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UVODNA RIJEČ

Poštovani suradnici, autori i čitatelji,

TEHNIČKI GLASNIK je, po posjećenosti na Portalu znanstvenih časopisa Hrvatske Hrčak, u prvih 50 časopisa iz svih znanstvenih područja (na kraju studenog 2015. bili smo na visokom 43. mjestu) i u top 10 u području tehničkih znanosti (na kraju studenog 2015. našli smo se na izvrsnom 8. mjestu).

Nažalost, ovaj lokalni uspjeh nam nije pomogao u prepoznatljivost na globalnoj razini. Dana 21. ožujka 2015. podnijeli smo na ELSEVIER prijavu za uključivanje časopisa u međunarodnu bazu podataka SCOPUS. Pregled je dovršen 8. srpnja 2016. od strane Savjetodavnog odbora (Content Selection & Advisory Board - CSAB) i donesena je konačna ocjena da se časopis u sadašnjem trenutku ne uključi u SCOPUS. Sažeti zaključak CSAB je „iako je časopis (u odnosu na prvu prijavu) značajno poboljšan s većim brojem objavljenih članaka na engleskom jeziku, još uvijek ne ispunjava uvjete za uključivanje u međunarodne baze podataka kao što je SCOPUS, i to prvenstveno zbog svoje slabe citiranosti". Sljedeća prijava je moguća nakon srpnja 2018. uz uvjet da se navedeni razlozi otklone.

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Naposljetku, pozivam Vas, naši cijenjeni suradnici, autori i čitatelji, da svojim prilozima pridonesete našem radu i pomognete nam u našim namjerama.

Srdačno Vas pozdravljam!

Dr. sc. Milan Kljajin, red. prof. u tr. zvanju
Glavni urednik časopisa ***Tehnički glasnik***

INTRODUCTORY COMMENT

Dear associates, authors and readers,

According to the number of visits recorded on the Portal of Scientific Journals of Croatia Hrčak, TECHNICAL JOURNAL is in top 50 journals in all scientific areas (at the end of November 2015, we were ranked very high, at position 43) and in top 10 in the area of technical sciences (at the end of November 2015, we were placed at the excellent position 8).

Unfortunately, this local success did not help us in recognition on the global level. On March 21, 2015, we applied to ELSEVIER for the Journal to be included in the international database SCOPUS. The Content Selection & Advisory Board (CSAB) completed the overview on July 8, 2016. It was decided that the Journal would not join SCOPUS at the moment. The CSAB's summarized conclusion states that "although the Journal (in comparison to the first application) has significantly improved with a greater number of articles published in English, it still does not meet the conditions for being included in an international database such as SCOPUS, mainly for its low citation". The next application is possible from July 2018, on condition that the above mentioned reasons are eliminated.

The success will depend on all of us: the publishing office and the chief editor; members of all the bodies of the journal and reviewers; and especially our valuable authors without whom success will not be possible. Therefore, during the following two-year period, the publishing office commits itself to finding a way to stimulate potential authors to submit their works exclusively in the English language, to be cited in other journals, and in this way to help the TECHNICAL JOURNAL in meeting the conditions required for being included in the international databases.

Finally, I invite you, our dear associates, authors and readers, to contribute to our work with your papers and therefore help us in our intent.

Kind regards,

Full Professor Milan Kljajin, Ph.D.
Chief Editor of the ***Technical Journal***

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IMPACT OF RIGHT-TIME BUSINESS INTELLIGENCE TOOLS ON EFFICIENCY IN DECISION MAKING

UTJECAJ *RIGHT-TIME* ALATA POSLOVNE INTELIGENCIJE NA EFIKASNOST POSLOVNOG ODLUČIVANJA

Branimir Dukić, Danijel Bara, Stojanka Dukić

Original scientific paper

Abstract: *As a result of the dynamics of modern business the risks of modern business demand that business applications have a rational component in making decisions. By using the data, a rational component in the decision making is enabled, as well as the knowledge needed to process and interpret the data when making business decisions, and using the concept of business intelligence is applied. The growing dynamics of business contributed to the need for growth in speed in making business decisions, which induced the evolution of a new concept in terms of business intelligence that has been made in the form of right-time business intelligence tools. As a new concept that has only recently emerged from the theoretical framework, right-time business intelligence concept blurs the distinction between rational strategic and operational decision-making, allowing the operational level of decision-making to use platforms and tools that were until recently reserved for strategic decision-making. Business intelligence greatly improves business decision-making, in particular through the reduction of latency in business decision, which was confirmed by conducted primary research. Its general conclusion is that there is cohesion between performance and the successful application of business intelligence tools.*

Keywords: *Business intelligence, right-time business intelligence tools, rational business decision*

Izvorni znanstveni članak

Sažetak: *Rizici suvremenog poslovanja koji su posljedica dinamičnosti suvremenog poslovanja od poslovnih subjekata zahtijevaju aplikaciju racionalne komponente u odlučivanju. Racionalna se komponenta u odlučivanju osigurava upotrebom podataka te znanja potrebnih za njihovu obradu i tumačenje prilikom donošenja poslovnih odluka, a aplicira se kroz koncept poslovne inteligencije. Porast dinamičnosti poslovanja utjecao je na potrebu rasta brzine poslovnog odlučivanja, što je induciralo nastanak novog koncepta u okvirima poslovne inteligencije koji je opredmećen u vidu right-time alata poslovne inteligencije. Kao novi koncept koji je tek nedavno izašao iz teorijskih okvira, right-time koncept poslovne inteligencije briše razlike između racionalnog strateškog i operativnog odlučivanja, omogućujući operativnoj razini odlučivanja da koristi platforme i alate koji su donedavno bili rezervirani za strateško odlučivanje. Poslovna inteligencija uvelike unapređuje poslovno odlučivanje, posebice kroz smanjenje latencije u poslovnom odlučivanju, što je potvrđeno provedenim primarnim istraživanjem, čiji je generalni zaključak kako postoji kauzalnost između uspješnosti poslovanja i uspješne primjene alata poslovne inteligencije.*

Ključne riječi: *poslovna inteligencija, right-time alati poslovne inteligencije, racionalno poslovno odlučivanje*

1. INTRODUCTION

In the last twenty years, human society has been going through a phase of profound changes mainly induced by the enormous increase in processing and communicational skills of information and communication technology. The consequences of the changes caused by information and communication technology on modern businesses, especially those operating in the areas of developed market conditions, are the globalization and the increase in transparency. This, as a consequence, implies intensifying competitive relationship among the participants in the competition. In addition, global growth of general and specific knowledge of people arising from the global transparency of information and knowledge has an impact on consumer emancipation. This further complicates the position of the companies, which are therefore forced to take care of the needs and behavior of each individual with whom they have or intend to establish an interchanging relationship. In general, these evolved business conditions have led to a decrease in average margins and fierce fighting between companies for each job and for every consumer. In these conditions, businesses have almost no right to make an error, because any significant error can affect the survival of enterprises. To avoid mistakes in business, companies are investing considerable effort to use a rational approach to business

decision making, which means an approach that is based on data and knowledge.

Focus on rational decision-making has led to the evolution and increasingly intensive use of the concept of business intelligence, which focuses on the pursuit of the collection of a large volume of data from different data sources in order to ensure reliable and high-quality components for rational decision-making management. However, growth in data quantity derived latency in the creation of management information. Therefore, on a scientific level, informational management has been increasingly focused on problem solving latency data in the process of business decision-making. The solution which has recently imposed from the perspective of scientific theories came in the form of right-time business intelligence tools. It is a new approach that is just making its way into business practice, which aims to provide necessary well-timed management information for the management, even when it comes to the operational level of management. Since this is a new concept, right-time business intelligence tools are placed in the focus of research. Accordingly, the aim of the study was to determine the essential features of these tools and to explore the causality between the quality of business decision-making and performance of application business intelligence tools. To prove the initial hypothesis which argues that there is proportional relationship between the quality of business decisions and success using right-time business intelligence, a survey was conducted by interviewing experts from business entities in Croatia that use business intelligence tools, and the results obtained by statistical analysis, are presented in this paper. The results presented here are part of a broader research that generally explored the assumption that the application of business intelligence tools means greater success of those businesses that use right-time business intelligence tools.

2. RIGHT-TIME BUSINESS INTELLIGENCE TOOLS

Right-time business intelligence tools present a separate, relatively new concept in terms of business intelligence. As well as traditional business intelligence tools, right-time business intelligence tools rely on the concept of storing data as a function of data transformation in the management information. In his definition of a data warehouse, Inmon [1] states the time invariance of data as one of four key features that affect the quality of data, and tells how the data is time-dependent - it means that the data in the data warehouse has the dimension of time, further claiming that the warehouse data consists of images (*snapshots*) of transaction data taken at regular intervals. This feature enables analytic functionality and trend analysis of business over time, as the transactional systems always keep only the current value of the transaction. This means that in order to obtain the condition at some point, it is necessary to sum up all the transactions within the required period. Timeliness deals with the age of the data, and timeliness of data. Zmud [2] and Hilton [3] were early supporters of timeliness as a specific dimension of the quality of data or information. Similarly, Miller [4] underlines the timeliness, as one of the fundamental characteristics of quality information. Given the correlation between timeliness and quality of information it makes sense to analyze the time cycle, and the lifetime of information. Therefore, it can be concluded that timeliness of information is an essential feature of a quality information system. Hence the importance of the right-time business intelligence tools, as a concept whose basic idea is to provide well-timed information. However, not all information at all times is equally important. In today's time of rapid market changes, the amount of information grows intensely, and their timeliness is the key factor in business success. Therefore, the concept of timeliness is the one concept that is constantly changing and is in constant need for redefining. Alongside the timeliness, accuracy and accuracy are essential features of information.

According to the theory of decision-making, what is relevant is the relationship between the speed of decision-making and management levels. Strategic decisions relate to the longest period of time; therefore, for the purposes of rational strategic decision-making, usually the highest volume of aggregated data is used. Consequently, making such decisions approach is systematic and lasts the longest. Until recently, business intelligence is used mainly for making strategic decisions. A powerful tool in this sense was the data warehouse as a data repository, subjectively oriented, comprehensive in-time and aggregated. Under certain circumstances, data warehouse was consumed by the tactical decision-making level. In principle, until recently the operational decision-making levels were focused on transactional data sources; small amounts of native (transactional) data were used for operational decision-making. Such decisions were taken by very quickly, but due to time-limited sources of information, the relevance of such decisions was often questionable. The problem of the significance of such operational decisions is proportional to the level of correspondence between operational decisions and strategic business principles.

The changes, which modern society implies, especially in terms of speed of change, reduce significantly the period in which strategic decisions are made. Also, they increase the importance of operational decisions since an increasing number of operational decisions corresponded to the strategic decisions. As a result of these conditions, the loss of a clear division between the strategic, tactical and operational decision-making often happens. Thus, on the one hand, for management to make strategic decisions there is often equal or less time than time to make operational decisions; on the other hand, a clear distinction between strategic and operational decisions is lost. In such conditions, a growing need has been developed for increasing speed of decision-making at all levels of decision-making. The term, which is linked to the speed of business decision-making, is latency of decisions. Decision latency is the time that is necessary to make people understand the situation, decided on a course of action and initiate action. Bara and Knežević indicate that: “Reducing data and analysis latency primarily depends on technical solutions. Recent technologies especially in real-time data warehousing provide help in this regard. But, the main thing dealing with decreasing decision latency

requires changes in business processes as well as how people use provided information while carrying out their jobs. Providing real time data does not automatically create business value and quality business decisions unless it is used in a well-timed manner. Dealing with decision latency is usually more challenging than data and analysis latency." [5] The benefit of reducing latency is shown in Figure 1.

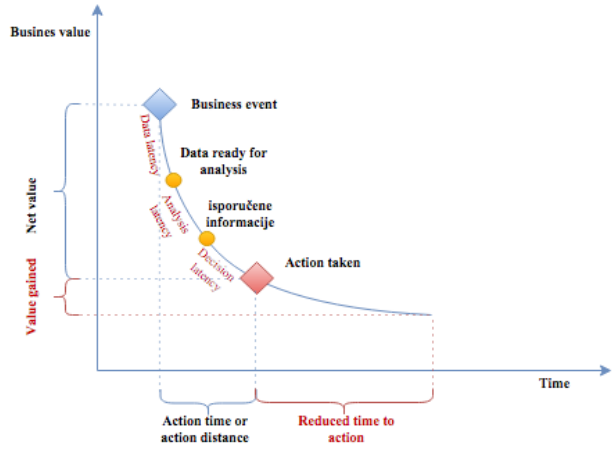

Figure 1. The benefit of reducing latency

It can be concluded from Figure 1 that the quality of information, and thus the quality of decisions made, correlates with shortening the latency. Modern business conditions dictate that increased amounts of data is collected, especially from the environment, which logically results in the growth of latency.

However, apart from the volume of data, the size of the latency is affected by the available knowledge that serves as a function of business decision-making. Under the influence of the increase in the dynamics of business, there is also considerable growth in the volume of data. In a similar manner, under the influence of the volume of science, scientific method increases the number of data processing. Primary focus of this research is solving latency problem in decision-making caused by the abundance of data.

When it comes to the growth in the volume of data, it is primarily related to the data that is being generated in the environment of a business entity. With the growth of the sensitivity and complexity of the market, which is caused by globalization and the intensification of competitive relationship in the market, the need for collecting data on actual consumers and their needs and behavior is growing. Today, the information that the customers provide is the key data for the survival of most businesses, but such data are the basis for the creation of knowledge about customers, based on which customer relationships are managed.

In late 1996 and early 1997, Ernst & Young and Business Intelligence Ltd. conducted a joint survey [7]. 563 senior executives in Fortune 1000 enterprises in North America and Europe responded to questions about their opinions on knowledge. Eighty-seven percent (87%) of the respondents reported that they worked in businesses intensive in knowledge. The types of knowledge reported as "very important" or "extremely important" were:

- Knowledge about customers (96%),
- Knowledge about best practices/effective processes (87%),
- Knowledge about our own competence and capabilities (86%),
- Knowledge about our own products and services (85%),
- Knowledge about emerging market trends (83%), and
- Knowledge about competition (81%).

In the same survey, five key benefits of active knowledge management were listed by more than 80% of the respondents during the above mentioned survey by Ernst & Young and Business Intelligence Ltd., these were:

- Increased responsiveness to customers (83%),
- Innovation: more consistent success in designing new products/services and processes (83%),
- Efficiency: increased productivity of knowledgeable workers (83%),
- Improved decision-making (83%), and
- Flexibility: ability to change and adept to change more rapidly (82%).

From the above research, two important conclusions can be drawn. First, for the adoption of orientation towards customer value, organizations must have extensive knowledge of their markets and target consumers. Second, managers must use the advantage of learning about consumers in high-performance with consumers. For example, the internal processes of the organization that work to deliver value must be matched with values of the consumers.

"Despite this conscious awareness of the strategic need for knowledge, most enterprises have more knowledge than their employees are aware. Thus, it is vital that relevant information and knowledge is communicated to decision-makers who can analyze and implement the wisdom." [8] Arguments in favor of management that is oriented towards consumers are convincing, and frameworks that exist describe the concept that managers should develop a focused competitive advantage towards consumers. [9]

In one view of organizational management, it is argued that the creation and delivery of world-class value to consumers at the same time increases the value of the organization. [10]

Over the past 15 years, the database technology has progressed to the point where providing information to business people has become easier. The enormous increase in the quantity of data available in a single business should at first glance be enough to analyze data about their consumers, but businesses "as much information as they have about their customers, it seems that they still want more." [11]

The fact is that businesses are buying information about their customers from credit bureaus, telecommunications companies, banks, etc., and thus the amount of data is growing rapidly [12]. In many cases, businesses are buying external data to compare with their own data, test their data at regular intervals in order to

verify the accuracy of their own data, for example, location data, demographic data and more. Also, businesses buy extra data for mitigating operational risks. For example, understanding the consumer's credit history can help an entity to determine the risk of doing business with the consumer.

Many businesses are buying consumer data in order to target marketing campaigns, which, when successful, generate more revenue than what the data was paid for. Marketing departments have changed their decision making strategies, from the ones based on emotions in their campaigns to the ones which are based on careful analysis of the facts on the basis of massive data sets of customers [13]. Even businesses with a large amount of their own data decide to purchase data. Usually, it is the information on annual household income, the model and age of cars that consumers have, on the frequency and the places where consumers go on vacation, and more. Therefore, businesses constantly aim to enhance the volume of data in order to create more complete information about its customers. Dyche and Levy [14] consider that consumers are the biggest assets of businesses, and therefore the data on consumers should be adequately treated.

In view of the above, the latency problem becomes one of the central problems related to the efficiency of business decision-making. In recent years, the problem of latency has been tried to be solved, primarily in academic terms, but lately more and more in pragmatic terms as well. The very concept, given the importance of the time dimension, has been named real-time business intelligence.

According to Tank [15], the implementation of real-time business intelligence can result in significant benefits to the organization, reducing the time spent in making decisions, which gives the decision-maker enough time and information to make a decision. This will result in more efficient decision-making process and reducing the cost, because the decisions are made in a well-timed manner in a competitive environment.

The meaning of real-time business intelligence mainly depends on understanding what real-time means for a business. Not surprisingly there are no agreed definitions here either. Real-time can mean: [16]

- the requirement to obtain zero latency within a process,
- that a process provides information whenever it is required by management or other processes,
- the ability to derive key performance measures that relate to the situation at the current point in time and not just to some historic situation.

The primary goal of real-time business intelligence is to connect the analysis of the management functions so that the analysis becomes an integral part of doing business to managers and teams of employees. [17]

When it comes to real-time business intelligence, data warehouse repositories need to be updated with the transaction data in real time. This type of update repository data is called feeding leaks. As the transactions are received, they are saved and become the repository of data growing historical record of activity.

Furthermore, real-time business intelligence system must have a very fast engine management rules that can analyze incoming traffic in the context of the historical database, and which can make decisions quickly enough so that the entity may have a value of immediate action. [18]

The global survey of 400 large businesses, revealed that businesses that utilize advanced analytics, are twice more likely to have better financial performance in their respective industries, three times more likely to make decisions as they imagined, twice as likely to be very frequently used data to make decisions, and five times more likely that a decision will be much faster than their market competitors. [19]

Traditional business intelligence systems have helped improve the strategic decisions that affect the success of a business entity. This, however, is not enough for the complete resolution of issues in today's dynamic marketplace. Real-time business intelligence gives businesses the power to automate many tasks and processes in the database, and thus provides more time to work on knowledge. [20]

Often, in theory and practice, for this type of business intelligence tools, as a kind of synonymous, instead of the term right-time appears the term real-time. But the prevailing attitude [21] to the right-time is actually a better word to use than real-time. When the notion of right-time emphasis is to deliver information at the right time which may include latency tolerant (up to a fraction of a second, and up to several days), while the real-time meant giving information without latency.

Since the latency is in pragmatic terms almost impossible to avoid, the advantage given to the concept of right-time is understandable. It goes in favor of the concept of right-time that in practice business processes are significantly slower than the data processing. Rutz et al. [22] state that there are significant benefits from the use of right-time business intelligence tools in relation to the real-time tools.

In order to succeed in the transition to digital operations, or the use of right-time business intelligence tools, businesses must take a few steps: [23]

1. Define what it means for their organization to be a right-time enterprise.
2. Determine what business problems the organization is trying to solve.
3. Take a systematic, iterative, and long-term approach to introducing new technologies and business processes.
4. Create a more responsive and open corporate culture, from the management ranks to the front lines.

In order to overcome all the problems and challenges in the way of the introduction of right-time business intelligence tools, in the transition to digital business or to right-time business intelligence businesses should overcome several technological obstacles: [24]

- **right-time data collection** - for a particular business, real-time and right-time can mean collecting data every five minutes, while for some other tasks that period is smaller or larger, which means that before defining the time of collection, it should be defined

what this means for business processes, which are the objectives to be achieved, and so on.

- **right-time processing** - one of the major problems of the concept of right-time business intelligence is the need for different processing speeds for different types of data. Since all data is not included in the data warehouse at the same time, even with the same frequency, its treatment is a major challenge.
- **right-time insight availability** - these tools must have the ability to create reports on demand, unlike traditional business intelligence tools that have the predefined reports at the agreed time.
- **right-time use of insights** - a key use of this technology is not in solving technological assumptions but in the manner in which it is used. The obvious challenge is to implement the use of these technologies into existing business processes.

Right-time business intelligence tools have recently released the theoretical framework and become applied technology for decision making in the developed world. Due to this fact it is interesting to examine what the situation is with the application and the application effects of right-time business intelligence tools in the Croatian businesses.

3. ANALYZING THE IMPACT OF RIGHT-TIME BUSINESS INTELLIGENCE TOOLS ON EFFICIENCY

Research on the interdependence of the successful application of right-time business intelligence tools and quality of business decision-making was carried out in the context of wider research whose overall results are presented in the doctoral thesis of Danijel Bara, co-author of this article. The questionnaire was completely filled in by 125 respondents. The sample consists of those experts that in their businesses apply some of the tools of business intelligence.

Therefore, all those respondents whose business entities do not use business intelligence tools were excluded from further analysis (10 respondents). The two respondents that gave inconsistent and mutually exclusive answers were also excluded. In the final analysis, responses from 113 respondents were taken into account and statistically analyzed.

3.1. Analysis of socio-demographic characteristics of respondents

For the purposes of the relevant overview of answers, primarily their socio-demographic characteristics were explored. Table 1 shows the respondents by gender, age, education level and occupation.

Table 1. Respondents by gender, age, education level and occupation.

	Respondents	%
Gender		
Male	95	84,1
Female	18	15,9
Total	113	100
Age		
18-27	3	2,7
28-35	25	22,1
36-50	77	68,1
51-65	8	7,1
Total	113	100
Education level		
Secondary education	6	5,3
College education	8	7,1
University qualifications	66	58,4
Master's degree and Ph.D.	33	29,2
Total	113	100
Occupation		
CEO	9	8,0
Economist	24	21,2
Informatics, IT experts	29	25,7
Other	48	42,5
Missing answers	3	2,7
Total	113	100

The following table shows the distribution of respondents according to the characteristics of a business entity in which they are employed (Table 2).

Table 2. Characteristics of a business entity where respondents are employed

	Respondents	%
Size		
Micro and small	35	31
Medium	23	20,4
Large	55	48,7
Total	113	100
Company activities		
Financial and insurance	20	17,7
Information and communication	56	49,6
Other	37	32,7
Total	113	100

3.2. Analysis of the link between the quality of business decisions and successful application of business intelligence tools

In this study methods of descriptive and inferential statistics were used, as well as factor analysis. Exploratory factor analysis was used to determine the latent variables relating to the sources and the importance of information in an enterprise. According to the hypothesis, classification of particles is expected according to sources of information, where the answers should be classified according to the way the estimated volume of the collection of data from internal or external sources of information. When it comes to interpretation of the results, the fact that an entity applies the tools of business intelligence is not sufficient for the business entity to be called successful. Even if a business entity displays the need, desire, knowledge, understanding the process, and finally the use of business intelligence tools, this still does not indicate the actual application of business intelligence tools. In other words, if the management of a business entity on a daily basis does not use business intelligence tools, and business intelligence tools are not used as the basis in making business decisions, the issue of cost-effectiveness of these tools should be raised, as well as understanding of the tools, regardless of whether it is the

business entity applies right-time business intelligence tools or classic business intelligence tools.

This research analyzed the connection between the quality of business decision-making on the success of the application of business intelligence tools, and tested the assumption that the application of business intelligence tools successfully applies only to those businesses that used the right-time business intelligence tools. The methodological challenge in testing these hypotheses is in the measurement variable quality of business decision-making, and the success of the application of business intelligence tools.

One of the variables, which is created on the basis of pre-existing variables, represents business success. Business success is often measured by financial indicators, and in this context, we look at business success through frequency of use business intelligence as the basis for decision-making by management. Successful businesses are those who do so to a greater extent. Table 3 shows the successful application of business intelligence tools.

Table 3. The success of the application of business intelligence tools

The success of the application of business intelligence tools	N	%
Yes	70	61,9
No	43	38,1
Total	113	100

Successful application of business intelligence tools was recorded in almost 62% of businesses in the sample. Once new variable was created, it opened the possibility of seeking the existence of links between the use of right-time business intelligence tools and successful application of business intelligence tools. In other words, the assumption that businesses that use the right-time tools are more successful in applying (exploitation) business intelligence tools than those used by traditional business intelligence tools (Table 4) will be investigated. Since both variables were measured at the nominal level of measurement mentioned, assumption is tested by chi-square test of independence.

Table 4. The success of the application of business intelligence tools

		The success of the application of business intelligence tools		Total	Test indicators
		Yes	No		
Application of right-time business intelligence tools	Yes	37	10	47	χ^2 = 9,608 p = 0,002
		78,7%	21,3%	100,0%	
		52,9%	23,3%	41,6%	
	No	33	33	66	
		50,0%	50,0%	100,0%	
		47,1%	76,7%	58,4%	
	Total	70	43	113	
		61,9%	38,1%	100,0%	
		100,0%	100,0%	100,0%	

Businesses that are successful, that have a constant in the application of business intelligence tools, in equal proportion are those who apply the right-time tools (52.9%) or classic (47.1%) business intelligence tools. How do the businesses differ when it comes to the success of the application of business intelligence tools? From a more close-up comparison of the data only for those who apply right-time business intelligence tools, it is evident that there are more of those who successfully apply these tools (78.7%) than those who are less successful (21.3%). According to the results of the chi-square test between the analyzed characteristics, there is a statistically significant correlation.

If you consider the claim that in applying business intelligence tools, businesses that apply right-time business intelligence tools are more successful and then the results presented in the table above, it is possible to conclude that such a claim is rejected. However, it was observed that those businesses that use right-time business intelligence tools have a higher percentage of successful application of business intelligence tools (78.7%) than those businesses that apply classical tools of business intelligence (50%).

It is obvious that there is some link between business performance and selecting the degree of application business intelligence tools.

Furthermore, we analyzed whether there was an observed significant change in the operations of businesses due to the successful application of business intelligence. To test the changes that are visible in an enterprise by introducing business intelligence tools, but also changes the future brings, 22 statements measured at 5-graded Likert scale were used. In this variable, responses of respondents who applied right-time business intelligence tools and of those who applied classic business intelligence tools were not divided, but the emphasis was on changes that were adopted (made) by business intelligence tools.

With the intention of discovering dimensions which can describe the expected and current changes factor analysis was used. The appropriateness of conducting factor analysis was confirmed by KMO measure (KMO = 0.78) and Bartlett's test (2 = 936.616, p <0.001). Rotated factors table (Varimax method using the Kaiser criterion) yields the distribution of the particles (Table 5) to six factors with the total explained variance of 65.7%.

Table 5. Factor analysis (rotated factor matrix)

Factor	Particles (statements)	Loading	Cumulative % of explained variance
1	Ensuring integration with business strategy	0,78	14,55
	The wider aspect of understanding the business as a whole	0,77	
	Strengthening strategic planning	0,76	
	Faster and better decision-making ability	0,71	
2	The desire to increase profitability	0,84	25,81
	The desire to increase competitiveness	0,78	
	improved efficiency	0,53	
	Better overview of threats and opportunities		
3	Excellence in Customer Service	0,80	36,84
	Increasing professionalism in the collection and analysis of information	0,79	
	Optimization of resource allocation	0,53	
	Harmonization in the mindset of the employees of a business entity		

4	The increase in information exchange	0,71	46,9
	The growth of the knowledge base	0,69	
	The rapid increase in the volume of data	0,66	
	Understanding the importance of information	0,51	
5	A deeper insight into data	0,82	56,8
	Easier data collection and analysis	0,79	
	Reducing costs	0,49	
	Better quality of information		
6	The requirements of regulators	0,80	65,7
	Requirements of stakeholders	0,80	

With factor analysis, six dimensions (constructs) were proposed which measures changes in an enterprise through the application of business intelligence tools. Analyzing the answers, it can be concluded that the particles are classified into meaningful dimensions. On the basis of clusters of particles dimensions have been named as follows:

Factor 1: Changes in the quality of decision-making
Factor 2: Changes to the market economy
Factor 3: Changes in the quality of business
Factor 4: Changes relating to data
Factor 5: Changes relating to information
Factor 6: Changes regulatory nature

Before testing the difference, according to the established dimensions depending on the degree of success of the application of business intelligence tools, justification of the use of these proposed dimensions is confirmed based on the value of Cronbach Alpha.

Table 6. Descriptive description constructs changes in the business entity as a result of the application of business intelligence tools

Changes to the business entity as a result of the application of business intelligence tools	Arithmetic mean	Standard deviation
The quality of decision-making	4,03	0,78
Market operations	3,97	0,77
Business quality	3,54	0,77
Data	4,01	0,67
Informing	3,75	0,71
Regulation	3,21	1,09

Businesses differ in their perception of the changes brought by the application of business intelligence tools. In identifying statistically significant areas with the visible positive change through the application of business intelligence tools, new constructs were compared to the success of the application of these same tools. The results of t-test for independent samples are shown in Table 7.

Table 7. The results of t test procedures for independent samples

Changes to the business entity as a result of the application of business intelligence tools	The success of the application of business intelligence tools	Arithmetic mean	Standard deviation	t-test	
				t	p
The quality of decision-making	Yes	4,07	0,72	0,710	0,479
	No	3,96	0,89	0,671	0,504
Market operations	Yes	4,10	0,67	2,393	0,018*
	No	3,74	0,87	2,232	0,029*
Business quality	Yes	3,68	0,64	2,526	0,013*
	No	3,30	0,91	2,315	0,024*
Data	Yes	4,06	0,63	0,964	0,337
	No	3,93	0,74	0,924	0,359
Informing	Yes	3,81	0,67	1,190	0,237
	No	3,64	0,78	1,144	0,257
Regulation	Yes	3,30	1,06	1,160	0,249
	No	3,04	1,14	1,135	0,260

* p<0,05

Statistically significant differences at a significance level of 5% were observed for the constructs of market operations and the quality of operations. The construct that measures changes in businesses related to market operations differs depending on the degree of success of the application of business intelligence tools. This indicates that businesses which have successfully applied the tools of business intelligence noticed positive changes in their operations in terms of market operations. In other words, it can be concluded that businesses that have successfully implemented business intelligence tools, or use them on a daily basis as a basis for decision-making in business decisions generate positive changes in terms of profitability, competitiveness, efficiency and clarity the threats and opportunities (construct market operations). Apart from market operations, those businesses that are successful in implementing business intelligence tools recorded a significantly higher average score on the construct of quality business.

