

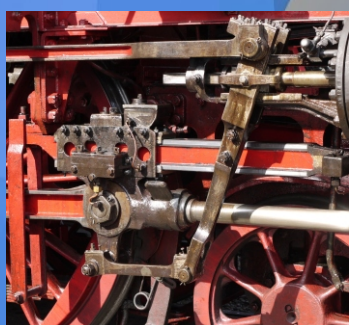
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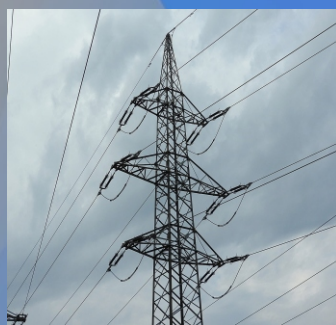
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Structural Network for the Implementation of "Industry 4.0" in Production Processes

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Abstract: In the last ten years, the development and implementation of robotics, sensor and digital technology in the world from introduced us the third industrial revolution to the fourth industrial revolution. In its development strategy, Germany introduces digital technologies in production processes called "Industry 4.0" in 2011. The German example is followed by the following countries: USA, Great Britain, Sweden, Japan and other. Almost all technologically developed countries strive to introduce advanced technologies into production processes in order to maintain their competitive positions in the market. The implementation of the fourth technological revolution depends on a number of new and innovative technological achievements, i.e., the implementation of patents for the basic technologies of Industry 4.0. It is necessary to integrate production processes in all phases of product development, as well as monitoring during its working life through the use of advanced technologies. When automating production processes, we must include intelligent sensors, intelligent robots and connect everything to the Internet using digital technologies that closely monitor the product development process. It is also required to collect large amounts of data through network communication used during the production process. The paper presents a structural network with all levels for the implementation of Industry 4.0 in the production process of the metal industry.

Key words: Industry 4.0, robot, smart sensor, digital technology, production process, smart automation.

1. Introduction

In the last 20 years, there has been a development of digital technologies that are implemented in the production processes themselves. We are at the beginning of the fourth industrial revolution because many industrial development strategies of countries in the world that are considered technologically advanced advocate the transformation of industrial production through the implementation of all advanced technologies, especially digital technologies. Germany first announced part of its High-Tech Strategy 2020 program in Hanover in 2011 under the title "Industry 4.0", while in the USA, in 2012 the Advanced Manufacturing Partnership Steering Committee provided recommendations for positioning the USA for long-term leadership in advanced technology. Similarly, in 2013, the UK Government Office for Science highlighted the strategy under the title "The Future of Manufacturing - A New Era of Opportunity and Challenge for the UK", while China under the title "Made in China 2025" wants to become the most technologically advanced country in the world; The Government of Japan presented its strategy under the name "Robot Revolution" [1, 12-14, 20-21], and the Swedish Government's strategy for new industrialization is to strengthen the capacity of companies for change and competitiveness through automation and digitalization. Industry 4.0 is creating radically new approaches that will involve individuals and institutions in a revolutionary way. The Industry 4.0 platform aims to match supply and demand in a very affordable way by providing the customer with a wide range of products without both parties interacting. The inclusion of digital technologies with other advanced technologies will transform the production processes in industrial production due to the fact that the price of this technology is constantly declining in the market and are increasingly widespread in production processes, and the second reason is that ICT technologies are implemented with other technologies and enable digital transformation of production processes [1-2, 7, 9, 16-19, 24-32]. When it comes to the transformation of production processes, it is impossible to imagine without the inclusion of robotics,

digital and sensor technology. The second generation of industrial robots has been developed, and new generations of robots must be intelligent and autonomous, thus increasing the reliability of the production process, as well as reducing the time to produce the finished product, as well as precision and adaptability beyond human capabilities.

2. The implementation of patents in technologies that are the basis for Industry 4.0 expands the application of Industry 4.0

To date, we have had three industrial revolutions in the world: the invention of the steam engine was marked as the first industrial revolution, and the invention of electricity as the second industrial revolution. The rapid development of informatics and automation electronics was marked as the third industrial revolution, while the world today is on the brink of the fourth technological revolution "Industry 4.0" as shown in Fig. 1.

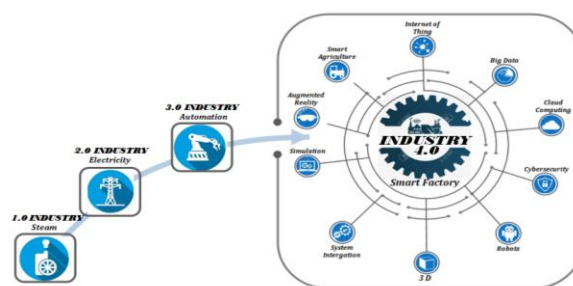


Fig. 1. Industrial revolutions in the world and their evaluation

Industry 4.0 is a digital transformation of production/related industries and the process of creating new value [3-5, 22-23, 28, 30-32]. Digital transformation must be integral, comprehensive, involving all actors in global politics, from the public and private sectors to civil society and academic community [6, 29]. Within the fourth industrial revolution, a new value chain is being formed that relies primarily on Cyber-Physical Systems

(CPS) which is also another name for the Internet of Things (Internet of Things), and its associated service most often implemented in the cloud (Cloud Computing). The implementation of Industry 4.0 is taking place through the massive use of the Internet of Things (IoT). Some studies estimate that by 2025, there will be 26.30 billion devices in homes equipped with sensors, processors and embedded software and connected to the Internet of Things (IoT). Numerous patents are responsible for this trend of implementation of basic technologies from Industry 4.0, as shown in Fig. 2 [25], which shows the trend of applying for patents of the fourth industrial revolution - Industry 4.0, which were applied to the EPO's free database "European Patent Office (EPO)" in the European Union until 2016.

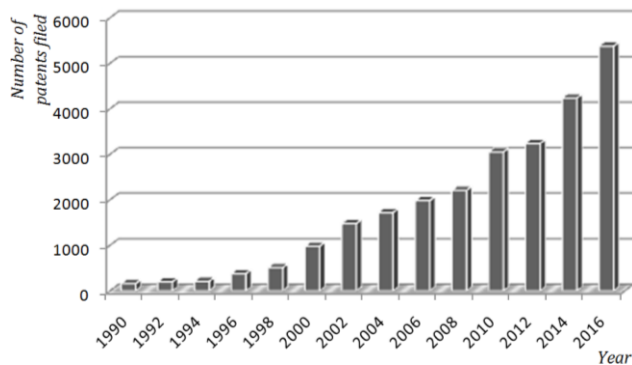


Fig. 2. Number of filed patents of the fourth industrial revolution - Industry 4.0 in the European Union [25]

By analysing Fig. 2, we come to the conclusion that we have a continuous growth of patents from the basic technologies of the fourth industrial revolution in the European Union. From 1990 to 2016, it can be roughly concluded that the trend of patent filing and applications follows an exponential function, so that in 2016 the number of patents reached 5.380. We see that the latest available data on filed patents signal the implementation of Industry 4.0. In order to create an image of which countries in the world and which are the base technologies of Industry 4.0 where the largest number of patents filed, we need to do analyse Fig. 3 [8]. By analysing Fig. 3 we come to the conclusion that in the first place in the world is robotic technology in terms of reported and implemented innovations, where China is in first place, Japan in second place. In second place is RFID technology, then in third place is cloud computing, in fourth place are smart sensors and the last fifth technology 3D printing by reported and implemented innovations.

The trend of applying Industry 4.0 innovations allows only limited conclusions about patents and their implementation, as there are a huge number of low-quality patents from Industry 4.0 in China. The second reason why this trend of innovation in China should be taken with a grain of salt is the dysfunctional government policy that rewards the registration of innovations regardless of their quality and the third reason is that many reporting innovations from China's industry seem lower quality their acceptance rate is significantly lower.

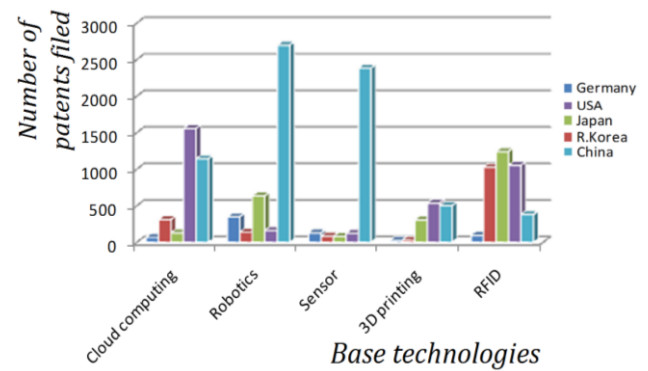


Fig. 3. Trend of patent applications from the five basic technologies of Industry 4.0 in technologically developed countries [8]

3. Structural Network for the Implementation of Industry 4.0 in Industrial Production Processes of the Metal Industry

For the implementation of "Industry 4.0", regardless of the principles on which the scenario is based, it is necessary that the application of innovation, software and hardware structure comes first. After that, in second place is the education of users - consumers, i.e., training programs for the general population. In order to implement Industry 4.0 in third place it is necessary to integrate with new technologies that we have listed as shown in Figure 4. It is necessary to enable CPS to monitor industrial production processes, connect data obtained through implemented sensors in production processes with virtual and simulation production models, in other words, create a virtual copy of the physical production process. The development and implementation of powerful computers enables the CPS to make its own decisions within the production process of the "smart factory", in other words, decentralization is performed, there is no need for central planning and supervision. In order to implement all of the above, it is inconvenient to establish an Industry 4.0 value chain, which means between new technologies such as IoT, ICT, CPS, etc., with consumers, devices and tools. Many research institutions around the world are working on the development and implementation of various "Industry 4.0" implementation scenarios. In Germany prof. M. Herman and his colleagues identify project principles such as: interoperability, decentralization, virtualization, real-time capability, service orientation and modularity, on which the Industry 4.0 implementation scenarios are based. Until recently, we had a traditional linear supply chain, but today many product supply chains are being transformed from a static array into a dynamic array that is evolving to an optimal state. Development and Implementation of Industry 4.0 in the production processes of the industry - Smart factory is characterized by the following most important characteristics: *connectivity, optimization, transparency, proactivity and agile flexibility*. The connectivity of the production process is one of the most important characteristics. By implementing a large number of smart sensors that provide continuous data sets, ensure that data is constantly updated and provide current operating conditions, and the integration of data from operating and business systems, as well as suppliers and customers allows us to view the input and output supply chain processes and in this way we are

able to increase the overall quality of the supply network itself with our products. Another feature is the optimized production process that allows us high reliability, optimization of energy input from the input, production and output chain, minimal manual intervention, automation during the production process, reducing costs and waste, etc. The data captured by smart sensors is transparent, allowing greater visibility throughout the production chain, allowing the organization to make the right decision or make autonomous decisions through analysis provided by tools such as real-time displays, alerts and notifications. The production process becomes a proactive process where employees and systems are able to anticipate and act on time before a problem arises. This feature includes the identification of anomalies, by having the ability to predictively solve the problem of quality in the production process of the product, as well as monitoring safety and maintenance. The agile flexibility itself enables the production process to adapt to the schedule and changes of the product with minimal intervention. Industry 4.0 implementation allows independent configuration of equipment and material flows depending on the product being produced and scheduled changes that we can monitor in real time, and the structural network of Industry 4.0 implementation in the metal industry production process is shown in Fig. 4. [10, 12, 14, 18].

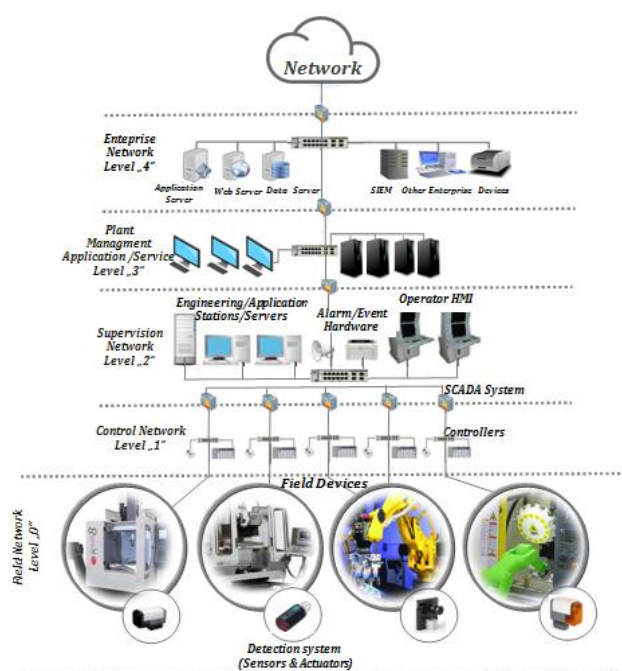


Fig. 4. Structural network scheme with all levels for the implementation of Industry 4.0 in the production process of the metal industry [10, 12, 14, 18]

Fig. 4 shows us that the structural implementation network of Industry 4.0 in any production, including the textile industry, consists of five levels. Zero level is a network of production processes of the textile industry where sensors are installed to monitor production processes and to detect systems. After the zero level comes level 1, i.e., the control network, where we can use controllers to act to eliminate errors that occur in the production process. The third level is the supervision network that monitors everything, and gives a signal/alarm

if something is wrong. In the third new is the operations management network, and in the last level 4 is the company network that is connected to all possible information via the cloud as shown in Figure 4. Industry 4.0 not only serves large companies; currently small companies can compete with large companies on a way they had never been able to before.

4. Conclusion

We can conclude that new technologies include: IoT (Internet of Things), robotics, cloud computing, smart sensors, radio frequency identification, cyber-physical systems and big data, are key in the application of the Industry 4.0 concept, in all industries, and the same so in the metal industry as shown by the structural network with all levels for the implementation of Industry 4.0, because it implies complete digitalization of all production processes, also when creating an idea about a product, product engineering, production organization, process control and industrial services. There is a continuous increase in the application of Industry 4.0 in the world, and this is confirmed by the trend of applying for patents from Industry 4.0 from basic technologies: Cloud Computing, Robotics, Sensor, 3D printing, RFID, both in the European Union and in the world. With the application of Industry 4.0 in production processes, the company has advantages such as: increasing efficiency, increasing the speed of production, increasing product quality, increasing flexibility, increasing operational safety. In addition, with the implementation of Industry 4.0, the company expands its access to the global economic market because it has a wide user base. There are three challenges when it comes to the Industry 4.0 application in the company. The first challenge relates to methods and methodology, especially how to integrate machines and devices within the production process. The second challenge is education, i.e., how to prepare new generations of engineers who need to work and implement Industry 4.0. The third challenge is about society, primarily how to explain to people that Industry 4.0 creates new opportunities and brings a better quality of life for all of us, without having to be afraid of change and everything that Industry 4.0 brings. Great attention in the world is paid to Industry 4.0 and the role of man in integrated factories, which are getting closer to realization day by day.

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Sequence-level knowledge distillation for image captioning model compression

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Abstract: One of the most important tasks on the edge between natural language processing (NLP) and computer vision (CV) is image captioning. There are many papers dedicated to researches in a field of improving image captioning models quality. However, compression of such models in order to be used on mobile devices is quite underexplored. More than that, such an important technique as knowledge distillation which is widely used for model compression isn't mentioned in almost any of them. To fill this gap we applied the most efficient knowledge distillation approaches to several state-of-the-art image captioning architectures.

Keywords: IMAGE CAPTIONING, KNOWLEDGE DISTILLATION, MODEL COMPRESSION

1. Introduction

Image captioning [1] is a very challenging task of generating human-like descriptions for the images in the automatic way. It is a very important task while talking about practical applications such as help for visually impaired people.

Modern methods which successfully solve this task with a high quality are based on the neural networks architectures. Most of them are based on encoder-decoder architectures. Both the encoder and the decoder could be of very different architectures. Usually, convolutional neural networks (CNNs) are used for the encoder part [2], [3], [4], [5], [6] and recurrent neural networks (RNNs) [7] or transformer architectures [8] are used for a decoder part. There are also some specific for image captioning methods such as self-critical training which could help to boost models' quality even more.

However, developing research increases not only the quality of the models, but also their size. Because of that, state-of-the-art models for image captioning could be hardly used on mobile devices where they could potentially find a wide variety of applications. So, the task of compression the model is very actual but still unexplored. There are some works on image captioning models size reduction, such as [9], [10], [11], [12]. But there are some methods for model compression that aren't covered by modern research.

To contribute to closing this gap and do a step forward using image captioning models for real-time mobile applications in this work we investigate one of the neural networks models compression method called "knowledge distillation". Unlike the overview of this family of methods in [13], we particularly concentrate on sequence-level knowledge distillation approaches and their variations.

2. Knowledge distillation

Knowledge distillation is a method that could be described in the following way. Suppose that we have a training dataset and want to train some compact model on it. But instead of training it straight away on the training data, bigger models are firstly trained. It is called "teacher". The initial compact model, called "student", is trained to mimic the "teacher". It could be trained in a different way from trying to learn intermediate representations of the "teacher" model to training on the final "teacher" model outputs.

Sequence-level knowledge distillation is a type of knowledge distillation techniques for sequence generation tasks, in which the "student" model is trained on the dataset generated by fully applying the "teacher" model. It differs from trying to force "student" to generate every next word the same as the "teacher" model would generate.

3. Sequence-level knowledge distillation parameters

We investigate the following parameters that could influence sequence-level knowledge distillation quality:

- Beam size used for generating sequence with "teacher" model
- "Student" model size
- Type of the image captioning model: whether "student" model is of the same, but smaller, architecture as "teacher" or different
- Intermediate training: whether small model is trained on the outputs of big one, or some intermediate model is firstly trained as "student" and then used as a "teacher"

4. Experiments

We trained model of the two different architectures to check our hypothesis more reliable. One of the architectures is called "Bottom-Up and Top-Down Attention" (Up-Down) [14] and the other is called "Attention on Attention Network" (AoANet) [15]. Both models were used with EfficientDet-d0 [16] encoder. We also trained models of two different sizes of such architectures, called "medium" and "small". All of the models trained were trained for 30 epochs using cross-entropy loss and then for 10 more epochs using a self-critical approach following state-of-the-art image captioning models training techniques [6]. All the models were trained and tested on Google Cloud Platform using servers with 8 CPU cores, 32 GB of RAM and 1 Tesla V100 GPU accelerator.

To compare the results, we train all the models on the same MSCOCO [17], which is the most common image caption benchmark dataset. It consists of 82,783 training images and 40,504 validation images. There are five different captions for each of the images. We used the standard Karpathy split from [5] for offline evaluation. As a result, the final dataset consists of 113,287 images for training, 5000 images for validation and 5000 images for testing.

We also performed preprocessing of the dataset by replacing all the words that occurred less than five times with a special token <UNK>. Further to following commonly used procedures, we truncated the words to maintain a maximal length of the caption equal to 16.

We use common metrics such as BLEU (B@4) [18], METEOR (M) [19], ROUGE-L @ [20], CIDEr © [21] and SPICE (S) [22], but concentrate our attention on the two last ones as they usually correlate with the human judgment.

