the importance of its third mission in several official documents. However, that is more visible in the presence of GRAFOS's students and teachers in co-operation with the economy, local and national authorities, lifelong learning programs, humanitarian actions, volunteering etc. Throughout 2020 and 2021 that mission was in most part directed towards dealing with the consequences of the Zagreb and Petrinja earthquakes.

3.1 Earthquakes in Croatia 2020; Professional and Scientific Engagement of GRAFOS' Teachers and Students in the Aftermath of Disasters

The Faculty of Civil Engineering and Architecture Osijek (GRAFOS) was directly and indirectly active in the process of minimizing the consequences of the 2020 earthquakes in Zagreb and Petrinja.

GRAFOS's students and teachers participated in evaluating the level of the damage and usability of buildings affected by the earthquakes, both on a professional and on a scientific level. They were involved in the creation of reports regarding earthquake consequences, in seismic activity monitoring in eastern Slavonia and the rest of Croatia, in providing expert lectures and consulting, publishing scientific research regarding Zagreb and Petrinja earthquakes, as well as in volunteering on locations damaged by the earthquakes.

GRAFOS employees surveyed damaged buildings in the Petrinja region in January 2021 [7] and February 2021 as volunteers. GRAFOS teachers participated in Croatian

Center for Seismic Engineering conference called *Renovation of Zagreb after the earthquake* [8].

GRAFOS teachers participated in the creation of a preliminary report on earthquake consequences in Petrinja. The report was finalized in January 2021, as a part of collaboration between the American Earthquake Engineering Research Institute (EERI) and the Structural Extreme Events Reconnaissance (StEER) Network. The report involved thirty experts from renowned universities like Stanford University, University of California, Texas Tech University, Oregon State University and Swiss Federal Institute of Technology Lausanne. The seismic report, damaged buildings' illustrations, building regulations and building tradition, infrastructural damages, observed geotechnical damages were all included in the report [9]. GRAFOS teachers took part in scientific research of the Zagreb and Petrinja earthquakes with results published in 2021 [10], [11]. GRAFOS students were involved in volunteer activities in disaster areas as well, mostly on an individual basis [12].

3.2 Earthquakes in Croatia 2020; Educational Aspects of GRAFOS' Teachers' and Students' Involvement in the Aftermath of Disasters

Besides direct involvement, GRAFOS teachers included the topic of earthquakes and earthquake consequences in the educational process.

In the 2018 EUA report related to the trends in higher education, conducted by the European University Association (EUA Trends Report), many universities joined in the trend of dealing with practical problems and projects in teaching and learning. Projects arose from local and wider communities' needs and were often initiated by students [13]. Such approach to education is supported to a great extent by Project Based Learning (PBL). Project Based Learning is a teaching method that encourages students' active participation in research aimed at a specific project, problem or task. In Project Based Learning students are given a task based on facts, a problem they need to solve, or a specific goal they need to achieve, while knowledge, skills and attitudes are acquired in the course of solving a specific problem/example. In addition to knowledge and skills related to teaching and learning, students develop communication and interpersonal skills, problem-solving skills, critical thinking, etc. This type of education takes place in phases (from research to presentation), with students being able to see and examine results in real time [14, 15].

Teachers of the Undergraduate University Study of Architecture and Urban Planning at GRAFOS practice PBL within several courses. In 2020 and 2021 PBL [16] was used as a basis to tackling problems related to alleviating earthquake consequences in Croatia, specifically within study courses *Architectural Design*, *Residential Buildings* and *Urban Planning 2*.

Study course *Architectural design* tasked the students with designing shelters for people affected by natural disasters. The results and students' designs are presented in the following text.

4 STUDENTS' RENSPONSE TO RESIDENTIAL CHALLENGES CAUSED BY NATURAL DISASTERS

Natural disasters have recently become more frequent and dangerous, resulting in numerous civilian casualties and inflicting material damage. The consequences of natural disasters are both expensive and protracted as they result in humanitarian crises that last for years and require huge reconstructive investments.