4. CONCLUSION

The growth dynamics of business in the past two years contributed to the change of a large number of principles that were used in the industrial age. Many of these are associated with the management. One of the important changes is reflected in the ever increasing rise of the share that rational decision-making components have in the growth of the data amount on the one hand and methods of data processing on the other. Furthermore, due to the growth dynamics of the business, the available time limits for decision-making are increasingly shorter, both at the operational and at the strategic decision-making level. This leads to changes in the principles of the decision making, which is reflected in the requirement that the operational and strategic decision-making share the same platform and the same tools of business intelligence, which was almost unthinkable until a couple of years ago. In this respect, the tendency to reduce latency in business decision making, gets an increasingly important role as a measure of the efficiency of business decision-making. As a result of these tendencies right-time business intelligence tools were developed and are slowly but surely entering the business practices from the academic sphere and systematically pull down all prejudices related to the principles of business intelligence.

In order to measure the correlation between the quality of business decision-making on the success of the application of business intelligence tools, the research was carried out by interviewing experts from business practices in Croatia. The research results indicate that businesses that have successfully implemented business

intelligence tools, or use them on a daily basis as a stepping stone for business decisions, generate positive changes in terms of profitability, competitiveness, efficiency, and are given better overview of the threats and opportunities in business.

Further research in this area certainly should answer the question of systematic measurement of the quality of implementation of right-time business intelligence tools and adequately quantify them, in order to define standards of the success of right-time business intelligence tools applications.

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INITIAL ATTITUDES OF MECHATRONICS STUDENTS TOWARD LEARNING ENGLISH FOR SPECIFIC PURPOSES

INICIJALNI STAVOVI STUDENATA MEHATRONIKE O UČENJU ENGLESKOG JEZIKA U STRUCI

Ivana Jurković

Original scientific article

Abstract: *This paper presents the results of a research that was conducted among mechatronics students for the purpose of identifying their attitudes toward learning English for specific purposes in their prospective profession. The main objective was to identify which elements of learning English as a foreign language for specific purposes are observed as being the most important from the students' perspective. The target population in this research included students enrolled in the first year of mechatronics studies for the purpose of collecting their initial attitudes toward learning English for specific purposes.*

Keywords: *English for specific purposes, ESL, initial attitudes, mechatronics*

Izvorni znanstveni članak

Sažetak: *Članak predstavlja rezultate istraživanja provedenoga među studentima mehatronike s ciljem utvrđivanja njihovih stavova prema učenju engleskog jezika kao jezika struke. Glavni cilj bio je utvrditi koje elemente učenja engleskoga jezika kao jezika struke studenti smatraju najvažnijima. Ciljana populacija u ovom istraživanju bili su studenti prve godine studija mehatronike, budući da je cilj istraživanja bio prikupiti podatke o njihovim inicijalnim stavovima prema učenju engleskoga jezika u struci.*

Ključne riječi: *engleski jezik za posebne namjene, engleski kao drugi jezik, inicijalni stavovi, mehatronika*

1. INTRODUCTION

The main objective of foreign language classes at Croatian higher education institutions is to provide students with a solid foundation necessary for developing language competences related to their prospective profession. As Kordić and Papa point out, teaching a foreign language for professional purposes differs from teaching a foreign language as a general language, because it is pragmatically oriented, as it should meet the learner's needs that are conditioned by the labor market [1]. As English language plays an important role in the contemporary labor market, the focus of this research was placed on English rather than other foreign languages that are traditionally taught at Croatian higher education institutions. The methodology that is usually applied in such classes is ESP (English for Specific Purposes), which implies that the learner's reason for learning affects all decisions related to the content and method [2]. As Dragičević [3] points out, everyone is aware of the need of knowledge transfer within a certain country and outside its borders. One of the most important roles therein is played by language as a means of communication. The difference between teaching a foreign language generally speaking and language of a certain profession, i.e. language for specific purposes is that teaching a language for specific purposes combines both the linguistic and professional content. Dudley-Evans and St John [4] describe learning and teaching English for specific purposes in the following manner: ESP is defined in the way to meet the students' requirements, it uses the existing methodology and activities of the discipline it serves, and it is oriented towards the language suitable for these activities – grammar, lexicon, register, learning skills, discourse and genre. As Hutchinson and Waters [5] point out, there is no clear-cut boundary between learning and teaching general English and English for specific purposes.

This research focuses on the attitudes of mechatronics students toward learning English for specific purposes for the purpose of offering an insight into their reasons for learning English, which are vital from the aspect of ESP.

1.1. Learning English for specific purposes in technical sciences

Most of bachelor-level study programs in the area of technical sciences in the Republic of Croatia include English language classes. The basic reason for implementing English classes in professional study program curricula is the fact that English has become the language of international communication. Furthermore, professional books, journals and other sources may

frequently be found only in English. Bearing in mind that the content of English classes in primary and secondary schools is usually confined within the scope of general English, many students do not get confronted with engineering terminology and professional literature in English language until they enroll in the first year of their studies.

This research was conducted among students of the Professional Program of Study in Mechatronics at the Technical College in Bjelovar. This program of study is organized in six semesters, i.e. three years. Foreign language (English or German) is taught in all six semesters.

2. METHOD

During the first English class within the first year of their studies in the academic year 2015/16 students were asked to fill in the questionnaire prepared for the purpose of conducting this research. The participation in the research was voluntary and anonymous.

The questionnaire consists of two parts. The first part includes general information about the subjects – previously completed secondary school, number of years of learning English before college, average grade in English in the last two grades in secondary school, self-assessment of English knowledge and skills, the information on spending a longer period of time abroad in a country where English is spoken as the first language, and the general attitude regarding the importance of learning English for future bachelors of mechatronics. The second part of the questionnaire includes the students' attitude related to the degree of significance of different areas of English acquisition (the four skills: reading, listening, speaking, writing, general vocabulary, technical terminology, grammar, presentation skills in English, creating a CV and a job application in English, business correspondence).

As the questionnaire includes ten key areas of English language acquisition, subjects were asked to award each area with one of the grades from 1 to 10, whereat 1 signifies the lowest grade (the least important area of English language acquisition) and 10 represents the highest grade (the most important area of English language acquisition). Subjects were instructed that each area should be awarded with a single, different grade for the purpose of representing the attitude towards each of the aforementioned areas of English language acquisition according to the level of significance.

Methods of descriptive statistics were used for analyzing the sample and the results of the research.

2.1. Sample

The sample included a total of 47 full-time students of the Professional Program of Study in Mechatronics of the Technical College in Bjelovar who are enrolled in the elective course "English". Students enrolled in the elective course "German" were excluded from the sample due to the topic of the research which is related to learning English for specific purposes at college.

Figures 1, 2, 3 and 4 provide further information about the sample from the aspects of previously completed secondary school, number of years of learning English before college, average grade in English in the last two grades of secondary school and self-assessment of English knowledge and skills.

The majority of the students (91 %) included in the sample had completed a four-year professional secondary school, whereas 9 % of students had finished grammar school. The aforementioned percentages point to the relative homogeneity among subjects from the aspect of secondary school education.

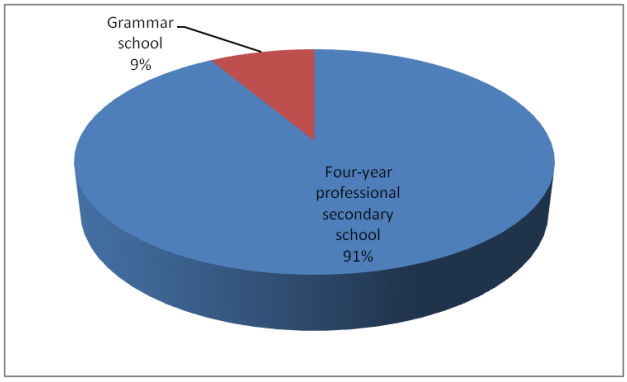

Figure 1. Sample distribution regarding the previously completed secondary school education

Regarding the number of years of learning English before college, the majority of students had learned English for 12 years. The number of years of learning English before college ranges between eight and twelve, which means that this should not be a relevant factor of differences in the attitudes towards learning English for specific purposes at college. A total of 72 % of students had learned English for 12 years before college, while the percentage of those learning English for eight and nine years amounted to 11% and 17 % respectively. The average period of learning English before college amounts to 11 years.

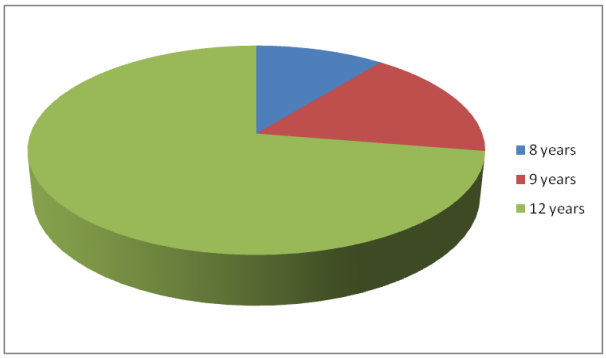

Figure 2. Sample distribution regarding the number of years of learning English before college

The average grade in English in the last two grades of secondary school was obtained by adding the two grades, dividing the sum by two and representing it as an integer. The average grade of the sample amounts to 3.

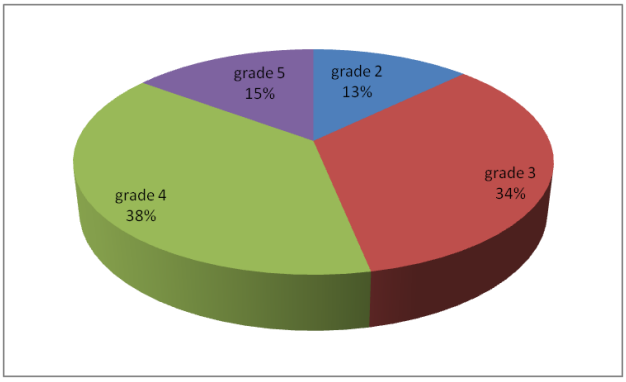

Figure 3. Sample distribution regarding the average grade in English in the last two grades of secondary school

The self-assessment of English knowledge and skills involved three grades – excellent, good and bad. As visible from Figure 4, most students assess their English knowledge and skills with the neutral grade "good".

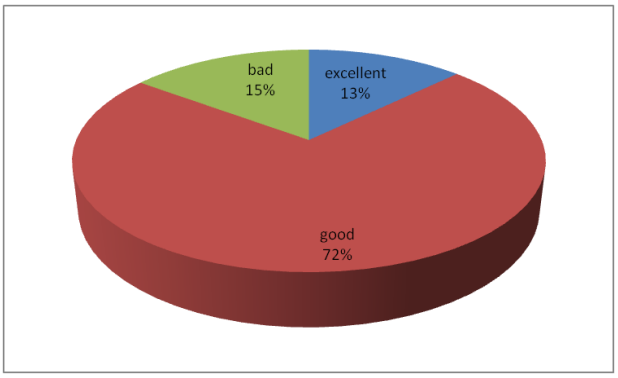

Figure 4. Sample distribution according to the students' self-assessment of English knowledge and skills

None of the students had spent a longer period of time abroad in a country where English is spoken as the first language.

All students regard learning English for specific purposes at college important for future bachelors in mechatronics.

3. RESULTS

Among the ten areas listed in the questionnaire, speaking skill was in average evaluated as the most important element of English language learning at college, whereas presentation skills in English were averagely evaluated as being the least important among the ten elements.

The four skills of language learning (reading, listening, speaking and writing) as a whole were graded with high grades, whereat speaking was evaluated as the most important and writing as the least important.

Vocabulary was generally regarded as more important than grammar. However, when comparing grammar and general English vocabulary, grammar was graded as more important. Technical terminology was evaluated with higher grades than general English vocabulary and grammar.

If ordered according to the grade the elements of learning English within technical studies, according to the results of this research are as follows: speaking skill, listening skill, reading skill, writing skill, technical terminology, grammar, CV and job application in English, general English vocabulary, business correspondence, presentation skills in English.

The overall results may be found in Figure 5 and in Table 1. The element with the highest grade (speaking) is marked in green and the one with the lowest grade (presentation skills in English) in red.

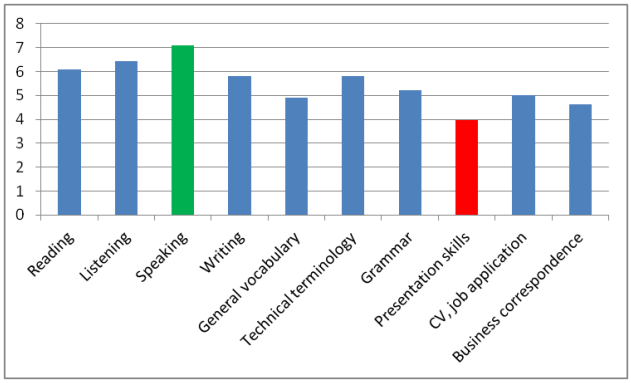

Figure 5. Results

Table 1. Results

ELEMENT OF ENGLISH LANGUAGE LEARNING	AVERAGE	SD
speaking skill	7.11	2.70
listening skill	6.45	2.68
reading skill	6.09	2.55
writing skill	5.81	2.46
technical terminology	5.81	3.00
grammar	5.23	2.78
CV and job application in English	5.00	2.99
general English vocabulary	4.91	2.58
business correspondence	4.62	3.28
presentation skills in English	3.98	2.49

From the results it is visible that the standard deviation is high, which means that students' attitudes towards various elements of learning English for specific purposes in engineering and technology are not homogenous. However, a general trend may be noticed i.e. the fact that students consider the speaking skills to be the most important element (7.11 on the 1-10 scale), and presentation skills in English as the least important element (3.98 on the 1-10 scale) of learning English at college.

4. DISCUSSION

Similar research studies have been conducted among students enrolled in various study programs. Research conducted by Miščančuk [6], which involved a similar sample of students (mostly engineering students), showed similar results as this one from the aspect of the importance of the speaking skill. Speaking was evaluated as the most important language competence, as 63.24 % of the sample considered it to be very important.

Jelovčić [7] carried out a similar research at the Faculty of Humanities and Social Sciences in Zagreb and obtained similar results from the aspect of the language learning skills. The speaking skill was evaluated as the most important by the majority of students.

It may be concluded, therefore, that mechatronics students share the standpoint of other engineering students and students of humanities and social sciences from the aspect that spoken communication represents a vital part of learning English for specific purposes in their profession.

5. CONCLUSION

The objective of this paper was to determine the initial attitudes of mechatronics students about learning English for specific purposes at college. As expected and confirmed by previous research in the same field, most students consider the spoken communication to be the vital part of the overall English competence. As opposed to this, most students consider presentation skills in English to be least important part of learning English for specific purposes, which is partially contradictory to the claim that spoken communication is the most important element, as presentation skills belong to the area of spoken communication.

Further research may be conducted for the purpose of determining whether there is any difference between first-year students and their third-year colleagues from the aspect of the importance of presentation skills which may play an important role at their future workplace.

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DIFFERENT MATHEMATICAL MODEL FOR THE CHOPPER CIRCUIT

DRUKČIJI MATEMATIČKI MODEL ZA SKLOP TRANZISTORSKOG PRETVARAČA (CHOPPER-A)

Erol Can, H. Hüseyin Sayan

Original scientific paper

Abstract: *In this study, dc-dc boost converter circuit is described as transformer circuit for direct form of energy in the electrical machine driver system of electrical and electronic engineering. First, mathematical equations of the converter circuit are created when circuit switch opened and closed controlling two states. Then, the equations are resolved for common equation so that the state space equation is formed in matrix form. A mathematical model of the converter circuit is performed at the Matlab Simulink.*

Keywords: *DC-DC boost converter, new mathematical model, transformer circuits*

Izvorni znanstveni rad

Sažetak: *U ovom istraživanju opisan je sklop istosmjernog uzlaznog pretvarača kao transformatorski sklop za izravne oblike energije u vozačkom sustavu električnog motora u elektrotehnici i elektronici. Prvo su kreirane matematičke jednadžbe sklopa pretvarača, a sklopka sklopa otvaranjem i zatvaranjem kontrolira dva stanja. Zatim su riješene jednadžbe za opću jednadžbu tako što je jednadžba prostora stanja formirana u matričnom obliku. Matematički model stvorenog pretvarača sklopa izveden je u Matlab Simulink.*

Ključne riječi: *DC-DC uzlazni pretvarač, novi matematički model, transformatorski sklopovi*

1. INTRODUCTION

Nowadays, renewable sources of energy are focused so that increasing energy needs can be tolerated [1-3]. Since renewable and DC sources are also converted for some driver circuits, motors and some loads can be driven [10]. Therefore, power electronic circuits were used to convert electric energy for loads driven in scientific articles [11]-[12]. In addition, industry and some workspaces have not worked with known transformer circuits which are not regulating DC (direct current) current. DC-DC converter circuits in power electronic applications can be used to the direct current motor for control of the direct current source [5]. In this study, steady state equation of the boost converter has been created. The equation is unlike the other applied scientific studies [4-8]. Mathematical equations of the converter circuit are created according to the circuit switches opened and closed that control two states. Then, the equations are resolved for common equation so that steady space equation can be formed in matrix form. When a new mathematical model of the converter circuit is performed at the Matlab Simulink, optimal result can be achieved for power electronic circuits.

2. BOOST CONVERTER CIRCUIT DESIGN

DC-DC boost converter given in Fig. 1 is used to increase from low voltages to high voltages. The converter circuit mathematical model is demonstrated for the relationship between equations of input and output voltages. In the equations, V_g is input voltage, V_L is inductance voltage, and i_L is inductance current, R is resistive load, C is capacitor for converter output voltage and D is duty time for switches, I_z is the skill of the converter to load change.

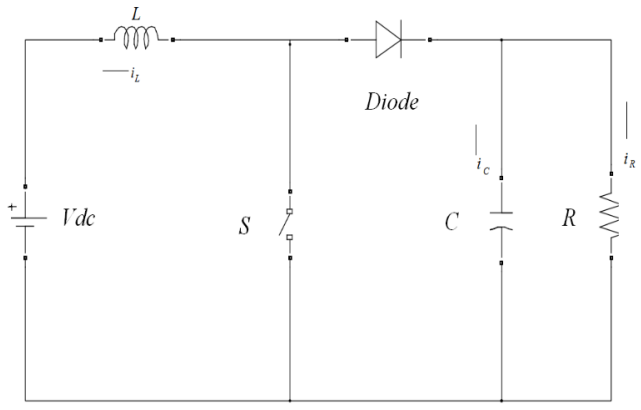

Figure 1. Boost converter circuit model

The pulse width modulation signal is applied to *S* that is switch of converter circuit as shown in Fig. 1. *DT* time shows the switching time is ON. (*(1-D) T)* time indicates switching time is OFF as shown in Fig. 2.

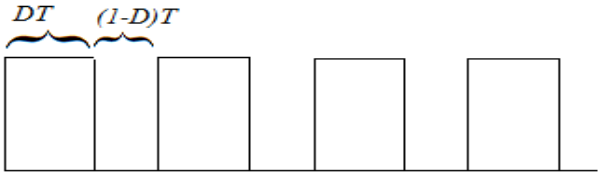

Figure 2. Pulse width modulation according to switching time.

The boost converter circuit equations are generally founded as follows:

$$Vg = VL = Vdc \quad (1)$$

$$\frac{di_L}{dt} L = Vg \quad (2)$$

$$\frac{di_L}{dt} = \frac{Vg}{L} \quad (3)$$

$$I_{\max} - I_{\min} = (\frac{Vg}{L})DT \quad (4)$$

$$Vg = VL + Vc \quad (5)$$

$$\frac{di_L}{dt} L = Vg - Vc \quad (6)$$

$$\frac{di_L}{dt} = \frac{Vg - Vc}{L} \quad (7)$$

$$I_{\min} - I_{\max} = (\frac{Vg - Vc}{L})(1 - D)T \quad (8)$$

$$(\frac{Vg - Vc}{L})(1 - D)T = -(\frac{Vg}{L})DT \quad (9)$$

$$Vc = (\frac{Vg}{1 - D}) \quad (10)$$

The equations of inductance current and output voltage have to be formed as $x = Ax + Bu$ for steady space.

For *S* = ON

$$Vg = VL \quad (11)$$

$$\frac{di_L}{dt} L = Vg \quad (12)$$

$$i_L = \frac{Vg}{L} \quad (13)$$

$$\dot{V} = \frac{I_Z}{C} \quad (14)$$

Variables obtained in the above equations are shown in matrix form as Eq. (15).

$$\begin{bmatrix} i \\ \dot{V} \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}}_{DA_{on}} \cdot \begin{bmatrix} I \\ V \end{bmatrix} + \underbrace{\begin{bmatrix} \frac{D}{L} & 0 \\ 0 & \frac{D}{C} \end{bmatrix}}_{DB_{on}} \cdot \begin{bmatrix} Vg \\ I_Z \end{bmatrix} \quad (15)$$

For *S* = OFF

$$Vg = VL + Vc \quad (16)$$

$$\frac{di_L}{dt} L = Vg - Vc \quad (17)$$

$$\frac{di_L}{dt} = \frac{Vg - Vc}{L} \quad (18)$$

$$i = \frac{Vg}{L} - \frac{Vc}{L} \quad (19)$$

$$\dot{V} = (I - \frac{V}{R} + I_z) \cdot \frac{1}{C} \quad (20)$$

$$\dot{V} = \frac{I}{C} - \frac{V}{RC} + I_Z \frac{1}{C} \quad (21)$$

$$\begin{bmatrix} i \\ \dot{V} \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & -\frac{1}{C} \\ \frac{1}{C} & -\frac{1}{RC} \end{bmatrix}}_{(1-D)A_{off}} \cdot \begin{bmatrix} I \\ V \end{bmatrix} + \underbrace{\begin{bmatrix} 0 & 0 \\ 0 & \frac{1}{C} \end{bmatrix}}_{(1-D)B_{off}} \cdot \begin{bmatrix} Vg \\ I_Z \end{bmatrix} \quad (22)$$

A and B are created to form a common state space equation which has variables for converter circuit as given in Eq. (23) and Eq. (24).

$$A = DA_{on} + (1 - D)A_{off} \quad (23)$$

$$B = DB_{on} + (1 - D)B_{off} \quad (24)$$

Finally, matrix form is given as below:

$$A = (D - 1)\begin{bmatrix} 0 & -\frac{1}{L} \\ -\frac{1}{C} & -\frac{1}{RC} \end{bmatrix} \quad B = \begin{bmatrix} \frac{D}{L} & 0 \\ 0 & \frac{1}{C} \end{bmatrix} \quad (25)$$

2.1. Simulation experimentation

After the mathematical models are formed, created matrix form of the converter circuit is performed. Then, converter circuit is performed at the Matlab Simulink as shown in Fig. 3.

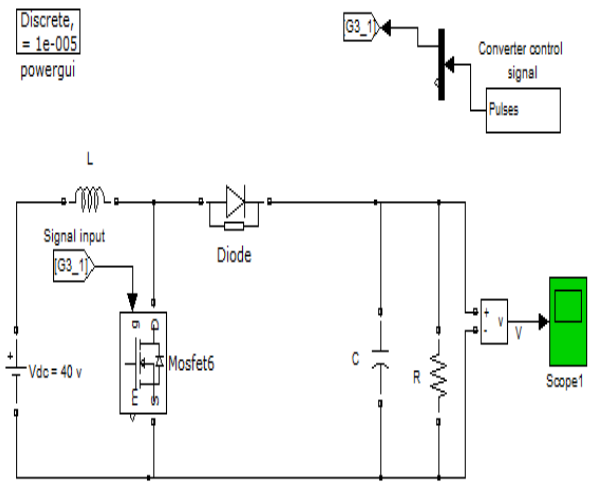

Figure 3. Boost converter in Matlab Simulink model

When 40 volt of direct voltage is applied to converter of input, the output voltage of the converter circuit increases 400 volt on output of the boost converter for 0.9 value of duty cycle as shown in Fig. 4.

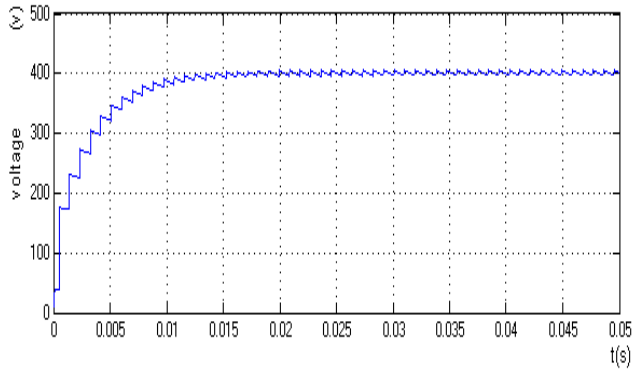

Figure 4. The simulated boost converter output voltage

3. RESULTS

A new mathematical model of the boost converter circuit is calculated so that models can be examined in the study. In general, the mathematical models are formed with duty time. Two considered situations are created in order to create different mathematical model and the matrix form. After creating mathematical model, the effect of the output voltage equation which is *(Vg/ (1-D))* is observed on the circuit of the output voltage when simulation is performed according to input voltage (*Vg*). 40 volt of input voltage can be increased to 400 volt of output voltage with for 0.9 value of duty cycle. New mathematical model using converter achieves that input voltage is boosted as 1x10.

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PHOTOVOLTAIC SYSTEM DESIGN FOR CONSUMERS IN ISOLATED OPERATION

PROJEKTIRANJE FOTONAPONSKIH SUSTAVA ZA POTROŠAČE U OTOČNOM RADU

Igor Petrović, Dinko Begović, Zoran Vrhovski

Preliminary note

Abstract: *All present product suppliers use website with product data, analysis and solutions in order to gain trust from their consumers. In this paper a case study is presented where electrical energy consumption measurement system is used in order to provide design results of minimal isolated PV plant necessary for electrical energy supply system. Measured results are available on-line for registered users. This kind of history data set is sufficient to determine minimal technical demands for future PV plant. Methodology presented in this paper can also be used in design any similar electrical or other energy supply, both in isolated of grid connected operation.*

Keywords: *AMR/AMI, design, energy consumption, photovoltaic*

Prethodno priopćenje

Sažetak: *Danas svi dobavljači proizvoda koriste mrežne stranice s podacima o svojim proizvodima, analizama i primjerima korištenja kako bi stekli povjerenje svojih kupaca. U ovom radu prikazan je način korištenja sustava za daljinsko očitanje brojila električne energije u svrhu projektiranja minimalnih zahtjeva na fotonaponski sustav u otočnom režimu rada za pokrivanje potrebne proizvodnje električne energije za tog potrošača. Rezultati takvih mjerenja potrošnje mrežno su dostupni za svakog registriranog korisnika. Ovako dobivena baza podataka dovoljna je za određivanje minimalnih tehničkih zahtjeva na buduće fotonaponsko postrojenje. Također, metodologija prikazana u ovom radu može se primijeniti u projektiranju bilo kojeg sličnog sustava za napajanje električnom energijom, jednako u otočnom ili mrežnom radu.*

Ključne riječi: *AMR/AMI, fotonapon, potrošnja energije, projektiranje*

1. INTRODUCTION

The renewable energy sources are in present considered as best solution for energy production considering sustainable environmental development, as described in [1]. In big electrical energy distribution networks it is common to implement renewable electrical production systems with no effect to end user. In this paper the case scenario of isolated PV electrical energy production system is analyzed, with certain error span for results, as presented in [2] and [3].

A single professional end user in electrical energy distribution network is randomly selected, and for that user a standard professional design of isolated PV system is conducted, using methods like in [4] and [5], regarding users energy consumption behavioral. The selected user data is privileged and therefore will not be given in this paper. The data about his behavior is gained using measured consumption from electrical energy distributer, and it is concluded that it is not related to daylight. The installed electrical power of this user is not intended to be generalized in Watts, but rather p.u. in terms of maximal power values as this research is meant to give general overview for this type of energy production and consumption. Since most of demands are not admitted for Sun tracking, presented in [6], [7] and [8], fixed PV system is selected for this application. The methods and analysis used in this paper supply designers with input data for appropriate technical documentation on PV system design.

2. DETERMINATION AND DESIGN OF ISOLATED PV SYSTEM WITH LOAD

Most common method for PV system electrical energy production is web database PVGIS, available in [9]. It can provide simple empirical results adjusted to the specific location. Since the results are estimated, not modeled, but gained from empirical measured electrical values, not hydrological average values, it can be considered that the results are enough accurate for this type of research.

The main user parameters for this PV system design are daily consumed electrical energy and maximum electrical consumption power. Designed PV system must be able to obtain enough electrical energy for each day of consummation, and also cover the peak of power for each day. Since the consumer behavioral is not related to daylight it is obvious that isolated PV system must be equipped with energy storage, as presented in Figure 1, PV system configuration is designed to meet all requirements from the consumer. Installed PV modules must gain

sufficient energy during a single day with highest energy consumption. Battery bank must be able to store a single day highest energy from PV modules and at the same time provides highest required electrical output power. DC-AC converter must be able to provide required electrical output power.

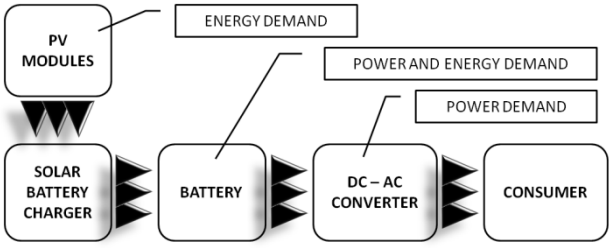

Figure 1. Configuration of isolated PV system with load

All requirements listed in this section are used for basic prediction of PV system electrical energy production using PVGIS. The location of designed PV system is in North-West Croatia.

Finally, the isolated PV system with load design must provide list of parameters as shown here:

- PV module power
- Selected PV module
- Number of PV modules
- Battery bank energy storage
- Battery bank maximum output power
- DC-AC converter maximum output power

3. AMR/AMI SYSTEM FOR MEASURING AND REMOTE SUPERVISION WITH HISTORY DATABASE

Remote meter reading for electrical energy consumption is a technology that allows automatic collecting of measured electrical energy consumption readings. Also, one can gain access to control the readings of measured values, events and alarms from electrical measuring equipment. Those data can be obtained on demand, or periodically according to a predefined schedule. Once the data is available in remote station it is stored in a single database for various analyses, calculations and/or malfunction detection.

HEP ODS upgraded standard basic AMR (*Automatic Meter Reading*), as presented in [10], system with such remote reading for electrical energy consumption. This system is equipped with certain characteristics of AMI (*Advanced Meter Infrastructure*), as presented in [11], as it allows two-way communication between measuring and remote equipment, remote configuration of measuring and communication devices, and finally power management for consumer in terms of on/off control using the switching devices inside the field devices. The basic structure of such AMR/AMI system is presented in Figure 2.