Firstly, we investigated beam size influence on the knowledge distillation. We use 4 different values for beam size: 1, 3, 5 and 10. The results of experiments with different beam sizes are shown in the next Tables 1 and 2. Beam size equals to "-" corresponds to a model trained on the original dataset.

Table 1: Beam size influence on knowledge distillation for Up-Down models

Model	Beam size	B@4	M	R	C	S
Up-Down						
Medium	-	35.2	27.1	56.1	119.2	20.9
Medium	1	35.6	27.1	56.5	117.6	20.8
Medium	3	35.9	27.1	56.6	118.4	20.7
Medium	5	35.4	26.9	56.2	117.6	20.6
Medium	10	35.8	27.1	56.6	118.5	20.8
Small	-	33.6	26.2	55.5	114.3	19.8
Small	1	35.2	26.8	56.2	116	20.3
Small	3	35.2	26.7	56.1	115.6	20.4
Small	5	35.3	26.7	56.1	115.8	20.4
Small	10	35.4	26.9	56.3	116.6	20.5

Table 2: Beam size influence on knowledge distillation for AoANet models

Model	Beam size	B@4	M	R	C	S
AoANet						
Medium	-	38.5	28.5	58.3	129.1	22.1
Medium	1	37.9	28.3	57.8	126.3	21.8
Medium	3	37.6	28.1	57.6	125.3	21.6
Medium	5	37.8	28.3	57.9	125.9	21.8
Medium	10	38	28.3	57.8	126.3	21.7
Small	-	36.6	27.6	57.4	122.9	20.9
Small	1	37.3	28	57.4	124.3	21.5
Small	3	37.5	28	57.5	124.5	21.5
Small	5	37.4	27.9	57.3	124.2	21.5
Small	10	37.2	28	57.4	123.8	21.5

As it could be seen from the results, beam size influences knowledge distillation quality, but in a non obvious way. For both Up-Down architecture models the best beam size is equal to 10 while for AoANet architecture the situation is a bit different: for medium model performance is the same for beam sizes of 1 and 10 and for a small model the best one is equal to 3. However, we could conclude that the boost that could give a knowledge distillation approach depends on the model size. It didn't help for a medium size model, but helped a lot for a small one increasing its metrics of

CIDEr by 2.3 and 0.9 points and SPICE by 0.7 and 0.6 points for Up-Down and AoANet correspondingly.

Secondly, we conducted experiments to clarify whether the teacher model architecture influences the final quality or it is not the architecture, but the model metrics that make a difference. We trained Up-Down models with the AoANet teacher model and vice versa: AoANet models with Up-Down teacher. Results are shown in the next Table 3.

Table 3: Architecture influence on knowledge distillation for models

Model	B@4	M	R	C	S
Up-Down					
Medium	36.6	27.3	57.2	119.7	20.9
Small	35.3	27	56.3	116.8	20.6
AoANet					
Medium	37	28	57.1	123.5	21.7
Small	37	27.8	57.3	122.8	21.4

Both Up-Down models increased their metrics, but AoANet models metrics had a decrease. As initially AoANet teacher model is better than Up-Down teacher model, this could support the point that only the quality of a teacher model influences the quality after the distillation.

The last experiment we conducted was the following. We distilled a small model from the medium one trained on the same dataset, as the initial teacher model and also trained a small model on the medium one, distilled from teacher one. By these experiments we wanted to check whether "intermediate" training when the small model is trained on a model closer to it by amount of parameters will help to boost the metrics. The results of such experiments are shown in the next Table 4.

Table 4: Intermediate training influence on knowledge distillation for models

Teacher Model	B@4	M	R	C	S
Up-Down					
Medium on original dataset	34.7	26.6	55.9	114.9	20.3
Medium distilled from big	35.2	26.8	56.2	115.5	20.3
AoANet					
Medium on original dataset	37.3	27.9	57.2	123.4	21.3
Medium distilled from big	37	27.8	57.1	122.7	21.4

As it could be seen from Table 4, intermediate training didn't help at all in any variant. As the medium model quality is less than a big one, we could conclude that the size of the teacher model also doesn't matter, only its quality is important.

5. Conclusion

This study investigates different aspects of a sequence-level knowledge distillation for image captioning task. By conduction extensive experiments we provide the following conclusions:

- knowledge distillation effect is strongly influenced by the teacher model's quality, but not by its architecture or size

- increase in metrics which could be obtained using knowledge distillation depends on the student model size: it could help for small models, but not help for medium ones
- beam size for sequence generation affects overall quality, but in unpredictable manner, so should be carefully chosen in every case.

As a result of applying all the approaches from this paper, we managed to increase the small model CIDEr score by 2.3 points and SPICE score by 0.7 points without increasing the size of the model.

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Application of ergonomic software solutions in the concept of Industry 4.0

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Abstract: Continuous development of technology brings daily improvements implemented in various processes, systems, machines, tools, or equipment. The development of these technologies is currently most often in the synergy of the Industry 4.0 strategy, which forms a solid foundation for modern industrial practice. In this continuously evolving environment of industrial practice, digital concepts for every manufacturing sector come to the fore. Part of every production sphere is the worker, the person forming part of the production process, who undoubtedly requires the same attention as the production system itself. The ergonomics industry deals with the issue of the humanization of technology in the workplace, where it is necessary to ensure the adaptation of the machine to humans and not by suitable working conditions. The presented article is focused on highlighting and describing the basic connections between the general principles of ergonomics, the principles of modern understanding of ergonomics in digital form, which is rapidly developing in the engineering industry in conjunction with Industry 4.0 strategy for practice. The conclusion of the article provides a general summary of the issue with the ideas of developing the concept of ergonomics software solutions in mechanical engineering. This article was supported by research grants VEGA 1/0431/21 and KEGA 004TUKE-4/2020.

Keywords: DIGITAL ERGONOMICS, INDUSTRY 4.0, HUMANISATION OF TECHNOLOGY, SYNERGY, CONCEPTUAL IMPLEMENTATION

1. Introduction

The knowledge and technologies acquired in the first decades of the new millennium create space for the creation of a more suitable working environment in connection with better working conditions for employees. Continuously improving technologies and principles are part of various methodologies, procedures and concepts that bring the expected improvements in common synergy. [1] The current trend in the field of industrial solutions is the advancement of all manufacturing companies in terms of Industry 4.0, i.e., among other things, in the digitization and interconnection of their machines, equipment, logistics systems, services with active human participation in the workplace. [2] Such mass digitization represents the concept of creating an integrated PC system, which consists of models, simulations, analyses, or 3D visualizations. Not only research and development centres in international corporations, but

also research and educational institutions are concerned with the implementation of Industry 4.0 into production practice in general. Examples of the presented issues and research are, for example [3-7].

2. Industry 4.0 and Digital Ergonomics Interaction

The Industry 4.0 concept is currently considered to be the most current part of technological industry development. It represents significant progress towards digitization of industry, digitization of automation and robotization of production, based on the cyber interconnection of production information systems in industrial enterprises, i. e. digitization in all three attributes of the production process - software, equipment, and people. Industry 4.0 in all its modern interpretations (Fig. 1) represents the application of the concept of a digital network interconnection of objects and data exchange with each other in industrial enterprises. [8]

Kagermann, Wahlster & Johannes (2013)	Industry 4.0 utilizing the power of communications technology and innovative inventions to boost the development of the manufacturing industry.
Qin, Liu & Grosvenor (2016)	Industry 4.0 encourages manufacturing efficiency by collecting data smartly, making correct decisions and executing decisions without any doubts. By using the most advanced technologies, the procedures of collecting and interpreting data will be easier. The interoperability operating ability acts as a 'connecting bridge' to provide a reliable manufacturing environment in Industry 4.0. This overall consciousness gives Industry 4.0 the most important aspect of artificial intelligent functions.
Schumacher, Erol & Sihn (2016)	Industry 4.0 is surrounded by a huge network of advanced technologies across the value-chain. Service, Automation, Artificial Intelligence Robotics, Internet of Things and Additive Manufacturing are bringing in a brand-new era of manufacturing processes. The boundaries between the real world and virtual reality is getting blurrier and causing a phenomenon known as Cyber-Physical Production Systems (CPPS).
Schwab (2016)	Industry 4.0 is differentiated by a few characteristics of new technologies, for example: physical, digital, and biological worlds. The improvement in technologies is bringing significant effects on industries, economies and governments' development plans. Schwab pointed out that Industry 4.0 is one of the most important concept in the development of global industry and the world economy.
Wang et al. (2016)	Industry 4.0 makes full use of emerging technologies and rapid development of machines and tools to cope with global challenges in order to improve industry levels. The main concept of Industry 4.0 is to utilize the advanced information technology to deploy IoT services. Production can run faster and smoothly with minimum downtime by integrating engineering knowledge. Therefore, the product built will be of better quality, production systems are more efficient, easier to maintain and achieve cost savings.
Mrugalska & Magdalena (2017)	The modern and more sophisticated machines and tools with advanced software and networked sensors can be used to plan, predict, adjust and control the societal outcome and business models to create another phase of value chain organization and it can be managed throughout the whole cycle of a product. Thus, Industry 4.0 is an advantage to stay competitive in any industry. To create a more dynamic flow of production, optimization of value chain must be autonomously controlled.

Fig. 1 Worldwide recognized definitions of Industry 4.0 strategies. [8]

The fourth industrial revolution is based on new technologies applied in the production process, such as robotics, artificial intelligence, the Internet of Things (IoT), autonomous vehicles or 3D printing. It interprets the application of IoT (Internet of Things) into the production process, thus conceptually creating industrial IoT, i.e. IIoT (Industrial Internet of Things). The current trend of

digitization, automation and data exchange of production technologies is based on deep industrial integration through information technology and associated data processing. This integration has four basic characteristics [9]:

- Integration of engineering processes - this is the integration within the entire life cycle (from life cycle planning, development, implementation, testing, to sales services). Integration of engineering processes includes:
 - The general innovation model,
 - Efficiency innovation model,
 - Effective product management.
- Acceleration through exponential technologies - not completely new technologies, they just become more accessible for wider use and their main task is to enable individual solutions, increase flexibility and save costs in the process of industrialization.
- Vertical integration of production systems - information interconnection of all systems across the entire company structure. Smart - production systems, plants, products, interconnected logistics systems, marketing, services oriented to the individual needs of specific client requirements - personalization. Vertical integration of production systems includes:
 - IT Integration,
 - Analysis and data management,
 - Cloud solutions,
 - Operational efficiency 2.0.
- Horizontal integration - interconnection across the supply chain - the interconnection of suppliers - customers, from the manufacturer to the final distribution to the customer, service. It is a new generation of global, value-added connections, networks, involving the integration of partners and customers. Horizontal integration includes:
 - Business model optimization,
 - "Smart" supply chain,
 - "Smart" logistics,
 - IT security management,
 - New taxation models,
 - New IP management.

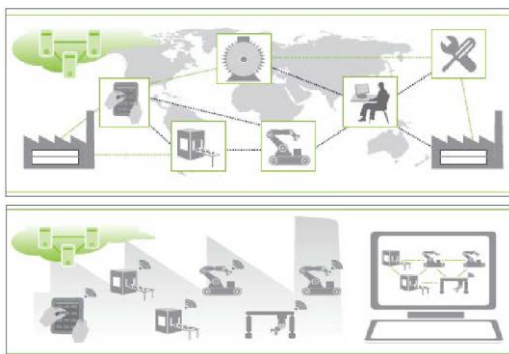


Fig. 2 Graphical interpretation of horizontal (up) and vertical (down) integration. [9]

The gradual deployment of intelligent production systems significantly affects, in terms of the Industry 4.0 strategy, the human-machine-environment interaction (Fig. 3) and thus the tasks performed in this interaction and the organization of work as a whole.

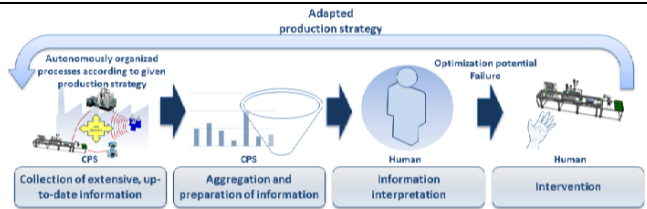


Fig. 3 Interaction of human and machine in Industry 4.0. [10]

To ensure the optimal human-machine-environment relationship, the principles of industrial ergonomics are applied in manufacturing companies, which is classified as an area of science aimed at achieving optimal adaptation of the working environment and workers' activities. Comprehensively, several components fall into the field of industrial ergonomics (Figure 4), such as the assessment of physical workload, posture at work, lifting and carrying, machine-human interactions, but also the classification of lighting conditions, thermal comfort, noise, and vibration effects on the worker. [11]



Fig. 4 Basic interpretation of ergonomics. [11]

Ensuring an optimal working environment is a demanding process that requires not only technical knowledge but also knowledge of general or specific industrial ergonomics. As technologies, processes or ideologies evolve, so did the views and possibilities of how to correctly identify ergonomics in the concept of a manufacturing company. Chronological complex determination of the term ergonomics is presented in Figure 5. [12]

The work system in industrial practice in connection with a comprehensive ergonomic assessment allows to implement [13]:

- ergonomic rationalization - searching for the most advantageous behaviour of the already existing work system,
- ergonomic modelling - finding out the probable behaviour of the existing system when changing boundary conditions,
- ergonomic analysis - experimental investigation of the structure and behaviour of the existing work system,
- ergonomic design - creating a new work system with the required behaviour.

All the above ergonomic processes can be implemented in the Industry 4.0 strategy concept, forming a new concept called digital ergonomics.

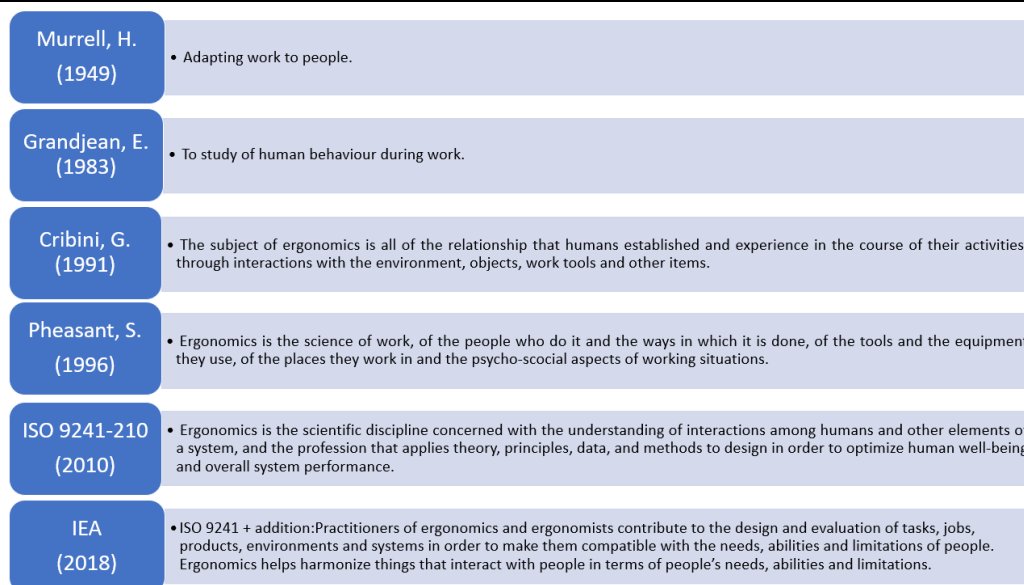


Fig. 5 Worldwide recognized definitions of *Erqnomics* in chronological order. [12]

3. Digital Ergonomics in Manufacturing Plants

The basic idea of digital ergonomics is the creation of digital twins of the work environment, workers, or work system by the Industry 4.0 strategy. The intersection of the Industry 4.0 concept and digital ergonomics is represented in Figure 6. The digital twin can be understood in ergonomics as a digital sensor model of a real object within the simulation process with an active setup. The basis for the digital twin is cumulative massive data collected in a real-time environment. [14]

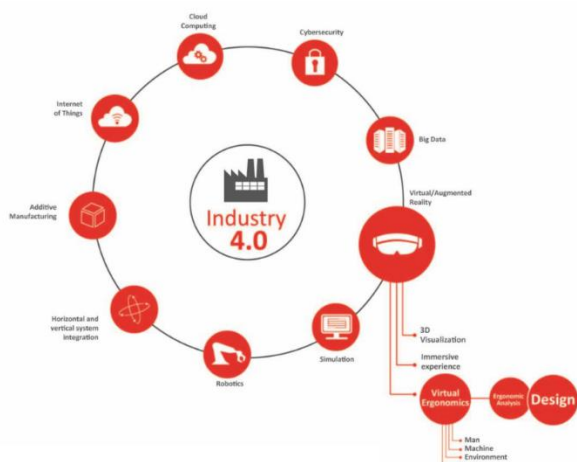


Fig. 6 Digital ergonomics in Industry 4.0 strategy. [14]

In the field of ergonomic assessment of the working environment, digital ergonomics can be used in industrial practice, for example, in analyzing the lighting of an individual workplace, production cell or hall. Various software solutions are used for digital analysis, while in practice the free lighting tool Dialux Evo is most often used.

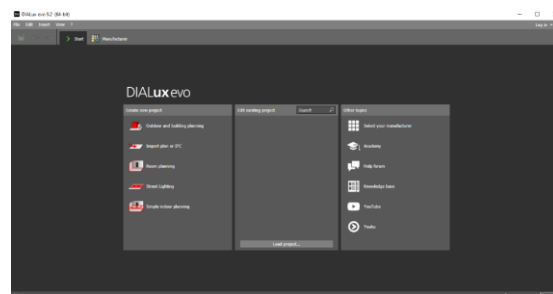


Fig. 7 Main screen of Dialux Evo.

With its free availability and wide compatibility, Dialux Evo ensures the possibility of application in production companies in the field of management, design and the design offices of architects. Its advantages include the ability to create your lamps, or the option of choosing from a wide range of predefined lamps from world-renowned lighting manufacturers. Based on the results of the simulation, it is possible to create a lighting study providing information on photometric values, specific flux, or layout of the lighting system. Analyses of lighting systems by implementing elements of digital ergonomics in industrial practice (Fig. 8) ensure compliance with established norms of regulations and standards in the field of work environment lighting.

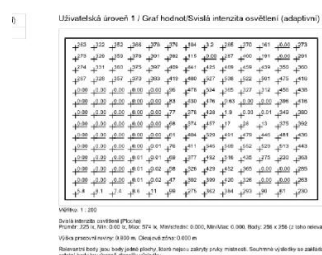
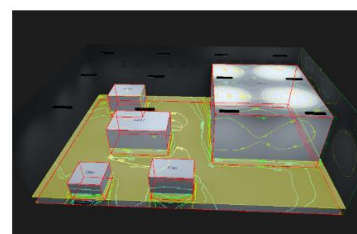


Fig. 8 Digital interpretation of lighting analysis in industrial practice.

Elements of digital ergonomics can also be implemented within the ergonomic assessment of the worker's physical load. In industrial practice, by this implementation, it is first and foremost necessary to identify the depth of the analysis. If it is an analysis providing only informative data, it is possible to use several mobile applications for fast screening of physical activity, such as ErgoMine or Intergo, which are mainly a substitute for the so-called ergonomic checklists. For ergonomic analysis of physical activity, complex simulation solutions are used in industrial practice, enabling simulations of work environment and work activities of employees, for example by application of digital ergonomic tool Tecnomatix, module Jack.