The architects and builders have an important role in the process of both restoring the lost infrastructure and responding to the basic human need for accommodation and safety. Building after a disaster has to deal with short term needs for immediate shelter as well as long term needs for wide ranging reconstruction because relocated population often keeps living in temporary shelters with limited approach to water, sewage and electricity.

4.1 Study Course Architectural Design

Architectural design course is part of the Undergraduate University Study of Architecture and Urban Planning at GRAFOS. It is a first study year course with the goal of introducing the students to different aspects of project and design thinking [17].

4.2 Preliminary Research

The choice of the project task relevant to Croatia after the earthquake and pandemic of 2020 was followed by preliminary research necessary for defining students' assignments. Preliminary research included the topic of natural disasters (definition, typology and damage, natural disasters registry), shelter architecture (definition, prevention, adaptive and modular architecture) as well as referent examples of various shelters used after natural disasters.

4.2.1 Natural Disasters

According to the Croatian Law on Protection against Natural Disasters [18] it is considered that a natural disaster is a sudden occurrence that disrupts usual course of life, causes victims, damage/loss of the property to a great extent, as well as the damage of the infrastructure and/or the environment.

Republic of Croatia possesses a unique digital database of damages caused by natural disasters called the Natural Disaster Damage Registry. The data, based on the damage estimations conducted by the municipal/city/county, is collected and documented in the Damage Registry. The Registry data contain the following: assessed damage content, final damage assessment, cost of repair [19].

Natural disasters typology includes earthquakes, storm and hurricane winds, fires, floods, droughts, frost, snow and snow-drift, pandemics, whirlwinds, environment pollution, causes being natural, technical, technological or biological events.

Table 1 Shelter design recommendations in case of various natural disasters

Type of Disaster	Cause of Disaster	Location of Shelter	Design Guidelines
Earthquake	displacement from the ground	avoiding fault lines, rivers and coastal areas	light materials, firm and stable structures
Flood	water level increase, humidity	avoiding floodplain and high water level areas	waterproof materials, lifting shelters above the ground
Wind/Storms	wind load	avoiding strong wind areas, tall buildings and trees	foundation reinforcement, ideal building shapes

4.2.2 Shelter Architecture

Shelter is a building or a part of a building constructed for protection and rescue of people and material goods in case of disasters caused by war destruction or other activities conducted by man or natural forces [20].

According to a detailed classification, there are seven types of shelters: emergency shelter, temporary shelter, temporary residence, transitional shelter, progressive shelter and permanent housing [21].

When designing shelters, it is important to consider climatic, geographical, constructive and economic aspects of design. A modular approach to shelter design contributes to the increase in flexibility and has a potential to combine the units thus enabling the survival of existent communities.

Prevention or Recovery?
Problems caused by natural disasters could be assessed through discourses of prevention or recovery. Design solutions of buildings resistant to possible future damages caused by natural disasters are defined by prevention or resistance architecture. Design solutions of buildings to be used after natural disasters are defined by immediate recovery. In this case, architects have to take into account the extent of damage caused by natural disaster, required infrastructure, speed of construction, available construction typology including materials, technology, etc. during recovery of the area. Design solutions should consider minimal needs required for functioning of the unit/ community/ more communities over a longer period of time, with adaptability and modularity being an important aspect of the project quality.

Prevention - Adaptive/adjustable Architecture
Building of safe houses as a part of "how to live with danger" concept is a basis for the adaptive/adjustable architecture. Understanding risks, settlement planning, safe construction, as well as improvement and renewal after the catastrophe are all included in this type of architecture.

The adjustable building is usually comprised of the following:
- lightweight structures - structures made of light materials, more resistant to earthquakes
- safe and firm structures - prevention of the wind penetration

- safe ground anchorage - additional anchoring of the building
- raising structures above the ground - prevention of the flood impact
- additional diagonal stiffeners of the wind bonds - prevention of the horizontal wind load
- careful shaping of the building - compact buildings are more resistant to earthquake. [22]

Recovery - Modular Architecture

The use of prefabricated units that can be multiplied sums up the concept of modular architecture. Their rapid and cheap production, storage and transportation as well as swifter assembly in natural disaster circumstances is achieved by the multiplication of the same or alike units.