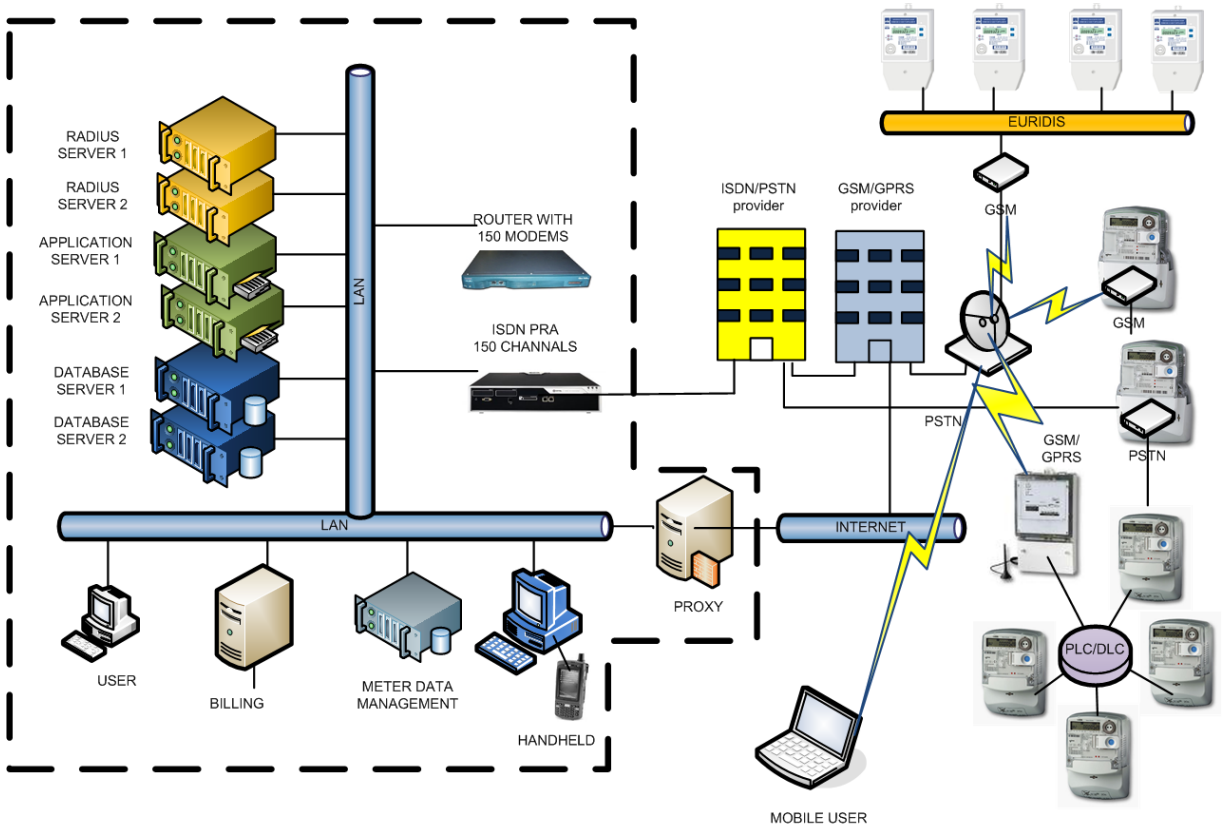

Figure 2. AMR/AMI system scheme

Figure 3. The consumer login interface for AMR/AMI monitor website

The website in Figure 3 is created for system consumers in order for them to be able to monitor their electrical energy consumption if they are equipped with one of the described measuring field devices and remote access. When consumer is logged in this website one can access and/or use 3 important measuring pieces of information in order to fully understand the way that he is supplied with electrical energy:

1. Three (3) months of historical measured data,
2. Download recorded data,
3. Use downloaded data for planning and energy management.

The monthly or semi-annual electricity consumption data is available for all other measuring field devices. All of these services are available with no charge to user. Random sample for history data website interface of active power is presented in Figure 4. The active power is presented as numerical values and graph, all in kW. The same website interface of reactive power is presented in Figure 5. The reactive power is presented as numerical values and graph, all in kVAr.

The sample of downloaded database for active power is presented in Figure 6. The database can be downloaded in CSV (comma separated value) file format. This kind of format is easily accessed through Microsoft Office Excel, Access, or any other standard database tool.

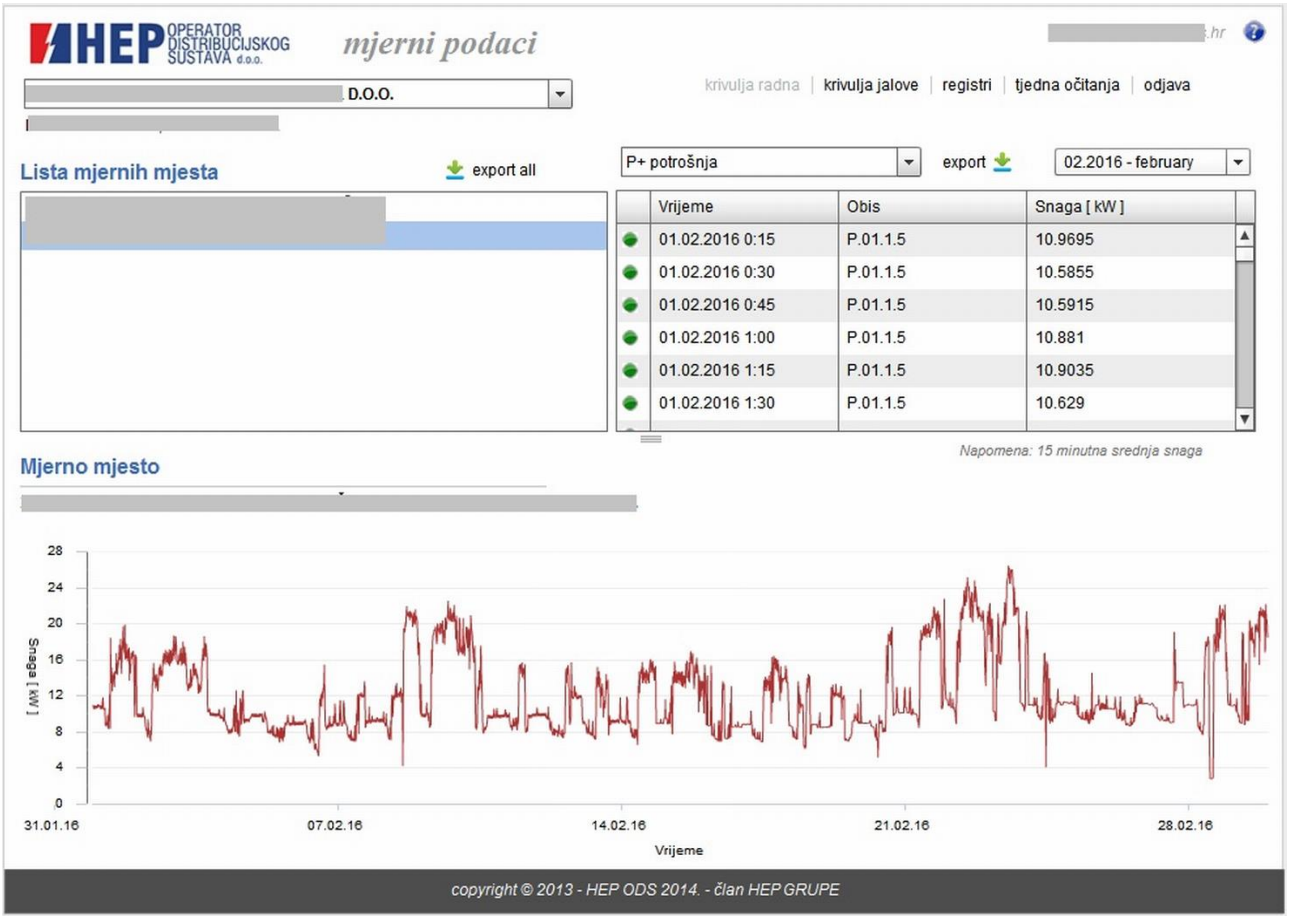

Figure 4. Website interface for history data of active power consumption, sample for random consumer

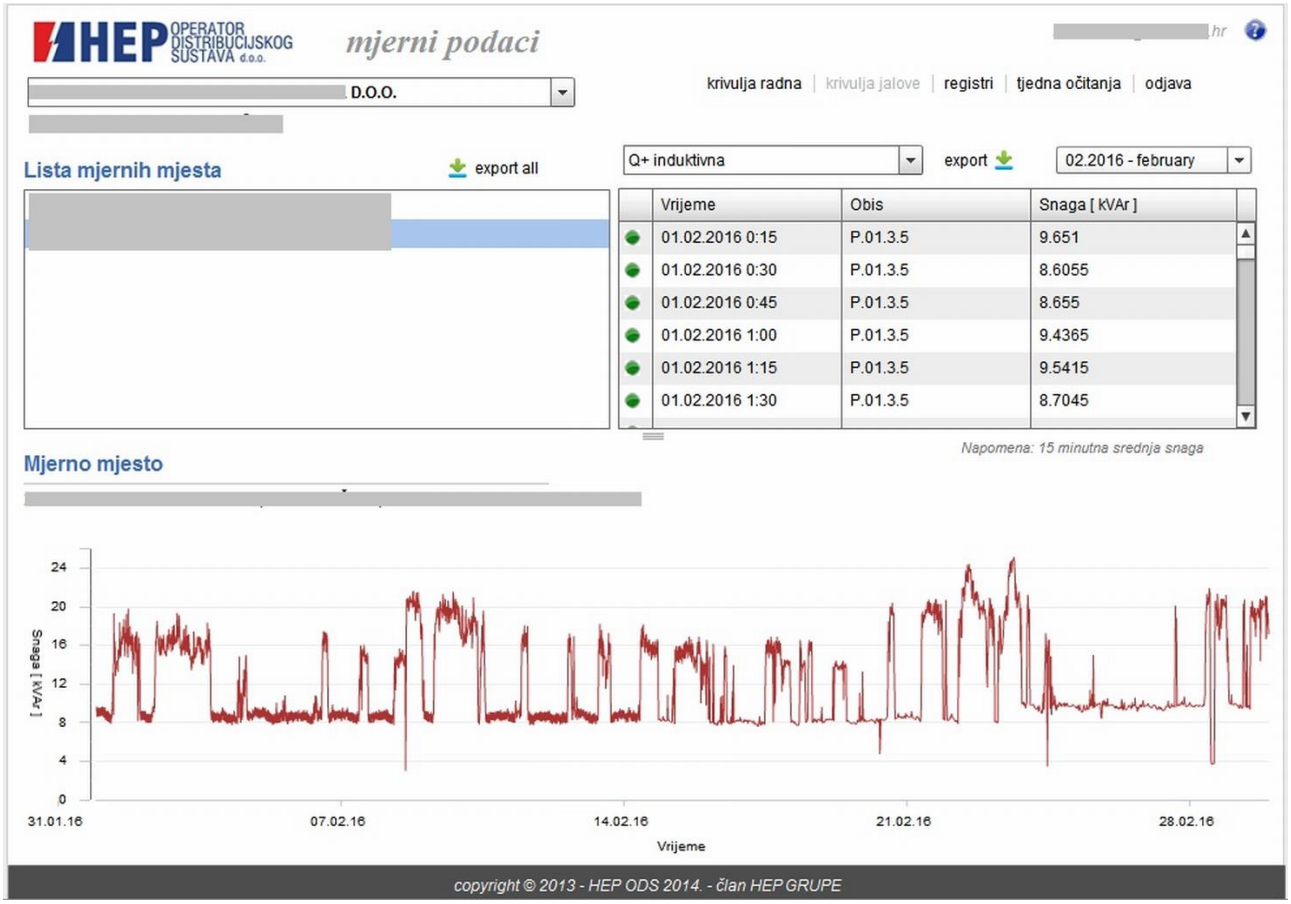

Figure 5. Website interface for history data of reactive power consumption, sample for random consumer

	A	B	C	D	E	F
1	OIB	Consumer	Meas. Point	Name	Address	Status
2	N/A	N/A	N/A	N/A	N/A	U
3	Meas. Point	Time	Meter	OBIS code	Power [kW]	Constant
4	N/A	1.2.2016 0:15	N/A	P.01.1.5	10,97	15
5	N/A	1.2.2016 0:30	N/A	P.01.1.5	10,586	15
6	N/A	1.2.2016 0:45	N/A	P.01.1.5	10,592	15
7	N/A	1.2.2016 1:00	N/A	P.01.1.5	10,881	15
8	N/A	1.2.2016 1:15	N/A	P.01.1.5	10,904	15
9	N/A	1.2.2016 1:30	N/A	P.01.1.5	10,629	15
10	N/A	1.2.2016 1:45	N/A	P.01.1.5	10,593	15
11	N/A	1.2.2016 2:00	N/A	P.01.1.5	10,86	15
12	N/A	1.2.2016 2:15	N/A	P.01.1.5	10,91	15

Figure 6. Example of downloaded/exported data

4. RESULTS AND ANALISYS

Measured data of electrical energy consumption is provided for random user in period from February 3 (Monday) until February 9 (Sunday) of 2014. Electrical power consumption measurement results for each day are presented in Figure 7. It can be seen that the user is intensively working every day in three shifts, except from Saturday 3rd shift until Monday 1st shift. Also, electrical power has partial oscillation while in full commission for all work shifts.

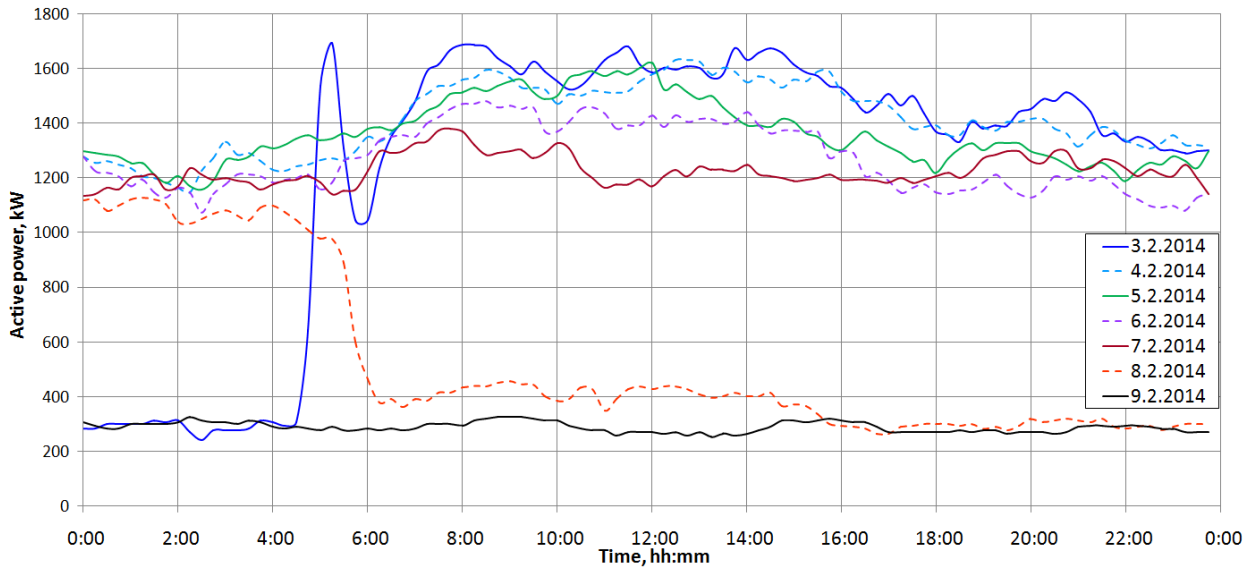

Figure 7. Electrical power consumption measurement results from February 3 until February 9 of 2014

From electrical power it is easy to calculate energy consumption by simple integration for each measured day. Electrical energy consumption of the user is presented in Figure 8.

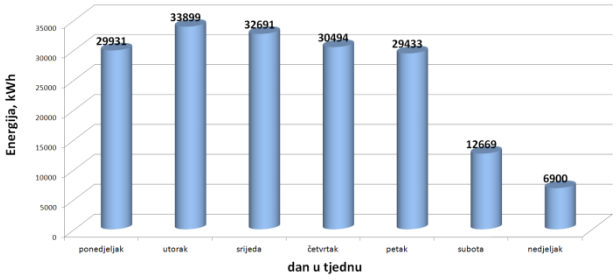

Figure 8. Electrical energy consumption from 03. February till 09. February of 2014

Standard analytic calculations can be applied to power and energy measured data of electrical energy consumption. The main results from available data are minimal, average and maximal power and energy values. These results are provided in Table 1.

Table 1. Consumer behavior analysis

	Minimum	Average	Maximum
P / kW	-	1048 kW	1692 kW
E / kWh	6900 kWh	25145 kWh	33899 kWh

Since power and energy are supposed to be self-sufficient, the analysis must be applied on daily basis. The results given in Table 2 are daily measured energy consumption cumulative. From these daily energies one can conduct a design of PV system.

Table 2. Consumer daily measured energy consumption cumulative

DATE	DAY	DAILY ENERGY kWh
3.2.2014	Monday	29931
4.2.2014	Tuesday	33899
5.2.2014	Wednesday	32691
6.2.2014	Thursday	30494
7.2.2014	Friday	29433
8.2.2014	Saturday	12669
9.2.2014	Sunday	6900

The PV system energy production shows average daily energy per kW of installed PV power for any month. The results are gained from on-line web tool PVGIS for Europe, available at [2]. For measured period (February) PV energy production is 2.23 kWh/kWpp. Therefore, the isolated PV system is derived from maximum necessary number of PV modules in Table 3. It is obvious that the maximum values in this measurement are gained in Tuesday. Therefore, the whole PV system is designed using the results in Tuesday, while some reserve is also applied. The reserve is supposed in order to cover any energy losses due to bad weather or any other reduce in energy production.

Table 3. Consumer daily measured PV power with number of modules

DATE	DAY	PV POWER kW	NR. OF MODULES pcs
3.2.2014	Monday	13421	53684
4.2.2014	Tuesday	15201	60804
5.2.2014	Wednesday	14659	58636
6.2.2014	Thursday	13674	54696
7.2.2014	Friday	13198	52792
8.2.2014	Saturday	5681	22724
9.2.2014	Sunday	3094	12376

In this case study PV system must be composed of 61000 PV modules with peak power of 250 W. This will ensure 15250 kW in described PV system. The battery block must ensure at least 33899 kWh and 1692 kW continuously. Finally, the inverter block must ensure roughly 1700 kW continuously.

$$k_{AVG} = \frac{P_{AVG}}{P_i} = \frac{1048}{15201} = 0.068943 \approx 6.9\% \quad (1)$$

$$k_{MAX} = \frac{P_{MAX}}{P_i} = \frac{1692}{15201} = 0.111308 \approx 11.1\% \quad (2)$$

In order to cover energy demand of consumer through PV plant it is necessary to invest in several times bigger installed power of PV modules and battery resources respectively to the average or maximum consumption, like gained in (1) and (2), and all because of daily electrical energy production characteristic for PV plant which is not related to daily electrical energy consumption characteristic for selected consumer.

5. CONCLUSION

In this paper the on-line webpage database is used to gain access to consumer behavior in order to improve design of PV plant in isolated operation. Measured data is also used for billing the electrical energy consumption to end user, and therefore is relevant for this case study. The results of PV plant resources are derived from maximum gained power of consumption, but also consumption behavior, which in this case has a great impact on PV plant design. The result is that PV plant is supposed to be almost 10 times bigger than maximum gained consumption power of installation, and almost 20 times bigger than average daily power consumption. Therefore, in this or similar cases it is necessary to ensure a high price of final product piece in order for PV plant energy production to be profitable.

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KNOWLEDGE MANAGEMENT IN UNIVERSITY: PREPAREDNESS OF MASTER OF INFORMATION SCIENCES GRADUATES FROM THE FACULTY OF HUMANITIES AND SOCIAL SCIENCES IN OSIJEK FOR THE LABOR MARKET

UPRAVLJANJE ZNANJEM NA SVEUČILIŠTU: PRIPREMLJENOST MAGISTARA INFORMACIJSKIH ZNANOSTI S FILOZOFSKOG FAKULTETA U OSIJEKU ZA TRŽIŠTE RADA

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Preliminary communication

Abstract: *Knowledge management can help universities to achieve their goals more effectively. Knowledge transfer is a very important part of the knowledge management process in higher education. Starting from this fact, the purpose of this study was to assess master of information sciences graduates' preparedness for the labor market in the context of knowledge transfer activities. The sample included master of information sciences graduates from the Faculty of Humanities and Social Sciences in Osijek. According to the results, respondents were moderately satisfied with the knowledge and skills gained during the study, which implies that they were not fully prepared for the labor market. The findings also indicate that their level of satisfaction was not significantly influenced by sociodemographic characteristics. The study suggests that it is necessary to improve knowledge transfer processes within the institution.*

Keywords: *knowledge management, knowledge transfer, labor market, level of satisfaction, master of information sciences graduates*

Prethodno priopćenje

Sažetak: *Upravljanje znanjem može pomoći sveučilištima da učinkovitije ostvare svoje ciljeve. Transfer znanja vrlo je važan dio procesa upravljanja znanjem u visokom obrazovanju. Polazeći od te činjenice, svrha ovog istraživanja bila je procijeniti pripremljenost magistara informacijskih znanosti za tržište rada u kontekstu aktivnosti transfera znanja. Uzorak su činili magistri informacijskih znanosti koji su završili Filozofski fakultet u Osijeku. Prema rezultatima, ispitanici su bili umjereno zadovoljni znanjima i vještinama stečenim tijekom studiranja, što implicira da nisu potpuno pripremljeni za tržište rada. Rezultati također ukazuju da njihova razina zadovoljstva nije bila značajno uvjetovana sociodemografskim obilježjima. Studija sugerira da je potrebno poboljšati procese transfera znanja unutar institucije.*

Ključne riječi: *magistri informacijskih znanosti, razina zadovoljstva, transfer znanja, tržište rada, upravljanje znanjem*

1. INTRODUCTION

In recent years, the idea of knowledge management has become very popular because of the increased awareness of the importance of knowledge for the organization's prosperity and survival, and the growing ability of information and communication technologies to support activities related to knowledge creation, distribution, and use [1]. Today, knowledge is often viewed as the most valuable strategic resource, which contributes significantly to achieving organizational goals. Successful organizations realize that they have to manage their intellectual capital to remain competitive and relevant in a dynamic and turbulent world. In an attempt to accomplish this aim, organizations have initiated and developed a range of knowledge management projects and programs [2]. However, although many organizations understand the importance and potential of knowledge management, there are still a lot of problems to be solved.

Knowledge management is an interdisciplinary field, which includes management science, economics, engineering, information and computer sciences, sociology, psychology, human resource management, business intelligence, but also many other disciplines. Therefore, it is not surprising that there are a variety of definitions of knowledge management. According to Robinson et al. [3], knowledge management is "a method of exploiting, or transforming knowledge as an asset for organizational use to facilitate continuous improvement." Bergeron [4] defined knowledge management as "a deliberate, systematic business optimization strategy that selects, distills, stores, organizes, packages, and communicates information essential to the business of a company in a manner that improves employee performance and corporate competitiveness." García-Holgado et al. [5] consider that knowledge management is

"the planning, organizing, motivating, and controlling of people, processes and systems in the organization, oriented to ensure that its knowledge-related assets are improved and effectively employed." From an interdisciplinary perspective, Jashapara [6] defined knowledge management as "the effective learning processes associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environments to enhance an organization's intellectual capital and performance." Taking into account the above definitions, it can be concluded that knowledge management involves the activities of knowledge creation, capture, storage, organization, validation, presentation, retrieval, transfer, sharing, and application.

Universities, as higher education institutions, play a crucial role in the social, economic, and technological development of a country. They are especially important for building a knowledge economy and learning society, which are based on education, research, creativity, innovation, and the intensive use of information and communication technologies. However, universities will need to multiply their engagements and impacts, since their potential is still not fully used. In this context, the present study examines the role of knowledge management in higher education. The main aim of the study is to assess master of information sciences graduates' preparedness for the labor market. In order to explore the effectiveness of knowledge transfer activities, as an integral part of knowledge management, the study is focused on graduates' satisfaction with the knowledge and skills gained at university. More precisely, the study seeks to determine how much they are satisfied with the competencies acquired during their higher education.

2. HIGHER EDUCATION AND KNOWLEDGE MANAGEMENT

By nature, higher education institutions are knowledge-based organizations that are responsible for the creation and dissemination of knowledge. The mission of universities is to produce highly skilled graduates and researchers who are able to contribute effectively to society. Now, more than ever, universities have to provide students with knowledge that will help them attain their full potential in a rapidly changing world. Since the traditional education does not meet the needs of an information and knowledge society, universities should be transformed into learning organizations [7]. These are organizations that have developed knowledge management systems, which allow them to continuously adapt to the complex and changing environment based on learning [8]. Organizational learning and knowledge management are complementary to each other. In modern organizations, knowledge is generated by processes of organizational learning. On the other hand, the outcome of such processes is managed by knowledge management systems [9].

Many factors have contributed to the increasing importance of knowledge management in higher education. Metaxiotis and Psarras [10] single out the following ones: the growth of learner centered knowledge as well as action learning, the shift from closed to open knowledge systems, the increasing significance of work-related learning that can be integrated into academic programs, the recognition of work experience as a key source of learning, the growth of continuous or lifelong learning available to all, and the explosion of information and communication technologies which are able to revolutionize teaching and learning practices.

According to Nawaz and Gomes [11] there are many benefits of adopting knowledge management in higher education, such as improvement of services to students and faculties, minimization of time needed for the research, encouraging institutions to intensify interdisciplinary research activities, enhancing competitiveness and responsiveness of universities, concentration on the quality of research at the institutional level, reduction of administrative costs, improvement of curriculum development, and enhancement of human, organizational, innovation, and financial capital. Therefore, it is important for universities to adopt knowledge management practices and to provide high-quality study programs that enable students to become knowledge workers. In addition, higher education institutions have to encourage students' and faculty members' engagement in lifelong learning in order to improve their knowledge and skills.

Agarwal and Marouf [12] presented a theoretical framework for successful knowledge management initiation in a college or university. It consists of four stages: plan, design, implement, and scale up. In the first phase, it is necessary to form a knowledge management planning team and to identify goals and priorities. The design phase includes determination of the current state, development of success measures, and creation of action plan. In the implementation phase, a pilot is launched and support is provided. Also, early results are presented. The final stage includes usage of knowledge gained to realign strategy with university or college objectives, and scaling up to other units.

The purpose of knowledge management tools is to simplify and improve organizational processes related to knowledge creation and sharing. These tools have a great potential, but without an adequate strategy and developed organizational culture, they bring limited benefits. Based on the literature review, Pinto [13] identified the following knowledge management tools: knowledge repositories (document management, edition collaboration, documents sharing, searching and retrieval advanced mechanisms), knowledge maps (categorizing and indexing knowledge in taxonomies, creating knowledge maps, inserting tags and labels in documents, alerting to relevant information), workflow tools (business processes automation, support automated flows of activities, support documental flows), learning system (evaluation and progress tracking, collaboration tools, reusable learning and object libraries, workgroups, scheduling and reporting tools, searching and matching tutorials), corporate portal (environment personalization, filtering relevant information, search and retrieval advanced mechanisms, tasks and calendar management, unified access environment to other tools, integration), collaboration tools and web 2.0 applications

(interaction and collaboration), and ontologies (include information/knowledge categorization).

Siadat et al. [14] determined four main effective groups of factors on successful implementation of knowledge management in higher education. These are management, cultural, organizational, and technical factors. Their understanding is crucial for the development of knowledge management system. However, despite the progress that has been made in recent years, knowledge management projects have not yet been fully implemented in higher education [15]. Therefore, it is necessary to accelerate the process of knowledge management implementation in universities.

3. SAMPLE AND METHODS

The survey was conducted in May and June 2015, and included 58 master of information sciences graduates from the Faculty of Humanities and Social Sciences, Josip Juraj Strossmayer University in Osijek. Table 1 shows the distribution of respondents by selected sociodemographic characteristics.

Table 1. Sociodemographic characteristics of respondents

Characteristic	Number of respondents	Percentage
Gender		
Female	48	82,8
Male	10	17,2
Age group		
24 – 28	37	63,8
29 – 50	21	36,2
Employment status		
Employed	43	74,1
Unemployed	15	25,9
Year of graduation		
2007 – 2011	12	20,7
2012 – 2015	46	79,3

There were more women than men in the sample. The majority of respondents were between the ages of 24 and 28, and were employed. Graduates who completed their studies between 2012 and 2015 dominated the sample. Despite the relatively small number of respondents, the sample included approximately one-third of all master of information sciences graduates from the Faculty of Humanities and Social Sciences, Josip Juraj Strossmayer University in Osijek.

Descriptive statistics were used to analyze the data. In addition, the Mann-Whitney test was performed to determine whether the differences between the groups are significant. The level of significance was set at $p < 0,05$ (two-tailed).

4. FINDINGS

Respondents rated their level of satisfaction with the knowledge and skills gained during the study on a five-point scale ranging from 1 (completely dissatisfied) to 5 (completely satisfied). Their responses were summarized using descriptive statistics (Table 2).