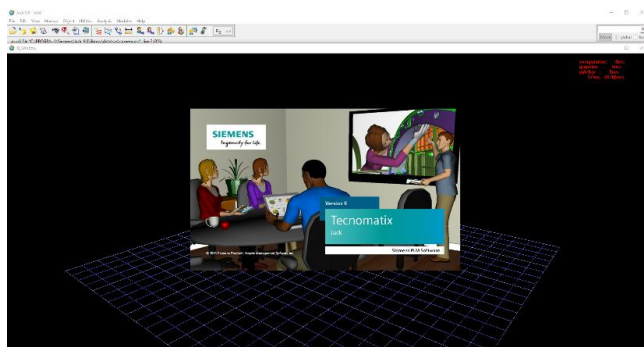


Fig. 9 Main screen Tecnomatix – Jack modul.

Work activities performed in industrial practice can be digitized using the Jack module, i.e. create a digital twin of a real work system and then subjected to analyses, based on which it is possible to reduce the risk of workplace risk, increase work efficiency or improve ergonomic standards. The created digital twin provides space to create several alternative improvements with the subsequent selection of the most suitable alternative by ergonomic standards and legislation (Low Back Analysis, NIOSH, OWAS, RULA, REBA, Fatigue Analysis, etc.).

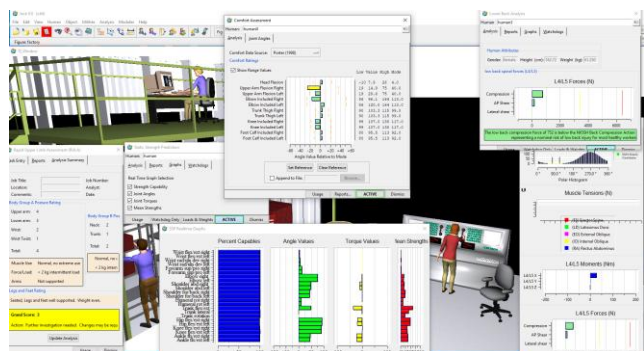


Fig. 10 Digital interpretation of physical load analysis in industrial practice.

4. Conclusion

Elimination of risks in ergonomics, increasing the efficiency of ergonomics of work activities, reducing the burden, and improving the factors of the working environment, but also the preventive measures in the system - man-machine - environment, of which the worker is the basic element, are a priority in every industry and non-manufacturing sector. Ergonomic assessment of assembly processes, in production as well as in logistics, administration and maintenance require increasingly complex approaches. These approaches can be provided by implementing digital tools in the process of analysis and assessment. The presented article is a summary of knowledge devoted to the implementation of digital tools in the field of ergonomics, primarily for assessing lighting as a physical factor of the work environment and physical activity, which has a direct impact on the worker. The article presents the basic possibilities of implementation and provides an overview of the issue from practice. In conclusion, it is possible to state the need

for such digital connections with practice and follow up on the assessment of possible emerging risks in creating digital ergonomic environments.

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Ultra-short laser patterning of silk fibroin thin films - a potential scaffold platform in tissue engineering applications

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Abstract: Silk-based scaffolds are specifically investigated in various tissue engineering applications, including for cartilage, bone, nerve, muscle, skin, or corneal regeneration. Guiding muscle cell growth is a challenging task in muscle tissue engineering. In this work, a self-assembled silk fibroin thin films were processed by ultra-short laser radiation to investigate its potential for guiding muscle cell proliferation. The ultra-short laser processing of silk fibroin (SF) have produced micro channels which are suitable for self-assembling and orientation of muscle cells and provides a niche for its attachment. Silk fibroin is an excellent candidate as a biomaterial for tissue engineering applications. Moreover, bacterial biofilm formation on surfaces are associated with persistent microbial contamination. Thus, recently new approaches are needed to impede bacterial surface colonization. Using femtosecond laser irradiation (wavelength 800 nm), laser-induced surface microstructuring is applied to achieve non-thermal, precise, and crack free surface processing with different topographical designs on silk fibroin thin films in order to enhance repelling of bacteria attachment.

KEYWORDS: BIOMATERIALS, TISSUE ENGINEERING, LASER PATTERNING, ANTIMICROBIAL, CELLULAR ADHESION

1. Introduction

Tissue engineering is a field in biotechnology that deals with the creation, regeneration, and improvement of the function of biological tissues. The purpose of the matrix is to create a biomimetic environment that stimulates cell adhesion, differentiation, and proliferation. In this way, the cells can be reorganized into new three-dimensional tissue. In the process of tissue regeneration, the matrix itself decomposes, leaving only the new tissue. The main focus of this study is on the creation of laser-structured, tissue matrices based on silk and fibrin for the regeneration of muscle and nerve tissue. Silk has specific amino acid motifs (RGD motifs), which are necessary for stable cell adhesion and are part of the natural extracellular matrix surrounding the cells in vivo [1]. The main disadvantages of biomaterials are the weak mechanical properties and the possibility of an immune response from the recipient after implantation. Thanks to its main building block, the protein fibroin, silk fibers have extremely good mechanical properties (strength, toughness, elasticity, strength), which presents the main features which are the base in the use of silk matrices for the regeneration of tissues, subjected to mechanical stress under normal physiological conditions. [1]. In order to be biocompatible, the outer layer of silk thread made up of the protein sericin is removed, thus the material does not cause an immune reaction from the body in which it is placed. Another biological material with extensive application in tissue engineering is fibrin, which is a biopolymer that plays a major role in blood clotting and wound healing. Most often, fibrin is applied in tissue engineering in the form of a hydrogel, and its application gives the best results in the regeneration of muscle, skin, and cartilage tissues. In addition, the fibrin-based hydrogel stimulates angiogenesis and the growth of dendrites from neurons [2].

Most chemical methods use organic chemicals to control the properties of the matrices, leaving residual toxic traces. In addition to chemical methods, the properties of various cell matrices can be controlled by physical methods, the most promising of which are laser sintering and laser-based surface modification. Laser techniques are non-contact and do not require the use of chemicals for additional treatment of the matrix. Irradiation with ultra-short laser pulses is an alternative approach by which these shortcomings can be overcome, as they possess extremely high processing accuracy and do not lead to the formation of thermal deformations on the processed material due to their extremely short pulse durations. Research in recent years has shown that surface modifications through the application of ultra-short pulse laser pulses change the topography of the material and thus can improve its properties and functions. Specific to tissue engineering, this type of modification on cell matrices leads to the creation of micro and nanostructures on the surface of the material, which in turn can strongly affect cell adhesion, orientation, and differentiation and subsequently can enhance bacterial rejection. For example, for

proper differentiation and orientation, muscle cells must occupy a certain parallel conformation. This structuring of the cells is extremely important, as it generates the uniaxial force required for proper muscle development. Obtaining certain parallel patterns by applying laser-induced modeling can direct muscle cells to occupy the correct conformation and thus stimulate the creation of muscle tissue. In addition, the surface laser treatment leads to a change in the wettability of the material, which allows control over its interaction with living cells and extracellular structures.

Silk, is a natural biopolymer material, and has become a promising hi-tech material. Silk fibroin (SF) origin is from Bombyx mori silkworm. It represents a fibrillar protein composed of three parts: heavy chain fibroin (391 kDa), light chain fibroin (27 kDa), and P25 (25 kDa). Silk fibroin possess high level of biocompatibility, and tunable biodegradation rate, as well as strong mechanical characteristics. SF can be processed into versatile forms, thus it becomes a favorable material for development of various drug delivery platforms, medical devices, and tissue-engineering matrices SF in an aqueous state or dissolved in organic solvents is explored to synthesizing films, and nanofibers, for diverse biomedical applications Fig.1.



Fig. 1 Types of scaffolds based on silk fibroin.

Besides the vast of excellent biocompatibility properties that SF possess and makes it a perfect candidate for a wide range of applications, a major drawback with SF is related to the absence of antibacterial properties. Bacterial infection is of considerable importance and when an implantable biomaterial is applied into the body. Biomaterial contamination represents a great treat and can evoke difficulties to heal infections, thus leading to risk to the

patient's health status. Despite the huge impact that medical implants have on patients' health and quality of life, the possibility of side effects after implantation remains. One of the most common complications is the development of a bacterial infection associated with the implant itself. *S. aureus* and *S. epidermidis* have been listed as the main pathogens that colonize implants and lead to severe inflammation [3]. When the implant is inserted at the site of injury, both human and bacterial cells compete for a place to attach to the material's surface. The initial adsorption of bacteria onto an inert and abiotic implant is unspecific and directed mainly by electrostatic, hydrophobic and van der Waals forces [4]. After they are attracted to the implant, microbes could bind irreversibly to the surface itself or to various serum proteins that have already been randomly adsorbed to the implant surface. Once the pathogens have attached to the surface, they proliferate and interact with each other in order to form an extracellular polysaccharide matrix—the bacterial biofilm [5]. The microbes, being embedded in such a layer, could become resistant to common antibiotic treatments. Consequently, the task of eliminating the developed infection becomes extremely hard. The effects of topographical features and roughness profile of different surfaces on bacterial attachment have been widely explored Fig. 2. Generally, with the increase in surface roughness, the surface area suitable for microbial adhesion also increases, which, in turn, results in a higher chance of a biofilm formation. Despite this general observation, it has also been discovered that surfaces with higher roughness allow the adsorption of serum proteins. In consequence, a thin coating is formed which masks the rough nature of the surface and impairs the interplay between the bacteria and the material. The surface topography and morphology are two key factors that influence bacterial behavior and are strongly correlated to the surface roughness.

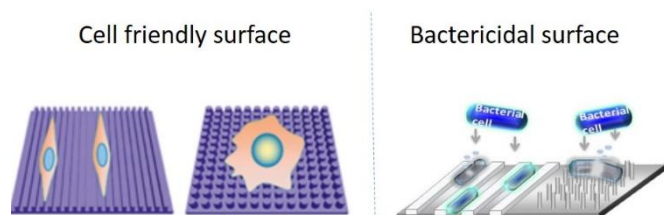


Fig. 2 Textured surfaces : Cell attractive for enhanced cellular adhesion and proliferation; Antibacterial structuring for prevention of microbial adhesion - biomimetic surface texturing.

Silk doesn't possess the cell adhesive components, such as arginine-glycine-aspartic acid (RGD) sequence, which enhances cell adhesion. Thus additional laser based treatment applied to thin SF films will introduce a morphological change expressed in deviation in surface roughness, making the surface from one hand bacteria repellent and on the other hand more cell friendly.

2. Materials and methods

Silk fibroin was extracted from *Bombyx mori* cocoons. The *Bombyx mori* cocoons were cut into small pieces and degummed in 0.2 M Na_2CO_3 solution at 100 °C for 1.5 h under stirring. The resulted degummed silk was rinsed with deionized water to assure the removal of sericin. And last step was to dissolve the sericin free silk in 9.3M LiBr solution for 3h at 60°C. The obtained viscous solution was finally dialyzed and centrifuged to remove the deionized water and remnants from the particulates. Subsequently, silk thin films were dried at drying oven at 37° C for 48h. Aqueous silk solutions were used to make thin films on the surface of glass slides Fig. 3.

Laser processing was carried out using $\lambda = 1030$ nm wavelength, $\tau = 150$ fs duration pulses (Ti:sapphire mode-locked Quantronix-Integra-C system) operating at a frequency of 500 Hz. Fig.4.

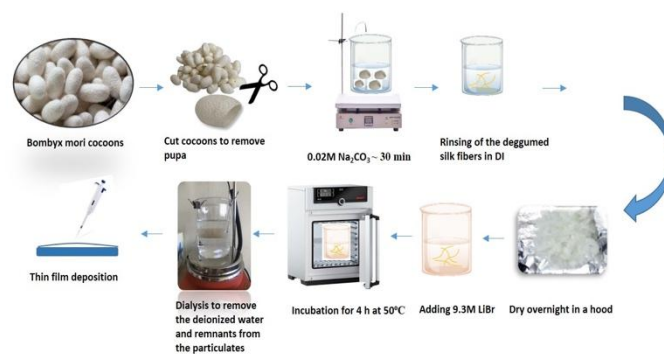


Fig. 3 Process of extraction of silk fibroin (SF).

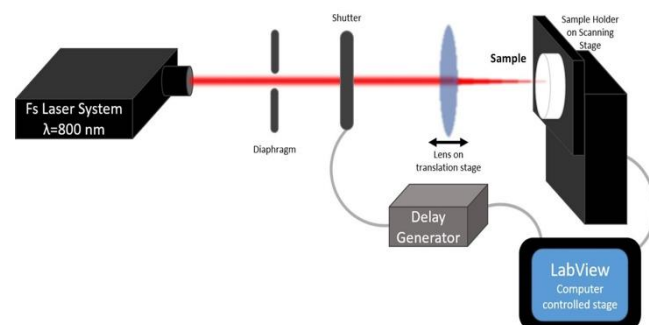


Fig. 4 Schematic of the femtosecond laser processing setup.

The samples were positioned on XY translation stage. The irradiations were performed in air. The number of pulses (N) delivered at each laser spot was defined by the speed of the translation stage, and the distance between each two consecutive laser-created spots (d_x) and the distance between two separate rows (d_y) was controlled between 32 μm and 45 μm . The laser fluence (F) was varied between 0.4 and 1.25 J/cm².

3. Results and discussion

The ability to control the surface properties of biomaterials and improve the adhesion of different types of cell cultures and biomolecules sets out the basic requirements for the development and use of new generation biomaterials for the purposes of tissue engineering and regenerative medicine. Various methods and approaches are used to improve the surface and volumetric properties of different type scaffolds, combining all kinds of knowledge from various fields such as physics, chemistry, biology, medicine.

The work of various research groups, clearly shows that the texturing of biomaterials has a significant effect on cellular development, compared to untreated "smooth" and non-textured surfaces. The literary reference shows that dependencies of cell behaviour are observed according to the characteristics of the given surfaces on which they are seeded. For example, Alexandre Cunha et. al. [6] show that by controlling the output laser parameters (energy, number of laser pulses, radiation polarization), different sized textures of Ti-6Al-4V surfaces are produced by laser processing with ultra-short pulses. The resulting structures exhibit hydrophilic behaviour and high affinity for HBSS solution (Hank's balanced salt solution). The surfaces thus treated, are characterised by an increase in surface wettability and can be used to control the behavior of hMSCs cells by exploring the change in their cytoskeletal form and proliferation. Another research group of Liang et.al., treated surface of NiTi alloys by femtosecond laser irradiation and observed growth of osteoblasts cells, oriented along the laser created grooves, as a result, large amount of synapses and filopodia were formed due to the grooves, holes and nanoparticles on the alloy surface. Moreover, as a result of the femtosecond laser treatment, noticeable improvement of biocompatibility due to

formation of micro-patterns of NiTi alloys was achieved. Surface patterning on micro and nano- scale is critical for distinguishing the effects of cell shape, focal adhesion, and ligand input for improving cell functions. Thus, the different kinds of structures, such as grooves, grate, ladder and pit will lead to the observation of different effects of cell behaviour by altering their geometry [7].

One of the recent concepts of creating scaffold-type structures for tissue growth is based on seeding well-selected cell cultures, providing mechanical attachment and "directed cells growth" on artificial grafts [8, 9]. The creation and modeling of the so-called "scaffold " for the needs of tissue engineering is a major challenge due to requirements related to the mechanical and morphological properties of the surface as well as their biodegradability [10,11].

Femtosecond laser processing can also provide other types of surface geometries (foam and bubble – like structures) by varying translation stage scanning speed, applied laser energy, pulse number and sample positioning. The films of silk fibroin were irradiated by a fs-laser beam Fig. 5.



Fig. 5 Image of femtosecond laser patterned thin film of silk fibroin. Creation of modification zones under irradiation with a range of laser parameters.

It can be observed that the laser irradiation of the silk fibroin films induces different modifications expressed also in the color of the processed areas, due to effect the local heat distribution and pressure waves generated by the laser interaction. The surface morphological characteristics of silk fibroin films can be tailored by (i.e. ridges, grooves structures) by single and multiple pulses from femtosecond laser irradiation and varying the scanning velocity. A typical SEM image of a laser - induced porous foam formation on the surface of silk thin film after irradiation with single pulse is shown on **Fig. 5**.

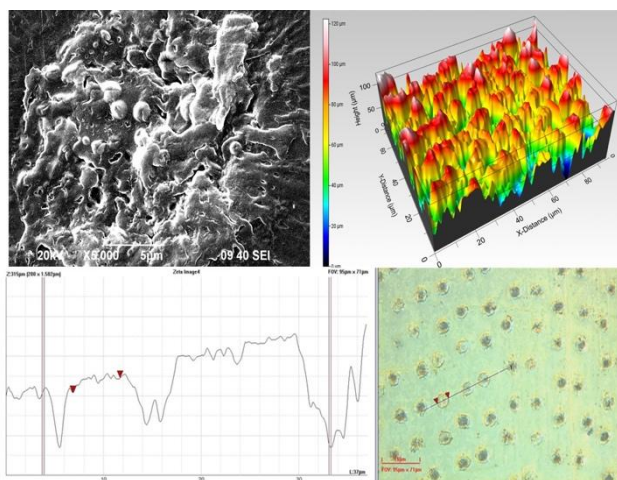


Fig. 6 SEM image and optical profilometer surface mapping of silk fibroin film after laser exposure to $\lambda = 800\text{nm}$, $\tau = 150\text{fs}$, $N=1$, $E = 0.4\text{J}/\text{cm}^2$.

Surface modification in the form of foam formation produced after irradiation by fs-laser pulses under high repetition rate, is a complex phenomenon, which involves interplay between strong energy deposition localization, low heat conductance, and surface tension effects. Thus modification process is triggered via strong ionization and electron ejection from the surface. After increase of the applied laser energy (E) to $0.8\text{J}/\text{cm}^2$ formation of ridge is observed at the ablation zone surroundings **Fig. 7**.

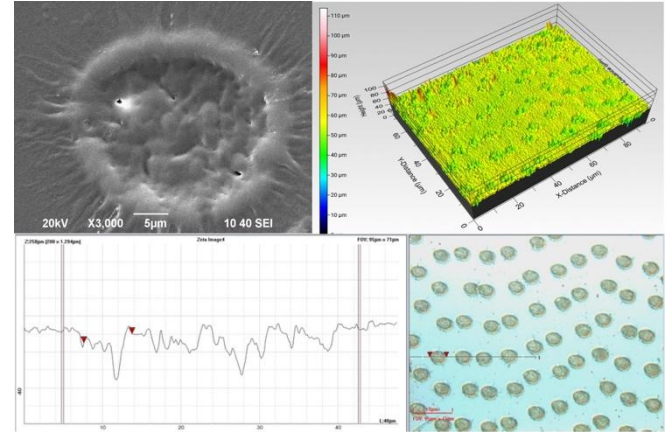


Fig. 7. SEM image and optical profilometer surface mapping of silk fibroin film after laser exposure to $\lambda = 800\text{nm}$, $\tau = 150\text{fs}$, $N=1$, $E = 0.8\text{J}/\text{cm}^2$.