The advantages of modular constructions include shorter time for construction work, less need for labor, safer work conditions, better product quality, less material waste and smaller environmental impact. Logistic aspects of crisis management (supply, transport, storage) are most challenging and expensive in this case. The factors to be taken into account when designing a modular system include type and extent of disaster, climate and geography of the affected area, among others.

4.2.3 Reference Examples

Temporary shelter for earthquake victims in Nepal, Barberio Colella Arc, 2013

After the 2013 earthquake, hundreds of thousands of people in Nepal lost their houses. A temporary shelter unit was designed by the Barberio Colella Arc office for accommodation of 4 to 10 people by means of modular units 4 by 11,7 meters long. The modules could be quickly built and delivered, they are made of local materials, and once built, they create spaces with respect to users' needs and facilitate life of a community after the earthquake.
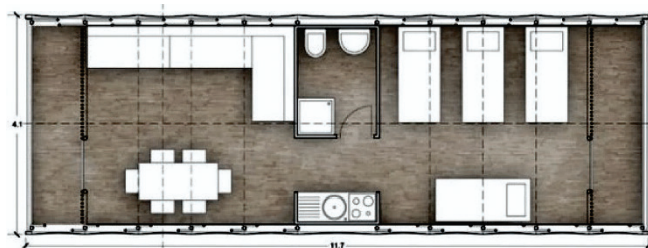
Figure 2 Temporary shelter for earthquake victims in Nepal, Barberio Colella Arc, 2013, visualization and layout

Alternative housing for the earthquake victims in Petrinja, Faculty of Architecture Zagreb, 2021

The teachers of the Faculty of Architecture in Zagreb have designed 20 types/60 subtypes of modular prefabricated houses for the earthquake victims in the Petrinja region.

Those houses, half prefabricated and/or prefabricated, are made of light materials with varying layouts based on modular design. All the proposed house designs take into account traditional architecture features, escaping simplistic shape imitations, and creatively interpreting local life. [23]
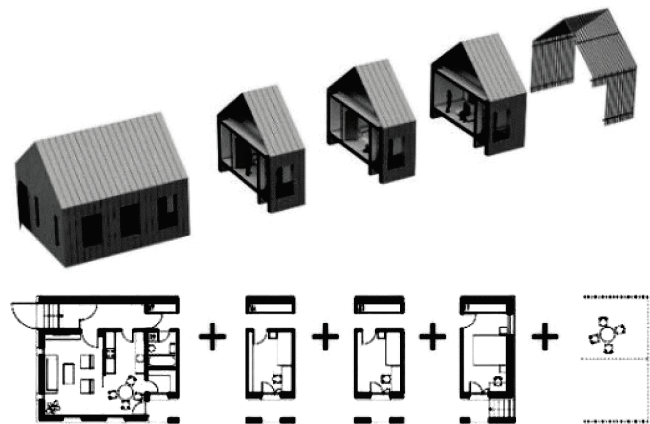
Figure 3 The examples of the modular object solution for the earthquake victims in Petrinja, author: Luka Korlaet

Temporary shelter for all the types of natural disasters, Abeer Seikaly, 2013

In 2013, Abeer Seikaly defined the solution of a shelter to be used for all types of natural disasters. The modular unit represents a structure made of fabric adjustable to different climates, by shape and materials similar to a tent used by nomadic desert people. It is shaped following wave curves and inwrought in flexible fabric membrane. The shelter could be multiplied to create a settlement. Abeer Seikaly primarily considers the placement of a large number of refugees who could find a place for a temporary stay that allows them "to weave" their new lives.