Table 2. Level of satisfaction with the knowledge and skills (descriptive statistics)

Knowledge and skills	Mean	Median	Standard deviation
General knowledge and skills			
Communication with customers and public	3,43	4,00	1,06
Communication with colleagues and superiors	3,62	4,00	1,18
Written and oral presentation	3,55	4,00	1,08
Teamwork and leadership	3,48	3,00	0,98
Evaluation of an organization's success	4,10	4,00	0,89
Analysis of users and their needs	4,02	4,00	0,89
Knowledge of ethical principles and regulations	3,84	4,00	1,06
Library knowledge and skills			
Library circulation	3,34	3,00	1,31
Collection development	3,74	4,00	1,19
Knowledge and use of reference materials	4,17	4,00	0,90
Databases search	3,21	3,00	1,06
Creating and managing databases	3,09	3,00	1,25
Digitization	3,57	4,00	1,01
Organization of bibliographic records	4,19	4,00	0,85
Information finding, evaluation, and use	3,86	4,00	1,19
Cataloguing	3,33	3,00	1,32
Use of library automation software	2,83	3,00	1,27
Technical processing of library materials	3,26	3,00	1,32
Preservation of library materials	3,66	4,00	1,02
Digital preservation	3,81	4,00	1,00
Knowledge and skills in publishing			
Management of publishing organizations	3,57	4,00	1,13
Publishing products	3,45	3,00	1,05

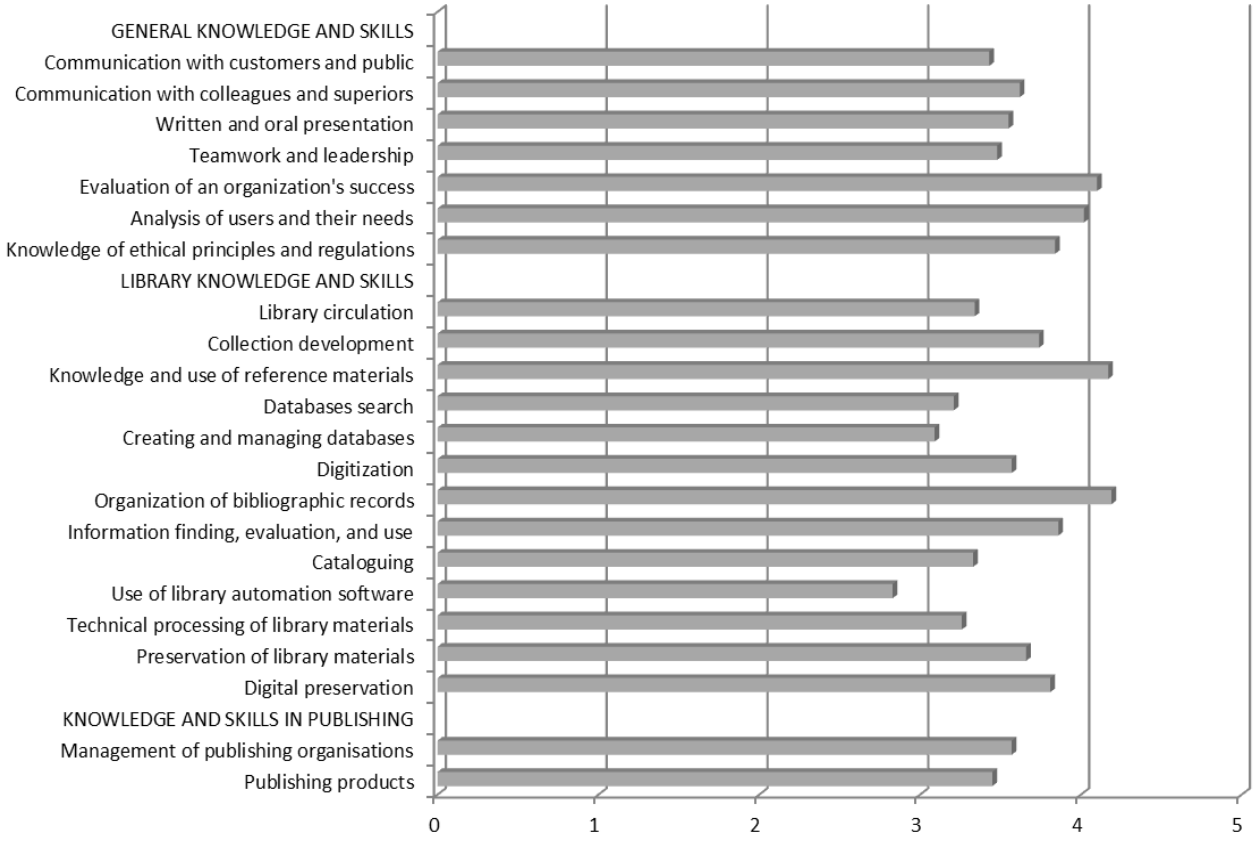

Figure 1. Level of satisfaction means

The knowledge and skills were classified into three categories: general, library, and those in publishing. Overall, respondents tended to be slightly more satisfied with the general knowledge and skills than with those related to librarianship and publishing. The mean values, also shown in Figure 1, indicate that they were most satisfied with the following knowledge and skills gained during the study: organization of bibliographic records, use of reference materials, evaluation of an organization's success, and analysis of users and their needs. In these four cases, the means are greater than 4.

Table 3. Analysis of differences in the levels of satisfaction with the general knowledge and skills

General knowledge and skills		Gender		Age group		Employment status		Year of graduation	
		Female	Male	24 – 28	29 – 50	Employed	Unemployed	2007 – 2011	2012 – 2015
Communication with customers and public	Mean rank	30,45	24,95	27,72	32,64	29,30	30,07	32,58	28,70
	Z , *p*	*Z*=0,979	*p*=0,328	*Z*=-1,120	*p*=0,263	*Z*=-0,150	*p*=0,881	*Z*=0,740	*p*=0,459
Communication with colleagues and superiors	Mean rank	29,92	27,50	29,53	29,45	29,36	29,90	24,71	30,75
	Z , *p*	*Z*=0,416	*p*=0,677	*Z*=0,008	*p*=0,993	*Z*=-0,101	*p*=0,919	*Z*=-1,135	*p*=0,256
Written and oral presentation	Mean rank	29,42	29,90	28,61	31,07	28,97	31,03	20,33	31,89
	Z , *p*	*Z*=-0,075	*p*=0,940	*Z*=-0,546	*p*=0,585	*Z*=-0,415	*p*=0,678	*Z*=-2,183	*p*=0,029
Teamwork and leadership	Mean rank	29,21	30,90	32,91	23,50	30,40	26,93	27,17	30,11
	Z , *p*	*Z*=-0,293	*p*=0,769	*Z*=2,142	*p*=0,032	*Z*=0,712	*p*=0,476	*Z*=-0,557	*p*=0,578
Evaluation of an organization's success	Mean rank	29,63	28,90	26,74	34,36	29,13	30,57	26,38	30,32
	Z , *p*	*Z*=0,121	*p*=0,904	*Z*=-1,754	*p*=0,079	*Z*=-0,294	*p*=0,769	*Z*=-0,759	*p*=0,448
Analysis of users and their needs	Mean rank	29,22	30,85	31,23	26,45	30,08	27,83	29,79	29,42
	Z , *p*	*Z*=-0,285	*p*=0,776	*Z*=1,093	*p*=0,274	*Z*=0,463	*p*=0,643	*Z*=0,061	*p*=0,951
Knowledge of ethical principles and regulations	Mean rank	28,66	33,55	30,19	28,29	28,91	31,20	24,75	30,74
	Z , *p*	*Z*=-0,863	*p*=0,388	*Z*=0,424	*p*=0,672	*Z*=-0,465	*p*=0,642	*Z*=-1,136	*p*=0,256

Table 4. Analysis of differences in the levels of satisfaction with library knowledge and skills

Library knowledge and skills		Gender		Age group		Employment status		Year of graduation	
		Female	Male	24 – 28	29 – 50	Employed	Unemployed	2007 – 2011	2012 – 2015
Library circulation	Mean rank	30,14	26,45	31,50	25,98	30,29	27,23	34,79	28,12
	Z , *p*	*Z*=0,635	*p*=0,526	*Z*=1,222	*p*=0,222	*Z*=0,612	*p*=0,541	*Z*=1,243	*p*=0,214
Collection development	Mean rank	30,86	22,95	27,51	33,00	28,53	32,27	31,50	28,98
	Z , *p*	*Z*=1,391	*p*=0,164	*Z*=-1,228	*p*=0,219	*Z*=-0,757	*p*=0,449	*Z*=0,469	*p*=0,639
Knowledge and use of reference materials	Mean rank	28,28	35,35	30,92	27,00	28,30	32,93	32,50	28,72
	Z , *p*	*Z*=-1,290	*p*=0,197	*Z*=0,909	*p*=0,363	*Z*=-0,978	*p*=0,328	*Z*=0,736	*p*=0,462
Databases search	Mean rank	27,55	38,85	30,59	27,57	30,14	27,67	31,38	29,01
	Z , *p*	*Z*=-1,996	*p*=0,046	*Z*=0,675	*p*=0,500	*Z*=0,500	*p*=0,617	*Z*=0,440	*p*=0,660
Creating and managing databases	Mean rank	28,26	35,45	30,04	28,55	30,72	26,00	31,33	29,02
	Z , *p*	*Z*=-1,249	*p*=0,212	*Z*=0,325	*p*=0,746	*Z*=0,950	*p*=0,342	*Z*=0,425	*p*=0,671
Digitization	Mean rank	29,20	30,95	28,24	31,71	29,47	29,60	31,00	29,11
	Z , *p*	*Z*=-0,305	*p*=0,760	*Z*=-0,789	*p*=0,430	*Z*=-0,019	*p*=0,985	*Z*=0,356	*p*=0,722
Organization of bibliographic records	Mean rank	29,10	31,40	27,15	33,64	31,24	24,50	34,46	28,21
	Z , *p*	*Z*=-0,409	*p*=0,683	*Z*=-1,503	*p*=0,133	*Z*=1,420	*p*=0,156	*Z*=1,216	*p*=0,224
Information finding, evaluation, and use	Mean rank	30,56	24,40	27,92	32,29	29,13	30,57	28,88	29,66
	Z , *p*	*Z*=1,094	*p*=0,274	*Z*=-0,988	*p*=0,323	*Z*=-0,290	*p*=0,772	*Z*=-0,141	*p*=0,888
Cataloguing	Mean rank	29,48	29,60	28,91	30,55	29,56	29,33	28,92	29,65
	Z , *p*	*Z*=-0,011	*p*=0,992	*Z*=-0,358	*p*=0,720	*Z*=0,037	*p*=0,971	*Z*=-0,128	*p*=0,898
Use of library automation software	Mean rank	30,88	22,90	29,36	29,74	30,57	26,43	27,42	30,04
	Z , *p*	*Z*=1,386	*p*=0,166	*Z*=-0,075	*p*=0,940	*Z*=0,831	*p*=0,406	*Z*=-0,484	*p*=0,629
Technical processing of library materials	Mean rank	30,42	25,10	27,78	32,52	27,87	34,17	22,17	31,41
	Z , *p*	*Z*=0,918	*p*=0,359	*Z*=-1,045	*p*=0,296	*Z*=-1,265	*p*=0,206	*Z*=-1,722	*p*=0,085
Preservation of library materials	Mean rank	29,28	30,55	28,18	31,83	28,26	33,07	29,08	29,61
	Z , *p*	*Z*=-0,216	*p*=0,829	*Z*=-0,824	*p*=0,410	*Z*=-0,988	*p*=0,323	*Z*=-0,091	*p*=0,928
Digital preservation	Mean rank	30,01	27,05	27,68	32,71	28,87	31,30	26,63	30,25
	Z , *p*	*Z*=0,517	*p*=0,605	*Z*=-1,134	*p*=0,257	*Z*=-0,492	*p*=0,623	*Z*=-0,683	*p*=0,495

Respondents were the least satisfied with the knowledge and skills in using library automation software. It is necessary to mention that students believe that such software is difficult to learn, since it requires advanced ICT competencies. Only the mean value of this item is less than 3. However, it can be concluded that master of information sciences graduates have generally positive attitudes toward the knowledge and skills gained at university, but not to a sufficient extent. This is also confirmed by the median values. Most of the medians are greater than 3, indicating respondents' satisfaction with the acquired knowledge and skills. Still, there are many areas in which master of information sciences graduates were neither satisfied nor dissatisfied.

The significance of differences in the levels of satisfaction with the general knowledge and skills based on gender, age, employment status, and year of graduation were analyzed by the Mann-Whitney test. The results of testing are shown in Table 3. According to the Mann-Whitney test, younger and older master of information sciences graduates differed significantly in their ratings of teamwork and leadership skills gained during the study. The mean ranks indicate that younger graduates were more satisfied with such skills than their older colleagues. Also, graduates who completed their studies between 2012 and 2015 were significantly more satisfied with the acquired written and oral presentation skills than those who graduated earlier.

Table 4 presents the results of the analysis of differences in the levels of satisfaction with library knowledge and skills. The Mann-Whitney test confirmed that only the difference in satisfaction with the acquired database searching skills between female and male graduates were statistically significant. According to the mean ranks, male graduates were more satisfied with database searching skills gained during the study than their female counterparts.

The Mann-Whitney test was also used to examine the significance of differences in the levels of satisfaction with the knowledge and skills in publishing (Table 5). The results indicate that there was no significant difference between any of the groups.

Table 5. Analysis of differences in the levels of satisfaction with the knowledge and skills in publishing

Knowledge and skills in publishing		Gender		Age group		Employment status		Year of graduation	
		Female	Male	24 – 28	29 – 50	Employed	Unemployed	2007 – 2011	2012 – 2015
Management of publishing organisations	Mean rank	29,14	31,25	29,72	29,12	29,81	28,60	27,29	30,08
	Z , *p*	*Z* = -0,363	*p* = 0,717	*Z* = 0,126	*p* = 0,900	*Z* = 0,240	*p* = 0,811	*Z* = -0,518	*p* = 0,605
Publishing products	Mean rank	29,40	30,00	29,47	29,55	29,87	28,43	24,50	30,80
	Z , *p*	*Z* = -0,096	*p* = 0,923	*Z* = -0,008	*p* = 0,993	*Z* = 0,287	*p* = 0,774	*Z* = -1,190	*p* = 0,234

5. CONCLUSION

Higher education has an important role to play in providing qualified staff for the labor market. The question is, how successful are Croatian higher education institutions in fulfilling this mission? This issue is particularly acute in times of crisis, when unemployment is high and many graduates cannot find jobs. The purpose of the present study was to determine how well master of information sciences graduates are prepared for the labor market in the context of knowledge transfer activities within university.

Knowledge management can be very useful to higher education institutions. However, despite its benefits, knowledge management is still not integrated into higher education environments. Therefore, in time to come, it is necessary to pay more attention to knowledge management as a means by which universities can more effectively achieve strategic goals and objectives.

The study was focused on knowledge transfer as a process of transmitting knowledge from teachers to students. Knowledge transfer is a very important part of knowledge management in higher education institutions, since they have a core responsibility to equip students with necessary competencies and thus prepare them for the workplace. The results of the study show that master of information sciences graduates from the Faculty of Humanities and Social Sciences in Osijek were moderately satisfied with the knowledge and skills gained during the study. This implies that, in their opinion, they were not fully prepared for the labour market. The findings further suggest that responses of the surveyed graduates were mostly consistent throughout. There were only a few statistically significant differences noted in the levels of graduates' satisfaction with the knowledge and skills gained at university. Therefore, the level of satisfaction was not substantially influenced by sociodemographic characteristics, such as gender, age, employment status, and year of graduation.

Overall, the study indicates that it is necessary to improve knowledge transfer processes within the institution and to better prepare students for the challenges of today's job market. Some steps in this direction have already been made. Since it was observed that the current curriculum was not satisfactory, new academic programs have been initiated. It is expected that these programs will enable students to develop the competencies that fully meet the labor market and community needs. In addition, more attention began to be paid to students' practical training not only in libraries, museums, and archives, but also in private enterprises that employ information professionals. Despite a lack of funds, student visits to information institutions outside Croatia are also planned. In this way, students will have the opportunity to expand their knowledge and experience. Further efforts must be made to motivate students to do their best in achieving learning objectives and to encourage them to participate in scientific activities. It is also necessary to consider the introduction of new methods of teaching, especially those involving specialized technologies. However, since teachers are the key factor in the education process, they are most responsible for student achievement. Hence, without effective teachers it would not be possible to achieve the desired improvements in students' knowledge and skills, and to prepare them for the future.

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ANALYSIS OF VARIOUS NVH SOURCES OF A COMBUSTION ENGINE

ANALIZA RAZLIČITIH NVH IZVORA MOTORA S UNUTARNJIM IZGARANJEM

Amar Singh, Shubham Bharadwaj, Sunny Narayan

Subject review

Abstract: *The powertrain is the "heart" of a vehicle. It is the singular most expensive and most complex part of every vehicle. The powertrain consists of the engine, intake, and exhaust subsystems, and the transmission and drivetrain systems. The powertrain is one of the major sources of vehicle sounds and vibrations. In general, powertrain vibration and sound sources consist of the following: 1. Engine, including combustion-related sounds and vibrations, reciprocating unbalance, rotating unbalance, crankshaft torsional oscillations, etc; 2. Valve Train system, including valves, cam system, timing belt, or chain; 3. Accessories, including their unbalance and resonance; 4. Intake system and exhaust system vibrations; 5. Driveshaft first-order resonance; 6. Universal joint second-order bending vibrations and torsional vibrations; and 7. Axle vibrations due to gear tooth conjugation error, transmission error, pinion par eccentricity, slip-stick between pinion and ring gear, etc.In this work various sources of noise in an engine have been analyzed.*

Keywords: *engines; noise; vibrations*

Pregledni članak

Sažetak: *Pogonski sklop je 'srce' vozila. To je najskuplji i najsloženiji dio svakog vozila. Pogonski sklop sastoji se od motora, unosa i ispušnih podsustava te prijenosnih i pogonskih sustava. Pogonski sklop jedan je od glavnih izvora zvukova vozila i vibracija. Općenito, izvori vibracije i zvukova pogonskog sklopa sastoje se od sljedećeg: 1. motora, uključujući zvukove vezane uz izgaranje i vibracije, klipne neravnoteže, rotirajuće neravnoteže, torzijskih oscilacija koljenastog vratila…; 2. sustava razvodnog mehanizma, uključujući ventile, CAM sustav, razvodni remen ili lanac; 3. dodatnu opremu, uključujući i njezinu neravnotežu i rezonanciju; 4. vibracije usisnog sustava i ispušnog sustava; 5. rezonancija prvog reda vratila; 6. vibracija savijanja drugog reda kardanskog zgloba i torzijskih vibracija; i 7. vibracije osovine uslijed pogreške konjugacije zupčanika, pogreške u prijenosu, zupčanik prema ekscentričnosti, slip-stick gibanje između zupčanika i prstenastog zupčanika… U radu su analizirani različiti izvori buke u motoru.*

Ključne riječi: *motori, buka, vibracije*

1. INTRODUCTION

Engine vibrations can be classified as internal and external vibrations [1-3]. The internal vibrations are referred to as the vibrations of internal components of the engine, induced by the inertial force of moving parts and the variable pressure of combustion [4]. These vibrations usually must be suppressed to avoid engine malfunctions and damage/fracture and noise of parts. The frequently encountered vibrations are torsional and bending vibrations of the crankshaft, and vibration of the valves-camshaft system. The severe torsional and bending vibrations of the crankshaft could lead to fracture of the shaft and/or damage to the bearings [5]. Most of the internal vibrations result in noise, and are unlikely to cause dangerous stress of parts. The external vibrations are referred to as the vibrations of the entire engine system as a block, which is usually integrated with the transmission case. The external vibrations are due to unbalanced moment, inertial moment, or variable-output torsional torque. Engine vibrations are mainly due to the variable gas pressure in the cylinder, and the inertial force from the motion of the crank mechanism. Engine vibrations have detrimental effects on the internal parts, and can cause them to malfunction and thus have a reduced lifetime. Engine vibrations could also be transmitted to the engine's supportive base-like frames, or its accessories, and therefore lead to the vibrations of other systems [6-13]. Internal vibrations mainly lie in the torsional vibrations of crankshaft systems. The crankshaft has mass and elasticity; therefore, it constitutes a torsional vibration system. Under the excitation of the periodically modulated torsional torque, the crankshaft system is capable of making torsional vibrations. In operation, the crankshaft rotates and has an average torque applied to it. A static torsional deformation is associated with the crankshaft system.

Torsional vibration of the crankshaft system is a periodically varied torsional deformation superposed on the static deformation of the crankshaft. Torsional vibration always exists for an operational engine crankshaft. But it is not readily perceptible as the whole engine vibration [14]. The strength of the torsional vibrations can be estimated through measurement. If the frequency of the harmonic excitation torque coincides with the natural frequency of the crankshaft, the resonance

occurs. If the resonance situation is severe, a disaster consequence such as crankshaft failure could occur. The external vibration is referred to as the block vibration of the entire engine system together with the transmission case, in which the bending resonance has been critical. In the engine crank system, the reciprocal motion of the piston system leads to reciprocal inertial force; the rotating crank generates centrifugal force. In multiple-cylinder engines, the cranks are arranged uniformly to attain uniform firing of each cylinder. The first and second inertial forces are usually balanced (except for the second inertial forces in a four-cylinder, four-stroke engine). The balance of the reciprocal inertial moment and centrifugal moment depend on the configuration of cranks. On the other hand, the output torque of the engine and the turnover moment applied on the entire engine are periodic due to the periodic variation of gas pressure and reciprocal inertial force.

These forces or torques result in vibrations of the complete engine block, which is usually treated as six-degree-of-freedom, including the up-down, front-rear, left-right, pitch, yaw, and roll. Thus, the isolation of whole engine block is necessary, and it will be discussed in a later section. The engine is usually mounted on the supportive base, such as the frame or sub frame of the vehicle, which is connected with the body.

In real applications, the engine undergoes various impact excitations and periodic excitations. The impact excitations are due to gap effects in moving parts such as bearings and piston-cylinders. The impact-induced response only lasts a short period of time and decays quickly due to damping dissipation. The main excitations leading to steady vibrations come from different force or torques, including the following: 1) Periodic tangential and radial forces acting on the crankshaft: these forces are from the gas pressure in the engine cylinder, the inertial and gravity forces from the piston, connecting rod, and crankshaft[15]. These forces are the primary sources of engine vibrations. 2) Excitation forces and torques due to rotating parts, such as the centrifugal force or torque caused by static or dynamic unbalance of the rotating parts. The engines of most road vehicles use a four-stroke process. An engine finishes a full working process with four steps (strokes): air intake, air compression, combustion (explosion or firing), and exhaust [16].

These steps are shown in Fig. 1. It takes a 180° rotation angle of the crank to complete one step of the process. As such, a full process takes a 720° rotation angle of the crank, i.e., two rotation cycles. Among the four steps, the combustion process produces force when compressed gas is combined and fired. Consider an ideal model of a single cylinder engine, in which a firing pulse appears every two cycles, or there is a "half" firing pulse for each cycle. The firing order, simply called order, is defined as the firing number in each cycle. Thus, the basic firing order for a single cylinder engine is the half order. For an engine with two cylinders, there is a half firing order for each cylinder in one cycle; i.e., there exists a whole firing order in one cycle for the two cylinders. Hence, the basic firing order for a two cylinder engine is 1st order. Similarly, there are two firing pulses, three firing pulses, and four firing pulses for a four-cylinder engine, six-cylinder engine, and eight-cylinder engine in one cycle, respectively [17]. Thus, their corresponding firing orders are 2nd order, 3rd order, and 4th order, respectively.

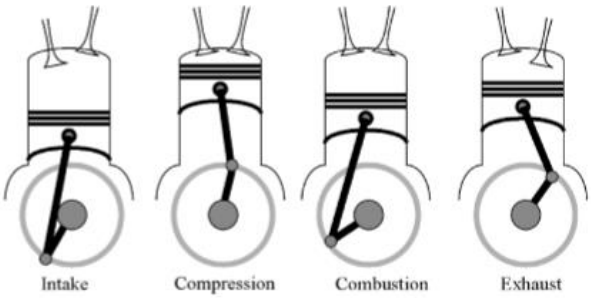

Figure 1. Engine Cycle

The typical noise sources of engines are schematically plotted in Fig. 2. The others such as engine block and injection pump are not indicated in the figure [18].

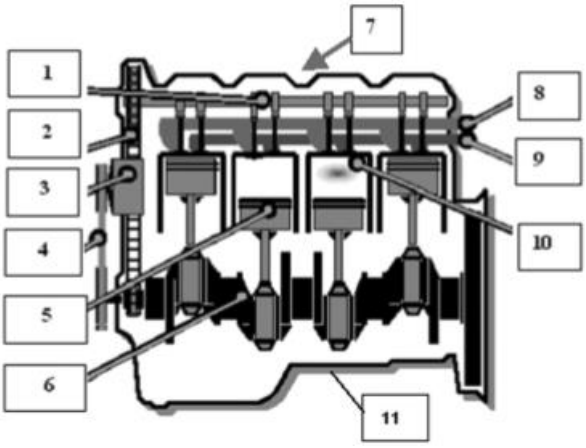

Figure 2. Engine noise sources

Fig. 2 Schematic of typical noise sources of an engine (1. valvetrain; 2. timing chain (or belt) noise (radiated from its cover); 3, 4. the noise from accessories such as oil pump, belt/ pulley, and fan system; 5. piston slap noise; 6. bearing noise; 7. structural noise of valve cover; 8. intake noise; 9. exhaust noise; 10. combustion noise; 11. oil pan (sump)).

Combustion noise intensity is proportional to the square of the pressure rise rate. The sound pressure level of noise is proportional to the logarithm of heat generation or release rate in the cylinder. Combustion noise is also dependent on ignition delay, speed, and torque load [19]. Mechanical noise mainly comes from the piston slap, the friction and impact response of the valve train, the meshing of gear and tooth belt, belt slippage, bearing operations, timing system and accessory systems, and oil pump systems. Mechanical noise is proportional to engine speed. The resonance of the engine block structure also radiates noise [20]. For the noise radiated from the engine surface, it is mainly from the radiation of the engine block surface and the bottom oil pan. The head of the cylinder and the cylinder cover also radiate noise. Aerodynamic noise includes the fan noise, intake, and exhaust noise. Fan noise is determined by speed, blade dimensions and configurations, and number of blades. The intake noise

and exhaust noise are due to the pressure pulse, flow friction, and turbulence. The effect of tailpipe and surface radiation of silencer vibration are also primary sources of exhaust noise. The wide variations in engine design make it difficult to give a general ranking of engine noise in terms of sound pressure level [21]. As an example, Fig. 3 shows the contributions of variable sources to the total sound pressure level of noise (1 meter away from engine) of an engine. The noise contributors include: exhaust noise, intake noise, fan noise, combustion noise, piston slap noise, noise of accessories and belt, and valve system noise.

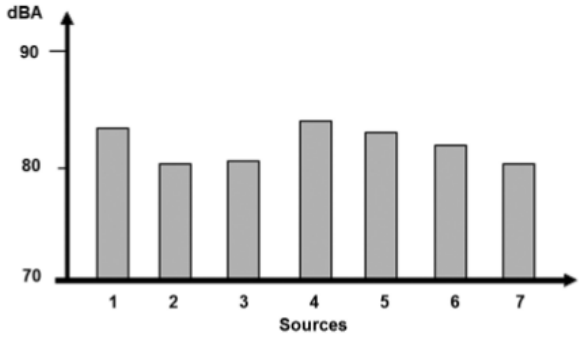

Figure 3. Contributions of varied sources to total sound pressure level of noise (1 meter away from engine) of an engine (1. exhaust noise; 2. intake noise; 3. fan noise; 4. combustion noise; 5. piston slap noise; 6. noise of accessories and belt; 7. valve system noise).

For various operational conditions, the contributions of the noise sources are quite different and are highly dependent on engine type. The specific frequency ranges of primary noise sources of a typical engine are illustrated in Table 1. The frequency ranges of the primary noise sources of an automotive engine are dependent not only on the engine and system structure, but also on operating speed and load. Therefore, the estimation and identification of specific frequencies must be determined through testing and analysis. By comparing the fundamental frequency and harmonics of these identified individual source noise with the spectrum of total noise, the contribution of individual noise source to total noise can be determined [22].

Table 1. Frequency ranges of noise sources

Source	Frequency ranges-Hz	Factor effecting
Combustion noise	500-8000	In cylinder pressure
Piston slap	2300-8000	Skirt-liner gap
Valve noise	500-2000	Acceleration ,valve seat gap
Cooling fan	200-2000	Engine speed
Intake	50-5000	Engine speed
Exhaust	50-5000	Engine speed
Injection	2000	Pump type
Gear	4000	Number of tooth
Accessory	3000	Alignment

Table 2 shows the decomposition of radiated noise from a V-6 engine. The testing of automotive engine noise is usually conducted in a semi anechoic chamber according to SAE-J1074. The room constant should be larger than four times the measurement surface [23]. In measurement, to avoid the disturbance of vibration and exhaust noise, the engine is installed together with a dynamometer on a base isolated from the rest of the floor; the exhaust tail pipe is connected with a pipe toward the outside of the test room. The background noise of the test room should be at least 3 dBA lower than the noise to be measured. The testing of the total engine noise needs to take into account the overall testing conditions. The steady test conditions should cover real operating conditions. In ramp-up testing from idle, the speed increase rate should be smaller than 15 rpm/s [24].

Table 2. Noise sources

Parts	dBA
Block	78
Head	76
Crank case	79
Intake manifold	78.9
Base	77.3
Cam cover	78.3
Front cover	77.97
Exhaust manifold	74.5
Oil pan	73.7

2. COMBUSTION NOISE

Engine combustion noise originates from the combustion in the cylinder. When fuel is injected into the engine cylinder chamber where high-pressure air exists, gasoline spark-ignites the mixed gas, and then part of the ignitable gas start to burn. The pressure and temperature increase rapidly. Then the combustion propagates from the firing part to other areas, and is associated with a continuous increase of temperature and pressure in the cylinder, with the combustible gas experiencing a circular flow motion. The pressure wave in the cylinder impacts the wall of the combustion chamber, which results in the structural resonance of the chamber. The cylinder parts usually have high stiffness and their natural frequencies are very high [25]. The frequencies of radiated noise are accordingly in the high frequency range. The pressure within the cylinder also exhibits periodic variation, which results in low-frequency vibrations of the cylinder. The combustion of mixed gas results in gas pressure changes, which results in structural vibration of the engine. The vibration radiates to the air through the engine surface and is perceived as combustion noise. In practice, it is difficult to distinguish combustion noise from mechanical noise. For convenience, we assume that the combustion noise is the noise due to combustion, originating from the pressure vibration within the cylinder and piston, transmitted to the cylinder cover, piston, connecting rod, crankshaft, and engine block, to the surroundings. We assume that the mechanical noise includes noise from mechanical

interaction, impact and friction in piston-cylinder impact, timing gear or belt, valvetrain, injection mechanism, accessories, and belt. Generally, in a direct-injection diesel engine, combustion noise is higher than mechanical noise; in a non-direct-injection diesel engine, mechanical noise is higher than combustion noise; in low-speed operation, combustion noise is always higher than mechanical noise. The gasoline engine has less severe combustion; both its combustion noise and mechanical noise are lower than that of a diesel engine [26].

The generation of combustion noise has been attributed to the rapid change of cylinder pressure in the combustion process. The effect of combustion consists of the dynamic load due to rapid pressure change and the high-frequency gas vibration and impulsive wave [27]. The strength of the noise from the gas dynamic load depends on the rate of pressure rise and the timing of the maximum pressure rise rate [28]. If pressure remains constant, the noise cannot be generated. The variation of cylinder pressure is characterized by the rate of pressure rise, dp/dt. In terms of experiment, the noise strength of combustion noise varies with cylinder pressure, i.e.

$$I \approx [p_{\max}(\frac{\mathrm{d}p}{\mathrm{d}t})_{\max}]^2 \quad (1)$$

I is the sound intensity of the combustion noise, p_{max} is the maximum pressure or pressure peak in the cylinder, and $(\mathrm{d}p/\mathrm{d}t)_{max}$ is the maximum rate of pressure rise.