The porosity of the ablation zone is diminished, leading to formation of a melted layer and filling of the pores. In the case of 'bubble' types of structures, the roughness parameter (S_a) of the irradiated zone was measured to vary from $28\mu\text{m}$ to $17\mu\text{m}$ for single pulse irradiation, along with increasing laser fluence values. The characteristic 'sponge-like' structure transforms to morphological structure with folded central part, leaving area with edges.

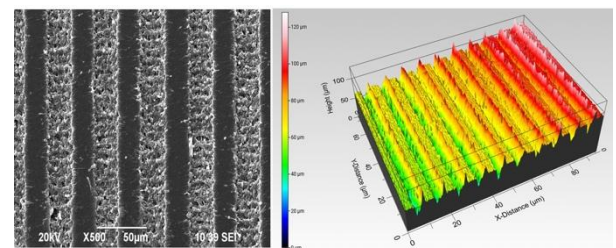


Fig. 8. SEM image and optical profilometer surface mapping of microchannels silk fibroin film produced after laser exposure to $\lambda = 800\text{nm}$, $\tau = 150\text{fs}$, $N=5$, $E = 0.4\text{J}/\text{cm}^2$.

Laser patterning in the form of micro channels results in a precise removal of a material, and formation of clean stripe – like channels **Fig.8**. The direct ablation of silk fibroin thin film hasn't induced damage to the surroundings of the processed zone. The proposed geometry is suitable for muscle and nerve cell 'Contact guidance', which is of main importance to control cellular morphology, orientation and direct cell migration. This type of patterning will permit the cells to occupy the bottom of the microchannels and align along the shapes of the produced microchannels. Micro-patterning technology, can enable the geometric control of muscle and neuronal cell alignment.

We have used the Fourier Transform Infrared Spectroscopy (FTIR) in transmittance mode to evaluate the molecular and crystalline structures of the silk fibroin thin films before and after irradiation with a range of laser fluences and scanning velocities **Fig.9**.

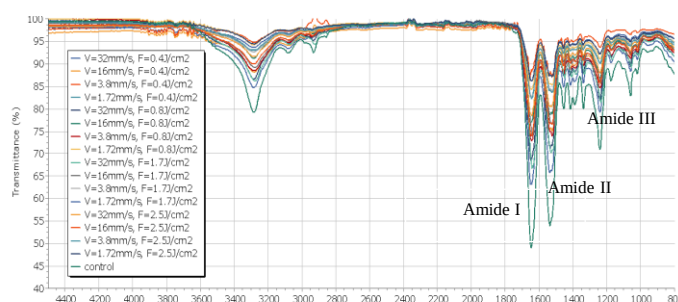


Fig. 9 FTIR transmittance spectra of silk fibroin films before and after laser irradiation with a range of energies between $E = 0.4 \text{ J/cm}^2 - 2.5 \text{ J/cm}^2$ and scanning speed in the range of $V = 1.7 \text{ mm/s}, 3.8 \text{ mm/s}, 16 \text{ mm/s}, 32 \text{ mm/s}$.

FTIR spectroscopy was employed to analyze the conformational changes that are established during laser processing process. The α -helix is represented by a strong absorption bands at 1656 cm^{-1} (amide I) (C=O stretching vibrations), 1540 cm^{-1} (amide II) (secondary N-H bending), and 1230 cm^{-1} (amide III) (C.N stretching vibrations and N.H bending). The FTIR measurements demonstrate that the silk fibroin matrix is not affected by the applied laser radiation, the main amide groups are present in all spectra. The only difference is observed in the decrease of the peaks intensity in comparison to untreated sample.

Conclusion

Laser patterning of micrometer dimensions of silk fibroin thin films is demonstrated using fs-laser exposure to diverse energies and scanning speeds. Obtaining porous microstructured thin-film surfaces with porous characteristics from naturally derived polymers (silk) could be used for muscle and nerve cells engineering and/or in cell directional growth and tissue regeneration. The obtained design of processed silk fibroin with topographical and chemical features suitable for engineering biointerfaces with multiple functionalities is a main factor in creation of effective topographical bioplatfroms equipped with a possibility to regulate cells fate.

Acknowledgments

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Design and 3D printing of holders for XRF analysis requiring small volumes of sample

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Abstract: The preparation of XRF tablets with small amounts of samples produced from various synthesis is a challenging operation. Zeolites and other types of samples with minimal volumes are frequently provided for analysis by X-ray fluorescence spectroscopy. Here we present three types of holders made of PLA (polylactic acid) using commercially available 3D printing technology. The employed material is a bioactive thermoplastic aliphatic polyester extracted from renewable resources and is biodegradable. The holders have reduced diameters of the measured area and can accommodate powders, sheets or solid state samples. The holders are basically three-dimensional plastic models that can be designed and printed based on the provided sample. They are low cost and can be easily applied in practice. The design of the first type of holders is targeting powder samples, allowing the reduction of the required amount from 5-10 g per sample to 1 g. The second type of holders aimed the XRF analyses of textile like materials while the third type of design aimed metal alloys. Examples of the use of the holders are the analyses of coins (here 2 leva is shown) and textile samples containing different metals (e.g. zinc).

Keywords: 3D PRINTING, XRF HOLDER, SAMPLE PREPARATION

1. Introduction

The 3D printer we used is commercially available and is from the Creality Ender-3 V2 FDM 3D Printer series (**Fig. 1**).

The software used allows the selection of the appropriate thickness of the production layers in terms of accuracy / resolution and speed of production. Each axis can be controlled individually and the distance of each step/movement can be set (0.1mm / 1mm / 10mm).

The integrated all-metal body of the printer is equipped with Carborundum Glass Platform. It allows the printing bed to heat up faster and the prints stick without distortion. The Creality Ender-3 V2 printer is equipped with proprietary hardware that includes a 32-bit motherboard.

Fused Deposition Modeling (FDM) is a form of 3D printing technology in which the material is applied by laying down consecutive layers. Supported printing materials are threads of PLA [1-7], TPU [8-10], carbon fiber [11-14] and other linear threads [15].



Fig. 1 3D printer Creality Ender-3 V2.

them, layer by layer, until they are finished. 3D printing software has many platforms that are completely free to use. Some of them are open source cross-platform tools.

The material used to make the three types of holders is thermoplastic aliphatic polyester PLA (polylactic acid), commercially available. The optimization of the production of different types of holders is necessary due to the different types of samples for analysis. **Fig. 2** shows a holder suitable for analysis of tablets of powder samples, **Fig.3** - holder for textile like materials and **Fig. 4** - holder for metal alloys.

The tested materials are powder sample of titanosilicate ETS-4, textile sample with zinc content and metal alloy – e.g. 2 leva coin. They are characterized by X-ray fluorescence spectroscopy (WDXRF) and these results are supported by powder X-ray diffraction (PXRD).

X-ray fluorescence analysis was used to determine the chemical composition of the different type of samples. The chemical elemental composition was determined by a Supermini200 spectrometer - Rigaku, Japan. Data collection was performed by wave-dispersed X-ray fluorescence at 50 kV and 4.00 mA. The data processing is performed using the ZSX software package. The sample is placed in a holder with an irradiated area of 20 and 20 mm in diameter.



Fig. 2. Holder for tablets

2. Materials and methods

Software used for preparing the 3D models for printing is Ultimaker Cura. Another open-source 3D printing software – Blender, is used to design virtual models of the real solid objects (holders), that are then transformed into readable format for the 3D printer using Ultimaker Cura software. This process of breaking up a 3D object into a readable format is called slicing. When the process of cutting a 3D object is complete, it generates a readable language for the 3D printer. This language is called G-code. Once the cutting is complete, the exact G-code commands that will be needed to complete the printout are produced. The 3D printer interprets the instructions and then combines (hardens) the material to create the 3D object. The 3D printer creates objects by printing



Fig. 3. Holder for textile



Fig. 4. Holders for metal alloys

Powder X-ray diffraction (XRD) was used for phase identification, that was also used for the 3D printed holders. The samples were measured at room temperature on an Empyrean diffractometer MalvernPanalytical, the Netherlands. Data collection was performed using Cu radiation ($\lambda = 1.5406 \text{ \AA}$) at 40 kV and 30 mA and a PIXcel3D detector in the range $2 - 90^\circ 2\theta$, step $0.013^\circ 40 \text{ sec/step}$.

3. Results and discussion

The results of chemical analysis performed on the basis of X-ray fluorescence spectroscopy (WDXRF) using a 3D printed powder sample holder are presented in Table 1. From Table 1 it can be seen that the difference between the analysis using a 3D holder and with conventional holder is in the range of 2-4%, which is an expected result. This difference is due to the reduction of the measuring area by 1 cm. In this way the required amount of sample is reduced from 5 g to 1 g. This holder is very suitable for small amount samples.

Table 1: Chemical composition on powder zeolite sample measured by small 3D printed powder holder and ordinary holder.

Cd-ETS-4 small 3D printed powder holder		Cd-ETS-4 ordinary holder	
elements	mass %	elements	mass %
Cd	11.9337	Cd	9.5992
Na	2.4532	Na	2.4395
K	1.6994	K	2.2764
Ti	38.1830	Ti	36.6379
Si	44.8179	Si	48.3618
Total	99.30872	Total	99.3148

The results of the chemical analyses of the second type 3D holder suitable for textile samples are presented in Table 2.

Table 2: Chemical composition of a textile samples containing Zn, measured with a 3D printed holder for textil.

Textile Samples			
Initial sample – Ch		Ch Zn	Zn Ch Zn
elements	mass %		
Mg	2.0489	3.3095	–
Al	2.0315	1.0582	0.9888
Si	–	1.6520	2.1623
S	6.4242	1.6520	1.1701
Cl	12.2734	1.5989	1.9027
K	6.2269	1.5899	3.0173
Ca	6.8172	5.2794	7.4254
Ti	60.2514	6.9571	13.0993
Fe	3.9265	0.4572	1.1555
Zn	–	77.1993	69.0784

As it can be seen from Fig.3, the holder is ideally suited for this purpose. This is because the “Lego like click” holder allows the textile sample to be pressed between the two parts of the holder thus it does not tear in a vacuum environment.

The use of a 3D printed holder for solid (alloy) sample allows the measurement the sample on small and large diameter focusing the X-ray beam on the desired area (Table 3. and Fig. 4) The table shows that with a 3D the printed holder with a small diameter of about 20 mm, the value of nickel decreases by about 3%. This is an expected result considering that the measurement was performed only on the yellow area of 2 leva. In the analyzing the alloy with the help of a large 3D printed holder (25 mm), the measurement was performed on the full area of 2 leva (white and yellow part).

Table 3: Chemical composition of metal sample (2 leva), measured with a 3D printed holders for metal alloys with different diameter.

Holder	Small diameter 20 mm	Large diameter 25 mm
Elements	Mass %	
Al	0.1115	0.1139
Si	0.2683	0.2629
P	0.0469	0.0393
S	0.0943	0.0547
Cl	0.5087	0.3066
K	0.5830	0.4907
Ti	0.6270	–
Mn	0.0506	0.0936
Fe	0.0582	0.0619
Ni	5.6433	8.9648
Cu	75.0869	74.3068
Zn	16.9214	15.3048

For the determination the phases by powder X-ray diffraction (PXRD) again we used the 3D printed holder for the textile sample (Figs.5 and 6) and the holder for the alloy sample – 2 leva (Figs.7 and 8).

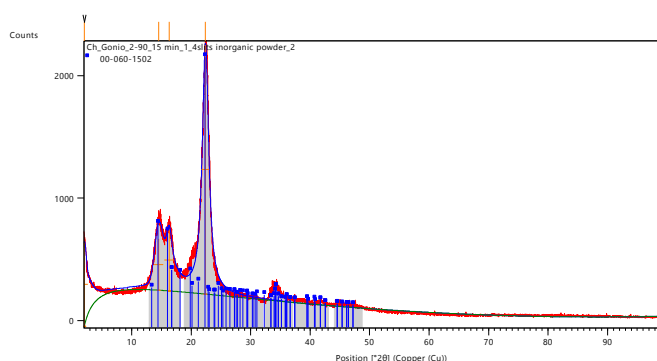


Fig. 5. Diffraction pattern of textile sample Ch measured with 3D holder

Table 4: Pattern List of textile sample Ch

Ref. Code	Compound Name	Displ.[°2θ]	Scale Fac.	Chem. Formula
00-060-1502	Cellulose-Iβ	-0.386	0.846	(C ₆ H ₁₀ O ₅) _n

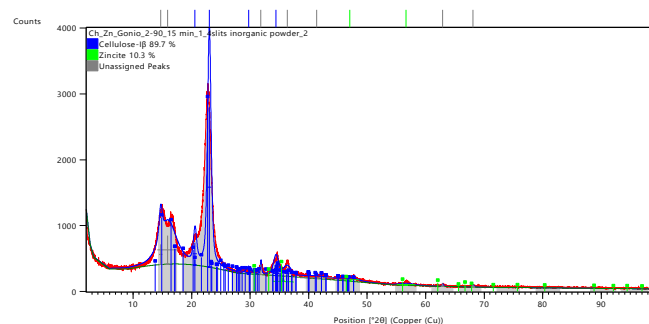


Fig. 6. Diffraction pattern of textile sample ChZn measured with 3D holder

Table 5: Pattern List of textile sample Ch Zn

Ref. Code	Compound Name	Displ.[°2θ]	Scale Fac.	Chem. Formula
00-060-1502	Cellulose-Iβ	0.058	0.634	(C ₆ H ₁₀ O ₅) _n
00-001-1136	Zinc Oxide	-1.132	0.045	Zn O

X-ray phase analysis of textile samples confirms the data from the chemical analysis for the presence or absence of zinc in the tested samples (**Tables 4, 5**).

For examination of the phase composition of the alloy sample - 2 leva the same holders were used as those used in the WDXRF chemical analysis of the alloys (**Fig. 4**)

The results from PXRD confirm those of WDXRF e.g. that the sample in a 3D holder with a diameter of 25 mm is an alloy of Cu, Mn, Ni and Fe (**Fig.7, Tables 3,6**). Phase analysis shows that the sample measured by the conventional holder only on the white part contains Fe and Ni (**Fig. 8, Table 7**). The results of the chemical analysis show mainly copper, zinc and a little nickel, but it should be noted that the study was conducted only on the yellow part of the 2 leva with 3D holder, a diameter of 20 mm (Table .3).

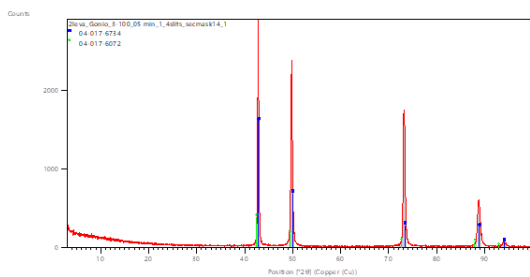


Fig. 7. Diffraction pattern of alloys from 2 leva measured with 3D holder – 25mm diameter

Table 6: Pattern List of alloy sample 2 leva the yellow part

Ref. Code	Compound Name	Displ.[°2θ]	Scale Fac.	Chem. Formula
04-017-734	Copper	0.000	0.553	Cu _{0.10}
	Manganese			Mn _{0.40}
	Nickel			Ni _{0.50}
04-017-072	Iron	0.000	0.130	Fe

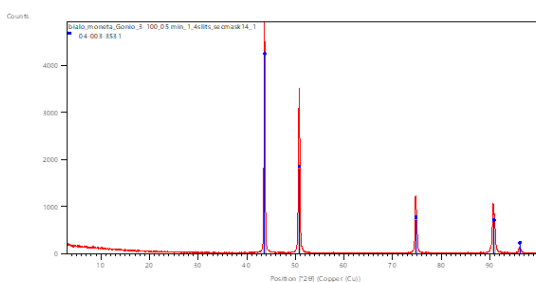


Fig. 8. Diffraction pattern of alloys from 2 leva measured with 3D holder – 20mm diameter

Table 7: Pattern List of alloy sample 2 leva the white part

Ref. Code	Compound Name	Displ.[°2θ]	Scale Fac.	Chem. Formula
04-003-3531	Iron Nickel	0.000	0.851	Fe _{0.5} Ni _{0.5}

4. Conclusions

Our experiments have shown that commercially available 3D printers and materials for it can be successfully applied in the field of science research. The advantages are the low price and

affordability of the products. Another indisputable positive is that a holder can be made according to the type and size of the sample.

Acknowledgements

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An overview of existing methods for evaluating mobile applications to change user behavior

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Abstract: *Advances in behavioral science are growing and technologies and portable devices are evolving. Taking into account the characteristics of human behavior and existing biases and heuristics, better and more effective applications can be designed to influence the acquisition and development of positive habits such as goal setting and achievement. This includes goals such as sports, healthy eating, acquisition of daily routine self-care skills, timely medication and more in order to gain self-confidence, confidence and develop an identity. This article will review existing methods for evaluating and synthesis behavioral interventions. The results of the study will be used to build an application to achieve goals.*

Keywords: BEHAVIOR CHANGE, TECHNIQUES, TAXONOMY, INTERVENTIONS, HEALTH BEHAVIOURS, BEHAVIOR CHANGE TECHNIQUE, ASSESSMENT, RATING, SCALE DEVELOPMENT

1. Introduction

In the age of digitalization and communication, the needs of citizens, business and society as a whole and their requirements for the efficiency and effectiveness of digital technologies are changing.

Increasingly in the fast-paced dynamic daily life, it is technology that determines our behavior, our way of life. In most cases, our brains prefer shortcuts, automatic mode, and can be very easily engaged with the dynamic content offered by technologies such as television, the Internet, mobile devices and tablets. The web deprives us of the ability to concentrate, think deeply and think adequately. We can't keep our attention for long when we read, then "scan" or "look quickly" at the content, which is a sign that we are not only superficial, but also impulsive. Phones are the brain outside our body that we rely on more than our own brains. Technology has many advantages as well as many disadvantages.

According to Chawla, in [6] there are basically 7 categories of applications that are successfully used by users: Game applications, Business applications, Educational applications, Lifestyle applications, Entertainment applications, Utility applications, Travel applications. The most commonly used of them are Game Apps and Entertainment Apps, which when overused can lead to a sedentary lifestyle, and unplanned activity sooner or later leads to health problems such as obesity, negative thinking, depression and dissatisfaction from life. This is one of the shortcomings of technology.

One of the main benefits of using technology is that it can save us time to take advantage of and acquire or upgrade a skill [9], change our habits and improve our health, which is offered by Apps for a way of life [6]. These applications can be further categorized into three categories: applications in support of health professionals (for medical reference, such as drug forms); applications aimed at patients with specific conditions such as diabetes, etc. (applications that will inform consumers about the glycemic index of certain foods); and applications aimed at promoting healthy behavior (smoking cessation, physical activity, weight management and health improvement, etc.) [10].

Factors that influence behavior are the wide range of personal psychological, social and environmental factors (contextual) that are considered by the theory of behavior. Such factors are emotions, habits and routine actions. Behavior is a key factor in people's health, achievements and successes.