Figure 4 Temporary shelter for all the types of natural disasters, Abeer Seikaly, 2013

Temporary shelter system for the Japanese flood victims, Shigeru Ban, 2018

A temporary modular shelter system for the flood victims in Japan was designed by the architect Shigeru Ban in 2018, and it was shaped from paper tubes and textile blinds with dimensions 2 by 2 meters. The units were built in evacuation centers of the affected area, and a unit could be built in a few hours. Shigeru Ban was inspired by traditional Japanese architecture where fabric (tatami, straw, bull-rush) and paper (barriers made of rice paper) enable flexibility and transparency of the space.
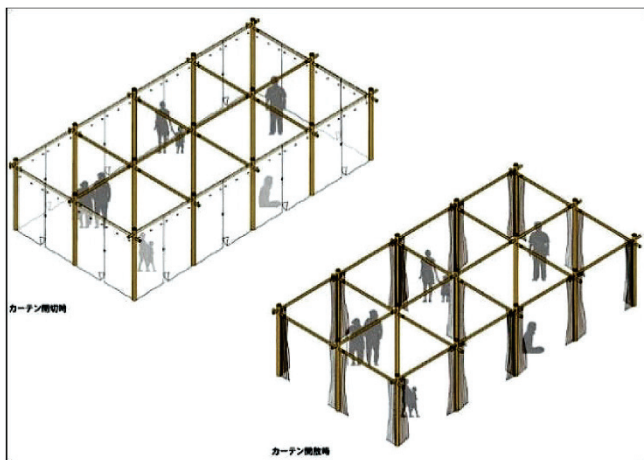
Figure 5 Temporary shelter system for the Japanese flood victims, Shigeru Ban, 2018

Temporary shelter from strong winds and high temperatures, Christian Weber, 2014

Aiming to secure accommodation for a large number of people participating in a music festival in Black Rock desert, architect Christian Weber defined a shelter solution in 2014. The shelter was designed with the primary goal to protect from strong winds, cold nights and heat in desert areas. The basic shelter module is a hexagonal unit with a 195 cm base line and 2 meters high. The unit is resistant to wind, dust and temperature oscillations in desert which range from 40 to 50 °C.

Figure 6 Temporary shelter from strong winds and high temperatures, Christian Weber, 2014

5 STUDENTS' SHELTER DESIGNS

Study course *Architectural design* is a second semester course that usually consists of three design assignments for students. The topic of the second assignment in academic year 2020/2021 was the design of a shelter suitable for people to use after natural disasters. Incentives for such topic were the consequences of both the corona virus pandemic as well as consequences earthquakes that struck Zagreb, Petrinja, Sisak, Glina and the surrounding regions in 2020.

The financial consequences of the March and December 2020 earthquakes are estimated to be worth around 160 billion kuna, amounting to 40% of the Croatian Gross Domestic Product (GDP) per year [24]. At the same time,

consequences of the global corona crisis have led to a record drop of the Croatian GDP of 8,4% for the whole of 2020 [25].

A part of the above-mentioned costs refers to accommodating the population affected by the earthquakes by means of mobile homes and residential/office containers in Zagreb (total of 76 units) and Petrinja (262 units). Residential containers were part of an existing economic contingency stock of the Republic of Croatia, though the large number of containers within the contingency (over 170) has already been allocated across hospitals and health centers related to consequences of the pandemic. Public donations of containers and mobile homes were insufficient so 722 containers had to be urgently procured in 2021 [26].

Although the project task was extremely demanding for the students of the first year of undergraduate studies, both students and teachers agreed that such urgent, real problems had to be addressed and that including socially responsible architecture in architectural education is essential.

Students were given two possible options of the assignment. Option A, called PREVENTION / RESISTANCE / RESILIENCE, referred to shelters designed with the aim to achieve resistance to the impacts caused by the consequences of natural disasters. Option B, called RECOVERY / IMPROVEMENT / RENEWAL, referred to solutions designed as shelters to be used after natural disasters.