The pressure in the cylinder of a diesel engine is larger than that of a gasoline engine, and the maximum rate of pressure rise is much higher than that of a gasoline engine; therefore, the combustion noise of a diesel engine is much higher than that of a gasoline engine. For a diesel engine, the direct-injection type has the highest cylinder pressure and the pressure increase rate, therefore it has higher noise. For a direct-injection engine, combustion noise is closely related to the combustion process [29]. The combustion process of a diesel engine consists of four phases: retarded combustion, rapid combustion, slow combustion, and late combustion. In the retarded combustion phase, the variation of pressure and temperature in the cylinder are small, and their effects on combustion noise are small. However, the retarded phase has a significant effect on the combustion process; therefore, it has indirect and significant effect on combustion noise [30]. In rapid combustion, the cylinder pressure increases rapidly, and it directly affects engine noise and vibrations. Combustion noise is generated mainly in the phase of rapid combustion. When cylinder pressure increases severely, cylinder parts experience a sudden dynamic load with a certain strength, the effect of which equals a slapping excitation. The engine is an intricate mechanical vibration system, for which different parts have different natural frequencies, and most fall in the high frequency range. Therefore, combustion noises radiated to the air through the transmission of engine parts are in the middle and high frequency ranges, which happen to be the most sensitive range of human hearing capability. A slow combustion phase also has an effect on engine high-frequency vibrations and noise. A late combustion phase has a small effect on combustion noise [31]. Normally, combustion noise of gasoline engines accounts for a small part of their total noise; however, when combustion-related knock occurs, cylinder pressure increases rapidly and leads to high-frequency knocking noise [32].The high-frequency vibrations of gas in the retarded combustion phase of a diesel engine, the firing and propagation of fuel result in the rapid pressure rise in the local district, and it also leads to the propagation of impulsive pressure waves. These impulsive waves reflect multiple times after they reach the wall of the cylinder. This process forms the high-frequency vibration of gas. It lasts quite a period of time in the expansion process.

The frequency of high-frequency vibration of gas in the cylinder can be estimated from sound velocity c and engine bore d as

$$f \approx \frac{c}{2d}. \quad (2)$$

3. SPECTRUM CHARACTERISTICS OF CYLINDER PRESSURE

The spectrum plot of cylinder pressure can be derived from the graph of cylinder pressure versus time. Cylinder pressure can be measured using a pressure sensor mounted on a cylinder head and connecting the sensor with the inside of the combustion chamber [33]. A minor change in the pressure curve has no significant effect on engine power, but it does have a significant effect on noise. An engine's power is determined by the averaged pressure curve from multiple cycles, whereas combustion noise is dependent on the actual curve reflecting transient pressure variation in each cycle [34]. The cylinder pressure curve usually is a variation of cylinder gas pressure with respect to time. To understand the frequency signature of cylinder pressure, the spectrum of cylinder pressure has been used. Fig. 4a plots the pressure of cylinder gas and the spectrum of a typical engine. As shown in Fig. 4b, the pressure spectrum is a function of gas pressure, the shape integration of the pressure curve, rate of pressure rise, and the second-order rate of pressure rise [35]. The spectrum of cylinder pressure can be classified within three regions [36]:

I. Low-frequency region: in this region, the maximum of cylinder pressure level is mainly determined by integration of the pressure curve and the value of pressure peak. The higher the maximum pressure of the cylinder, the higher the peak in the low-frequency range in spectrum curves.
II. Middle region of the spectrum has the feature that the pressure level decreases linearly in a logarithmic law; the slope depends on the rise rate of cylinder pressure $\mathrm{d}p/\mathrm{d}\varphi$. It is a function of the thermal release quantity at the beginning of combustion. The larger the $\mathrm{d}p/\mathrm{d}\varphi$ the more flat the straight-line portion, whereas the smaller the $\mathrm{d}p/\mathrm{d}\varphi$, the steeper the straight-line portion. The maximum rate of pressure rise plays an important role.
III. Third region exhibits a peak of pressure level. This is due to the rapid elevation of the pressure of the cylinder in the local district at the beginning of combustion, which results in the high-frequency

vibrations of gas and is related to second derivative of in-cylinder pressure.

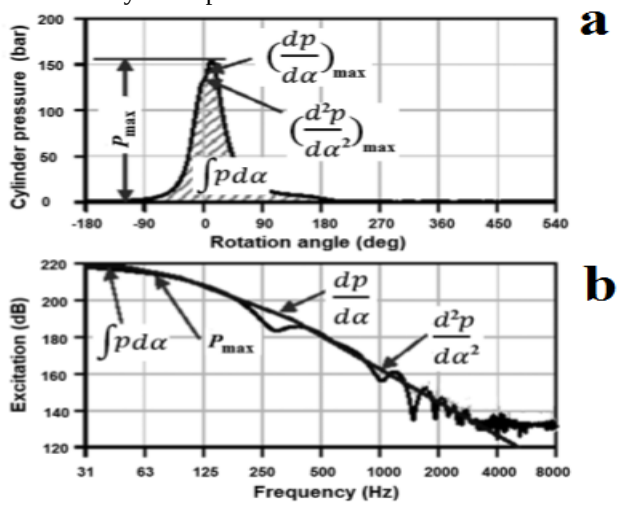

Figure 4. In-cylinder pressure analysis

The spectrum of cylinder pressure of some engines exhibits a line spectrum at a low-frequency range, which has several peaks at specific frequencies [37]. These specific frequencies are the firing frequency and their harmonics. In intermediate and high frequency ranges, the spectrum is continuous due to the rapid elevation of cylinder pressure in an impulsive way. The shape of the spectrum curve of cylinder pressure at a low frequency range is not affected by engine speed, except that the curve shifts toward high frequency when the rotating speed increases. This is because when the rotating speed varies, the pressure curve shape remains unchanged with respect to crank rotating angle. The high-frequency vibration of gas is mainly dependent on the size of the combustion chamber and the propagation speed of the impulsive wave. The frequencies corresponding to the pressure peaks in the third region of the curve are almost independent of engine speed [38,39]. From the spectrum of cylinder pressure, we learn that cylinder pressure is essentially the sum of a series of harmonics with different frequencies and amplitudes. Based on the superposition principle, the quantity of the cylinder equals the sum of the individual effects of the respective harmonics; therefore, the excitations of combustion gas to the cylinder can be considered as the sum of the individual excitations of this series of harmonics. The excitation of harmonics can be transmitted from the inside of the cylinder to the engine surface through three major paths, which results in surface vibrations and radiates noise. The first path goes through the piston, connecting rod, crankshaft, and main bearing, through which the vibration transmits to the surface of the engine block.

The second path goes through the cylinder head to the cover. The third path is the transmission from the sidewall of the cylinder to the outside of the cylinder and block. Many experiments demonstrate that most vibration energy from combustion is transmitted from the larger ends of the connecting rod and main bearing to the structure of the engine, and results in the surface vibration of the engine and radiated noise. The magnitude of combustion noise is not only dependent on the spectrum of the cylinder pressure, but also on the structural response and damping property of the engine. This is because noise is due to vibrations, and the vibrations depend on the properties of excitation and the structural response of the vibration system. The difference of pressure level between the inside of the cylinder and the outside of the engine is characterized by a decay, which is an attenuation quantity reflecting the inherent characteristics of engine structures. The decay is a constant value for a specific engine. Fig. 5 is the typical structural attenuation property of an engine [40]. It is independent of the property of excitations and the spectrum of the cylinder gas pressure. The engine's operating parameters such as speed, load, and the adjustment of the fuel supply system have no substantial effects on this property.

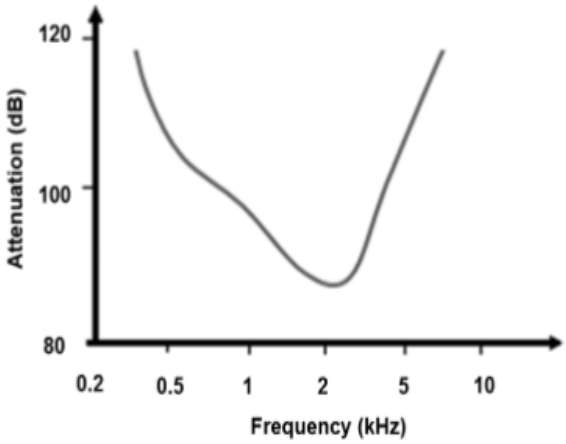

Figure 5. Engine structural attenuation

The structural attenuation curve could be divided into three regions [41]:

1. Below 1000 Hz, the attenuation is quite high. This is because most of the structural parts of the engine have relatively larger stiffness, and their natural frequencies are at the middle and high frequency ranges. Therefore, vibration response in the low frequency range is relatively small due to a larger structural decay, despite the fact that the excitation of pressure is larger.
2. In the middle frequency range from 1000 to 4000 Hz, the structural attenuation is small. This is because most of the parts' natural frequencies fall in this frequency range, which gives rise to a low attenuation property.
3. Above 4000 Hz, structural attenuation is very high. This high frequency range is above the natural frequencies of most parts; therefore, the structural attenuation is quite high. The engine's structure is an attenuator to combustion noise. The attenuation is larger at both low and high frequency ranges. The sound pressure level of the engine is high in the range of 800 to 4000 Hz, which corresponds to the range of low structural decay of the engine. In the low frequency range (below 800 Hz), despite the fact that cylinder pressure level is high, the noise radiated by the engine is low due to the engine's high structural attenuation.

In the high frequency range (above 4000 Hz), the structural attenuation is high and the cylinder pressure is small, while the noise sound pressure level is low. In this

range, cylinder pressure level decreases with increasing frequency, and structural attenuation increases with increasing frequency. Therefore, noise decreases rapidly with increase in frequency. In the middle frequency range (800 to 4000 Hz), cylinder pressure is not as high as that in the low frequency range, but the structural decay is at a minimum in this frequency range. Therefore, the structural response is strong, and the sound level pressure attains its peak in this range. From the above observations we learn that combustion noise can be suppressed by reducing cylinder pressure through combustion optimization and by increasing structural decay of the engine structure. The rate of pressure rise is a fundamental factor controlling combustion noise; it mainly depends on the retarded spark timing and the quantities of mixture formation of combustible gas formed during the delay. A shorter retarded spark timing means that if the initial point of fuel injection is the same, and if the starting point of combustion is relatively earlier, the injected fuel quantity before the combustion is relatively smaller; therefore, the amount of combustible gas formed before firing is less, and the pressure increase after the firing is slow. Conversely, the longer the period of ignition delay, the greater the quantity of the combustible gas formed before firing. The fuel could combust simultaneously in the second phase of the combustion process, which results in a higher rate of pressure increase and higher maximum combustion pressure, and accordingly leads to higher combustion noise [42]. Therefore, in the design of the combustion system, the retarded combustion usually should be reduced as much as possible from the standpoint of noise control. For a specific engine structure, many factors affect retarded combustion. In normal operating conditions, compression temperature and pressure are the major factors influencing retarded combustion [43]. The advance angle of fuel injection and the features of combustion also have significant influence. The influence of the structure of the combustion chamber and operating parameters on combustion noise is due to their influence on retarded spark timing through compression temperature and pressure [44].

a. The structure and layout of the combustion chamber and the entire combustion system design have obvious influence on the rate of pressure increase, maximum combustion pressure, and spectrum of cylinder pressure.
b. Temperature and pressure: when compression temperature and pressure are increased, the physical and chemical preparation process of the fuel spark will be improved; the retarded spark is also reduced. The final temperature of compression mainly depends on the compression ratio, and also on the cooling water temperature, piston temperature, cylinder head temperature, and intake temperature [45]. The increase of compression ratio allows the gas temperature in retarded combustion to increase, and the final temperature and pressure at the end of compression to increase. This, accordingly, reduces retarded combustion, the rate of pressure increase, and the combustible fuel quantity accumulated in the period of retarded combustion, which also reduces the maximum value of thermal release rate and combustion noise. But the increase in compression ratio results in the increase of cylinder pressure, which leads to the increase of piston impact noise; therefore, it will not lead to significant reduction of total engine noise [46]. The compression increase results in a higher intake temperature and accordingly reduces the combustion noise of the direct injection diesel. The higher the intake temperature and the later the fuel injection, the higher the gas temperature and the shorter the retarded spark timing. The higher the load and the higher the temperature of the cooling liquid, the higher the temperature of the cylinder, and the shorter the retarded spark timing.
c. Fuel injection parameters: the parameters of the fuel system, including advance angle of fuel injection, injection pressure, number of injection nozzles, and the fuel supply law all influence the combustion process. If the other conditions remain the same, the increase of injection pressure results in the increase of injection rate and the increase of fuel quantity in combustion delay. The high-pressure injection improves the mixture of fuel and air, and increases the rate of combustible fuel generation [47]. This leads to the increase of combustible fuel accumulated in the period of ignition delay, and therefore increases combustion noise. Under the condition that the other parameters are unchanged for the injection system, the reduction of the injection fuel area results in an increase in the resistance of the fuel injection hole and reduces the rate of fuel injection, while reducing the quantity of fuel injection in combustion delay and reducing the noise of the direct-injection diesel.
d. Engine speed: if the other conditions remain unchanged, the increase of speed reduces the fuel injection time, and increases the fuel injection speed and the fuel quantity injected in the period of combustion delay. The increase of speed also increases the maximum cylinder pressure, the maximum of the rate of pressure increase, and the combustion noise. But usually the effect of engine speed on combustion noise is not extremely significant.
e. Load: for the indirect-injection diesel and gasoline engine, as their pressure increase is relatively smooth, when the load varies, the maximum combustion pressure change is relatively small and remains at a small value, and the impact on the cylinder from the piston is small [48]. The sound pressure level of noise under a full load could be smaller than that under the no-load case by a couple of decibels. With the increase of load, the thermal release quantity will increase; the combustion pressure peak and the rate of pressure rise will also increase. This results in a higher noise level. On the other hand, with the increase of load, the temperature of the combustion chamber will increase; the gap between the cylinder and piston will be reduced, which could suppress noise.

Overall, the load has a small effect on engine noise. The basic approaches to reduce combustion noise: in principle, the combustion noise can be reduced in the following two aspects. The first one is from its root cause, which includes reducing the spectrum of the cylinder pressure, particularly the magnitude in the middle or high

frequency range; to reduce the period of ignition delay or reduce the quantity of mixed gas in the combustion delay [49].

The second approach is from the noise transmitting path: to increase the attenuation of the engine structure, particularly in the middle and high frequency range. The approach includes increasing the stiffness of the engine block and cylinder, and employing vibration isolation and sound insulation; reducing the gaps between parts such as piston and cylinder, cranks, and connecting rod; increasing the thickness of the oil film; using cylinders with smaller diameters; using greater numbers of cylinders or using a design with a larger ratio of stroke to cylinder diameter, to enable the output power to be less varied; or changing materials of the plate or shell parts (e.g., oil pan) by adding damping treatment. In general, combustion noise control requires trade-offs between the thermal efficiency and emissions. Several approaches used to reduce engine combustion noise include:

1. Piston with thermal insulation: the application of pistons with thermal insulation can increase the temperature of the cylinder wall, reduce the period of ignition delay, and reduce combustion noise of the direct injection diesel.
2. Injection delay: generally, the earlier the injection time, the larger the combustion noise. If the injection time is postponed, the combustion noise can be reduced. This is because the compression temperature and pressure in the cylinder varies with crank angles. The injection time affects the firing delay (combustion delay) through the compression temperature and pressure. If the injection time is set earlier, then the temperature and pressure are lower when fuel enters the chamber. Then the period of firing delay is increased, which leads to the increase of combustion noise. However, if the injection time is set too late, when fuel enters the chamber both the temperature and pressure become lower, and accordingly the firing delay is increased, which leads to the increase of combustion noise. An optimal time exists for injection delay.
3. Pre-injection: pre-injection has the function of separating the injection process into two stages, which allows fuel to be injected twice instead of once within one cycle [50].

In the first stage, a small portion of fuel is injected to precede the pre-reaction of firing before a major injection, to reduce the quantity of combustible fuel accumulated during combustion delay. This is an effective approach to reduce the noise of the direct-injection diesel. Improve the structure, layout, and parameters of the combustion chamber: the formation of the air mixture and combustion is influenced by the structure and layout of the combustion chamber, which not only affects the performance of the diesel, but also affects the firing delay, the rate of pressure rise, and thus the combustion noise. For the same condition, the sphere combustion chamber and biased cylinder chamber of the direct-injection diesel engine yield comparatively lower combustion noise [51]. A diesel engine with a separation chamber generally has lower noise. The optimization of the parameters of the combustion chamber can reduce combustion noise. Compared with the lower crankcase, the cylinder and cylinder head are usually very stiff, which allows them to resist the combustion pressures and prevent them from movement. It has been found that some special structure designs can attain better stiffness performance, including a lower crankcase, flat panels on the upper crankcase, and optimal substructures for oil pan and valve cover, etc. [52].The extra ribs applied to reinforce crankcase walls could reduce noise. It has been estimated that the total engine noise can be reduced by 3 dB by using the treated covers (sump, valve cover, etc.). The crankcase walls and the main bearing caps have been integrated to form a ladder-type structure [53].

Optimization of fuel pump: the injection rate has a significant effect on combustion noise. Certain experiments have illustrated that doubling the injection rate increases combustion noise by 6 dB. Therefore, the combustion noise can be reduced by decreasing the injection rate of the fuel pump. But this approach may worsen the high-speed performance and increase idle noise. Employ turbocharging techniques: turbocharging can increase the density of the air entering the cylinder, and increase the temperature and pressure of the air in the cylinder at the end of compression, thus improving the firing condition for the mixed gas and reducing the firing delay. The higher the turbocharging pressure, the shorter the firing delay period and the lower the pressure elevation rate, thus the lower the combustion noise. Some experiments have demonstrated that turbocharging allows combustion noise to be reduced by 2 to 3 dB.

Increase compression ratio: increasing the compression ratio can increase the gas temperature and pressure at the end of compression, shorten the period of firing delay, and reduce the pressure rise rate, thus reducing combustion noise. On the other hand, increasing compression ratio could increase cylinder pressure and increase piston slap noise.

Increase the quality of fuel: some ingredients in fuel may influence the physical and chemical processes of the gas mixture before firing, thus leading to a change in firing delay. Therefore, some high-quality fuel gives rise to short firing delays, thus lowering the pressure rise rate and the combustion noise.

Electronic control: a diesel engine with electronic control injection can optimize injection in terms of speed, load, air temperature, turbocharging pressure, and fuel temperature, thus effectively reducing combustion noise. The common rail injection system has been applied widely. The application of common rail injection can help to reduce the injection rate in the first injection period. The high frequency vibrations improve after the application of common rail injection, thus reducing combustion noise. Advantages of the common rail injection system are that the injection pressure is independent of engine load and speed, there are multiple timing and injection volumes, a variable profile of injection rate, flexible design, less constraints of cylinder number, and improved start-up properties.

4. MOTION BASED NOISE

Mechanical noise of the engine is referred to as the vibration- or impact induced noise of motion components of the engine under the effect of cylinder gas pressure and inertia forces [54].Mechanical noise of the engine consists of piston slap noise (it has also been referred to as indirect combustion noise), gear noise, valve train and timing system noise, accessory noise, bearing noise, block structure noise, etc. [55]. Mechanical noise is usually the main noise source of the engine in high-speed operations. A typical engine has several hundred moving pairs. In operation, the impact, friction, wear, and unbalance in rotation result in vibration and noise. The resonance due to the coincidence of natural frequency and excitation frequency leads to severe noise [56]. In the reciprocating motion process of the engine crank/piston, when it passes the upper or lower dead ends, the transverse force changes direction. [57]. This allows the contact zone between piston and cylinder to switch from one side to the other, which induces impact and cylinder vibrations. Each moving pair has a certain gap, which results in impact when it undergoes oscillatory motion; for intake or exhaust valves in alternative closing and opening motions, when the valve seats, it creates impact and noise[58]. The frequency of vibration depends on the number of valve operations per second. In general, the mechanical noise of the engine increases rapidly with the increase of operational speed [59-60].With the application of a high-speed and light engine, and the implementation of more strict noise regulations, the major difficulty of reducing engine noise lies in the reduction of mechanical noise.

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ADITIVNI POSTUPCI U PROCESU RAZVOJA NOVIH PROIZVODA S OSVRTOM NA TERMINOLOŠKA PITANJA

ADDITIVE PROCESSES IN THE DEVELOPMENT OF NEW PRODUCTS WITH A REVIEW OF TERMINOLOGY ISSUES

Tomislav Pavlic, Ivana Jurković, Tomislav Subota

Stručni članak

Sažetak: *Prije izrade eksperimentalnog dijela rada objašnjeni su postupci pomoću kojih su modeli izrađeni. Objašnjen je rad u programskim alatima Solidworks, Autodesk Meshmixer, Makerbot Desktop i Makerbot Digitizer, koji su se koristili pri razvoju tih modela. Izrađena je kutijica za lijekove. Rad sadrži osvrt na terminološka pitanja koja su se u hrvatskome jeziku pojavila uslijed ubrzanog razvoja ove tehnologije.*

Ključne riječi: *3D FDM printanje, 3D lasersko skeniranje, programski alati, MakerBot Replicator 2x, MakerBot Digitizer, kutijica za lijekove, terminologija.*

Professional paper

Abstract: *Before the experimental part of this paper, procedures used in making the models have been explained. Furthermore, this paper provides an insight into software Solidworks, Autodesk Meshmixer, Makerbot Desktop, Makerbot Digitizer, the tools used for developing the models. Medication box was made in the experimental part of this paper. The paper contains a review of terminology issues that have appeared in the Croatian language due to the rapid development of this technology.*

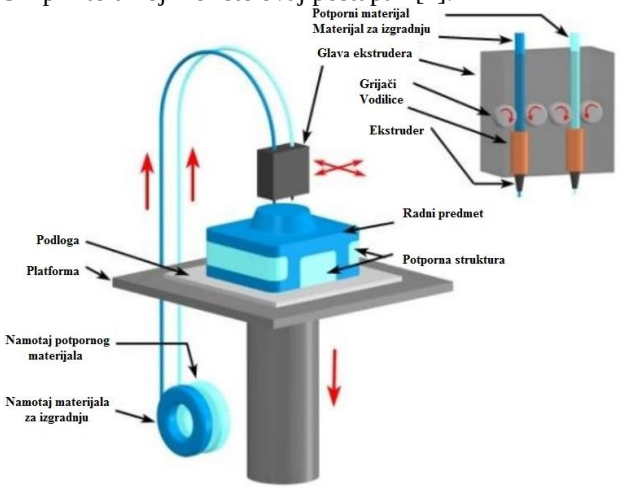
Key words: *: 3D FMD printing, 3D laser scanning, software, MakerBot Replicator 2x, MakerBot Digitizer, medication box, terminology.*

1. UVOD

Tema ovoga rada su aditivni postupci u procesu dobivanja novih proizvoda. Na početku razvoja svakoga novog proizvoda stoji ideja. Dobra ideja ključni je segment svakog novog proizvoda. Međutim, između ideje i gotovog proizvoda stoji mnogo posla. U radu su opisani osnovni aditivni postupci (FDM tehnologija 3D printanja i lasersko 3D skeniranje) potrebni za izradu eksperimentalnog dijela rada. Poseban naglasak stavljen je na 3D printer MakerBot Replicator 2x i 3D skener MakerBot Digitizer. Od programskih alata, koji su neizostavni dio svakog razvoja novog proizvoda, u ovome se radu spominju SolidWorks, MakerBot Desktop, MakerWare for Digitazer i Autodesk Meshmixer.

2. 3D (FDM) PRINTERI

FDM (engl. *Fused Deposition Modeling)* postupak razvio je S. Scott Crump kasnih 1980-ih, a komercijalizirala ga je tvrtka Stratasys 1990-ih. Istekom patenta na ovu tehnologiju nastala je velika *open source* zajednica s komercijalnom i DIY upotrebom (engl. *Do It Yourself*), koja najbolje iskorištava karakteristike ovog postupka. To je također doprinijelo velikom padu cijene 3D printera koji koriste ovaj postupak [1].



Slika 1. FDM postupak

U osnovi postupka, plastično se vlakno konstantno dobavlja kroz zagrijanu mlaznicu malog promjera. Zagrijana mlaznica topi dobavljeni materijal i nanosi ga u slojevima. Tijekom nanošenja materijala mlaznica se giba u X-Y ravnini ravnomjerno istiskujući materijal. Nakon završetka nanošenja jednog sloja platforma izvršava

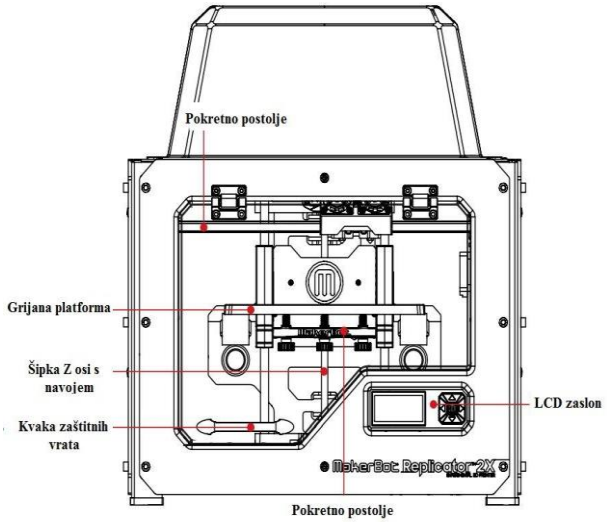
pomak po Z-osi te započinje nanošenje idućeg sloja. Platforma je kod nekih 3D printera također zagrijana na određenu temperaturu prilikom cijelog postupka. Budući da se materijal dobavlja kroz mlaznicu i izravno nanosi na prethodno očvršćeni sloj, mala je količina neiskorištenog materijala [2]. Najčešće korišteni materijal kod FDM postupka je ABS (eng. *Acrylonitrile Butadiene Styrene*), koji je vrlo lagan, izdržljiv i iznenađujuće čvrst materijal zbog kojeg je postao prvi izbor u plastičnoj industriji.

2.1. MakerBot Replicator 2x

Slika 2. MakerBot Replicator 2x

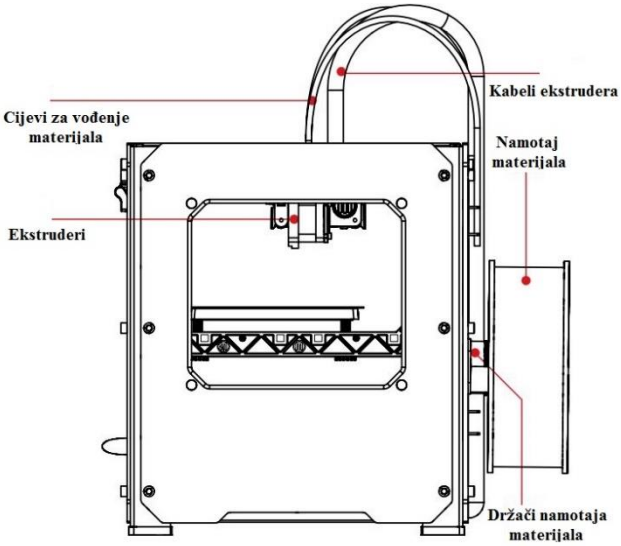
MakerBot Replicator 2x je 3D printer koji se koristi na Visokoj tehničkoj školi u Bjelovaru (u daljnjem tekstu VTŠBJ). Njegove su osnovne karakteristike sljedeće [3]:

- broj ekstrudera: 2;
- maksimalna veličina izrađenog predmeta: 22 cm x 16 cm x 15 cm;
- promjer mlaznice: 0,4 mm;
- promjer filamenta: 1,75 mm;
- materijal: ABS/PLA.



Slika 3. MakerBot Replicator 2x prednja strana [3]

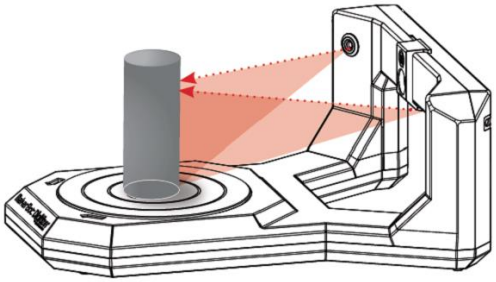
Ovaj model printera služi prvenstveno za edukaciju te nije pogodan za komercijalnu uporabu, ponajviše zbog njegove nepouzdanosti. Ali kao takav idealan je za uvod u postupak 3D printanja budući da sve prepreke do kojih može doći pomažu u daljnjem radu na njemu sličnim uređajima. Njegova najveća prednost je ta što je cijenom prihvatljiv te je zbog toga zanimljiv ponajviše hobistima i entuzijastima 3D printanja koji žele istražiti mogućnosti ove tehnologije. Sami tvorci MakerBot Replicatora 2x imali su cilj napraviti 3D printer dostupan svima koje to zanima i to su s ovim modelom printera i uspjeli.



Slika 4. MakerBot Replicator 2x bočna strana [3]

3. 3D LASERSKI SKENERI

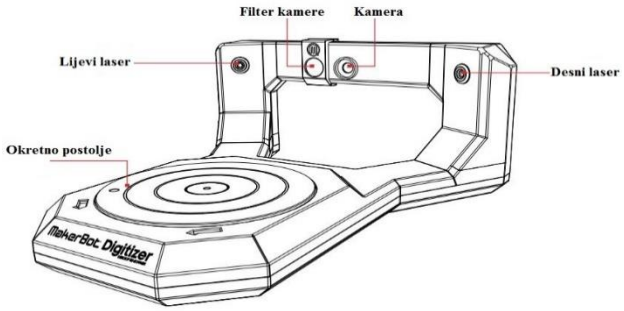
3D skeneri su uređaji koji se koriste za skeniranje predmeta ili okoline prikupljajući podatke o njihovim dimenzijama i izgledu (npr. boja). Prikupljeni podatci zatim se koriste za izradu digitalnih 3D modela, koji se zatim mogu koristiti u animaciji ili za vizualizaciju. Također, mogu se editirati u raznim programskim alatima u svrhu nastanka novog proizvoda ili se mogu koristiti pri dimenzionalnim i usporednim analizama. 3D laserski skeneri vrlo su precizni uređaji i s podrškom programskih alata za obrnuti inženjering u vrlo kratkom vremenu moguće je dobiti gotovi 3D model spreman za printanje ili druge tehnološke procese [4]. Kod laserskog skeniranja laserski snop prelazi preko površine predmeta te pomoću senzorske kamere, koja je ugrađena u skener, snima trodimenzionalne informacije predmeta. Na taj način moguće je dobiti vrlo točne dimenzije bez dodirivanja samog predmeta.



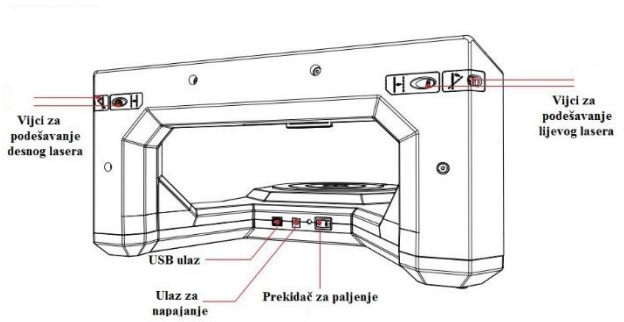
Slika 5. Primjer postupka 3D laserskog skeniranja

3.1. MakerBot Digitizer

MakerBot Digitizer je 3D laserski skener koji je u uporabi na VTŠBJ-u. Pogodan je za skeniranje predmeta do 20 cm promjera i 20 cm visine. Koristi dva lasera i 1,3 megapikselnu kameru s ugrađenim senzorom. Ima okretno postolje koje može okretati predmet težine do 3 kg [5]. Sam postupak skeniranja ne traje dugo (u prosjeku do 10 minuta). Poželjno je da prostorija u kojoj se koristi 3D skener bude mračna te je potrebno izbjegavati rad pokraj prozora i slično. Što se tiče površine samog predmeta, poželjno je da bude mat budući da odsjaj otežava postupak skeniranja tako što laserski snop teško prepoznaje površine na kojima je odsjaj. Postoje razni sprejevi kojima se predmeti mogu obraditi kako bi njihova površina bila idealna za skeniranje. Uređaj je idealan za upoznavanje s postupkom 3D skeniranja i poteškoćama koje se javljaju prilikom korištenja tehnologije 3D skeniranja na ovom i njemu sličnim uređajima.