Behavior change is always associated with effort, work and leaving the comfort zone, which requires a long period of time to achieve. To achieve a change in behavior, technologies are those that can offer the possibility of implementation without or with the remote intervention of specialists and in a combination of interventions. The team of authors in [5] argues that "there is a need to improve the evaluation of the design, implementation and effectiveness of health promotion interventions carried out through technology". In [10] they are also of the opinion that there is a need

for quality control in the development of applications for changing health behavior. Therefore, in this article the focus will be on an overview of existing methods that influence the creation and evaluation of mobile applications related to changing consumer behavior.

2. Existing methods, tools and taxonomies for evaluating a mobile application to change user behaviour

The increased capabilities of mobile phones, tablets, computers are exploding in the number of mobile applications that can deliver behavioral interventions [10]. Behavioral interventions are often considered part of a complex system and in a digital environment as viable methods for presenting behavior in various applications for weight control, physical activity or goal management.

The aim of the study is to determine the currently available methods and good practices for the evaluation and synthesis of behavioral interventions to be used in the development of a goal management application.

3.1 Behavior change technique (BCT)

The Behavior Change Technique Version 1 (BCTTv1) was developed by 400 international behavior change experts and is a hierarchical taxonomy [1] of 93 different Behavior Change Techniques (BCT) based on evidence of effective behavior change [2]. These techniques are classified and grouped into 16 categories with definitions and examples presented in [1]. This development is funded by the Medical Research Council [1] and provides a standardized approach to classifying the content of health promotion interventions [5]. This is the most useful tool used by psychologists in clinical practice [2]. BCT is a reproducible component of an intervention aimed at:

- change or redirect causal processes that regulate behaviour [3]
- to clarify the active ingredients of interventions to change health behaviour in systematic reviews [5]
- allows for a better assessment of the effectiveness of specific intervention techniques [4]
- be used by practitioners and researchers.

BCTTv1 offers a reliable method for identifying, interpreting and applying the active ingredients of behavioral change interventions [1]. Defines in a wide range of behavioral techniques for interventions such as physical activity, alcohol use, adherence to drugs, condom use and behavior of health professionals [3], smoking cessation, HIV testing, mental health, vaccination, changing eating habits in adolescents, to promote healthy behavior using social media in a web-based environment [5]. This framework is based on three levers for behavior change - motivation, opportunity and ability [2].

4.2 The CALO-RE taxonomy

The CALO-RE taxonomy is an advanced taxonomy of behavioral change techniques and is based on the initial systematic development of Abraham and Michie [8]. The abbreviation CALO-

RE [7] comes from The Coventry, Aberdeen, and London - Refined, the places where all researchers have contributed to the improved taxonomy. They introduce additional classifications of behavioral change techniques with fewer conceptual problems, less overlap between elements, and is more comprehensive [4]. This taxonomy is a clear guide created by 40 behavioral change techniques for researchers and practitioners. Its aim is to propose the identification and classification of more effective techniques for physical activity and healthy eating in interventions [4].

Self-efficacy, attitudes, motivation, intentions and perceptions of risk are a set of psychological precursors of physical activity [4,7]. They lead to increased participation in physical activity.

The development of taxonomy offers [7]:

- for the correct mapping of the theoretical constructions in techniques for behavior change and more realistic testing of the effectiveness of the individual theoretical components within the intervention.
- optimizing overlapping elements or redundant elements of behavior change techniques driven by multiple theoretical components or frameworks.
- strengthening the link between theoretical knowledge and behavioral change techniques may allow researchers to discover the basic mechanisms of intention and behavior of physical activity.

5.3 Mechanisms of Action (MoAs)

The term 'mechanism of action' (MoAs) is used by healthcare providers, such as doctors, pharmacists and psychiatrists, when discussing the treatment of medical and mental illness [15]. Many actions that take place in our bodies occur through a specific series of machine-like events and go through some mechanism of action (MoAs) to be performed.

MoAs are a set of theoretical constructions that can be characteristics of the individual (intrapersonal psychological processes) and characteristics of the social and physical environment (social support). They are defined as elements representing "beliefs about abilities", "knowledge" and "regulation of behavior", etc. [3].

It has been found that goal setting and self-control are related to techniques for self-regulated behavior and increased effectiveness in interventions aimed at diet and physical activity. These interventions can be applied on an individual level, in close relationships (family environment) [17] or in a group [16], with the influence of small groups offering social support and shared hope for personal change. In (fig. 1) presents a guide to the MRC process [16] for working with complex interventions. The common processes that may occur in group interventions should be described and evaluated "(1) how they are delivered and implemented (fidelity and quality of execution), (2) their mechanisms of action (causal processes that generate change) and (3) whether or not and how they can work differently in different settings and contexts (contextual influences)" [16].

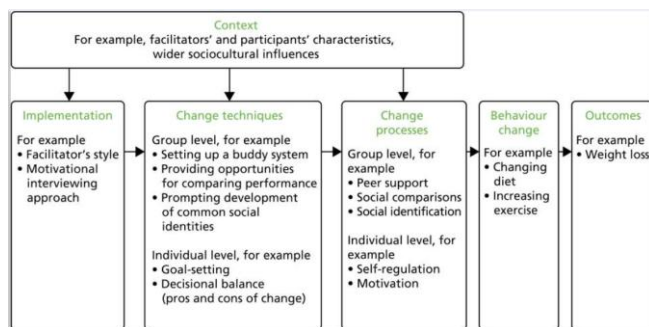


Fig. 1 Components influencing behavior change and outcomes in group interventions. *Грешка! Источникът на препратката не е намерен.*

6.3.1 The relationship between BCT and MoAs and its frequency

The link between BCT and MoAs is important not only for the development but also for the evaluation of interventions. In [3], 2636 summary hypothetical BCT-MoA relationships between 70 BCTs and 25 MoAs were identified, presented in two tables defining the relative frequency of BCT-MoAs and a heat map visually representing the frequency of BCT-MoA bonds with for easier interpretation. The first table in [3] describes the most commonly associated 51 BCT and MoA, which reflect hypothetical causal pathways. The second table presents the most commonly associated 24 MoAs with BCT. All of them can be used as a starting point and improvement of methods for design and evaluation of interventions, and can be used to develop a framework for designing and conducting empirical tests of BCT-MoA relationships.

Factors that facilitate behavior change, for example, may be:

- BCT "step tasks" - "setting easy tasks to perform, making them increasingly difficult but achievable until the behavior is completed"
- BCT "Restructuring the social environment" - "change or advice to change the social environment to facilitate the implementation of desired behavior or to create barriers to unwanted behavior"

Table 1: The most common connections are between BCT and MoAs

BCT - intuitive	MoAs
action planning	goal setting (behavior)
Solving problems	Beliefs in Abilities Environmental context and resources Skills
Health Information	Health Information Knowledge Conviction of Consequences Attitude to behavior Perceiving Sensitivity / Vulnerability Intention
Behavior Demonstration	Social Learning / Imitation
Expected regret Information about emotional consequences	Emotion
Behavioral practice / rehearsal, Demonstration of Behavior Verbal persuasion of abilities	Beliefs about abilities
Instructions on how to perform the behavior	
	Intention
BCT - less obvious	MoAs
Mental rehearsal for successful presentation	Valuables

Table 2: Specific relationships between BCT and MoAs

BCT - intuitive	MoAs
Behavior Demonstration	Social Learning / Imitation
Information on health effects Significance of the consequences Information on social and environmental consequences Information on emotional consequences Pluses and minuses Material incentive (behavior) Paste / Reframe Incompatible beliefs	Attitude to behavior
Information on health effects	Knowledge Beliefs about the consequences Intention Attitude to behavior Perceiving Sensitivity / Vulnerability

According to [3], the choice of BCT is made on the basis of Bandura's theory of self-efficacy - the stimulating attempt to master through behavioral practice.

7.4 Behavior Change Wheel (BCW)

Behavior Change Wheel (BCW) has been developed from 19 behavioral change frameworks, but none of these frameworks have been found to be exhaustive. The BCW model is also known as COM-B and is a systematic way of characterizing the intervention. BCW is designed to support the design of the intervention and to improve the intervention evaluation process. Outcomes can be related to mechanisms of action (MoA) and diagnose why an intervention does not achieve the desired goal. COM-B and BCW analysis provide a broader approach to addressing the issue, while addressing issues of ability (example: appropriate and convenient way to raise the topic of smoking that is rewarding) and opportunities (example: compliance) with advice for a short period of time [13]. BCW is designed to answer the question of whether an intervention strategy meets or does not meet expectations. This is not a behavior change plan, but an opportunity to use the available resources to achieve a strategy [13].

The process of designing behavioral change interventions involves understanding target behavior and designing specific behavioral change techniques [12].

The BCW model aims to address the constraints that behavior is driven primarily by beliefs and perceptions, unconscious biases, or the social environment by synthesizing the general characteristics of frameworks and linking them to a pattern of behavior to be applicable in any environment [13]. COM-B is useful because it ensures that the designer of the intervention will not be involved in thinking on one level only.

The BCW model consists of three layers (fig. 2). The first innermost level, using the COM-B model, determines the sources of behavior. The next level offers nine intervention functions, which are selected depending on the specific COM-B analysis. The third outermost level presents seven types of policies that can be used to provide these functions (example: educational, persuasive) to interventions.

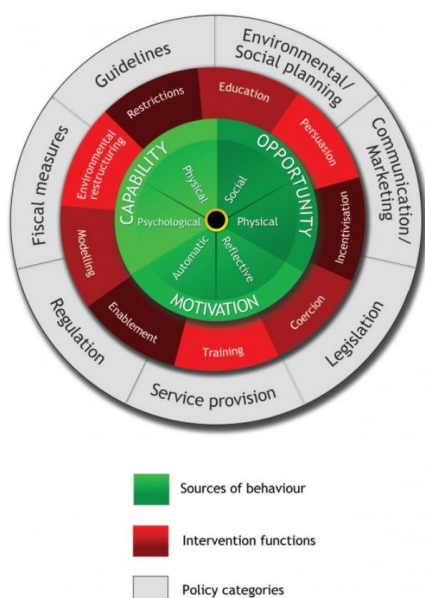


Fig. 2 Behavior Change Wheel.

The following should be considered when using BCW:

- The conditions in which a behavior takes place can be changed and therefore there is no specific practical method for the direct evaluation of interventions.

- In the absence of relevant evidence, assessment is the first principle for designing interventions. But if there is evidence, it should not be replaced by assessment.

- The time and resources to develop an intervention strategy will depend on the importance of the problem and the needs of the situation.

Intervention design can be more systematic using the MINDSPACE framework preferred by the UK government and Intervention Mapping, an approach that has been adopted in a number of other countries. None of these frameworks covers the full range of available intervention options that may be important and are indeed covered by other frameworks [13].

2.5 Application quality assessment tool

In [10], a tool for evaluating the quality of the application and its implementation is proposed, which is systematic and time-consuming (approximately 30 minutes per application). This tool offers nine key questions to be answered when creating an application and then assessing the quality of an application to change health behavior: 1. The purpose of the application, 2. Planning and development of the application (cooperation with the target group - users / professionals), 3. Usability (to include some special features for those with special needs (such as the ability to change the font size or read the text aloud)), 4. Initial assessment and adaptation (possibly subjective), 5. Behavior change techniques used (to make changes in the environment to maintain a change in behavior; self-monitoring; feedback on a behavior or its result; prioritizing actions in their plans), 6. Maintaining behavior and recurrence prevention, 7. Application evaluation, 8. Documentation and 9. Data protection. The tool can generate dialogue between clinician, application developers, patients, regulators and be used by application developers to improve the quality of applications and contained a relatively large number of questions.

2.6 Quality dimensions

According to [14], Maxwell proposes six dimensions of healthcare quality: accessibility (easy access to all patient groups), relevance to community needs, efficiency, equity (fairness in distribution), acceptability, efficiency and cost-effectiveness. Low price). And Donabedian offers three key elements on the quality of healthcare: structure (facilities and health professionals available), process (actions through which health care is provided) and results (results of actions). These quality measures were developed before the existence of mobile phones.

A measure of reliability for the presence or absence of BCTs can be established by calculating Cohen kappa corrected deviation statistics (PABAK).

2.7 Mobile Application Rating Scale (MARS) and ENLIGHT scale

The MARS scale is a multidimensional tool most widely used to assess the quality of MHA, containing four dimensions: engagement (5 elements: fun, interest, individual adaptability, interactivity, target group), functionality (4 elements: performance, usability, navigation, design of gestures), aesthetics (3 elements: layout, graphics, visual appeal) and quality of information (7 elements: accuracy of application description, objectives, quality of information, amount of information, quality of visual information, reliability, evidence base). Items rated 1 to 5 (1-inadequate, 2-poor, 3-acceptable, 4-good and 5-excellent).

The ENLIGHT scale is a quality assessment tool for MHA containing seven dimensions: usability (3 items), visual design (3 items), user engagement (5 items), content (4 items), therapeutic persuasiveness (7 items), therapeutic union (3 points), and general subjective assessment. Items are rated from 1 (= very bad) to 5 (= very good).

In [18] the constructive validity of MARS is evaluated and the simultaneous validity between MARS and ENLIGHT is determined

by correlation. It is found that there is a high correlation and good parallel validity between the two rating scales. MARS can become a reliable tool for assessing the quality of MHA.

In [11] it is a guide to international methods for evaluating health medical applications in the digital environment, where variants of the MARS instrument are presented.

3. Strategies and applicability of assessment methods in the digital environment

To improve the design of more effective interventions, a clearer understanding of the processes by which individual BCTs have their effects is needed. It is necessary to first have an understanding of the target behavior and then to use specific techniques in designing a behavior change intervention [12]. In order for an intervention to show that it leads to a change in behavior, it must be long-term enough, because a change in behavior takes time. In [13] argues that all behavior change interventions operate in a social context, and effectiveness is the only criterion for designing an intervention. The process of designing interventions presented in (fig. 3) is linear, but it is possible that there is a cycle between some of the steps. This makes this approach flexible.

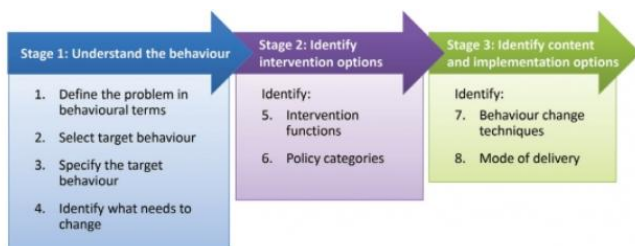


Fig. 3 Behavior change intervention design process.

Automated health behavior tracking offers the ability to track and collect data on users' location, movement, emotions, and social engagement. Mobile phones have many advantages: low cost; can collect, analyze and transmit data; provide location data; to assess the mode and speed of travel, etc. All these advantages predispose to tracking the status or use of text messages as a kind of warning, reminder to change behavior [10, 14]. Such interventions can be cheaper and more convenient, and partially replace professional care (in the absence of staff).

According to [10], most applications are not so much focused on behavior change as on intervention. Applications that promote self-control of diet and exercise according to [10] have been shown to reduce waist circumference and increase physical activity and diabetes control. It is argued that none of the applications studied encourage consideration of goal setting and then maintenance. Other applications according to [10] "ensure that feedback and monitoring last at least one year and encourage the development of a routine."

Another study [12] showed that "active video games" promote physical interactivity, lead to moderate activity and change in behavior, especially in children. Fun and interactive technologies (video games) can initiate better activity in conjunction with cycling compared to traditional training [12]. And in weight loss interventions it is found that receiving 2-5 personalized SMS per day, tips and questions on various topics has led to weight loss more than receiving only printed materials for weight control.

According to [14], studies with 400 Physical Activity (PA) applications have found that each application contains at least one BCT, with an average of 7 and a maximum of 13 BCT, and that for none of them a user is not involved in their development, they have been developed rapidly for commercial purposes and with the rare involvement of experts, there is no evidence of their effectiveness and alternative methods of evaluating applications are needed. The most common BCTs are feedback and monitoring, goal setting and action planning, and self-regulatory strategies are effective in increasing physical activity. There is no evidence that BCT can

increase behavioral change. Only 3 out of 9 BCTs were used in the BCT "Objectives and Planning" group. The most commonly used BCTs in physical activity applications are feedback on content behavior and quality. Evidence and theoretical frameworks are vital in developing behavioral change interventions.

According to [5], the Internet provides interventions that can be effective in promoting health and changing health behaviors. The need for the implementation and effectiveness of interventions to promote health and improve design evaluation through social media technologies is emphasized. It is argued that the behavioral mechanisms of social media interventions can have a positive impact by emphasizing the use of BCTs for goal setting and self-control in adolescents' diets, for self-directed activities such as tracking diary steps or using a pedometer in interactive social media. Several studies have found BCTs, such as explicit approval and virtual rewards, that influence individual attitudes and health behaviors. Approvals can be as positive messages from participants, forwarding emails and comments, likes on Facebook and Twitter. Virtual rewards such as likes, smiles, congratulations, badges, virtual gifts or stars are built into the design of the intervention to recognize the achievements of the participants. Studies have shown that the most common BCT on social media are social support, instructions on how to perform the behavior, a reliable source, social comparison, information on health consequences, instructions on how to perform the behavior, self-control of behavior, goal setting behavior, adding objects to the environment. It is emphasized that BCTs for goal setting and action planning have been used very little in the included studies.

In [19] the development of an application for weight monitoring is presented. Before the design of the application, a study was conducted on behavioral strategies, stating that self-monitoring is a "cornerstone" and problem-solving is an "active ingredient" in behavioral weight loss interventions. It has been found that people who use an application to overcome depression (problem solving) recover much faster than others who do not use the application. In order to evaluate the application on the feasibility, acceptability and use of the application, users were tested within 8 weeks and together with the application offers guidance and support through membership in a Facebook group. This is one of the ways an application can be useful together with an included social element. The results of the study show that applications may support behavior change.

4. Conclusion

The design and development of digital products and services requires multidisciplinary skills and an understanding of the contextual experience of potential users [14]. Behavioral interventions are often used to increase self-efficacy and aim to change behavior, which is a key factor in human health. The influence and support of relatives, the partner [17] are a social factor that indicates an influence on behavior change. Despite the huge amount of research, there is still insufficient evidence that digital interventions with individual factors improve people's ability to regulate their behavior.

Given the most common links between BCT and MoAs, the Behavior Change Wheel, the MARS, ENLIGHT Quality Assessment Tools or Scales, and the applicability of behavior change and assessment methods in the digital environment, it can be concluded that they are all necessary tools and shared experience for future application development. Existing methods and tools for developing and evaluating health mobile applications aim to help application developers anticipate the use of behavioral taxonomies in order to increase the trust, usability of users and clinics. The researches conducted on existing digital applications and the interventions used in them, their testing with users and their evaluation is an invaluable starting point that will be taken into account when creating an application for goal management.

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Logistics models – hybrid components

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SUMMARY: In this report we consider one of the fastest growing aspects of the business namely E-Logistics and its characteristics. The main purpose is to make comparison between E-Logistics and the traditional type of logistics, point out the advantages and the disadvantages, as well as the main principals of integration of the E-Logistics, and the opportunity for choosing hybrids between the different combinations of the principals for both types of logistics.