Students had to investigate different natural disasters (earthquake - whirlwind - fire - flood - drought - snow-drift/avalanche - soil avalanche - pandemic - air pollution - nuclear catastrophe), research reference examples for the disaster they have chosen to work on and propose and present specific design solutions. The project task limited the shelter to a space necessary for living of one or more persons over a longer period of time (place to sleep, eat, reside, store and a sanitary space), as well as additional places per choice. Special attention was dedicated to conceptual response to the topic, adequate dimensioning and functionality of the place, shelter construction, choice of materials and integration into the environment.

5.1 Task Choice and Analysis

At the beginning of the assignment students could independently choose the type of natural disaster which would be a starting point for shelter design. In most cases the students referred to floods (33%), earthquakes (31%) and avalanches (23%), as illustrated in Fig. 7. In those three cases, the connection between the form and function of the shelter is the most evident.

When given a choice between prevention and recovery, most students designed objects with respect to prevention of the possible future damages which is indicative of the high level of reflection regarding sustainable architecture, in line with environmental changes. A smaller number of students defined solutions which respond to the residential needs in the process of recovery from the consequences of natural disasters, and some students provided no response to any of the provided topics but dealt with the topics such as flexible and modular residences (Fig. 8).
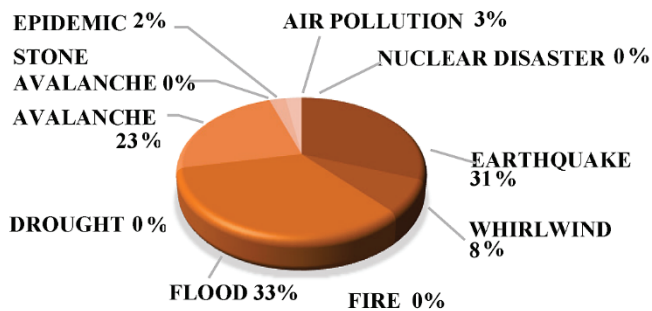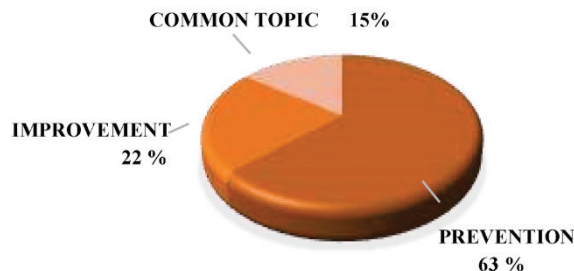
Figure 7 Analysis of chosen topics

Figure 8 Analysis of chosen responses on the topic

Designed shelters vary widely in terms of size and shape and most shelters range from 50 to 150 square meters in size (Fig. 9). Relatively large square footage of students' shelters is not surprising with respect to reference examples and given the educational aspect of the assignment.
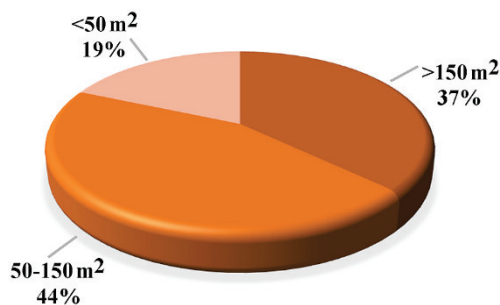

Figure 9 Average areas of the designed residential objects

5.2 Selected Students' Solutions

Students presented their final shelter designs to colleagues and teachers. The assignments were then assessed based on several criteria (concept, quality of technical and functional design, multiplication options, innovation etc). For this paper, best three shelter designs were chosen and are presented in detail, including students' descriptions and illustrations.