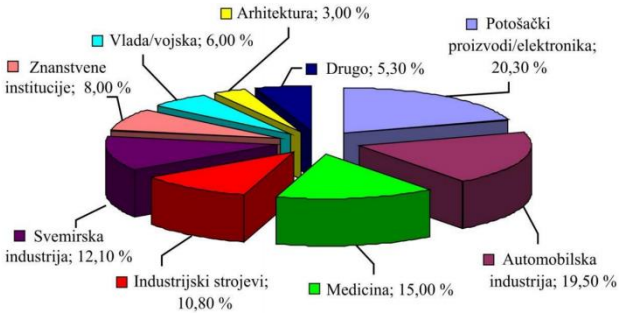
Slika 6. MakerBot Digitizer prednja strana [5]



Slika 7. MakerBot Digitizer stražnja strana [5]

4. DANAŠNJE STANJE U SVIJETU ADITIVNIH POSTUPAKA

AM (engl. *Additive Manifacturing*) tehnologije svakim danom nalaze sve više područja primjene u različitim granama ne samo industrije, nego i zabave, kulture i slično. Gotovo da nema područja svakodnevnog života u kojem aditivne tehnologije nisu zastupljene na ovaj ili onaj način, radilo se o medicinskoj uporabi, automobilskoj industriji ili potrošačkim proizvodima.



Slika 8. Uporaba aditivnih tehnologija u svijetu za 2012. godinu [6]

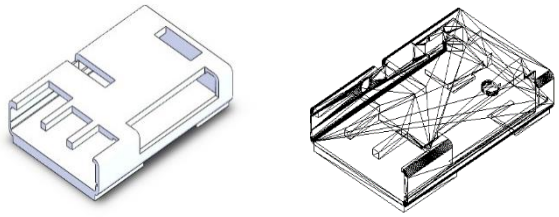
U svojem godišnjem izvještaju za 2014. godinu, Wohlers Associates, konzultanti specijalizirani za aditivne tehnologije koji prate razvijanje ove industrije zadnjih 25 godina, izvještavaju da je ukupno tržište aditivnih tehnologija, što uključuje sve proizvode i postupke, naraslo na 3,07 milijardi $, sa sveukupnim godišnjim rastom od 34,9 %, što je najveći rast u posljednjih 17 godina. Također predviđaju da će industrija aditivnih tehnologija nastaviti sa snažnim rastom sljedećih godina, ponajviše zbog prodaje 3D printera za osobnu upotrebu (onih sa cijenom nižom od 5.000 $), kao i zbog povećane uporabe tehnologije za proizvodnju dijelova, posebno metalnih, koji se koriste u konačnim proizvodima [7].

5. RAZVOJ NOVIH PROIZVODA KORIŠTENJEM ADITIVNIH TEHNOLOGIJA

Suvremeni zahtjevi tržišta postavljaju sve strože zahtjeve pred procese razvoja i proizvodnje novih proizvoda. To se posebno odnosi na skraćenje samog vremena razvoja i proizvodnje. Prednost korištenja aditivnih tehnologija kod razvoja novih proizvoda ogleda se u tome da je u relativno kratkom vremenskom razdoblju moguće konstruirati i izraditi prototip proizvoda uz prihvatljive troškove izrade. Isto se tako proizvod može na jednostavan način modificirati za neku drugu uporabu ili na neke druge dimenzije. Zato je ova tehnologija idealna za RP postupak (engl. *rapid prototyping*). Prvi korak pri izradi novih proizvoda je izrada 3D modela proizvoda, a to se provodi pomoću raznih programskih alata, kao što su SolidWorks, SolidEdge, Catia, Autodesk Meshmixer i mnogi drugi. U ovome poglavlju naglasak je stavljen na programske alate koji su korišteni pri izradi 3D modela čiji će postupak izrade biti prikazan u ovome radu.

5.1. SolidWorks

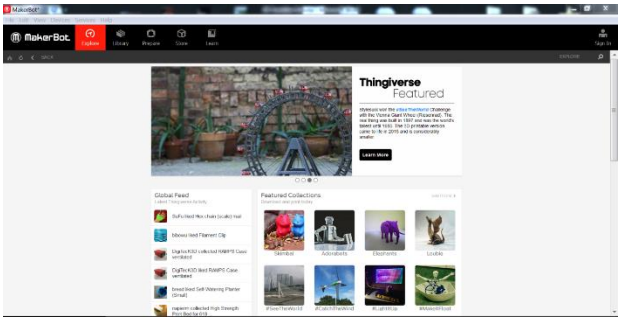
SolidWorks je programski alat koji je korišten pri konstruiranju 3D modela spomenutog u ovome radu. Nakon konstrukcije željenog 3D modela, potrebno ga je spremiti u formatu koji će ostali programski alati 3D printera i 3D skenera moći „prepoznati“. Naziv toga formata je *.STL (engl. *stereolithography*). On generira informacije potrebne za proizvodnju 3D modela predmeta tako što aproksimira površinu modela sa trokutićima [8]. Razlika između istih 3D modela spremljenih u *.prt (engl. *part*) i *.stl formatu prikazana je na slici:



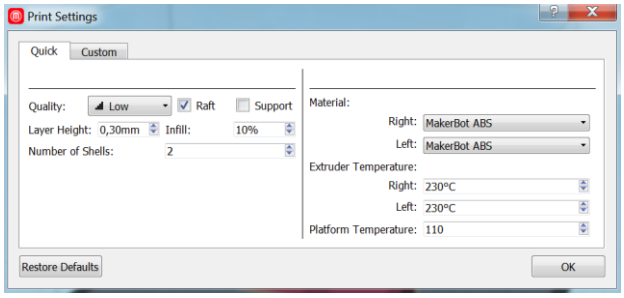
Slika 9. Razlika između *.prt i *.stl formata

5.2. MakerBot Desktop

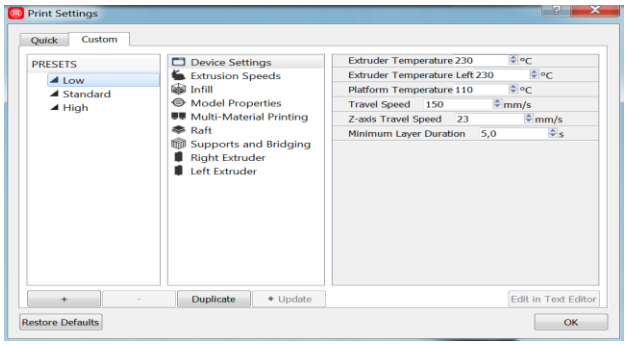
MakerBot Desktop je programski alat tvrtke MakerWare koji je programska podrška svim MakerBot 3D printerima. Služi za definiranje parametara pri 3D printanju, a ima i mnoge druge primjene.



Slika 10. Sučelje programa MakerBot Desktop



Slika 11. *Print Settings* (*Quick* opcije)



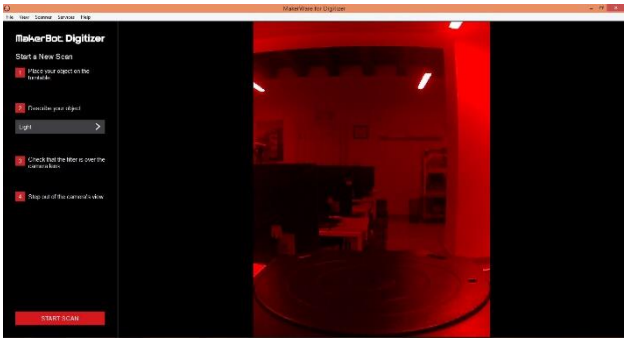
Slika 12. *Print Settings* (*Custom* opcije), kategorija *Device Settings*

Kod početka rada sa programskim alatom nude nam se dvije opcije: opcija *Quick* nudi osnovne postavke, slika 11., dok opcija *Custom* nudi mnogo više mogućnosti za upravljanje parametrima radi dobivanja predmeta željene kvalitete, slika 12.

Također moguće je napraviti vlastiti *Preset* u kojemu postoji mogućnost kombiniranja postavki i parametara različitih stupnjeva završne kvalitete predmeta te njihovo spremanje za buduću upotrebu. Stvoreni *Preset* moguće je editirati pomoću gore navedenih kategorija ili pomoću opcije *Edit in Text Editor*, gdje postoji mnogo postavki i parametara koji se mogu regulirati.

5.3. MakerWare for Digitizer

MakerWare for Digitizer je programska podrška za 3D skener MakerBot Digitizer. Njegove su mogućnosti prilično ograničene, a osim obrade skeniranog predmeta nema druge mogućnosti, kao na primjer dodatne programske obrade dobivenog predmeta.

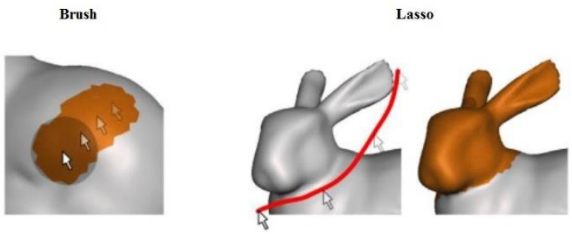


Slika 13. Sučelje programa MakerBot Digitizer sa prikazom kamere u realnom vremenu

Sučelje programa je jednostavno, a sastoji se od uputa za pripremu predmeta za skeniranje. Jedini parametar kojim se ovdje može upravljati je opis svjetline predmeta. Sam postupak skeniranja traje desetak minuta, što ovisi o kompleksnosti predmeta te o uvjetima u kojima se skenira. Programski alat ima mogućnost *Multiscan*, tj. da se isti predmet skenira više puta i u različitim pozicijama kako bi se obuhvatili svi dijelovi predmeta, što se ne bi moglo postići samo jednim skeniranjem. Nakon toga program spaja te skenove u jedan predmet, točnije u jedan oblak točaka.

5.4. Autodesk Meshmixer

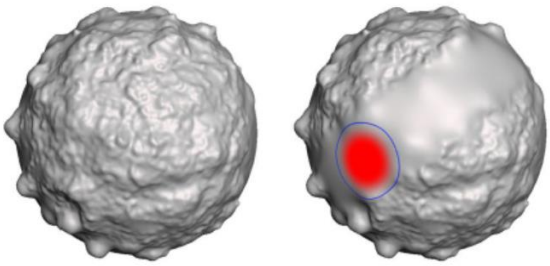
Autodesk Meshmixer programski je alat koji služi za izradu 3D modela ili za obradu površine predmeta dobivenih 3D skeniranjem. Neke od opcija programskog alata Autodesk Meshmixer prikazuju slike u nastavku.



Slika 14. Načini označavanja skeniranog predmeta opcijom *Select*

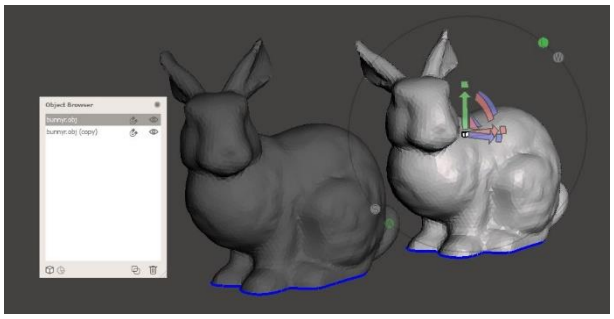
Opcija *Sculpt* nudi izbor različitih četki (engl. *Brushes*) koje služe za obradu površine predmeta. Različite četke

koriste se za različite operacije. Neke od najviše korištenih četki su *Draw*, koja služi za popunjavanje praznina na predmetu, *Flatten*, koja se koristi kada je potrebno odstraniti neke izbočine na predmetu i poravnati dio površine kako bi bio u ravnini s ostatkom predmeta, te *Drag*, koja služi za izradu izbočina na predmetu. Osim izbora četki, ova postavka nudi i definiranje parametara pri korištenju samih četki, kao što su jačina, veličina površine četke, dubina i brzina pomicanja pri radu s četkama. Također se može mijenjati boja obrađene površine tako da se razlikuju operacije izvršene pomoću različitih četki.



Slika 15. *Flatten* [9]

Opcija *Stamp* nudi mogućnost postavljanja različitih gotovih žigova na površinu predmeta, a *Edit* služi za editiranje predmeta. Nudi se velik broj mogućnosti, kao što su opcija zrcaljenja (engl. *Mirror*), gdje se s obzirom na postavljenu ravninu može zrcaliti dio ili cijeli predmet. Opcija *Duplicate* dopušta se da predmet umnoži, a opcija *Transform* da se taj umnoženi predmet pomiče po platformi. Opcija *Align* omogućuje da se predmet zarotira po bilo kojoj od triju osi, a opcija *Plane Cut* omogućuje da se odreže dio predmeta po bilo kojoj od tri osi. Postoje i dodatne opcije, ali ove se najčešće koriste.



Slika 16. *Duplicate* i *Transform*

Opcija *Analysis* služi za analiziranje različitih karakteristika predmeta, kao što su rupe u predmetu, dimenzije, debljina, položaj na platformi, stabilnost itd. Ponuđena je i opcija *Overhangs*, koja detektira dijelove predmeta na kojima će biti potreban potporni materijal.
Opcija *Shaders* omogućuje dodavanje različitih boja i uzoraka na površinu predmeta, *Export* služi za eksportiranje datoteke na vanjski uređaj, a *Print* nudi mogućnost izravnog printanja iz samog programa s obzirom na to da program Autodesk Meshmixer nema mogućnost spremanja datoteke u formatu *.stl koji je potreban za otvaranje datoteke u jednom od programa koji podržava uređaje za 3D printanje.

6. EKSPERIMENTALNI DIO

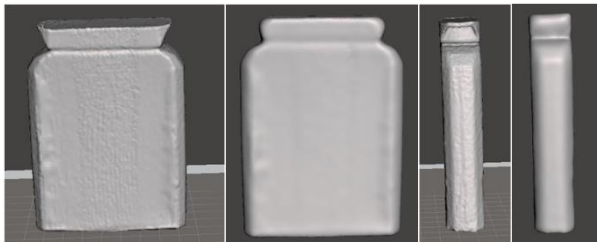
U ovom dijelu rada prikazan je postupak izrade novih proizvoda pomoću aditivnih tehnologija na primjeru reverzibilnog inženjerstva. Dijelovi koji su prikazani u nastavku izrađeni su korištenjem tehnologije 3D skeniranja i 3D printanja. Izbor parametara i postavki koji se mogu mijenjati na ovim uređajima i njima sličnima je ogroman. Svaka kombinacija parametara i postavki ima svoje konačne prednosti i nedostatke te je zato pri izboru parametara važno proučiti postavljene zahtjeve i fokusirati se na one primarne kako bi krajnja izrada proizvoda bilo što učinkovitija.

6.1. Kutijica za lijekove

Zadatak je bio repliciranje kutijice za lijekove, slika 17., s minimalnim izmjenama tako da je se prvo skenira 3D skenerom (MakerBot Digitizer), doradi se dobivena skenirana geometrija, a zatim da se dorađeni 3D model skenirane kutijice isprinta 3D printerom (MakerBot Replicator 2x).

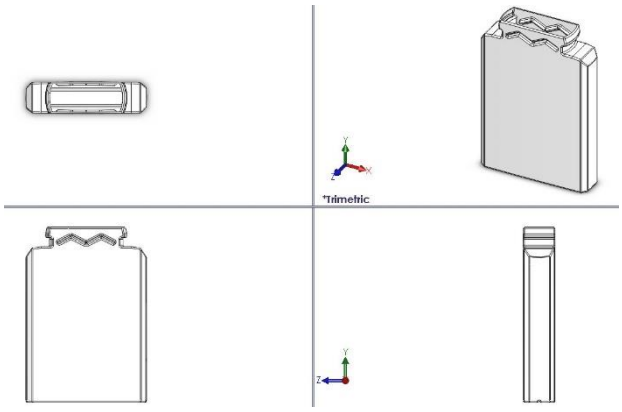
Slika17. Kutijica za lijekove

Kvaliteta površine skeniranog predmeta nije bila dobra. Sljedeći korak je obrada skeniranog predmeta u programskom alatu Autodesk Meshmixer. Skenirani predmet prvo je zaglađen opcijom *Smooth*, zatim je gornji dio obrađen opcijom *Erase & Fill*. Posljednji korak bio je taj da kutijica postane šuplja, a u tu je svrhu korištena opcija *Hollow*. Na slici 18. prikazana je kutijica prije (lijevo) i poslije (desno) obrade u programu Autodesk Meshmixer.



Slika 18. Prednja i bočna strana kutijice (dobiveno skeniranjem te zatim doradom)

Na gornjim slikama vidljiva je razlika između kvalitete površine skeniranog predmeta prije i poslije obrade u programskom alatu Autodesk Meshmixer. Predmeti dobiveni skeniranjem većinom trebaju dodatnu obradu u nekom od programskih alata. Mogućnost poboljšavanja samog skeniranog predmeta ponajviše ovisi o mogućnostima programskog alata koji se koristi i, naravno, o sposobnostima korisnika alata. Vrlo je teško ovakvom obradom dobiti idealnu kvalitetu površine predmeta, ali vidljivo je da je moguće značajno poboljšati izgled predmet. Printanje dobivenog predmeta direktno iz programa Autodesk Meshmixer je bilo neuspješno. Razlog tome je manjak parametara i postavki koji se mogu editirati kako bi print bio uspješan. Međutim, početni sken dao je osnovne dimenzije na temelju kojih možemo konstruirati kutijicu u programu SolidWorks, a zatim taj 3D model isprintati pomoću programa MakerWare.



Slika 19. 3D model kutijice izrađen u programu SolidWorks

Na slici 20. prikazana je kutijica za lijekove čije smo osnovne dimenzije dobili pomoću tehnike 3D laserskog skena, a konačni proizvod pomoću 3D printanja.

Slika 20. Kutijica za lijekove

7. OSVRT NA TERMINOLOŠKA PITANJA

Ubrzani razvoj novih tehnologija koje se temelje na korištenju 3D printera doveo je, kao što je to čest slučaj kod pojave novih tehnologija općenito, do terminoloških pitanja u hrvatskom jeziku. Razlog tomu je činjenica da je većina literature i softverskih alata napisana, odnosno izrađena, na engleskom jeziku, a budući da se tehnologija brzo razvija, pojavljuje se kontinuirana potreba za novim terminima za koje se često ne pronalaze odgovarajuće inačice koje se mogu adekvatno uklopiti u terminološki sustav koji se temelji na normama hrvatskoga standardnog jezika. Sličan problem uočen je i u drugim terminološkim područjima, kao što su, primjerice, područje računalno potpomognutog oblikovanja [12] te područje bežičnih računalnih mreža [13]. S obzirom na činjenicu da su softverski alati izrađeni na engleskom jeziku, a opcije koje se u njima pojavljuju predstavljaju okosnicu dotične tehnologije, nazivi opcija te funkcija koje te opcije sadrže preuzeti su iz engleskoga jezika te bi se, sukladno jezičnim normama, trebale pisati u kurzivu, što u praksi često nije slučaj (vidi [8]). Slično kao u području bežičnih računalnih mreža [13], engleski nazivi mogu se podijeliti na jednorječne (*preset, stereolithography*), višerječne (*Fused Deposition Modeling, Additive Manifacturing*) i složene kratice (*FDM, AM, RP, ABS*), dok u hrvatskom izostaju složene kratice jer se u hrvatskim tekstovima pojavljuju izvorne engleske kratice. Opisano stanje ukazuje na potrebu provođenja opsežnijeg istraživanja u kojem bi surađivali stručnjaci koji se bave aditivnim tehnologijama i jezikoslovci, a u svrhu predlaganja novih terminoloških rješenja i uređivanja hrvatske terminologije vezane za ovo područje tehnologije.

8. ZAKLJUČAK

Raznovrsnost primjene proizvoda u raznim granama svakodnevnog života jedna je od najvećih prednosti ovih postupaka. Taj trend će se povećavati sve većom prodajom 3D printera za kućnu uporabu. Jednostavnost i mnoštvo platformi za razmjenu ideja predstavljaju još jedan razlog zašto ovaj način razvoja privlači sve veći broj ljudi. Cilj ovoga rada bio je objasniti postupke aditivnih tehnologija s kojima studenti imaju priliku raditi na Visokoj tehničkoj školi u Bjelovaru te općenito približiti svijet aditivnih tehnologija svima kojima je takav način rada interesantan. Rad sadrži osvrt na terminološka pitanja koja su se pojavila u hrvatskome jeziku. Potrebna su daljnja terminološka istraživanja u svrhu uređivanja hrvatske terminologije vezane za ovo područje tehnologije.

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UPRAVLJANJE ELEMENTIMA KORISNIČKOG SUČELJA VIRTUALNE STVARNOSTI BEZ FIZIČKOG KONTAKTA S UNOSNIM UREĐAJEM U OKVIRU APLIKACIJE ZA UČENJE

CONTROLLING THE USER INTERFACE OF VIRTUAL REALITY APPLICATION FOR LEARNING USING CONTACTLESS INPUT DEVICE

Nikola Poljanec, Mihael Kukec

Stručni rad

Sažetak: *U radu je opisana izrada prototipne aplikacije za edukativne svrhe korištenjem beskontaktnog unosnog uređaja, prilikom čega je opisan sam uređaj, prototip aplikacije i način na koji radi. Prototip aplikacije simulira jednostavno sastavljanje računala u okviru sustava virtualne stvarnosti. Beskontaktni unosni uređaj koji je pri tome korišten je „Leap Motion" koji prenosi prirodne pokrete ruke u virtualni svijet tako da korisnik može upravljati elementima korisničkog sučelja na intuitivan način, korištenjem ruku i prstiju. Proces sastavljanja računala u okviru prototipne aplikacije pojednostavljen je tako da se ugrađuju samo najvažnije komponente. U radu se opisuju korišteni alati i prikazuje kako se „Leap Motion" uređaj koristi i integrira u program za izradu igara i aplikacija. Kako bi prototip aplikacije funkcionirao u navedenoj primjeni, izmijenjeno je i dorađeno postojeće korisničko sučelje i kôd za integraciju uređaja. U procesu izrade rada istražene su mogućnosti uređaja, način postavljanja i instalacije i sama ograničenja uređaja i takve tehnologije.*

Ključne riječi: *detekcija pokreta, virtualna stvarnost, sustavi za učenje*

Professional paper

Abstract: *The work describes the development of prototype applications for educational purposes using contactless input device. The prototype application simulates a simple assembly of computer systems within the virtual reality system. Contactless input device used is the "Leap Motion" device which conveys the natural movements of the hand in the virtual world so that users can manage the user interface elements in an intuitive way. The process of assembling computer within prototype applications is simplified, it includes only the most important components. The paper describes the tools used and shows how the "Leap Motion" device is used and integrated into the application. To make the prototype application functional for the specified purpose, we have modified and upgraded existing user interface and program code for integration of device. In the process of making the work we have studied the capabilities of the device, together with basic limitations of such devices and technologies.*

Keywords: *motion detection, virtual reality, learning systems*

1. UVOD

Aplikacijski prototip koji će biti opisan u ovom radu prikazuje i demonstrira osnove interakcije u virtualno stvorenom svijetu prenošenjem prirodnog pokreta ruke u računalo. Pri tome se koristi uređaj za praćenje pokreta naziva „Leap Motion". Tehnologija praćenja pokreta donedavno je bila skupa i neprecizna, no pojavom „Leap Motion" uređaja na tržištu cijena se smanjuje na razinu cijene standardnih unosnih uređaja te je tako postala dostupna i zanimljiva širem skupu krajnjih korisnika, što nam je omogućilo demonstriranje i ispitivanje mogućnosti te načina korištenja i implementiranja programskih sučelja uređaja na konkretnom primjeru primjene.

Razvijena prototipna aplikacija uz samo ispitivanje načina rada tehnologije praćenja pokreta ruke i prstiju ima i drugu važnu ulogu. Njome se prikazuju mogućnosti razvoja suvremenih virtualnih svjetova u području učenja i podučavanja, posebno na području sklapanja većih sustava ili proizvoda od manjih komponenata. Sam prototip je izrađen na primjeru sklapanja stolnog računala pa aplikacija ovog tipa može poslužiti za edukaciju ljudi koji nemaju iskustva sa sklopovljem računala i njihovim sklapanjem. Ovakav tip aplikacije moguće je primijeniti u edukaciji (npr. u osnovnim školama), za učenje osnova o sklopovlju računala, o računalnim komponentama i postupku sastavljanja računala. Iako učenje u virtualnom okruženju ne može zamijeniti učenje u stvarnom svijetu, virtualno okruženje nam pruža mogućnost bržeg i čak zabavnijeg učenja koje može biti prošireno i dalje od samog procesa koji se pokušava simulirati.

Tehnologija uređaja „Leap Motion" razmjerno je nova i unatoč određenim nedostacima ima široki spektar primjene. Zanimljivost upotrebe takve tehnologije dolazi od same ideje da računalo možemo kontrolirati rukama, što je promjena u odnosu na dosadašnju praksu korištenja

računala na klasičan način – mišem i tipkovnicom. Takav način upravljanja može biti koristan mnogim djelatnostima i strukama i otvoriti nove mogućnosti interakcije koja je intuitivna.

U narednim odlomcima opisani su glavni postupci rada, alati i programi korišteni u izradi rada, detalji programskog koda, kao i sam opis aplikacije, te se uz to objašnjava i prikazuje i sam uređaj „Leap Motion“ i tehnologija na kojoj radi.

2. PROGRAMSKI ALATI KORIŠTENI ZA RAZVOJ APLIKACIJE

Alati i programi korišteni u ovom radu su „Blender“ (verzija 2.73a), „Unity 4“ (Unity 3D platforma za razvoj interaktivnih 3D sadržaja verzije 4.6.2f1), program Paint.net (verzija 4.0.5) i razvojna okolina naziva „Monodevelop“ (verzija 4.0.1).

2.1. Programski alat „Blender“

„Blender“ je besplatan alata otvorenog kôda za stvaranje 3D računalne grafike. Koristi se za izradu animiranih filmova, vizualnih efekata, 3D virtualnih objekata, interaktivnih 3D aplikacija i video igara. [1]

„Blender“ u sebi uključuje module za 3D modeliranje, teksturiranje, uređivanje rasterske grafike, simulaciju fluida i dima, simulaciju čestica, simulaciju mekanih tijela, oblikovanje, tj. skulpturiranje, animiranje, praćenje kamere, renderiranje te video uređivanje i komponiranje [1].

2.2. Okolina za stvaranje računalnih 3D igara „Unity 3D“

Okolina za stvaranje računalnih igara, „Unity game engine“ ili skraćeno „Unity“, višeplatformski je softver za stvaranje igara, koji razvija tvrtka „Unity Technologies“. Alat uključuje platformu za razvoj igara i razvojnu okolinu (engl. Integrated development environment - IDE). Iako početno zamišljen kao alat za isključivo Mac OS sustave, proširio se na veći broj različitih platformi i postao primarni programski alat za razvoj (engl. software development kit - SDK) na Nintendo Wii U konzoli. [2]

Najprepoznatiji je zbog mogućnosti izrade igara ili aplikacije na više platformi paralelno (npr. mobilni uređaji, mrežni preglednici, osobna računala i konzole) [2].

Neke od glavnih značajki su uključena baza resursa, uključena podrška za tehnologije Direct3D, OpenGL i OpenGLES. Unutar samog programa postoje opcije za kompresiju teksture i postavke rezolucije za svaku platformu koju podržava. Materijali imaju podršku za „bump mapping“, „reflection mapping“, „parallax mapping“, sjena (engl. Shadowmaps), „render-to-texture“ (projiciranje slike na teksturu), dok od ostalih efekata podržava „screen space ambient occlusion“ (SSAO), dinamičke sjene i mape i „full-screen post processing“ efekte. [2,3]

2.3. Razvojni alat „Mono Develop“

Platforma za razvoj interaktivne 3D grafike i računalnih igara „Unity“ dolazi uz svoj program za uređivanje programskog koda pod nazivom „Mono Develop“. Sami podržani programski jezici izgrađeni su na temelju Mono implementacije „.NET Frameworka“. Programeri mogu upotrebljavati programski jezik „UnityScript“ (prilagođena verzija ECMAScript sintakse), programski jezik C# ili programski jezik Boo koji je orijentiran na sintaksu programskog jezika Python [4].

3. ULAZNI UREĐAJ ZA DETEKCIJU POKRETA

Prvi uređaj koji je koristio tehnologiju pokreta bila je konzola NintendoWii koja se primarno koristila u računalnim igrama. Tu tehnologiju kasnije je unaprijedila tvrtka „Microsoft“ razvivši sustav naziva „Kinect“. Kinect je za razliku od praćenja kontrolera, kojeg korisnik drži u ruci, pratio kretanje cijelog tijela. Nova generacija uređaja stvorena je najavom „Leap Motion“ uređaja. Radi na sličnom principu kao i Microsoftov Kinect, samo što je fokusiran isključivo na ruke [5-7].