KEY WORDS: E-Logistics, Elements of the logistic service, Logistics Models, Hybrid components

1. Introduction

Basic aspects and principals of the E-Logistic

The main information flows, moving inside and between the elements of the logistics system and the external environment form the logistics information system (LIS), which represent composition of Interconnected electronic sets, computer technology, as well as the software devices needed, supplying the correct answers to the functional tasks for the right management of the material flow. The information systems in the logistics are created to manage and handle the material flows in micro and macro-levels and on the basics of the different organization are divided into:

- planned;
- dispositive;
- operational.

In accordance to the logistics conception, the information systems related to different groups are integrated in one main information system with vertical and horizontal integration:

- the vertical integration is the link between the planned, the dispositive and the operational system, using vertical information flows;
- the horizontal integration is the link between the different tasks in the dispositive and the operational systems, using horizontal information flows. (2)

Logistics of the material flows

The highly automated logistic system (E-LIS) is new type of system, which is characterized as a system of interconnection of the computer technologies and the artificial intellect (AI) with the logistic processes in the frame of the company. LIS in correlation with the information system of the company, that provides correct information for organizing and implementation of the planning and execution of the logistics operations, form and define the E- LIS.

The methodological sequence of the problem solution is :

- defining E-LIS as an element of the company's automated information system;
- choosing the components that must be included in the E- LIS;
- synchronization and functional compatibility;
- structure of the components that define the system, making it main operational base;
- system marks that define the levels of recognition in the frame of the organization;
- concurrence of digitization, contemporary methods and high level of information system in the frame of the organization.

2. E-Logistics

E-LIS is a fundamental defying element of the company's information system. It is considered as an element of the company's information system because it works only if it is on the same E-Level as company's as it is shown at figure 1.

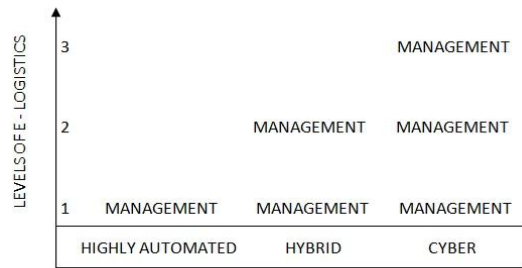


Figure 1.E-LIS

Therefore the digitization of the logistic activities, as an element of the overall company's development are also considered as complex decision via digitization of all company's main activities. The Impossibility or the reluctance of the company to install E-LIS as an irrevocable part of company's activities leads to impossibility of the organization to follow current trends and processes making it unstable to the processes in the environment. (2)

The functional dependence between E-LIS and the internal and external connections can be expressed with the following dependence:

$$E-LIS = F(S_v, S_w)$$

where S_v - Internal Connections;
 S_w - External Connections. (2)

The internal-structural interconnections are being explored and arranged by significance and affiliation in the E- LIS definitions. Here are also the interconnections of the logistics of the material flow and this is opportunity for using digital logistic information system, related to the material flow of the company. This includes establishment of virtual logistic model in the virtual reality. The external interconnections are related to the different types of logistic systems, including the connections with the external suppliers and clients.(1,2,3).

2.1. E-LIS Features

E-Logistics makes planning, execution and control of the logistic activities or tasks possible by using Internet technologies with the objective of economical improvement of the logistic services and improving the cooperation between the Supply Chain partners.

The prerequisites and conditions for the realization of E- Logistics are:

- integration of web based systems in the portfolio of the already existing ones;
- development of the classic organizational processes and procedures and their adjustment in the modern E-LIS system;
- inter-company and inter-departmental cooperation with main goal of focusing of all the partners in the supply chain to overcome any information barriers.

We should not underestimate the complexity of integration of the electronic logistics solutions in the already existing infrastructures and applications (2).

E-Logistics is the collective expression of logistics decisions taken in the frame of the organization, which are defined by electronics. At figure 2 we can see the connections between the components in the frame of the E Logistics.(2,9)

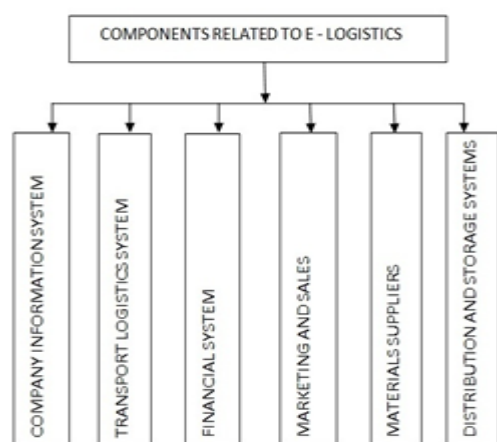


Figure 2. Connections between the components related to E-Logistics

These respective components are:

- company's information system, that gives an opportunity for quality execution of the logistics service;
- clients service system and opportunity for expanding the scope of operations and through high quality of execution to attract new ones;
- transport management;
- multi-channel distribution points and their equalization adopted in the frame of the company's integrated E-LIS;
- effective financial management and opportunity of higher level of monitoring;
- effective sales and marketing management, directed to clients and company necessities;
- correlation between suppliers and the buyers (2,9,10)

E-LIS provides opportunity for broad spectrum activities as well as opportunity for pooling maximum number of inner systems in one completed system, that provide high level of control, financial discipline and optimal use of the company's resources. But often the difficulties during installing that kind of systems in the frame of the organization such as:

- higher financial value;
- lack of well-trained staff;
- insufficient desire for development and progress in the face of the executives;
- potential losses of resources and clients, provoke the entrepreneurs to ask themselves what are the advantages of the E-LIS over the traditional logistics and the what is differences between the two types of logistics. These differences are revealed during comparison between the following circumstances that occur during logistics' services execution:

- Shipment Size – within with the traditional logistics the shipment size is high volume, looking for large capacity for maximum return, whereas during the E-LIS we look for small packages that provide an opportunity for decentralization end points of consumption.

- Clients – within the traditional logistics we have fixed markets, where the risk is minimized, because of the good market knowledge. On the other hand within the E-LIS there are clients' anonymity, but it provides opportunity for infinity in their type, size or number.

- Material Flow – within the traditional logistics is one way direction, while in the frame of E-LIS is two-way direction.

- Destinations – within the traditional logistics they are concentrated around a defined distribution center, while within the E-LIS the objects are scattered but that gives an opportunity for "seizing new territories".

- Model - within the traditional logistics we have stable and predictable model, while within E-LIS we have model that is variable and unpredictable but enabling opportunities for development and growth.

- Responsibility - within the traditional logistics is only for the logistic department, while within the E-Logistics the whole supply chain is responsible for the quality execution. (6)

2.2. E-Logistics. Advantages and Disadvantages

The E-Logistics consists of various configurations and while choosing specific configuration or hybrid of the different types this choice should be based on good knowledge of the following factors in the frame of the company or its environment:

- Financial factor;
- Personnel factor;
- Customer's need factor.

After careful analysis the company can proceed to choosing one or hybrid of the following principals of the E-LIS:

1. E-Logistics is being integrated directly to company's distribution network and via this method direct deliveries to the customer can be executed. The company makes personnel and resources corrections in the already existing delivery centers, therefore to execute large volumes of small deliveries. Main advantage is that the system can be quickly installed and adapt in company's framework and demands small amount of investments. Possible disadvantages are the risk of failure and a chance for a negative changes. I already existing and well working processes, as well as cost increase.

2. E-Logistics is being initiated in a separate distribution center, whence the deliveries are made. The advantage of this process is that it can be controlled and monitored by the company from the beginning until the final execution of the logistic service. Possible disadvantages are lack of flexibility during execution as well as risk of losing already established clients because of poor execution.

3. E-Logistic is performed by specialized external supplier. Main advantage is the chance of quick growing, because of the use of the expertise and already created infrastructure of the external supplier, but this can also lead to profit reduction, risk of information leaking about the company because of the fact that we use broker, who is independent from the company and the processes ongoing inside the organization.

4. E-Logistics is performed by a merchant, who is independent from the organization and the supplier delivers directly to the client. (Dropshipping). Disadvantages are strong dependence from suppliers execution as well as the complexity of combining several different products in one single delivery. On the other hand we have lowering handling operations costs and provides opportunity for efficient use of the stock.

5. E-Logistics is being performed through already existing infrastructure directly to the client (straight from the distribution center to the client or the client picks up the good on spot). The advantage is this is simple logistics decision, that does not requires extra effort or investments in short term. But in long term consideration this is not applicable because of the dynamic changes in the environment as well as the fact that in time progress it starts to exhaust additional company resources (from the distribution center to the client) or causes problems and difficulties for the client (when he picks it up on spot).

6. E-Logistic is being organized via already existing distributional networks as the shipment reaches to the client via existing storages which the client picks them up by his own (Flow-through process). Main advantage is the possibility for direct contact to the client including the opportunity of offering him additional services. The main risk is that while the company invests resources in the quality service to the client, he can lose his interest or his need to be disposable. (4,6)

2.3. Logistic Models

Every entrepreneur, who wants to trade via Internet is always facing the dilemma concerning the right logistic model for his business. What type of model should be chosen depends on different factors as financial resources, knowledge and usage of information technologies. The correct judgment of your own resources at one hand and the correct fixing of the needs of the consumer on the other hand can define the difference between success and failure. Customer's needs have imposed certain types of logistic models and in this case we can also choose one model or within company's development you can impose hybrid of several logistic models. A lot of models are used most often the essence of logistics and only way for quality execution is hybrid between these several models:

- *Own Warehouse* - Main advantages are quick execution, high level of conversion of the investment, as well as independence to all kinds of suppliers. Disadvantages are the necessity to "lock up" financial resources for indefinite period of time, small scope of products, risk of misjudgment of market's demands, high maintenance costs of the warehouse itself, salaries cost, depreciation costs.

- *Just In Time* - The advantages are low initial investment, opportunity for larger scope of the products, because the production or its delivery depends on market or customer's demands, as well as investment security and logistics execution security. The main disadvantages are the demand for excellent synchronous with the supplier, risk of delay during the logistics execution, because of lack or shortage or variety of specific goods, low level of conversion, as often the amount of the costs cannot be covered by the amount of the income, as regularly it can be even in the negative way.

- *Dropshipping* - The advantages are the low initial investment, opportunity for larger scope of action thanks to the larger range of products. In this model there are high level of conversion of the material flows, high level of investment security, as well as very rapid logistic service execution. Disadvantages are the demand for excellent synchronous with the supplier, dependence on his execution, shortage of goods or quantity and also this is very complex model for the suppliers that provides complex financial dealings and payment methods.

- *Extending Shop* - The advantages are basically the same as within the Dropshipping such as the low initial investment, opportunity for larger scope of action, high level of conversion of the material flow, high level of security during execution, small level of risk, rapid execution of the deliveries to the client. In this model there are no need of direct contact with the client. The main disadvantages are the difficult dealings with the clients (attraction and retention) because of the lack of direct contact with the client. The contact with the client is made by mediator and its presence (the mediator) makes the rate of return very low.

- *Freight Brokering* - The advantages are the simple level of logistics, larger scope of the activities, low cost and high level of investment conversion. The disadvantages are the extended period of time required for the deliveries, the risk of mistakes and the impossibility of controlling the whole process.

- *Fulfillment* - The company from the outside runs a full range of online store magazines. All deliveries flow into the warehouse. The company operating the warehouse deals with the sending of parcels and packaging. The payer pays for individual services performed for him. It can be, among others accepting products into the warehouse, storage itself, e.g. charges per item, packaging a package, packaging. In many cases, this is a beneficial solution, especially for websites that sell seasonal products, because you do not have to constantly maintain storage space and incur costs with hiring employees to operate it. In the case of large websites that trade all year round with a large assortment, the costs of fulfilling the service may exceed the costs of maintaining their own warehouse. In this case, a detailed calculation and cost comparison is needed.(5)

3. E-LIS hybrid model

The main difference between E-LIS and the other types of information systems is the level of integration of the information space. The systematization of concepts in this field of study allows three different approaches to define E-LIS:

- E-LIS is integral part of the corporate information system;
- E-LIS is higher degree of integration in the software decisions and also includes corporate information system;
- E-LIS is independent structure, isolated from other information systems.

It is therefore obvious that E-LIS is the essence of high category part of the Corporate Information System (CIS), because it includes distribution of products, purchase of materials and their transport, which is outside of automated functions, which means that LIS has higher degree of integration than CIS. On figure 3 is shown the advantage of LIS.



Figure 3. Advantages of E-LIS

The specificity of E-LIS is defined by the fact that flow management is performed in the frames of the business organization, as well as between the different participants in the logistic chain. In relation to this the information flows are divided into two types:

- Strategic (Coordinating);
- Functional (2).

Conclusion

The research shows that while the E-Business gathers all the attention, the E-Logistics stays away from the common model and is neglected as a main part of the business itself. Decisive for the success of the business is that eventually the stock or the service should reach the client. This leads to the conclusion that the main factor that measures the success is the high quality logistics execution, because no matter all the difficulties such as finding and define the client himself if the logistic service is not on a high level of execution, the client cannot be kept in the future. Deployment of the whole supply chain of the company on the principals of the E-LIS provides large amount of sustainability of the logistics processes in the frame of the organization and ensures that the company itself to develop in parallel with the direction of development of the customer's demands.

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Examination of the category of digitalisation of public services in the Digital Economy and Society Index among the Eastern Enlargement of EU

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Abstract: The European Commission pays particular attention to the digital development of the economy and society. The Digital Economy and Society Index (DESI) has been an essential tool for measurement and monitoring since 2014. In 2021, the cardinal indicators of the DESI index were aligned with the 2030 Digital Compass targets, which have four key areas: digitally skilled population; secure and sustainable digital infrastructures; the digital transformation of businesses, and digitalisation of public services. In the present study, the authors examined the development of digital public services over the past five years, using σ -convergence to measure differences between the Member States and β -convergence to examine how countries could catch up. The individual indicators under the digital public service category have also been analysed to identify critical areas that need to be developed in the future for the digital public service to catch up with the leading Member States. The areas most needing improvement were user-centricity, transparency, and cyber security.

Keywords: DIGITALISATION, DESI INDEX, PUBLIC SECTOR, DIGITAL COMPASS, CONVERGENCE

1. Introduction

The competitiveness of the European economy depends on a knowledge-based economy and support for research and development (R&D). While the former is closely linked to human capital development and its qualitative improvement, R&D activities presuppose the integration and development of information and communication technology (ICT)[1]. Since the 2000s, the European Union has given high priority to digital transformation: the Lisbon Strategy (2000), the Europe 2020 Strategy (2010) and the 2030 Digital Compass (2021). The latter package of measures, which aims to achieve Europe's complete digital transformation by 2030, was also called for by Covid-19, which will radically change the way we live today from 2020. Europe's digital transformation was summarised in four points: digitally skilled population, secure and sustainable digital infrastructures, the digital transformation of businesses, and digitalisation of public services, based on OECD guidelines and recommendations [2]. Two major policy initiatives will shape the EU's digital transformation in the coming years: the Recovery and Resilience Facility (RRF) and Digital Decade Compass [3]. In order to achieve the objectives quickly and on schedule, the proposed governance framework is based on the enhanced Digital Economy and Society Index (DESI), which has been tracking Member States' digital progress since 2014, as digitisation can only be achieved within a coherent and coordinated strategy, for which continuous measurement and monitoring is an essential tool. [4,5]. Thanks to the two policy initiatives outlined above, from 2021 onwards, DESI reports will have to include the digital reforms and investments made in the current year.

The DESI index currently aggregates the scores of 33 individual indicators and ranks the EU Member States according to a weighting system measuring digital performance and monitoring their progress. The assessment published in a given year is based on the previous year's data, so it always shows the year's results already closed. Therefore, the DESI index assessments published between 2016 and 2021 reflect 2015-2020. The European Commission collects the data included in the index from the Member States' competent authorities and various studies carried out by the Commission.

Adapting e-government measures is as challenging as it is beneficial. Its benefits include increased openness and transparency towards citizens and businesses and faster, more efficient and more accurate administration. However, there is a significant challenge in storing and using data securely and ensuring interoperability. During the first year of the pandemic, all EU governments have created or developed digital platforms within the framework of the RRF adopted by the European Council.

Our study proposes determining whether the fourth core indicator of the DESI index (desi_4), which tracks the development of digital public services in the EU Member States over the period

2016-2021, shows progress, convergence in performance, or convergence of Member States. We have focused on digital public services in Bulgaria, Hungary, and Romania to show the focus, gaps, and why.

2. Materials and Methods

The σ -convergence refers to the reduction of differences between regions over time, particularly between the Member States, while β -convergence focuses on identifying a possible catching-up process.

The σ -convergence (relative standard deviation or coefficient of variation) is a coefficient of variation that allows the comparison of multitudes or samples with different averages and characteristics. In our case, we work with a model of DESI index values, period 2016–2021. The coefficient of variation is the average relative deviation of the importance of the criteria from the mean, expressed as a percentage. If the dispersion of development levels decreases over time, we speak of σ -convergence. The calculation of relative dispersion is given by the formula: $V\% = \sigma_i / \bar{x} * 100$, where σ_i is the standard deviation of the desi_4 indices at t time, $\bar{x}$ is the mean of the desi_4.

Another well-known convergence indicator in the empirical growth literature is the β -convergence introduced by Barro – Sala-i-Martin [6,7]. This growth indicator is based on the neoclassical growth theories of Ramsey [8], Solow [9] and Koopmans [10]. Based on the hypothesis of absolute β -convergence, the following equation expresses the empirical relationship between growth per Member State and the initial level of development:

$$1/(T-t_0-1) * \ln(x_{it}/x_{it_0}) = \alpha + \beta * \ln(x_{it_0}) + \varepsilon_i,$$

where $1/(T-t_0-1) * \ln(x_{it}/x_{it_0})$ the average annual growth rate of the desi_4 index values for the i Member State; t_0 the start year; T represent the end year; x_{it_0} initial level of development of the desi_4 index; ε_i the error term assumed to be identically and independent distributed; α and β are the parameters to be estimated. In this expression, the initial level of development alone explains the rate of catching up. The strength of the effect is indicated by the sign and value of the β -coefficient. Univariate linear regression (OLS) was performed to estimate the α and β coefficients. However, the estimation would be fully explained and error-free only in the case of a perfect relationship ($r = 1$ or $r = -1$) and, therefore, ε_i is the error of the estimate. We use the least-squares procedure to minimise the squared error to estimate the coefficients α and β . We considered the β -coefficient to be significant only if the empirical significance level (p -value) was less than 5%. However, the concept of conditional convergence suggests that there is an excessive amount of unexplained information hidden in α and ε_i that needs to be extracted on a case-by-case basis. Still, in this case, we only tested absolute convergence.

After estimating the coefficient β , we can calculate the annual rate of convergence (constant progress rate):

$$\theta = -\ln(1+\beta*(T-t_0-1))/(T-t_0-1),$$

where β is the regression coefficient's value, T represents the end year, and t_0 represents the start year.