5.2.1 Domagoj Gregačević - Avalanche - Maginot Line

Student Domagoj Gregačević provides answers in his design to the questions of prevention in the areas exposed to avalanches and snow-drifts. The proposed solution/house operates as a monolithic rock inside of which the life is not disturbed during and after the natural disaster.
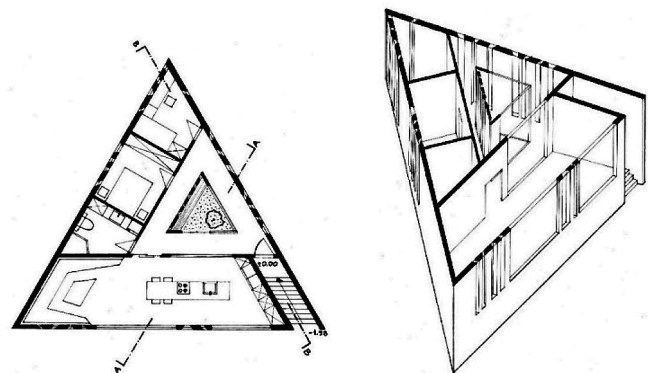
Figure 10 Domagoj Gregačević, Maginot Line, layout and axonometric display

The layout is a form of an equilateral triangle that, with its sharp angles, decreases the blow intensity of snow mass and redirects it away from the house. Two sloped trapezoidal facades exposed to the avalanche impacts are conceptualized as powerful walls, while the third facade is extroverted with the views directed towards the surrounding area. The house looks like a wedge stuck in a rock and reminds of a piece of mountaineering equipment. It is possible to connect the units into an assembly which then additionally diminishes the destructive power of the avalanche, and as such it presents a defense mechanism, i.e. the front line - the Maginot line that the solution got its name after.
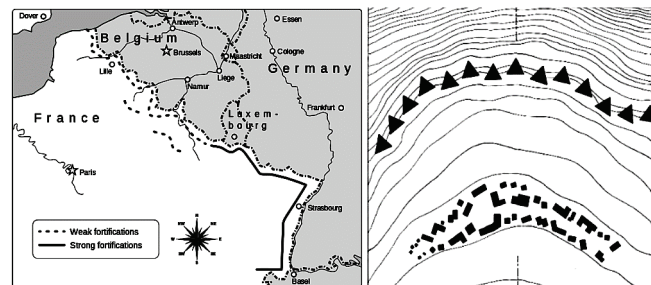
Figure 11 Domagoj Gregačević, Maginot Line
Maginot Line in France, shelter settlement proposal

5.2.2 Ana Domjančić - Pandemic - The Tree of Life

The challenge of preventive building in cases of epidemics and pandemics is tackled by student Ana Domjančić. The relationship between a man and his family / small community and nature is emphasized by the designed solution. There is a central atrium in the middle of a house in which the house pulls in the surrounding greenery. All rooms of the house are connected with the atrium, and they encircle it.

Glass walls that enclose the house can be completely opened so that ventilation of the object is enabled, as well as transformation from a closed in a (half) opened space.

There is a zone for self-isolation in the house that encompasses the bedroom, bathroom and terrace and that can be separated from the rest of the house.
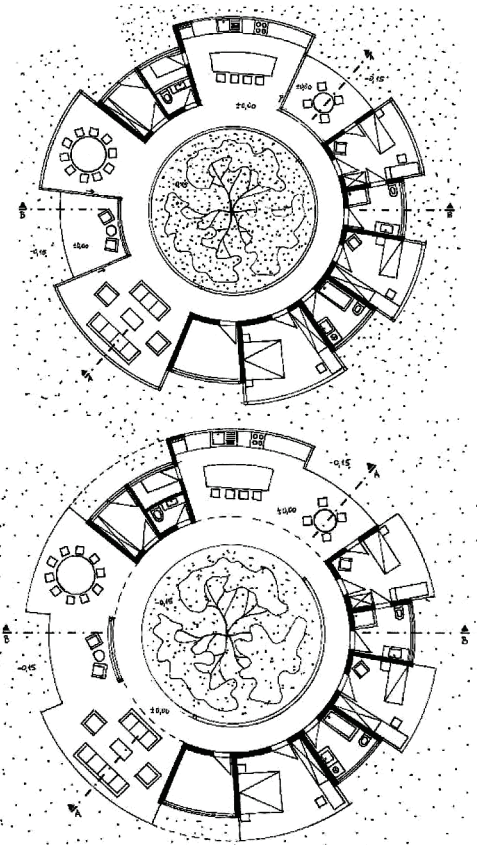
air through a system of pipes in the interior. Warmth, moisture, and other aspects of the outer residence are pulled into the house depending on the function of the room as well as the ideal conditions for human use. A man habits the atmospheric voids, and the walls become their room dividers.
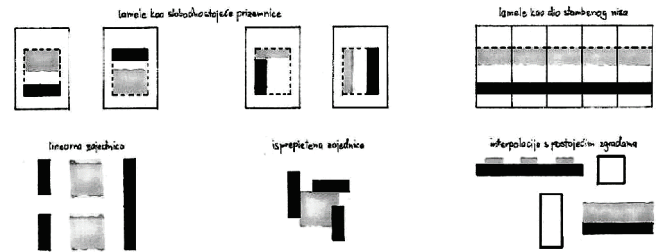