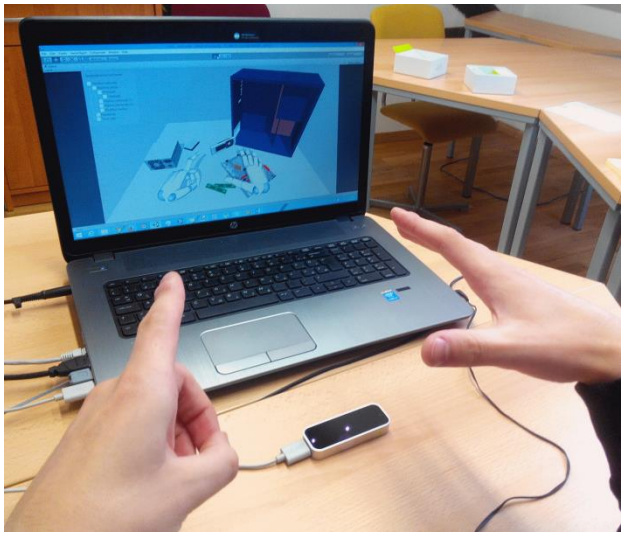
Slika 1. Uređaj “Leap Motion”

„Leap Motion“ je maleni uređaj koji se spaja pomoću USB kabla u računalo. Sam uređaj je dimenzija 8 cm x 3 cm x 1.2 cm (Slika 1). Sadrži 3 kamere i infracrvena senzora koji detektiraju pokret s preciznošću od 1/100 mm te ima kut pogleda od 150 stupnjeva. Tako preciznom detekcijom pokreta moguće je stvoriti precizne slike i crteže na ekranu. Polje interakcije od 150 stupnjeva omogućava korisniku slobodno pomicanje ruku u 3D prostoru, što znači da „Leap Motion“ aplikacije pružaju mogućnost da se (virtualni) objekti pomiču i da se njima manipulira baš kao u pravome svijetu. [5,6]

3.1. Instalacija i korištenje

Proces instalacije je jednostavan. Nakon priključenja uređaja na računalo putem USB kabla, uređaj treba postaviti ispred tipkovnice (prijenosna računala) ili između ekrana i tipkovnice (stolna računala). Nakon toga potrebno je preuzeti i instalirati softver sa službene stranice. Softver će korisnika upoznati s načinom na koji

uređaj radi i kako prati svih 10 prstiju u virtualnom prostoru iznad uređaja. Isto tako, s instalacijom pogonskih programa uređaja dolazi i program za kupovinu ostalih aplikacija za korištenje s „Leap Motion-om“.



Slika 2. Korištenje „Leap Motion“ uređaja unutar platforme za razvoj igara “Unity”

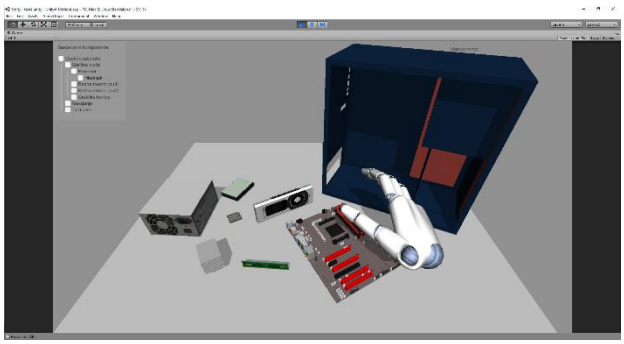
Za najbolje iskustvo prilikom korištenja uređaja preporučena visina interakcije s uređajem je 20 do 30 cm u slučaju kada je uređaj položen na stol, tj. na vodoravnu površinu, što je prikazano na Slici 2. Uređaj se može koristiti sa zaslonom pričvršćenim na glavu korisnika (engl. Head mounted display - HMD), kao što je „Oculus Rift“, i u tome slučaju uređaj se postavlja na sam HMD tako da gleda prema rukama korisnika, tj. prema naprijed.

3.2. Ograničenja uređaja “Leap Motion”

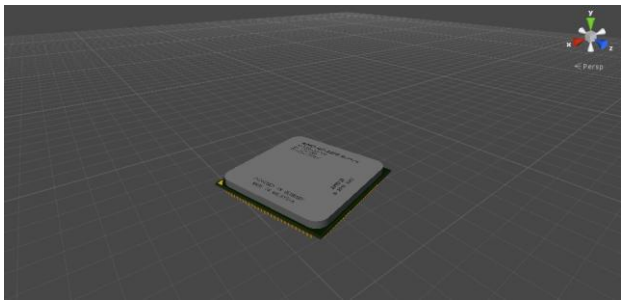
Glavni izvor ograničenja uređaja je nužnost optičke vidljivosti objekta koji se očitava, tj. za kojeg se pokušava detektirati pozicija u prostoru. Ukoliko se rukama izađe izvan polja dosega uređaja, gubi se vidljivost, tj. uređaj „ne vidi“ ruke te prestaje njihovo praćenje. Isto tako, ukoliko se uređaj koristi u visini između 5 i 15 cm značajno se smanjuju širina i dubina polja u kojem uređaj „vidi“ ruke, a kako kamere uređaja gledaju u samo jednom smjeru (okomito na prednju površinu uređaja) sve što se nalazi iza kamere postaje zaklonjeno, tj. uređaju nije vidljivo. Kako je potrebno osigurati optičku vidljivost, uređaj isto tako ne vidi objekte koji su zaklonjeni nekim drugim objektom. Primjerice, u slučaju kada korisnik skupi (stisne) šaku, uređaj „Leap Motion“ najvjerojatnije neće to moći vidjeti i ispravno očitati. Razlog tome je to što su u skupljenoj šaci prsti djelomično zaklonjeni i skriveni pa ih uređaj ne može ispravno detektirati. Za takve slučaje postoje modeli predviđanja o tome što korisnik radi i poze u kojoj bi šaka mogla biti. Unatoč tome, neželjena ponašanja mogu se dogoditi te rezultirati pogrešnim očitanjima.

4. OSTVARENI PROTOTIP APLIKACIJE

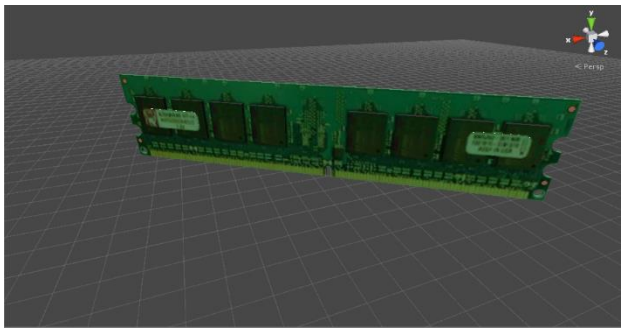
Ovdje će se opisati sama aplikacija, način na koji funkcionira i kako je koristiti. Aplikacija se može kontrolirati uređajem „Leap Motion“ ili pokazivačem miša. Prozor aplikacije sastoji se od 3 glavna dijela: glavnog prozora, panela za prikaz sastavljenih dijelova i panela za prikaz detalja. Glavni prozor (virtualni stol) prikazuje radnu površinu sastavljanja računala, što je prikazano na Slici 3.



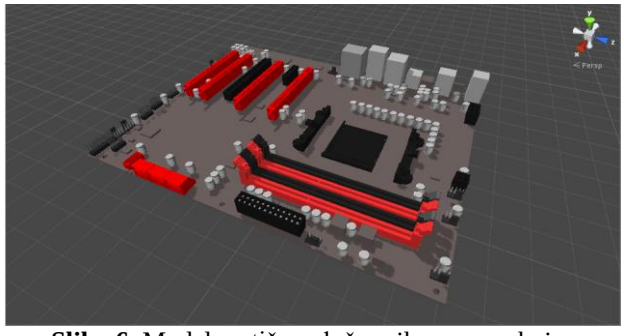
Slika 3. Glavni prozor aplikacije



Slika 4. Model procesora prikazan u okviru platforme „Unity“

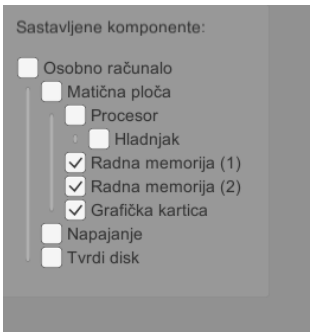


Slika 5. Model komponente radne memorije prikazane u okviru platforme „Unity“



Slika 6. Model matične ploče prikazane u okviru platforme „Unity“

Virtualno računalo sastavlja se od dostupnih komponenti, od kojih su neke prikazane na slikama 4, 5 i 6. Sastavljanje virtualnog računala u okviru izrađene aplikacije odvija se po redu, tj. hijerarhiji koja se prikazuje u gornjem lijevom kutu aplikacije (Slika 3), a detaljnije je vidljiva na Slici 7.



Slika 7. Prozor koji prikazuje koje komponente su sastavljene

Aplikacija implementira pravila za ispravno sastavljanje komponenti po hijerarhijskom redoslijedu pa tako, primjerice, prije nego matična ploča može biti ugrađena unutar kućišta potrebno je u nju ugraditi sve potrebne dijelove.

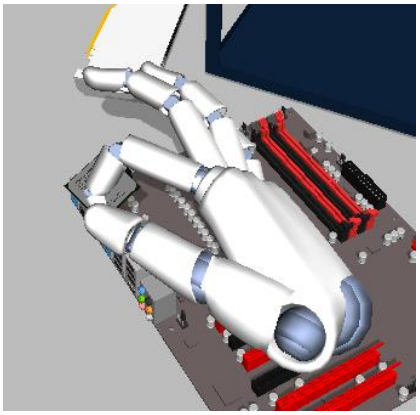
Kako bi se sastavilo virtualno računalo, najprije treba provjeriti je li uređaj pravilno spojen na računalo te je li ga pogonski program prepoznao, a nakon toga može početi sastavljanje. Komponenta se može uhvatiti gestom skupljene šake (engl. grab) ili gestom štipanja (engl. pinch). Da bi se tako odabrana komponenta ugradila na predviđeno mjesto, sve što treba je postaviti je iznad odgovarajućeg utora (engl. slot) i pričekati trenutak kako bi je aplikacija čvrsto pozicionirala na zadano mjesto. Prilikom prolaska, tj. prenošenja komponente iznad svakog utora, ukoliko je komponenta u dometu utora, na sučelju aplikacije iscrtat će se žuta linija od komponente do utora, čime se simbolizira da je komponentu moguće ugraditi u pojedini utor. Nakon uspješne ugradnje na hijerarhijskom prikazu, prikazanom na Slici 7, komponenta koja je ugrađena bit će označena.

5. IMPLEMENTACIJSKI DETALJI

Sastavljeni prototip aplikacije, tj. scena, uključuje resurse sa paketa „Unity 3D platform integration“ u kojemu se nalaze resursi kao što su grafika za virtualne ruke, pripremljeni „Leap Motion“ kontroler (virtualni uređaj) i nekoliko scena koje služe kao primjeri. [5,6]

5.1. Upravljanje virtualnom rukom

Implementacija virtualne ruke i integracija s platformom „Unity“ funkcionira tako što postoji virtualni uređaj (engl. controller) koji odgovara stvarnome uređaju. Pomaci i podaci virtualnog uređaja mogu se po potrebi skalirati i time se dobiva razlika između stvarnog i virtualnog pomaka. U protivnome pomak odgovara stvarnome pomaku. Integraciju uređaja „Leap Motion“ i platforme „Unity“ olakšavaju gotovi izrađeni i dostupni resursi i programske skripte. Tako se novi virtualni uređaj koji prenosi podatke s uređaja „Leap Motion“ integrira korištenjem i pozivanjem razreda iz „Leap Motion“ dinamički povezane knjižnice koda (engl. Dynamic-link library – DLL) [5, 6].



Slika 8. Hvatanje predmeta virtualnom rukom

Dostupni su i unaprijed pripremljeni skripte i objekti koji predstavljaju ruke. Tako pripremljene objekte odvlači se na odgovarajuće mjesto u parametrima skripte naziva „Hand Controller“. Virtualne ruke implementirane su kroz dva segmenta: grafika ruke i fizika ruke. Nakon što se podese oba segmenta odabirom grafike i fizike, sustav je spreman za korištenje podataka dobivenih s uređaja, koji se pak u virtualnom svijetu reprezentiraju grafičkim prikazom virtualnih ruku (Slika 8).

5.2. Ulazna točka aplikacije i inicijalizacija

Ulazna točka u implementiranu aplikaciju, tj. glavna skripta aplikacije, naziva se „GameControl“ skripta te je zadužena za upravljanje svim ostalim i može se nazvati „upraviteljem“ aplikacije. Prikazuje sastavljene objekte na ekranu, upravlja sučeljem za prikazivanje više detalja o komponentama te ispituje i prati koja komponenta je sastavljena i jesu li sastavljene grupe komponenata (procesor, matična ploča i PC kućište).

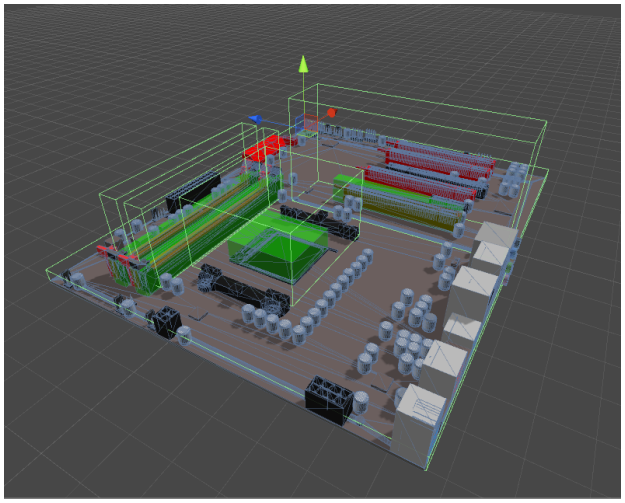
```
void Start () {
        Instance = this;
        komponenteField =  GameObject.FindGameObjectsWithTag("Komponenta");
        pcField = GameObject.FindGameObjectsWithTag("PC");
        holderField = GameObject.FindGameObjectsWithTag("Holder");
        MTBcomponentsField = GameObject.Find("MTB").
                        GetComponentsInChildren<PullObject>();
        CPUcomponent =
GameObject.Find("CPU").GetComponentInChildren<PullObject>();
        caseComponentField = GameObject.Find("PC_case").
                        GetComponentsInChildren<PullObject>();
        leapController = GameObject.FindObjectOfType<HandController>();
        foreach (GameObject o in komponenteField) {
            if (o.name == "MTB") {
                MTB = o;
                Destroy(o.rigidbody, 0.5f);
                break;
            }
        }
        foreach (GameObject o in holderField) {
            if (o.name == "mtb_holder") {
                MTB_target = o;
                break;
            }
        }
        foreach (GameObject o in pcField) {
            if (o.name == "PC_case") {
                PC_case = o;
                break;
            }
        }
        rightImage.CrossFadeAlpha(0f, 1f, true);
        ShowHelpBox("null");
}
```

Slika 9. Programski kôd ulazne točke u aplikaciju, metode „Start“

Metoda "Start", prikazana na Slici 9, poziva se prije iscrtavanja tako da je pogodna za inicijalizacijski programski kôd. Prvo se učitavaju sve komponente i odgovarajući utori u polja kako bi im se moglo pristupiti kasnije. Učitavanje u polje odvija se tako što se pretražuju svi objekti u sceni te se dohvaćaju prema odgovarajućoj oznaci (engl. „tag"). Nakon toga se kroz petlju iz liste izvlače glavni objekti u varijable i na kraju se postavljaju podaci u panel za prikaz detalja prikazan na Slici 7.

5.3. Komponente virtualnog računala

Komponente virtualnog računala od kojih su neke prikazane na slikama 4, 5 i 6 nose karakteristike te imaju mogućnosti iscrtavanja, što omogućava karakteristika naziva „Mesh Renderer". Nadalje, sve komponente koriste mogućnosti detekcije sudara s drugima, što je implementirano karakteristikom naziva „Mesh Collider – Rigidbody". Karakteristika naziva „Selected" omogućava interakciju s virtualnim komponentama.



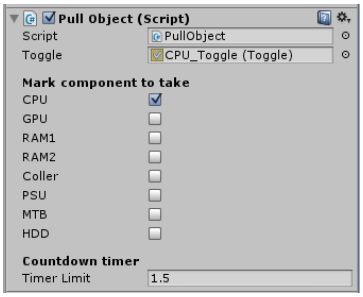
Slika 10. Matična ploča na kojoj su vidljivi prošireni rubovi (engl. Collider) koji služe kao okidači

Karakteristika „Mesh Collider" omogućava fiziku objekta, čime objekti u virtualnom prostoru dobivaju fizikalne karakteristike, tj. ponašanje kakvo se očekuje u stvarnom, fizičkom svijetu. Tom karakteristikom komponentama se definira prostor oko njih koji omogućava fizičku interakciju s drugim objektima ili taj prostor može služiti kao okidač određenih akcija (Slika 10). Moguće je detektirati sve objekte koji dodiruju, ulaze, ostaju unutar ili izlaze izvan granica proširenih rubova drugih objekata.

Karakteristika naziva „Rigidbody" komponentama omogućava djelovanje gravitacije, tj. možemo reći da daje masu objektu. Boja objekta određuje se karakteristikom naziva „Material". Ona ujedno određuje metodu sjenčanja koji se koristi na objektu, moguću teksturu (ili više njih) te se pomoću nje podešavaju svojstva svakog virtualnog materijala primijenjenog na 3D objekt.

5.4. Sastavljanje komponenata

Skripta naziva „PullObject" upravlja prihvaćanjem određene komponente na određeni utor. Time je osigurano ispravno spajanje komponenata virtualnog računala te se ne može dogoditi da se komponenta postavi na neodgovarajući utor. Tako, primjerice, utor za procesor može prihvatiti samo komponentu procesora (Slika 11).



Slika 11. Skripta „PullObject" u inspektor prozoru – utor uzima samo CPU komponentu

```
void OnTriggerStay(Collider c)
    {
        if (c.tag == "Komponenta" && !_assembled)
        {
            Debug.DrawLine(c.transform.position, transform.position,
Color.blue);
            lr.SetPosition(0, transform.position);
            lr.SetPosition(1, c.transform.position);

            curObjectType = TypeOfObject(c.gameObject);

            if (curObjectType == takingComponentType)
            {
                timer += Time.deltaTime;
                //Debug.Log("timer: " + timer);

                if (timer >= timerLimit)
                {
                    SnapObject(c.gameObject);
                    if (curObjectType == Helper.Components.CPU)
                    {
                        GameObject bla =
                               c.transform.Find("Coller_socket").gameObject;
                        bla.GetComponent<BoxCollider>().enabled = true;
                        bla.GetComponent<PullObject>().enabled = true;

             GameObject bla1 = bla.transform.GetChild(0).gameObject;

             bla1.SetActive(true);
                        }
                    }
                }
            }
    }
```

Slika 12. Programski kôd koji upravlja interakcijom objekta

Programski kôd koji upravlja interakcijom objekta, prikazan na Slici 12, detektira koliziju između objekata – okidača koji predstavlja utor i same računalne komponente koju pokušavamo priključiti na utor. Ukoliko se detektira ulazak objekta unutar okidača, prvo se provjerava je li objekt tipa „Komponenta" te se nakon toga provjerava je li objekt kompatibilan s utorom. Ukoliko je i to zadovoljeno, nakon 1.5 sekundi (postavka „Timer Limit" vidljiva na dnu Slike 11) komponenta se postavlja na utor i označava kao sastavljena. [8]

5.5. Implementacija upravljanja korisničkog sučelja mišem

Zbog potreba ispitivanja rada aplikacije kada nije dostupan uređaj "Leap Motion", implementirano je upravljanje korisničkim sučeljem skriptom za rad s mišem. Skripta naziva "MouseControl" pruža alternativu sklapanja računala s uređajem „Leap Motion". Ona sadrži programski kôd koji pruža manipulaciju komponenti s pokazivačem miša. [8]

Skripta kojom se reagira na događaje i akcije pokrenute mišem prikazana je na Slici 13. U metodi naziva „OnMouseDrag" nalazi se programski kôd koji omogućava akciju ekvivalentu uzimanju u ruku,

omogućava hvatanje komponente te njeno odnošenje i pozicioniranje iznad utora. Kako je manipulacija pokazivačem miša dvodimenzionalni način kontrole, kotačić miša koristi se za promjenu visine objekta. Metoda „OnMouseUp“ poziva se kada korisnik pusti tipku miša.

```
void OnMouseEnter() {
      glowObject.renderer.material.color =
              new Color(defColor.r, defColor.g, defColor.b, 0.275f);
}

void OnMouseExit() {
      glowObject.renderer.material.color =
              new Color(defColor.r, defColor.g, defColor.b, 0f);
}

void OnMouseDrag() {
      height += Input.GetAxis ("Mouse ScrollWheel");
      if (height < 5.9f) height = 5.9f;
      else if (height > 9f) height = 9f;

      Vector3 mousePos = MouseControl.mouse3DPosition;
      selectable = false;
      Screen.showCursor = false;
      if(rigidbody != null){
              rigidbody.isKinematic = true;
              transform.position = new Vector3(mousePos.x, height, mousePos.z);
      }

      GameControl3.Instance.SetCurentObject(gameObject.name);
      GameControl3.Instance.ShowHelpBox(gameObject.name);
}

void OnMouseUp() {
      selectable = true;
      height = 6.4f;
      Screen.showCursor = true;

      GameControl3.Instance.SetCurentObject("");
      GameControl3.Instance.ShowHelpBox("");

      if (gameObject.rigidbody != null) {
              rigidbody.isKinematic = false;
              rigidbody.AddForce(Vector3.up);
      }
}
```

Slika 13. Programski kôd metoda koje se aktiviraju akcijama miša

6. ZAKLJUČAK

Ovim radom prikazuje se kako jednostavna aplikacija koristi mogućnosti nove tehnologije. Uređaj „Leap Motion“ omogućuje korisniku upravljanje računalom na intuitivan način, svojim rukama, čime se postiže veći stupanj uranjana u virtualni svijet. Oponašanjem stvarnog svijeta pokušava se smanjiti jaz u interakciji između čovjeka i računala, čineći tako cijeli proces učinkovitijim i ugodnijim za korisnika.

Potrebno je istaknuti kako primjena ovakvog načina rada sa korisničkim sučeljem računala ima puno širu primjenu nego je prikazana u ovome radu. Moguće ga je primijeniti na interaktivne izloge u trgovini, manipuliranja objektima u softverima za izradu 3D modela, prezentiranja ne konferencijama, igranje igara, pomaganja ljudima s otežanom pokretljivošću itd.

Izrađena prototipna aplikacija, prikazana ovim radom, pruža mogućnost korisniku da svojim rukama manipulira komponente računala u tri dimenzije. Iako se najbolje iskustvo dobiva sklapanjem pravog računala, virtualno računalo možemo predočiti i priuštiti sklapanje različitih komponenti u različite sustave koji nam inače zbog svoje cijene ne bi bili dostupni. Nadalje, moguće je stvoriti i ostvariti simulacijsku okolinu u kojoj akcije nemaju svoje ishode u stvarnom svijetu, primjerice, virtualne komponente računala nije moguće (trajno) oštetiti, što onome koji uči i eksperimentira daje dodatnu slobodu. Uz to, unutar virtualnog okruženja korisnik je oslobođen straha od ozljede ili kvara i ima mogućnost slobodnog eksperimentiranja. Ostale primjene u edukaciji mogu biti od najjednostavnijeg učenja do prikazivanja interaktivnog učenja povijesti, matematike, fizike ili ostalih predmeta.

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APPLICATION OF PLC DEVICE IN MODELING THE ELECTRICAL MACHINE DRIVE SEQUENCE

PRIMJENA PLC UREĐAJA ZA MODELIRANJE ELEKTROMOTORNOG POGONA

Igor Petrović, Denis Čamber, Zdravko Petrović

Professional paper

Abstract: *In complex industrial processes the simplification of work is ensured using complex automation solutions. In such systems it is crucial to provide as much automated tasks as possible in order to reduce possibility of human error and ensure high level of excellence for final product. Complex automation solutions require high level of excellence in design, production and commissioning. In this paper the use of PLC application for testing single part of automated system is presented. The results of testing are described in several specific steps recorded during the actual testing. This will ensure determination of errors without connection of actual electrical machine drive.*

Keywords: *model, automation, testing, PLC*

Stručni članak

Sažetak: *Olakšavanje rada u složenim industrijskim procesima osigurava se korištenjem složenih sustava automatizacije. U takvim sustavima cilj je što više poslova odraditi automatizirano da bi se smanjila mogućnost ljudske pogreške i da bi se osigurala visoka produktivnost. Složeni sustavi automatizacije zahtijevaju visok stupanj kvalitete u projektiranju, izradi i puštanju u rad. U ovom radu prikazana je primjena PLC uređaja u ispitivanju jednog dijela automatiziranog sustava. Rezultati ispitivanja opisani su u nekoliko specifičnih koraka snimljenih tijekom ispitivanja. Na takav način omogućeno je utvrđivanje pogrešaka bez spajanja konkretnog elektromotornog pogona.*

Ključne riječi: *model, automatizacija, ispitivanje, PLC*

1. INTRODUCTION

When new technology objects are designed, it is common to implement automation solutions. Most often designers are trying to cover as much process as possible for designed object, and therefore automation can become very complex, as presented in [1]. In order to guaranty easy use of such systems many parameters must be taken into consideration, as well as their interdependence. Once the system is balanced it is easy to use, reliable and safe, as presented in [2]. But in order to get these characteristics for the system, it is necessary to maintain high level of excellence throughout design and construction process.

In this paper a case study of single electrical machine drive automation testing using PLC is described, somewhat similar to examples in [3]. The electrical energy supply and relay systems are tested for its correctness and functionality. The model used in this case study is equipped with all input and output data for tested system, but not with supposed automation programming solution. The used PLC is programmed so that one can manually configure any possible scenario, while containing only physical correspondence between elements. Results are intended to be considered as functions in logical order. If any of these functions defer from expected it is obvious that some errors are present inside the system and further analytics must be applied to determine them exactly. The results of this kind of testing can suggest the part of the system where errors occur.

2. AUTOMATION SYSTEM AND ELECTRICAL MACHINE DRIVE

The sample case of automation system used in this case study is divided in several functional units, as presented in Figure 1., where single arrows represent direction of signal interchange and double arrows represent direction of energy flow.

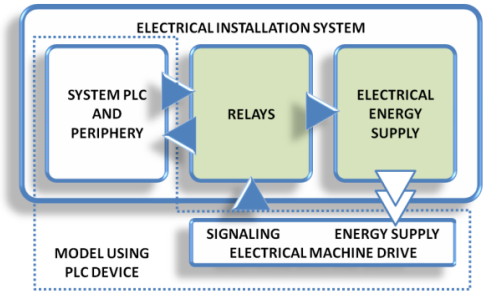

Figure 1. Block schematic for sample case of automation system

The sample case in this study is divided in Electrical installation system, mainly focused on electrical elements and wiring, and Electrical machine drive [4], concentrated on mechanical static and dynamical balance of process. The Electrical installation system is divided into functional subsystems:

1. System PLC and periphery
2. Relays
3. Electrical energy supply

All of these subsystems are hardware connected and they are exchanging information in order for the whole system to function properly. The Electrical machine drive is able to select if it is operated from System PLC and periphery (*Remote*) or directly from Electrical machine drive commands (*Local*), but in each case of operation the operation loop is gained through Relays and Electrical energy supply subsystems.

The information exchange is also presented in Figure 1, and it can be seen that information flow is designed as star configuration, with Relays subsystem as a center of grid. The Electrical machine drive is supplied with electrical energy from Electrical energy supply subsystem using standard Open/Close system and wiring presented in Figure 2.

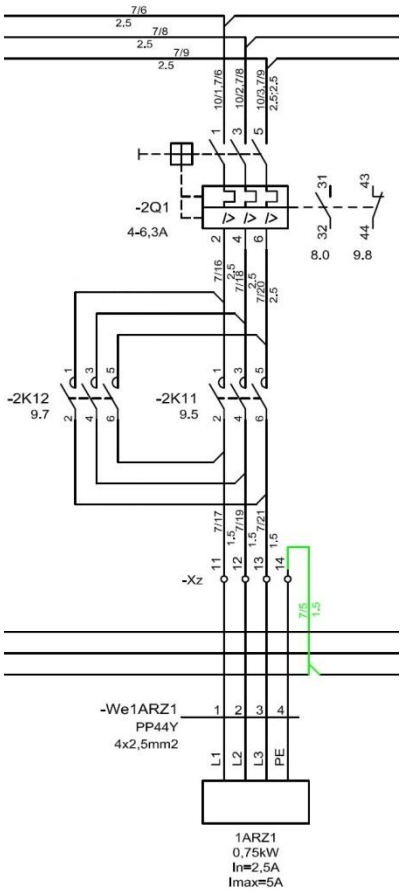

Figure 2. Standard Open/Close system and wiring

Considering the motion status of Electrical machine drive it responds to system through some information regarding open/close limit switches, open/close torque gained and thermistor switch. The Relay subsystem is using this information to operate and protect Electrical machine drive from over current or similar threats due to Electrical energy supply. The information is also forwarded to System PLC and periphery subsystem, where if Remote operation is selected, the program returns control signals for Relays to forward to Electrical energy supply.

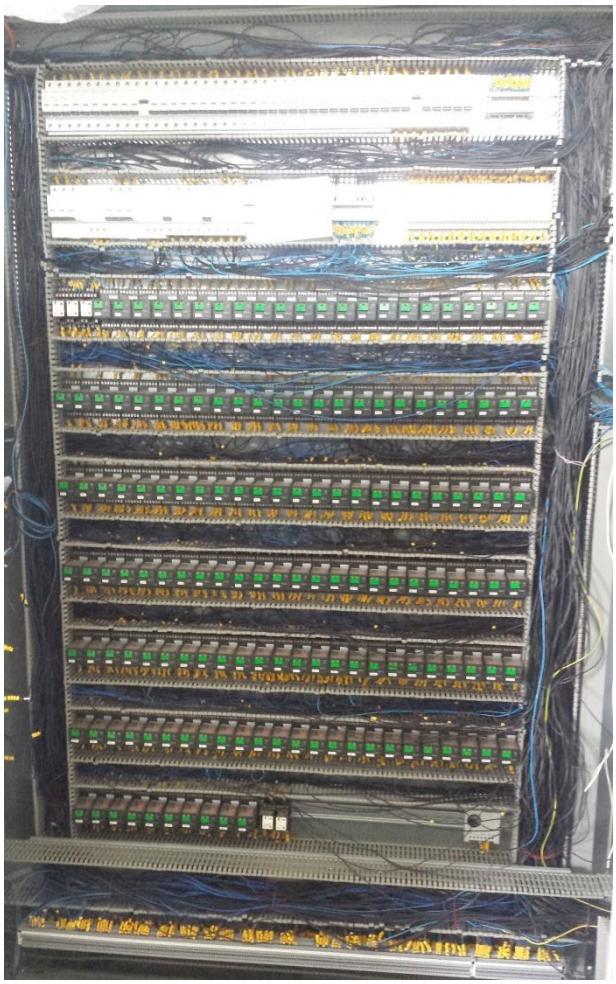

Figure 3. Example of Relays installation in sample case of automation system

Figure 4. Example of Energy supply installation in sample case of automation system

3. CONFIGURATION OF SIMULATION STATION

In order to gain high level of excellence for this product one must ensure as good testing as possible before delivery. Therefore, the testing is done using PLC device

described in [5] (not the one in System PLC and periphery), named Simulation station, which is equipped with model of Electrical machine drive and System PLC and periphery. The model is actually provided through program integrated in Simulation station.