We used the R statistics software version 4.0.2 for our analyses [11].

3. Results

Desi_4, the digital public services dimension of the DESI index, tracks the progress of digitisation of public services in the EU Member States based on five individual indicators. In 2016, the desi_4 main indicator scores ranged from 8.5% to 68%, with most Member States in 50% to 60% (8 items) (Fig 1). The best performing Member States are Estonia, Malta, Denmark, Finland and Sweden. By 2021, the dispersion of the main indicator values has decreased, with most Member States in the range of 60% to 80% (12 countries). Estonia is the only country to score above 90% for e-government services, but Denmark, Finland, and Malta are top performers. The situation in Romania, which is below the 10% mark for digital public services, is very disappointing. Greece, although performing significantly better than Romania, is in second to last place (25.56%) compared to the other Member States. Unfortunately, there is no change at the bottom of the ranking, with Romania (21.48%) still far behind second-last place Greece (42%). Typically, the last third of the list comprises the countries that joined during the enlargement of Eastern Europe, except for Greece.

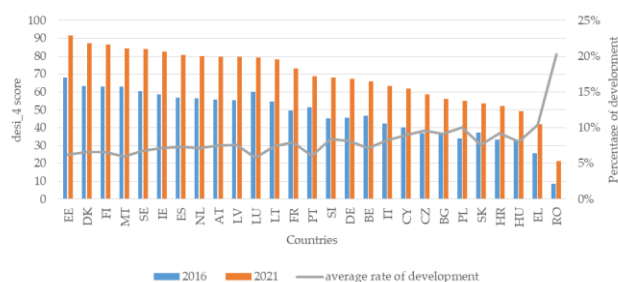


Fig 1. Country rank by desi_4 index in 2021—additional information from 2016 and the average rate of development.

Over the period 2016-2021, a slight convergence can be observed across the EU-27 Member States in the desi_4 main indicator. The data needed to perform the σ -convergence calculations are available in the DESI database [3]. The σ -convergence was analysed in three units: first for the EU-27 as a whole, then for the EU-14 countries, and finally for the group of countries that joined the EU during the Eastern European enlargements (2004, 2007, and 2013). In all three units, there is a very slight convergence of Member States, with only the countries that joined the EU during the eastern enlargements showing a higher reduction in the dispersion of digital public services (Fig 2).

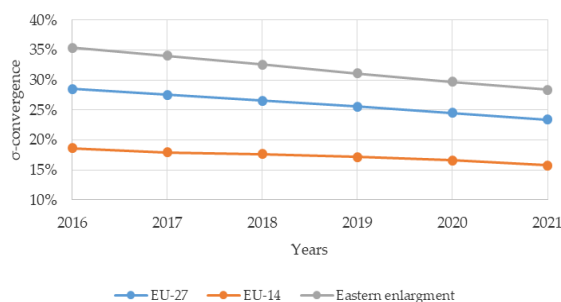


Fig 2. σ -convergence of desi_4 main indicator between 2016-2021

Over the period 2016 - 2021, EU Member States were characterised by β -convergence, i.e. a negative correlation between

initial development levels and the average volume growth rate of desi_4 (Table 1) and (Fig 3)). The linear relationship is strong ($R^2 = 0,906$), and the regression equation in the figure shows that the EU had a very high rate of β -convergence, i.e. the rate of narrowing of the development gap, averaging 6.46% per year. The regression coefficient can be considered significant as the p-value ($2,3 \times 10^{-14}$) is less than $\alpha (0,05)$.

Table 1. OLS regression of desi_4 main indicator

Obs.	R ²	Const.	β	θ	t-stat.	p-val.
27	0,9064	0,2883	-0,0552	6,46%	-15,5599	2,3E-14

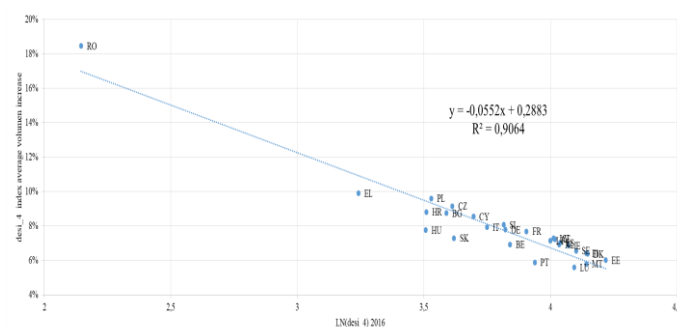


Fig 3. β -Convergence of desi_4 main indicator

The growth rate of the desi_4 main indicator was higher in countries with a lower initial value (e.g. Romania, Poland, Greece, Cyprus) and lower in countries with a higher initial value (e.g. Malta, Estonia, Denmark). The growth rate implies that countries that are less developed in terms of the desi_4 headline indicator are trying to catch up with the better performers. Romania is conspicuous by its lagging behind in digitising public services, being the worst performer for all individual indicators. Therefore, it is not surprising that it has the highest growth rate on average and also outperforms in terms of growth rate (+1.5%).

4. Discussion

In March 2021, the European Parliament adopted the Digital Agenda 2030: A European way to achieve the Digital Decade, in which the Digital Agenda oversee the Decade policy. To achieve the EU-wide digital goals by 2030, it set the following end-goals for the digitisation of public services:

1. 100% online delivery of key public services for EU citizens and businesses;
2. 100% of EU citizens have access to their health records;
3. 80% of EU citizens use a digital identity solution.

Looking at the absolute values of the desi_4 main indicator, the average rate of progress is very high, meaning that significant progress has been made in the digitisation of public services. Although progress is higher in the Eastern European and Balkan regions, they still do not influence the top ranking. Unfortunately, Bulgaria, Poland, Hungary and Romania have not significantly improved their positions, so the bottom of the list has not changed. The ranking of countries has not changed significantly based on the desi_4 core indicator. Some minor shifts were at the top, with Estonia maintaining its leading position and Luxembourg and Portugal slipping back into the middle.

The desi_4 core indicator groups five individual indicators: e-Government users, pre-filled forms, digital public services for citizens, digital public services for businesses and open data. Hungary scored above the EU average for e-Government services [12], as 70% of internet users have interacted with public administrations online in the past year. The figure is much lower (36%) in Bulgaria, while it is only 16% in Romania. Hungary

scores around the EU average for pre-filled forms, but Romania is far behind, scoring only 6 out of a possible 100 points.

Digital public services to citizens, an indicator is measuring the extent to which information and services are available to citizens digitally and how it is possible to take action online when issuing official documents (birth of a child, marriage, death, registration of address, etc.). In the case of Hungary, since January 2018, citizens have been able to act online and, if they have an electronic identity card, virtually all essential public services are available to them online. Those who do not yet have a new type of ID card will have to visit a government office before taking their first action online, but after that, the procedure is entirely online. Romania's performance in this respect is also inferior. In 2020 a supervisory authority was established (Autoritatea pentru Digitalizarea Romaniei – ADR) to coordinate digitalisation processes [13] coherently. Subsequently, several digitisation projects have been launched, mostly with non-reimbursable EU funding, with results expected later in 2023-2030. Projects have been launched in the last two years in the following areas: an electronic payment system, identification of barriers to the take-up of digitisation processes, the development of an e-health system, and the development of a digital action programme for the next ten years. Bulgaria's performance in this respect (57/100) is slightly better than Hungary and Romania but still well below the EU average.

Bulgaria's performance in providing digital public services to businesses (87/100) positions it towards the EU average (84/100), with a decisive role for the State e-Government Agency (SEGA), which is not only responsible for the overall project management of e-government reforms (solutions and resources) [14]. Since 2018, all institutions in Bulgaria have been required to use the Electronic Document Exchange platform, which contributes significantly to faster and more efficient administration. Further measures are planned for access to personal data, secure data storage and retrieval, and shared cloud infrastructure for public authorities. For businesses operating in Hungary, the use of the online system has been mandatory since 2018, but it needs further improvements, especially in terms of usability and user-friendly design. In Romania, the system also ranks last (49/100) for digital services for businesses, with serious shortcomings. The digital services system is rudimentary unstable, with insufficient capacity, little need, and low digital skills and motivation of public service ICT staff.

As an individual indicator, Open Access Data reflects the commitment of each government to 1) open data policies; 2) the impact of open data; 3) open data portals, and 4) the quality of open data. Bulgaria, Hungary and Romania are among the poorer performing countries in the area of open data. Their priority is to modernise their national portals and make them nationally accessible so that they are effectively capable of making data openly available. The quality of data publication is not yet a priority at this stage, nor is understanding the impact of open data.

In 2020, Bulgaria and Romania started working on several initiatives based on blockchain technology, involving both the private and public sectors. In a striking example, both states have established a node to connect to the European Blockchain Infrastructure for Services (EBSI) network. The project was funded by the European Commission, Innovation and Networks Executive Agency, Department Connecting Europe Facility (CEF). The project aims to accelerate the deployment of blockchain technology and its applications to individuals, companies, institutions and public bodies. A further objective is a ready-to-use decentralised digital services and reusable design for the future development of the infrastructure, enabling a solid cross-border foundation and interoperable trans-European digital communication for public and the public administration sector. Currently, three areas of use are targeted: European Self Sovereign Identity (ESSI), notarisation, and diplomas.

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Does Tourism 4.0 answers the needs of baby-boomers?

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Abstract: *New technologies have lately decisively entered our personal lives as well as penetrated our businesses, including tourism. Our paper discusses the role of technology in transformation of traditional high-touch services, co-created by tourism personnel, into high-tech services performed by tourists themselves in 'do-it-yourself' (DIY) way. The participant-observation research method has been applied to present the problem. The results point out certain types of services that are becoming hardly available to tourists without adequate digital equipment and certain technical competence. DIY type of services can be particularly challenging to the 'silver' tourists of the baby-boom cohort who are typically not as digitally competent as is younger travelling generation. The findings open serious questioning over general ability of tourists to physically, psychologically and culturally follow the pace of such technological change.*

KEYWORDS: TOURISM 4.0, NEW TECHNOLOGIES, BABY-BOOMERS, TOURISM SERVICES

1 Introduction

In 21st century, tourism industry has been speeding-up its growth generally thanks to favourable external economic factors. Subsequently to growth, the tourism services have adapted to socio-cultural (e.g. aging population) and technological changes (implementation of new technologies) in global environment.

Two demographical cohorts – baby-boomers and millennials – have in the new millennium become particularly important tourism segments. Baby-boomers are people born after the Second World War until mid-sixties while the millennials are those born between the 80ies and early 90ies (Santos et al., 2016, Kotler et al., 2017). These demographic cohorts represent two largest segments of tourists; however, the age difference contributes to their different approach in the way in which they organise travel and what kind of tourism services they prefer.

Among factors of external environment, the technological factors have significantly shaped the tourism ecosystem. Laptops, computer programs, smart phones and smart phone applications, information communication technologies (ICT) and high-speed internet (Bloomberg, 2018) enable tourists to design their travel to their preferences. On the other side, tourism services suppliers were able to implement new business models, generally highly supported by technology.

While the process of creation of tourism services in the 20th century was still predominantly people-oriented, in the new millennium suppliers have been gradually replacing people with machines and technological solutions (Tussyadiah, 2017). Conventional tourism services that used to involve personnel are increasingly changing to technological-based services. 'New reality of pandemic' has even sped up the infiltration of technological solutions without any human presence on the suppliers' side (Stankov and Gretzel, 2020). The 'mantra', how efficient, effective and affordable technologically-based services are, seems to overcome the voice of the customers, tourists, who may not be all so keen of transformation of traditional tourism services from 'high-touch' to 'high-tech'.

This transformation is an issue particularly with baby-boomers who are generally not so familiar with new technological solutions and are not as digitally literate as millennials are. The current research shows that Tourism 4.0 puts too much emphasis on the efficiency of technological solutions, while simultaneously neglecting real-life experience of their consumers, tourists (Pencarelli, 2020).

The question arises whether tourists really want the technological supported services to such extent and speed as they are currently confronted with. The study discusses this issue by giving some vivid examples as to how unpleasant or even disturbing experience it might be for tourists, particularly those who are not used to 'do-it-yourself' (DIY) service offering. Some of the crucial issues related to transformation of conventional tourism to e-tourism, smart tourism or Tourism 4.0 are the following: Firstly, has customers experiencing tourism really changed so much that they rather communicate and co-create their services with machines and not with people anymore. Secondly, were we can find in technology-based tourism services the element of hospitality, which used to be so crucial in tourism (Marchetti, 2020)? Hospitality still is –

according to (Wali, 2017) – one of the most important characteristics of people, the feeling that can be expressed only by people and which personify the relations among people (Kramer, 2019). Last, but not the least: how can we balance between conventional people-based tourism services and the e-services performed in interaction with the machines?

2 Theoretical framework

The terms 'high-touch' and 'high-tech' were introduced by Naisbitt decades ago when forecasting the social and economic megatrends (McDonnell, 2018). The personal service (high-touch) refers to human, emotional side in business relations that demands close relationship with the customer. The high-tech services are performed by customers themselves using the technological solutions for e.g. chatbots, applications, self-service machines, artificial intelligence etc. With the latest, the personal involvement of the service provider is not (always) necessary, while technological-based services might be performed/executed by interaction of customers with the technology. Emotions does not play a significant role in service performance. Each action is simply a step forward to the service completion. High-tech services do not include a notion of authenticity, which is needed at high-touch services.

New technologies, which are based on high-speed internet and network 2.0, accompanied by extent use of social media and mobile applications, have brought tourist and tourism suppliers to a closer cooperation, to active co-creation of tourism experience and to sharing them digitally with others (Neuhofer et al. 2015).

Services in tourism used to be of more high-touch nature than high-tech one. However, the fact is that in tourism we are increasingly dealing with the set of digital technologies developed originally for other industries and dubbed as Industry 4.0. The term Tourism 4.0 has been coined to highlight the technological changes (Starc Peceny, 2019; Zupan Korže, 2019) that has been rapidly embraced by suppliers of tourism services. Like it or not, tourists have been pushed to adapt to conditions set by suppliers; moreover, modern technology-based tourism services have changed the model of tourism services, which are more and more based on the principle DIY (McGuire, 2015).

Technology has significantly transformed creation and consumption of tourism services and the creation of tourism experiences in general (Gretzel and Jamal, 2009). In the consumer-focused society, consumers have been given such an important role in creating and consuming products/services that Ritzer and Jurgenson (2010) coined special term for them: 'prosumers'.

McDonnell (2018), however, shows that the rapid use of technology and digitalisation in our lives can bring a strong counter-effect. It might happen that in the technology-based era a growing need for people touch will appear again. Duality already exists: some people are attracted to high-tech services, while the other part try to run from it (Naisbitt and Naisbitt, 2017).

Technological advancement and innovation in the offering of tourism services have reflected in the differentiation of consumers' expectations. Some want suppliers to follow their expectations and design a personalized service. This is also the case in tourism and

hospitality industry (Kramer, 2019). Such expectations are particularly relevant for millennials that are also called generation Y, echo-boomers, tech-generation, and web generation, etc. (Santos et al. 2016, Kotler et al., 2017). They present one quarter of the world's population; by 2025, they will present half of the tourist population of the USA (Dimock, 2019; Kramer, 2019). They are the cohort that likes to travel and has from early life embraced the technology as well as gained technological competencies. They like to communicate using technological intermediaries: computers and mobiles (Kramer, 2019). Millennials are educated, self-centred, well-off, constantly 'connected' and highly technologically/digitally competent.

Baby-boomers, much earlier generation, present another quarter of world's population. Like millennials, they are also well-off and keen to travel. They have become one of the strongest forces for designing the market environment and tourism services (Kotler et al., 2017). However, their technological literacy differs, typically falls with age. Part of them are 'technology emigrants' who do not use the technology, apart from mobiles for calls and messages (Prensky, 2001). The other part is skilled in the use of technology, yet, not so much as millennials (Krishen et al., 2016). How many of the baby-boomers are technology literate, depends on the development level of the country.

While the older generations are more reluctant to accept new technologies, the technological generation gap between baby-boomers and millennials has been increasing (Nominet, 2017).

3 Research design

Data was collected using a research method of participant-observation. This method is a special mode of observations' methods, in which the participant is not merely a passive observer (Yin, 2018; DeWalt and DeWalt, 2011). He/she can be involved in variety of roles within the field-work observation and may actually participate in the action been studied. The method has been chosen while it can add new dimensions for understanding the actual use of new technologies (ibid.).

The first researcher, a member of baby-boomer's cohort, put herself in the position of participator-observer in various consumption opportunities of tourism services in 2021. Her data collection is based on her own experiences and observed experiences of the travellers, which were found in the similar position as she was.

Each observation has been shortly noted soon after each experience and further on transformed into a typed field report. The field reports have been processed with the method of content analysis, starting with the coding process and in the continuation using guidelines of Miles et al. (2014). In the first cycle of coding, the field notes have been labelled according to the essence/theme of the event. The further processing consist of labelling and extracting the most important parts of the field notes.

The finding are presented in descriptive way.

4 Results

The research has been focused only to those situations that – when performing technology-based tourism services in DIY way – create unpleasant experience to the observer. Situations have been presented by their themes/essence, starting with inconveniences that occurred in travel preparation and continuing to other inconvenient real-life travel situations.

In preparatory phase of travel, e.g. choosing the destination, places and attractions to visit, etc., technology might be supportive. However, if the future tourist is not equipped with the adequate hardware and software, she/he might find herself/himself in the rather unpleasant situations in the following steps.

Booking a flight is the starting point of tourist's travel experience after he/she has already chosen the desired destination. Several reservation/purchasing platforms offer variety of choices to the tourists. With simple 'clicks' on the computer/mobile screen, she/he can choose the most appropriate flight.

In our case, the observer has managed to perform all necessary steps toward purchasing the airline ticket, apart from the payment execution. The system refused to proceed the monetization of the

credit card payment for several times. As the purchase of the flight ticket was performed in the afternoon, it was not possible to check with the bank what went wrong. Next day, the bank employee revealed the real cause: the platform has implemented a new app for verifying purchases. In the next step, the observer wanted to download the necessary application for payment verification on her mobile phone, but unsuccessfully. The phone did not support the needed bank application: it was too 'old' for that.

After a few days, when the purchase of new smart phone and installation of the adequate application has been done, the observer has finally managed to purchase the airline ticket. However, the price has been 20 % higher as it was in the initial phase.

FINDINGS: Without adequate computer/mobile phone and adequate applications, the on-line purchase might be delayed and when finally done, more expensive.

At a *car-rental reservation*, the observer has successfully booked the car, but later tried to purchase additional car insurance. The reason for refusal of payment on the chosen platform remained unknown. Instead, the observer decided to purchase insurance on-site. Yet, the price for insurance executed on-site was almost twice as much as it should be via platform.

FINDINGS: The onsite purchase might be of much higher price than online.