Figure 12 Ana Domjančić, The Tree of Life, layout – closed and opened

Figure 14 Leon Lipovac, The Approximate Present, unit matching scheme

Figure 13 Ana Domjančić, The Tree of Life, section view - closed and open

5.2.3 Leon Lipovac - Environment Pollution – The Approximate Present

The question of permanent "natural disaster", i.e. environment pollution, is dealt with by student Leon Lipovac.

The (approximate) vision of catastrophic future confronts the student's vision of the approximate present. The cycle and behavior of the natural atmosphere is replicated and mapped onto within the architecture as an answer to air pollution by means of bringing external clean

Figure 15 Leon Lipovac, The Approximate Present, layout, axonometric display

On a conceptual level, this design was inspired by the vertical capsules from "The Fifth Element" movie in which the possibilities of partition and function compacting are examined. Shelter functions within different urban and rural situations are researched, taking into account aspects of both disaster prevention and recovery. The earthquake resistant construction is enabled by a light structure anchored on the reinforced concrete pedestal.

6 CONCLUSION

The "third generation" universities are dedicated to three missions - education, science and advancement of the community. They are oriented towards entrepreneurship and innovation, striving to become places of collective knowledge production.

The impact of the 2020 earthquakes in Zagreb and Petrinja, as well as the 2020 pandemic that affected the whole

world, has led to the integration of these actual topics in the educational process at The Faculty of Civil Engineering and Architecture Osijek (GRAFOS), considering that engineers have an important role in the process of restoring the lost infrastructure and responding to basic human need for accommodation and safety.

This paper presents the process of creating, executing and assessing a student assignment within the study course *Architectural design* at GRAFOS in 2021, based on real needs for designing shelters for a large number of people.

Students researched numerous recent examples of buildings and constructions that were used for urgent sheltering of people affected by floods, earthquakes, drought or hurricanes, and their design solutions were both innovative and bold. An aproach to education that includes practical projects and challenges in teaching, is ever more present in Europe and the world as evident from different reports on trends regarding development of higher education. Within that type of learning, students examine, cooperate, acquire new knowledge, develop critical thinking, communication skills as well as interpersonal skills.

By designing shelters and providing individual solutions to the consequences of recent natural disasters in Croatia, students of the Faculty of Civil Engineering and Architecture Osijek enforced the third mission of Osijek's university, already positioning themselves as a part of a community they operate in and whose advancement they contribute to.