The Simulation station is planned in one part to match electrical connection of Electrical machine drive and System PLC and periphery in other part. The connection links are made exactly to match connection terminals of Electrical machine drive and System PLC and periphery, and model ensures functionality match. The logic of System PLC and periphery is not the topic of this case study and is not implemented in model. Also, the model is equipped with SCADA application for monitor, measurement and operation control, using software solution described in [6]. The testing operator is fully able to monitor all incoming signals from Relays, monitor state of incoming energy flow from Electrical energy supply, and also operate all outgoing signals to Relays. Outgoing signals allow simulation of any scenario available and is not dependent on most of input signals. The measurement is not supported in this Electrical machine drive and therefore is not implemented in subject SCADA.

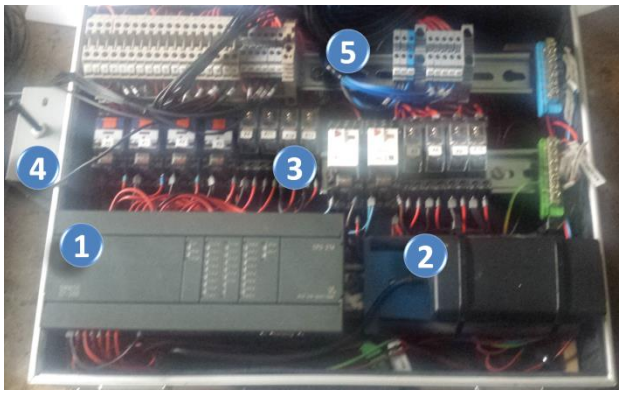

Figure 5. Simulation station

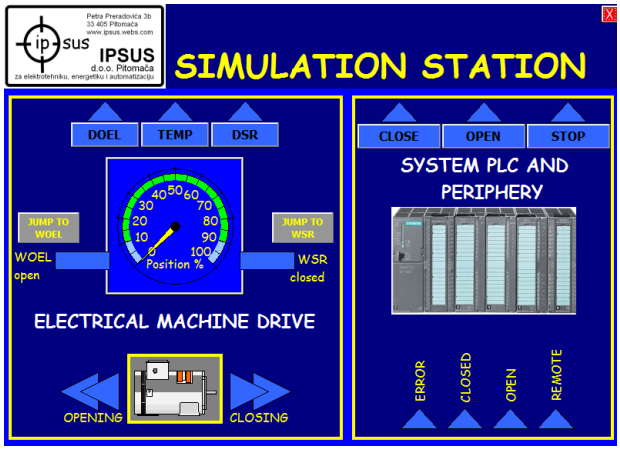

Figure 6. Offline screenshot of SCADA application

The Simulation station is presented in Figure 5 and consists of:

1. Power supply
2. PLC device with model program
3. Periphery for PLC device
4. Thermistor output model
5. Connection terminals

The offline SCADA screenshot is presented in Figure 6. Electrical machine drive part of model can be seen on the left side of the screen. It is equipped with five output signals from modeled drive, and two input power flows into modeled drive. Output signals are fully independent and can be activated at any time. Input signals are activated from Electrical energy supply and cannot be operated manually. System PLC and periphery part of model can be seen on the right side of the screen. It is equipped with three output signals from modeled PLC, and four input signals into modeled PLC. Output signals are partially dependent to inputs, and cannot be activated if Local operation or Error inputs are active. Input signals are activated from Relays and cannot be operated manually. Application is communicating with PLC device using PC/PPI interface through RS-232 port of computer.

4. TESTING RESULTS USING SIMULATION STATION

Testing results are made online during the actual testing in the Ipsus electrical workshop on 3rd March 2016. Testing is s sequentially conducted on 8 separate devices, using same procedure for simulation scenarios.

Figure 7 is a screenshot in moment (sample 1) when system is operated Locally to open, already hit open limit switch and just gained limit torque. In this moment the system should stop opening operation in Relays and Electrical energy supply. If opening stops, system works properly for this scenario. If the action does not stop it means that system has a fault.

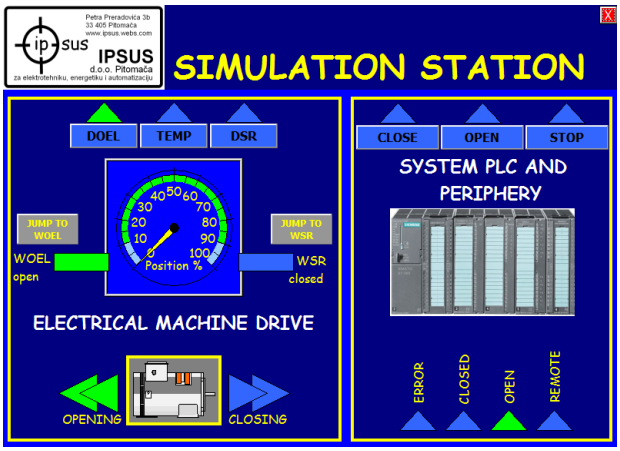

Figure 7. Testing – sample 1

Figure 8 is a screenshot in moment (sample 2) when system is operated locally and starts to close, and still hitting open limit switch. Limit torque is not active on either direction. In this moment system should be in normal closing operation in Relays and Electrical energy supply. If closing is operational system works properly for this scenario. If the action does not stop it means that system has a fault.

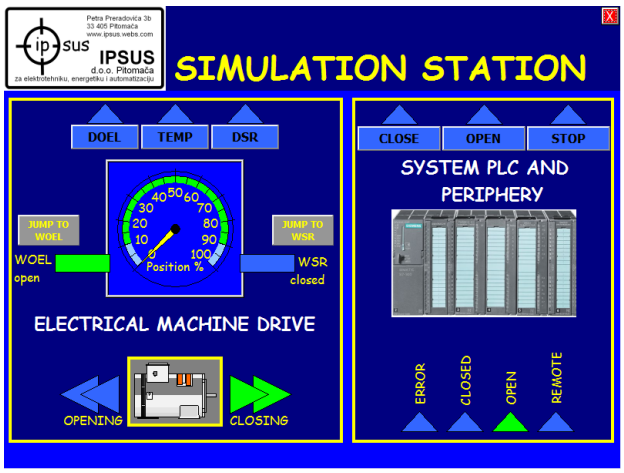

Figure 8. Testing – sample 2

Figure 9 is a screenshot in moment (sample 3) when the system is operated exactly like in sample 2, only in Remote operation. It starts to close, and still hitting open limit switch. Limit torque is not active on either direction. In this moment system should be in normal closing operation in Relays and Electrical energy supply. If closing is operational, the system works properly for this scenario. If the action does not stop, it means that the system has a fault.

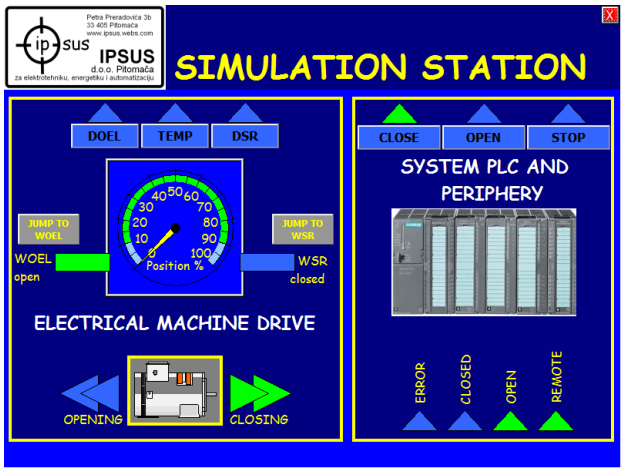

Figure 9. Testing – sample 3

Testing results indicated few errors. The exact errors were detected and changes were applied to gain full functionality of the tested system.

5. CONCLUSION

This case study presented simple testing improvement on the example of electrical machine drive with automation. Once the simulation station is configured and tested it is easy to use it for testing the electrical installation. Errors are usually present due to human factor, but in this way can easily be discovered and annulated. The upside of this kind of testing is that it reduces problems during, or even improves, commissioning.

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NASLOV NA HRVATSKOM JEZIKU (Stil: Arial Narrow,14pt, Bold, Verzal, Center)

12pt

NASLOV NA ENGLESKOM JEZIKU (Stil: Arial Narrow,14pt, Verzal, Center)

12pt

Ivan Horvat, Thomas Johnson (Stil: Times, 12pt, Bold, Italic, Center)

12pt

Kategorizacija članka

Sažetak: *Sažetak članka na hrvatskom jeziku sa najviše 150 riječ pisan jezikom članka (obično hrvatski). Sažetak mora što vjernije odražavati sadržaj članka. U njemu se navode upotrijebljene metode i ističu ostvareni rezultati kao i doprinos članka. Časopis TEHNIČKI GLASNIK / TECHNICAL JOURNAL objavljuje znanstvene i stručne radove iz područja strojarstva, elektrotehnike, graditeljstva, multimedije, logistike .... a također i iz njihovih graničnih područja. Ovaj dokument se koristiti kao predložak za pisanje članka kako bi svi članci imali isti način prijeloma (Stil: Times New Roman, 10 pt, Italic)*

10pt

Ključne riječi: *Abecedni popis ključnih riječi na hrvatskom jeziku (5-6 ključnih riječi). Ključne riječi u pravilu su iz naslova članka, a samo eventualno iz sažetka članak., (Stil: Times New Roman, 10 pt, Italic)*

10pt

Categorization article

Abstract: *Sažetak članka na engleskom jeziku (Stil: Times New Roman, 10 pt, Italic)*

10pt

Key words: *ključne riječi na engleskom jeziku (Stil: Times New Roman, 10 pt, Italic)*

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1. OBLIKOVANJE ČLANKA (Stil: Arial Narrow,12pt, Bold, Verzal, Align Center)

10pt

Članak se piše latiničnim pismom, a za oznake se može koristiti i grčko pismo. Opseg članka u pravilu se ograničava na osam stranica A4 formata (sukladno predlošku s uključenim svim slikovnim prilozima). Pri oblikovanju teksta članka ne smije se koristiti postavka za automatsko rastavljanje riječi.

10pt

1.1. Osnovna uputstva (Stil: Arial Narrow,12pt, Bold, Align Left)

10pt

(Uvlaka prvog reda 5mm) Dokument je formata A4 sa marginama 20 mm sa svake strane. Koristi se prijelom u dvije kolone međusobno udaljene 7 mm. Za tekući tekst se koristi vrsta pisma Times New Roman sa jednostrukim proredom, veličina pisma 10 pt, obostrano poravnanje.

Naslov članka mora jasno odražavati problematiku članka (sadrži ne više od 15 riječi).

Tekst članka dijeli se na poglavlja, a po potrebi poglavlja se dijele na podpoglavlja. Poglavlja se označavaju rednim arapskim brojevima. Podpoglavlja, kao dijelovi poglavlja, označavaju se s dva redna arapska broja kao npr. 1.1, 1.2, 1.3, ... Podpoglavlje se može podijeliti na još manje cjeline koje se označavaju sa tri redna arapska broja, npr. 1.1.1, 1.1.2, ... Daljnja podjela nije poželjna.

Nazivi glavnih poglavlja se pišu velikim slovima (verzalom) i poravnavaju se u centar, a nazivi podpoglavlja (kao i manjih cjelina) pišu se malim slovima (kurentom) te se poravnavaju u lijevo. Ako tekst naziva podpoglavlja i manjih cjelina prelazi u više redaka tada se definira viseća uvlaka (*Hanging intent*) 0,7 mm.

10pt

Grafičke oznake (*Bullet*) koje se koriste za označavanje stavki u nekoj listi, odnosno za nabrajanje započinju na početku retka, a nakon zadnje stavke dolazi razmak od 10pt:

- Stavka 1
- Stavka 2
- Stavka 3

10pt

Isto pravilo vrijedi prilikom numeriranja stavki u nekoj listi:

1. Stavka 1
2. Stavka 2
3. Stavka 3

10pt

1.2. Oblikovanje slika, tabela i jednadžbi (Stil: Arial Narrow,12pt, Bold, Align Left)

10pt

Slike (crteži, dijagrami, fotografije) koje čine sadržaj ugrađuju se u članak te poravnavaju se u centar. Kako bi slika uvijek zauzimala isto mjestu u odnosu na tekst prilikom uvoza moraju se definirati postavke *Text wrapping / Inline with text.*

Slike moraju biti pripremljene za grafičku reprodukciju sa minimalnom rezolucijom od 300dpi. Slike skinute s interneta sa 72dpi u veličini 1:1 nisu primjerene za reproduciranje u tisku zbog loše kvalitete.

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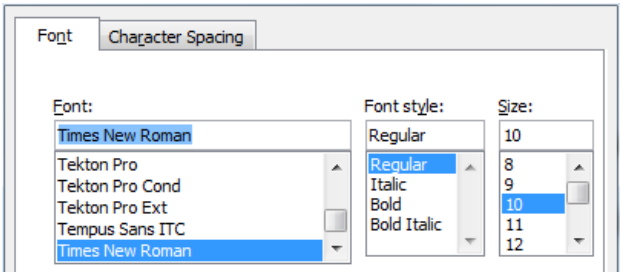

Slika 1. Tekst ispod slike [1]
(Stil: Times New Roman, 10pt, Align Center)
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Tisak knjižnog bloka je u crnoj boji stoga treba prilagoditi slike takvom načinu reproduciranja kako se svijetli tonovi (svijetle boje) ne bi izgubili u tisku ili tekst u slikama bio nečitljiv. Slike moraju ostati u koloru zbog objavljivanja u elektronskom obliku. Slike se kroz čitavi članak numeriraju u slijedu arapskim brojkama.
10pt

Tabela 1. Naslov tabele poravnat u centar
(Stil: Times New Roman, 10pt, Align Center)

	1	2	3	4	5	6
ABC	ab	ab	ab	ab	ab	ab
DEF	cd	cd	cd	cd	cd	cd
GHI	ef	ef	ef	ef	ef	ef

10 pt

Tekst i ostali podaci u tabelama oblikuju se kao Times New Roman, 8pt, Normal, Align Center.

Prilikom opisivanja slika i tabela fizikalne veličine i njihovi faktori ispisuju se kosim slovima latinične abecede ili grčkog alfabeta, dok se za mjerne jedinice i brojke upotrebljavaju uspravni znakovi.

Jednadžbe u tekstu numeriraju se arapskim brojevima u okruglim zagradama uz desni rub teksta, a na njih se u tekstu poziva pomoću broja jednadžbe u okruglim zagradama, npr. " .... iz (5) slijedi ...."
10pt

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad (1)$$

10pt

$$\cos\alpha + \cos\beta = 2\cos\frac{1}{2}(\alpha+\beta)\cos\frac{1}{2}(\alpha-\beta) \quad (2)$$

10pt

Veličine (varijable) koje se koriste u jednadžbama, ali i u tekstu članka ili u tabelama oblikuju se kao *kurziv* u istoj veličini teksta.

Slike i tabele koje su sastavni dio članka moraju se spomenuti u pratećem tekstu i na taj način povezati sa sadržajem, npr. „ … prikazano na slici 1 …" ili „ podaci iz tabele 1 …" i slično.
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2. UVODNE NAPOMENE

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Ponuđeni članak ne smije biti ranije objavljen, bilo u jednakom ili sličnom obliku, niti smije biti istodobno ponuđen drugom časopisu. Za sadržaj članka, autentičnost podataka i tvrdnji u njemu isključivo i u cijelosti odgovara autor ili autori.

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U **izvorne znanstvene članke** svrstavaju se radovi, koji po ocjeni recenzenata i Uredničkog odbora, sadrže originalne teorijske ili praktične rezultate istraživanja. Ovi članci trebaju biti napisani tako da se na osnovi danih informacija može ponoviti eksperiment i postići opisane rezultate, odnosno autorova opažanja, teorijske izvode ili mjerenja.

Prethodno priopćenje sadrži jedan novi znanstveni podatak ili više njih, ali bez dovoljno pojedinosti koje bi omogućavale provjeru kao kod izvornih znanstvenih članaka. U prethodnom se priopćenju mogu dati rezultati eksperimentalnih istraživanja, rezultati kraćih istraživanja ili istraživanja u tijeku, kojih se objavljivanje procijeni korisnim.

Pregledni članak sadrži cjelovit prikaz stanja i tendencija određenog područja teorije, tehnologije ili primjene. Članci ove kategorije su preglednog karaktera s kritičkim osvrtom i ocjenom. Citirana literatura mora biti dovoljno cjelovita tako da omogući dobar uvid i uključivanje u prikazano područje.

Stručni članak može sadržavati prikaz originalnog rješenja nekog uređaja, sklopa ili instrumenta, prikaz važnijih praktičnih izvedbi i slično. Rad ne mora biti vezan uz originalna istraživanja, nego sadrži doprinos primjeni poznatih znanstvenih rezultata i njihovoj prilagodbi potrebama prakse, pa je doprinos širenju znanja, itd.

Izvan navedene kategorizacije Urednički odbor časopisa pozdravit će i članke zanimljivog sadržaja za rubriku "Zanimljivosti". U ovim člancima daju se opisi praktičnih izvedbi i rješenja iz proizvodnje, iskustva iz primjene uređaja i slično.
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3. PISANJE ČLANKA

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Članak se piše hrvatskim jezikom te se metrološki i terminološki valja uskladiti sa zakonskim propisima, normama (ISO 80000 serija) i međunarodnim sustavom jedinica (SI). Materija u članku izlaže se u trećem licu jednine.

Uvod sadrži opis problema i prikaz važnijih rezultata radova opisanih u citiranoj literaturi. Navodi se način rješavanja problema, koji se opisuje u članku, kao i prednosti predloženog postupka.

Središnji dio članka može se sastojati od nekoliko dijelova. Treba izbjegavati matematičke izvode koji opterećuju praćenje izlaganja. Neizbježni matematički izvodi mogu se po potrebi, dati kao cjeline u obliku jednog priloga ili više njih. Preporuča se navođenje primjera kad je potrebno ilustrirati proceduru eksperimenta, postupak primjene rezultata rada u konkretnom slučaju ili algoritam predložene metode. Razmatranje treba u pravilu eksperimentalno potvrditi.

Zaključak u kojem se navode ostvareni rezultati i naglašava efikasnost korištenog postupka. Istaknuti treba eventualna ograničenja postupka kao i područja moguće primjene dobivenih rezultata.
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4. ZAKLJUČNE NAPOMENE

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Kako bi članci bili pripremljeni istovjetno ovom predlošku preporuča se ubacivanje sadržaja u njega. Gotovi članci pripremljeni u MS Word za Windows i prelomljeni prema ovom predlošku šalju se Uredništvu časopisa Tehnički Glasnik na slijedeću e-mail adresu: zivko.kondic@unin.hr

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5. LITERATURA

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Literatura se navodi redoslijedom kojim se citira u članku. Pojedine literarne reference iz popisa literature u tekstu pozivaju se odgovarajućim brojem u uglatim zagradama, npr. "…. u [7] je pokazano …". Ako su literarne reference poveznice (linkovi) hiperveza se mora ukloniti kao što je vidljivo kod literarne reference 8. Također se uklanjaju hiperveze sa e-mail adresa kod kontakta autora. U popisu literature svaka se jedinica označava brojem, a navodi se prema sljedećim primjerima (podnaslovi iznad referenci se izostavljaju – navedeni su samo kao primjer izvora):

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knjige:

[1] Franklin, G. F.; Powel, J. D.; Workman, M. L.: Digital Control of Dynamic System, Addison-Wesley Publishing Company, Massachusetts, 1990

[2] Kostrenčić, Z.: Teorija elastičnosti, Školska knjiga, Zagreb, 1982.

članci u časopisima:

[3] Michel, A. N.; Farrell, J. A.: Associative Memories via Artificial Neural Networks, IEEE Control System Magazine, Vol. 10, No. 3 (1990) 6-17

[4] Dong, P.; Pan, J.: Elastic-Plastic Analysis of Cracks in Pressure-Sensitive Materials, International Journal of Solids and Structures, Vol. 28, No. 5 (1991) 1113-1127

[5] Kljajin, M.: Prijedlog poboljšanja proračuna parametara dodira na primjeru evolventnih bokova zubi, Tehnički vjesnik/Technical Gazette, Vol. 1, No. 1,2 (1994) 49-58

članci u zbornicima znanstveno-stručnih skupova:

[6] Albertsen, N. C.; Balling, P.; Laursen, F.: New Low Gain S-Band Satellite Antenna with Suppressed Back Radiation, Proc. 6th European Microwave Conference, Rome, September 1976, 14-17

[7] Kljajin, M.; Ergić, T.; Ivandić, Ž.: Izbor robota za zavarivanje uvjetovan konstrukcijom proizvoda, Zbornik radova - 3. međunarodno savjetovanje proizvodnoga strojarstva/3rd International Conference on Production Engineering CIM '95, Zagreb, November 1995, C-35 - C-41

poveznice (linkovi):

[8] http://www.sciencedaily.com/articles/w/wind_power.htm (Dostupno:19.06.2012.)

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Kontakt autora:

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12pt

ARTICLE TITLE IN ENGLISH (Style: Arial Narrow, 14pt, Uppercase, Center)

12pt

ARTICLE TITLE IN CROATIAN (Style: Arial Narrow, 14pt, Bold, Uppercase, Center)

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Ivan Horvat, Thomas Johnson (Style: Times, 12pt, Bold, Italic, Center)

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Article categorization

Abstract: *Article abstract contains maximum of 150 words and is written in the language of the article. The abstract should reflect the content of the article as precisely as possible. TECHNICAL JOURNAL is a trade journal that publishes scientific and professional papers from the domain(s) of mechanical engineering, electrical engineering, civil engineering, multimedia, logistics, etc., and their boundary areas. This document must be used as the template for writing articles so that all the articles have the same layout. (Style: Times New Roman, 10 pt, Italic)*

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Keywords: *keywords in alphabetical order (5-6 key words). Keywords are generally taken from the article title and/or from the abstract. (Style: Times New Roman, 10 pt, Italic)*

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Kategorizacija članka

Sažetak: *Article abstract in Croatian (Style: Times New Roman, 10 pt, Italic)*

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10pt (The authors from abroad leave free space for the text of abstract in Croatian language.)

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Ključne riječi: *keywords in Croatian (Style: Times New Roman, 10 pt, Italic)*

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1. ARTICLE DESIGN (Style: Arial Narrow, 12pt, Bold, Uppercase, Align Center)

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The article is written in Latin script and Greek symbols can be used for labelling. The length of the article is limited to eight pages of international paper size of A4 (in accordance with the template with all the tables and figures included). When formatting the text the syllabification option is not to be used.

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1.1. General guidelines (Style: Arial Narrow, 12pt, Bold, Align Left)

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(First line indentation 5mm) The document format is A4 with 20 mm margins on all sides. A two column layout is used with the column spacing of 7 mm. The running text is written in Times New Roman with single line spacing, font size 10 pt, alignment justified.

Article title must clearly reflect the issues covered by the article (it should not contain more than 15 words).

Body of the text is divided into chapters and the chapters are divided into subchapters, if needed. Chapters are numbered with Arabic numerals (followed by a period). Subchapters, as a part of a chapter, are marked with two Arabic numerals i.e. 1.1, 1.2, 1.3, etc. Subchapters can be divided into even smaller units that are marked with three Arabic numerals i.e. 1.1.1, 1.1.2, etc. Further divisions are not to be made.

Titles of chapters are written in capital letters (uppercase) and are aligned in the center. The titles of subchapters (and smaller units) are written in small letters (lowercase) and are aligned left. If the text in the title of the subchapter is longer than one line, hanging indent of 0.7 mm is defined.

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Typographical symbols (bullets), which are being used for marking an item in a list or for enumeration, are placed at a beginning of a line. There is a spacing of 10pt following the last item:

- Item 1
- Item 2
- Item 3

10pt

The same rule is valid when items are numbered in a list:

1. Item 1
2. Item 2
3. Item 3

10pt

1.2. Formatting of pictures, tables and equations (Style: Arial Narrow,12pt, Bold, Align Left)

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Figures (drawings, diagrams, photographs) that are part of the content are embedded into the article and aligned in the center. In order for the figure to always be in the same position in relation to the text, the following

settings should be defined when importing it: text wrapping / inline with text.

Pictures must be formatted for graphic reproduction with minimal resolution of 300dpi. Pictures downloaded from the internet in ratio 1:1 are not suitable for print reproduction because of unsatisfying quality.

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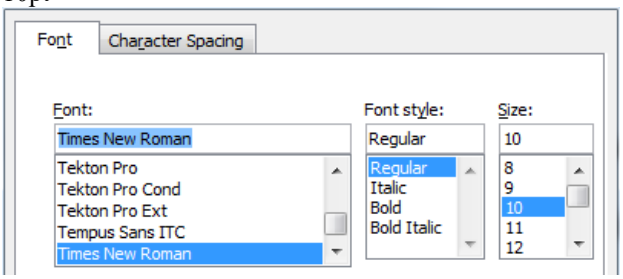

Figure 1. Text under the picture[1]
(Style: Times New Roman, 10pt, Align Center)

10pt

The journal is printed in black ink and the figures have to be prepared accordingly so that bright tones are printed in a satisfactory manner and are readable. Figures are to be in color for the purpose of digital format publishing. Figures in the article are numbered with Arabic numerals (followed by a period).

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Table 1. Table title aligned center
(Style: Times New Roman, 10pt, Align Center)

	1	2	3	4	5	6
ABC	ab	ab	ab	ab	ab	ab
DEF	cd	cd	cd	cd	cd	cd
GHI	ef	ef	ef	ef	ef	ef

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Text and other data in tables is formatted - Times New Roman, 8pt, Normal, Align Center.

When describing figures and tables, physical units and their factors are written in italics with Latin or Greek letters, while the measuring values and numbers are written upright.

Equations in the text are numbered with Arabic numerals inside the round brackets on the right side of the text. Inside the text they are referred to with equation number inside the round brackets i.e. " .... from (5) follows ...." (Create equations with MS Word Equation Editor - some examples are given below).

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$$F_{\text{avg}}(t,t_0)=\frac{1}{t}\int_{t_0}^{t_0+t}F\big(q(\tau),p(\tau)\big)\,\mathrm{d}\tau, \qquad (1)$$

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$$\cos\alpha+\cos\beta=2\cos\frac{\alpha+\beta}{2}\cdot\cos\frac{\alpha-\beta}{2}. \qquad (2)$$

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Variables that are used in equations and also in the text or tables of the article are formatted as *italics* in the same font size as the text.

Figures and tables that are a part of the article have to be mentioned inside the text and thus connected to the content i.e. „ … as shown in figure 1…" or „data from table 1…" and similar.

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Article that is offered for publication cannot be published beforehand, be it in the same or similar form, and it cannot be offered at the same time to a different journal. Author or authors are solely responsible for the content of the article and the authenticity of information and statements written in the article.

Articles that are accepted for publishing are classified into four categories: original scientific papers, preliminary communications, subject reviews and professional papers.

Original scientific papers are articles that according to the reviewer and the editorial board contain original theoretical or practical results of research. These articles need to be written in such a way that based on the information given, the experiment can be repeated and the results described can be achieved together with the author's observations, theoretical statements or measurements.

Preliminary communication contains one or more pieces of new scientific information, but without details that allow recollection as in original scientific papers. Preliminary communication can give results of an experimental research, results of a shorter research or research in progress that are deemed useful for publishing.

Subject review contains a complete depiction of conditions and tendencies of a specific domain of theory, technology or application. Articles in this category have an overview character with a critical review and evaluation. Cited literature must be complete enough to allow a good insight and comprehension of the depicted domain.

Professional paper can contain a description of an original solution to a device, assembly or instrument, depiction of important practical solutions, and similar. The article need not be related to the original research, but it should contains a contribution to an application of known scientific results and their adaptation to practical needs, so it presents a contribution to spreading knowledge, etc.

Outside the mentioned categorization, the Editorial board of the journal will publish articles of interesting content in a special column. These articles provide descriptions of practical implementation and solutions from the area of production, experiences from device application, and similar.

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3. WRITING AN ARTICLE

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Article is written in the English language and the terminology and the measurement system should be adjusted to legal regulations, standards (ISO 80000 series) and the SI international system of units. The article should be written in third person.

Introduction contains the depiction of the problem and an account of important results that come from the articles that are listed in the cited literature.

Main section of the article can be divided into several parts or chapters. Mathematical statements that obstruct the reading of the article should be avoided. Mathematical statements that cannot be avoided can be written as one or

more addendums, when needed. It is recommended to use an example when an experiment procedure, the use of the work in a concrete situation or an algorithm of the suggested method must be illustrated. In general, an analysis should be experimentally confirmed.

Conclusion is a part of the article where the results are being given and efficiency of the procedure used is emphasized. Possible procedure and domain constraints where the obtained results can be applied should be emphasized.

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4. RECAPITULATION ANNOTATION

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In order for the articles to be formatted in the same manner as in this template, this document is recommended for use when writing the article. Finished articles written in MS Word for Windows and formatted according to this template must be submitted using our The Paper Submission Tool (PST) (https://tehnickiglasnik.unin.hr/authors.php) or eventually sent to the Editorial board of the Technical Journal to the following e-mail address: tehnickiglasnik@unin.hr

The editorial board reserves the right to minor redaction corrections of the article within the framework of prepress procedures. Articles that in any way do not follow these authors' instructions will be returned to the author by the editorial board. Should any questions arise, the editorial board contacts only the first author and accepts only the reflections given by the first author.

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5. REFERENCES

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The literature is cited in the order it is used in the article. Individual references from the listed literature inside the text are addressed with the corresponding number inside square brackets i.e. "… in [7] is shown …". If the literature references are web links, the hyperlink is to be removed as shown with the reference number 8. Also, the hyperlinks from the e-mail addresses of the authors are to be removed. In the literature list, each unit is marked with a number and listed according to the following examples (omit the subtitles over the references – they are here only to show possible types of references):

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books:

[1] Franklin, G. F.; Powel, J. D.; Workman, M. L.: Digital Control of Dynamic System, Addison-Wesley Publishing Company, Massachusetts, 1990

[2] Kostrenčić, Z.: Teorija elastičnosti, Školska knjiga, Zagreb, 1982.

articles in journals:

[3] Michel, A. N.; Farrell, J. A.: Associative Memories via Artificial Neural Networks, IEEE Control System Magazine, Vol. 10, No. 3 (1990) 6-17

[4] Dong, P.; Pan, J.: Elastic-Plastic Analysis of Cracks in Pressure-Sensitive Materials, International Journal of Solids and Structures, Vol. 28, No. 5 (1991) 1113-1127

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articles published in conference proceedings:

[6] Albertsen, N. C.; Balling, P.; Laursen, F.: New Low Gain S-Band Satellite Antenna with Suppressed Back Radiation, Proc. 6th European Microwave Conference, Rome, September 1976, 14-17

[7] Kljajin, M.; Ergić, T.; Ivandić, Ž.: Izbor robota za zavarivanje uvjetovan konstrukcijom proizvoda, Zbornik radova - 3. međunarodno savjetovanje proizvodnoga strojarstva/3rd International Conference on Production Engineering CIM '95, Zagreb, November 1995, C-35 - C-41

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[8] http://www.sciencedaily.com/articles/w/wind_power.htm (Acessed:19.06.2012.)

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Author contact:

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Full Name, title
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