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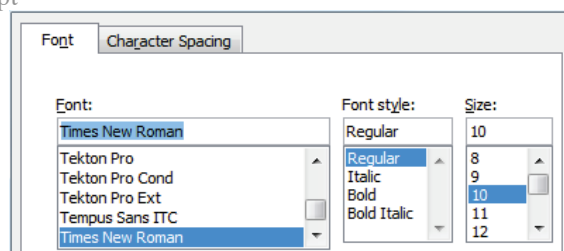
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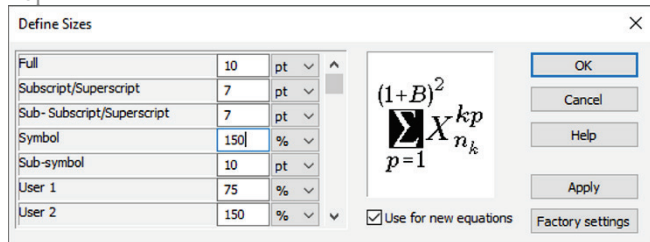
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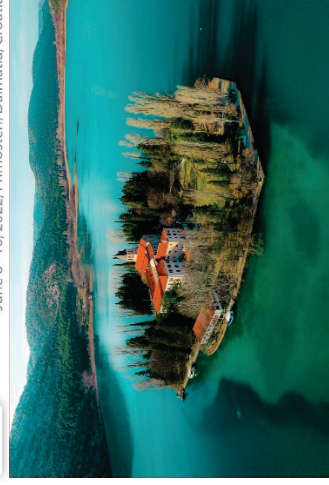Croatian Association for PLM

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June 8 - 10, 2022

GENERAL INFORMATION

International Conference *Management of Technology – Step to Sustainable Production* (MOTSP 2022), will take place from 8th June 2022 in Primošten, Dalmatia, Croatia as a joint project organized by the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb and *Croatian Association for PLM*. The main objective of this Conference is to gather international experts from academic entities, research laboratories and industries related to the field of Management of Technology and Sustainable Production. The Conference will also provide a platform for sharing knowledge, ideas and results between science and industry.

The management of technology, stimulation of innovation and invention, augmented reality, management of COVID 19 and transfer of technology are important challenges of the developed countries and countries in transition.

ORGANIZATION

Faculty of Mechanical Engineering and Naval Architecture
University of Zagreb, Ivana Lučića 5, 10000 Zagreb, Croatia
Croatian Association for PLM, Prilaz V. Brajkovića 12, 10020 Zagreb, Croatia

MAIN TOPICS

Management of Technology
Production, Operation Management
Strategic, Engineering Management
Industrial Engineering
Rapid Prototyping and Manufacturing
Computer Integrated Manufacturing CAD, CAM, CAPP, CAQ
Intelligent Manufacturing
Product Lifecycle Management (PLM)
Total Cost Assessment
Ergonomics
Sustainable Production
Social Responsibility
Total Cost Assessment
Financial Sustainability
Sustainable Transport Management
Transport Technology and Organization
Corona pandemic as a scientific challenge

Submission of paper titles and abstracts (up to 150 words) using abstract submission form at **motsp.eu**
Notification of acceptance of abstracts: **March 1st, 2021**
Final submission of full papers: **February 28th, 2022**
Notification of acceptance of full papers: **April 29th , 2022**

Chairman:
Full Prof. Predrag Ćosić, pcosic3@gmail.com
Secretary:
Assistant Professor Tihomir Opetuk, tihomir.opetuk@fsb.hr
Associate Professor Zdenka Keran, zdenka.keran@fsb.hr
E-mail: info@motsp.eu
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INFORMATION FOR PARTICIPANTS

CONFERENCE VENUE
Hotel Zora 4*/3*, Raduča 11, Primošten, Croatia
URL: www.zora-hotel.com
Tel: 00385 22 581 111 or 00385 22 571 881

Participants and accompanying persons of **MOTSP 2022** have a special offer from the **Hotel Zora 4*/3*,** Croatia. MOTSP2022 suggest to make a **reservation of accommodation** through
ivana.toric@zora-hotel.com

CONFERENCE LANGUAGE
English
Presentation: Presentations should take 15 minutes. Authors will have the possibility of using computers for the presentations (Power Point).

REGISTRATION
Registration should be acknowledged at the reception desk on
Hotel Zora 4*/3*, Raduča 11, 22202 Primošten
June 7, 2022   18:00 – 20:00
June 8, 2022,   8:00 – 9:00

Conference Fees
Early registration fee until May 15 - **EUR 480**
Late registration fee until May 20 - **EUR 499**

All accepted papers would be published in the Technical Journal Q3 (WoS). Paper publishing would be included by conference fee.

Primošten, Dalmatia, Croatia

Sveučilište
Sjever