Some airlines enable the travellers to *check-in the flight* with computer or mobile. In our case, the observer has been already used to this kind of DIY procedures and has performed it from home. However, when coming to the airport, her luggage needed to be checked-in as well and submitted to the suitable place. Several machines have been deployed at the airport hall. The first challenge for the observer was how to find a proper one, the second, how to execute the procedure of getting the luggage tag and the third one, how to submit the luggage to the conveyor. She felt rather uncomfortable without any previous experience with that and without any airport-staff support. Thus, she first observed what other travellers did and used 'trial-and-error' approach until she finally made it. However, DIY procedure was time consuming and hectic. She noticed that even younger generation was not quite comfortable with those DIY successive processes. Since a couple more or less of her age seemed to be 'quite lost' with all these procedures, she helped them.

FINDINGS: Having no previous experiences on DIY check-in procedures, several sequential steps might be hectic and time consuming, particularly for the elder travellers or passengers that do not flight often.

Buying food on the aircraft has already become a common practice of most airline companies. The inconvenience might occur, if a passenger does not have adequate mean of payment. It happened to the elderly couple, sitting next to the observer. As for purchasing items on the aircraft the credit card payment was the only option, the passengers were not able to buy food. One of their credit cards was not functional and they forgot the pin code for the other.

The observer faced the similar situation when visiting the nature park. The only possible mode of payment was DIY credit card payment to enter the park.

FINDINGS: The saying 'cash is the king' might not be valid anymore.

Previous online purchase of tickets for the trips, performances etc. might be necessary in certain cases if tourist wants to experience certain tourism events. It happened to the observer that she came to the site with no on-line pre-purchased ticket and could not joined the trip and neither to attend the performance.

FINDINGS: The tourism activities might need to be well-prepared in advance and the ways of attending them thoroughly pre-checked.

Browsing a restaurant menu via QR code has becoming a wide spread way of choosing the food and beverages, particularly in the pandemic period. However, the smart phone and adequate application are prerequisites for this kind of hospitality service. Without them, the browsing of menu might become an issue for the hungry tourist.

FINDINGS: There are additional technological procedures apart vending machines for buying food and beverages that have gradually penetrated into hospitality service.

DIY provision of hotel accommodation has been introduced in the last few years. The major reason is the cost reduction for the staff engaged in this type of hospitality service. By now, it has become acceptable for the middle-class (or lower graded) tourist accommodations. The observer experienced 'no-personnel-involved' way of overnight stay for the first time. She processed the room booking via reservation platform, paying by credit card. The confirmation letter included the code for entering the building and the room and further instructions for taking breakfast, which took place in the restaurant next to the hotel. The observer has not met any of the hotel personnel during her stay. In fact, the DIY accommodation service did not cause any inconvenience to her, apart the unsuccessful attempt to watch television. The TV meant to be managed by observer's smart phone; however, the observer was not skilled to do it.

FINDINGS: Provision of overnight stay with no personnel included has become acceptable to certain standard accommodation level.

5 Conclusion

The study raises the dilemma set forth by rapid and extensive use of technology in tourism. The question is, if/how DIY services, implemented in tourism, influence the tourism experiences of one of the most powerful tourism demographic segment – baby-boomers. Baby-boomers have time and money to travel; they look for adventures and personal fulfilment, but are less technologically competent than millennials.

The results of the study reveal that DIY technology-based tourism services might cause the 'silver' tourists inconveniences and consequently decrease the quality of their tourism experience.

The outcomes of the research are particularly applicable to tourism suppliers. They can use them as guidelines for designing their services 'hybrid' way: with a modest technology involvement, but in a way appealing also to those part of the tourists which still desire to experience a personal touch, not only high-tech.

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The evolution of albedo values of the Earth-atmosphere system under the influence of carbon dioxide pollutant concentrations

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Abstract: The current state of the unique atmosphere-Earth system is influenced both by the composition of constituent gases in the atmosphere and by the accumulation of polluting gases as a result of human anthropogenic activity. A number of scientific forums have found empirically that the anthropogenic accumulation of carbon dioxide in the atmosphere leads to a further increase in the average temperature of the atmosphere due to of the increasing of the green-house effect. The processes of photosynthesis consume amounts of carbon dioxide with the subsequent restoration of the necessary oxygen in the atmosphere. At the current stage, the situation is characterized by a decrease in the amount of oxygen in the atmosphere due to of its great consumption for the burning of fuels used in various industrial fields. The result of the burning of fuels leads to excessive accumulation of carbon dioxide in the atmosphere. The deforestation processes of the terrestrial surfaces decrease the global process of photosynthesis and respectively the amount of oxygen decreases. Deforestation has another negative effect on the ecosystem in general, such as increasing the albedo values of the Earth's surface. Ocean water also has albedo values that increase over time due to of the accumulation of carbon dioxide absorbed by ocean water. The albedo values are described by an empirical expression suggested in this study. This empirical expression is based on the heat calorimetric method which includes the amount of solar energy together with the energy supplement accumulated in the atmosphere due to of the anthropogenic activity as well as the thermal emission model of the Earth's "absolutely black body". as the result of the increase of the atmospheric temperature due to of the accumulation of carbon dioxide in the atmosphere, the albedo values are calculated over time and their subsequent increase is ascertained. Finally, knowing the albedo values, the values of the effective temperature of the Earth's surface are calculated which decreases over time. The linear decrease of the thermal emission energy is demonstrated depending on Earth's albedo values. It is shown that the degree of darkness (dimming) of Earth depends on more and higher values of the infrared wavelength of the emitted thermal energy.

Keywords: ATMOSPHERIC POLLUTION, CARBON DIOXIDE, GREENHOUSE GASES, CALORIMETRIC METHOD, BLACK BODY, INFRARED WAVELENGTH RADIATION, EARTH'S ALBEDO

1. Introduction

The state of the unique Atmosphere-Earth system is influenced by the presence of anthropogenic pollutant gases in the atmosphere. Modern anthropogenic activity is characterized by the increasing of the concentrations of gaseous pollutants that have a green house effect. One of the major green house components is carbon dioxide which has a ratio of 75% in comparison to other pollutants. It is known that the continuous accumulation of these gases in the atmosphere leads to an increase in the average value of the atmospheric temperature. The processes of deforestation and the accumulation of carbon dioxide in large quantities lead to high values of Albedo. Some papers and scientific publications show that the surface Earth's albedo is increasing with time. Last time NASA observatories have recorded a permanent increasing both of the average temperature of Earth's atmosphere and the excess concentration of the major green house carbon dioxide gas that comes from anthropogenic activity. A major factor beside the emissions of carbon dioxide which is an anthropogenic pollutant of the atmosphere that leads to the increasing of the average temperature of the Earth's atmosphere comes from Earth's albedo. The climatic state last time is influenced by the changeable value of Earth's albedo.

The thermal emission of this thermodynamic system in the approximation of the "absolutely black body" with the application of Albedo values leads to the increase of the values of the wavelengths of outgoing long wave radiation of Earth-Atmosphere system.

2. The actual state of the description of Earth's albedo

The global surface Earth's albedo is actually defined as the amount of solar energy that is reflected from the Earth's surface. This value is of order 0,3 (30%) [1]. Lately, the processes of deforestation of the terrestrial surface lead to the increasing of the albedo value of the land. The average value of the albedo of the forest surfaces is of the order of 0.15. The other values for various terrestrial components are presented on the Table 1.

Table 1. The Albedo's values of various samples

Samples	Albedo values
Open ocean	0.06
Worn asphalt	0.12
Conifer forest(Summer)	0.08; 0.09 to 0.15
Deciduous forest	0.15 to 0.18
Bare soil	0.17
Green grass	0.25
Desert sand	0.40

[based on 2;3;4;5;6].

The next Fig. 1 shows the maps of global deforestation.

We can see from the maps of Fig. 1 that the areas of deforestation are increased with time. The places of bare soil have the values of albedo higher than of forests area.

Another scientific paper [7] states that:" Starting with carbon dioxide concentration of 380 ppm and the increasing at the rate 0.2% /year within 100 years gives 456 ppm. The albedo will increase respectively from 0.3 till 0.36 within 100 years".

There is an interconnection between albedo's value and the carbon dioxide concentration. So, the scientific paper [8] states the following:"Since the pre-industrial period, changes in the soil cover caused by human activities, resulted in both net CO₂ release contributing to global warming (high degree of reliability) and an increase in the global albedo of the Earth, causing surface cooling (average degree of reliability)."

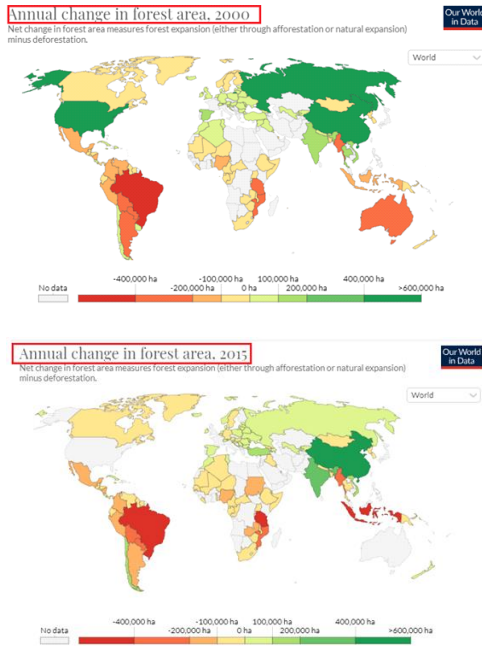


Fig. 1 The maps of global deforestation [9]

The registrations of NASA are shown on the diagram of the Fig. 2 and the linear trend states in general that Earth's albedo is increasing with time.

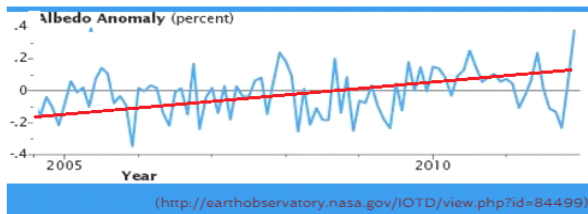


Fig. 2. The increasing of Earth's albedo with time [10]

The current state of the atmosphere and of the biosphere in general presented in the above mentioned scientific works does not show any clear quantitative relation that links the albedo values and the concentrations of carbon dioxide in the atmosphere. Each result for both albedo and carbon dioxide and oxygen concentrations is presented separately and is described mostly only from a statistical-informational point of view. It is mentioned only that the temperature rises, but the reasons that lead to the temperature rise are not presented very clearly in the scientific literature.

The albedo values vary over time, but the reasons of these variations are also not clearly discussed. The processes that take place in the atmosphere are really complex and remain a complex study problem. But the most important aspect is that the current state of each parameter of the atmosphere is influenced by the values of other parameters. For example, how does the variation of atmospheric temperature influence albedo values? It is known that the increasing of the concentration of carbon dioxide leads to an increase in the average temperature of the atmosphere. In its turn, the logical question is: how does the increase in the concentration of carbon dioxide influence the albedo values? These major questions are the problems of the study of this current scientific research.

This paper aims to obtain such quantitative empirical expression of Earth's albedo that depends on the temperature variation of the atmosphere and of the masses of carbon dioxide excess and oxygen depletion.

The interconnection between important parameters such as the values of the masses of carbon dioxide, oxygen, the temperature

of the atmosphere and the albedo values is a key issue of the study of this paper.

Taking into consideration that the Earth's atmosphere is a huge thermodynamic system and the temperature of this system is dictated mainly by the solar radiation then the current study aims at the following research issues: 1) application of calorimetric expression of the amount of heat necessary to maintain the current average atmosphere temperature; 2) by the application of this suggested calorimetric expression it is necessary to take into consideration that the amount of additional heat ΔQ accumulated in the atmosphere as a the result of anthropogenic activity and of the complex processes of photosynthesis and respiration of the biosphere together with the human population leads to the subsequently increases of the ambient temperature; 3) as the result of the interaction of the Earth with the solar radiation, it is necessary to take into consideration the own thermal radiation by the approximation of "black body" radiation and how the effective temperature of this radiation depends on the values of planetary albedo; 4) The combination of the suggested calorimetric method with the expression of thermal radiation. The actually known value of the Earth's emitted thermal energy must be compared with the calculated results of the suggested thermal quantitative expressions.

The Earth's effective temperature which is related to the Earth's own radiation is calculated by the expression from paper [11]:

$$T_{eff} = \sqrt[4]{\frac{I_{sc} \cdot (1 - A)}{4 \cdot \sigma}} \quad (1)$$

Where I_{sc} – Sun constant ($I_{sc} = 1367,7 \text{ W/cm}^2$); A – Earth's albedo; σ – Stefan-Boltzmann constant. The substitution of numerical values into the expression (1) gives the result $T_{eff} = 255 \text{ K}$, meaning that the atmosphere must be cold. But the average temperature of Earth atmosphere is 288 K . The difference of temperatures of the order 33 K is related to the greenhouse effect.

The suggested calorimetric method in this paper is described by the expression that contains the mass of the atmosphere – m ; the depletion of the quantity of oxygen from the atmosphere – $\Delta m(O_2)$ due to of the consumption for the burning of fuels and the accumulated excess of carbon dioxide in the atmosphere $\Delta m(CO_2)$. Then, this suggested calorimetric empirical expression in this paper is written as:

$$Q + \Delta Q(t) = c \cdot (m - \Delta m(O_2) + \Delta m(CO_2)) \cdot (T - T_{eff} + \Delta T(t)) \quad (2)$$

Q is the quantity of Sun energy for the maintaining of the average global temperature T of Earth's atmosphere; ΔQ is the accumulated quantity in the atmosphere due to of the burning of fuels; c is the specific thermal capacity of atmosphere; ΔT is the increasing of the atmospheric temperature due to of the accumulated excess of the energy from the anthropogenic activity of the burning of fuels. The value of effective temperature from the expression (2) is written as:

$$T_{eff} = T + \Delta T - \left(\frac{Q + \Delta Q}{c \cdot (m - \Delta m(O_2) + \Delta m(CO_2))} \right) \quad (3)$$

Then, the expression of Earth's albedo with the consideration of the expressions (1) and (3) is written as:

$$A(t) = 1 - \frac{4 \cdot \sigma}{I_{sc}} \cdot \left(T + \Delta T - \left(\frac{Q + \Delta Q}{c \cdot (m - \Delta m(O_2) + \Delta m(CO_2))} \right) \right)^4 \quad (4)$$

So, the value of albedo A depends on time due to of the fact that the respective values of ΔT ; $\Delta m(O_2)$; $\Delta m(CO_2)$; ΔQ are changeable with time. The Earth absorbs mostly the Sun energy reaching its surface and the small quantity from the initial energy is reflected. Approximately 70% of incoming Sun radiation is absorbed by the atmosphere and by the Earth's surface while around 30% is reflected back to space and does not heat the surface. [12]

The Earth's climate is a solar powered system. Globally, over the course of the year, the Earth system—land surfaces, oceans, and atmosphere—absorbs an average of about 240 watts/m² (annual input of 2×10^{24} joules of solar energy), which is about 70% from the incoming solar energy of about 340 watts/m² (3.1×10^{24} joules - annual total Sun energy that strikes Earth). The absorbed sunlight drives photosynthesis, melts snow and ice, and warms the Earth system. [13]

Results and discussion

Taking into the consideration the mass of atmosphere $5,148 \cdot 10^{18}$ kg and the thermal capacity of the atmosphere $c_{atm}=1005$ (J/(kg·K)), then the necessary quantity of Sun radiation to maintain the difference of temperatures of the order 33 K is calculated as:

$$Q = c_{atm} \cdot m \cdot (T - T_{eff}) = 1005 \cdot 5,148 \cdot 10^{18} \cdot (288 - 255) = 0,1707 \cdot 10^{24} (\text{Joule}) \quad (5)$$

This value of Q is applied for the calculation of T_{eff} by the expression (3).

The value $\Delta Q=3,05 \cdot 10^{20}$ (joule/year) represents the resultant accumulated heat in the atmosphere as the result of the main complex processes as: 1) burning of fuels; 2) global photosynthesis; 3) respiration of Land Biota together with the 7-8 billions human population and this ready value of $\Delta Q=3,05 \cdot 10^{20}$ (joule/year) is explained more in detail in the source [14].

The values of the depletion of oxygen from the atmosphere is of the order $\Delta m(O_2) \approx 18$ (gigatons/year) and the accumulation of the carbon dioxide in the atmosphere is $\Delta m(CO_2) \approx 15$ (gigatons/year). The respective increasing of ΔT of the average temperature of Earth's atmosphere is of the order 0,02 °C/year [14].

The calculated values of Earth's albedo with time by the table from [14] are represented on the Fig. 3.

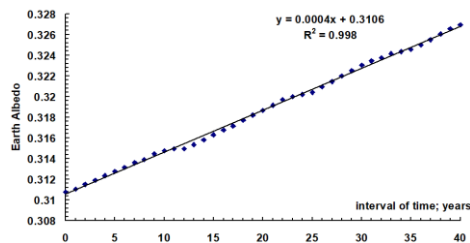


Fig. 3 The increasing of Earth's albedo with time (starting year 1980). [source: the recent paper based on the data from [14]].

The respective calculated values of effective temperatures of Earth are represented on the Fig. 4.

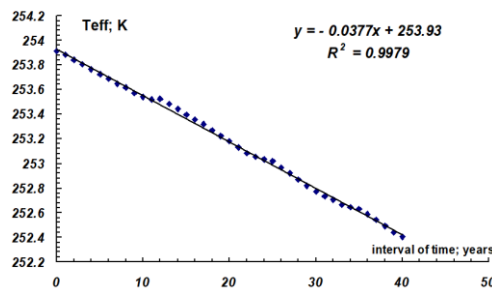


Fig. 4 The decreasing values of Earth's effective temperatures (starting year 1980. [source: the recent paper based on the data from [14]].

The calculated values of effective temperatures are of the orders of the values that are calculated in the paper [15]. The results from Fig. 4 and Fig. 5 must be validated by the global real values. The approximation of thermal radiation of "black body" of Earth is related to the values of effective temperatures of Earth. We obtain that higher albedo gives smaller values of effective temperatures. The respective emission capacity of "black body" of Earth is calculated by the expression of paper [16]:

$$E = \sigma \cdot T_{eff}^4 \quad (6)$$

where $\sigma=5,67 \cdot 10^{-8}$ is the constant of Stefan-Boltzmann. The average global effective temperature of Earth is 255 K. Then, the calculation the expression (6) of the thermal emission capacity is:

$$E = \sigma \cdot T_{eff}^4 = 239.74 (W / m^2) \quad (7)$$

The calculated value of the thermal emission capacity is of the order of the value from the paper [16]. The maximum of thermal emission capacity of Earth is from the range of longwave infrared radiation with the wavelength of the order 10 μm. (Fig. 5) [17]

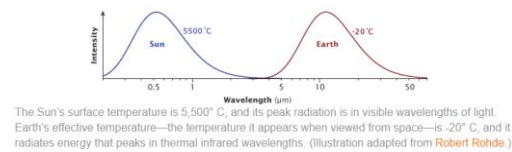


Fig. 5 The emissions peaks of Sun and Earth. [17]

According to Wien's displacement law the smaller effective temperatures give higher values of wavelength radiation as follow [18]:

$$\lambda \cdot T = b \quad (8)$$

where $b=2,898 \times 10^{-3} \text{ m} \cdot \text{K}$ is the Wien's constant. It is expected that higher values of Earth's albedo give higher values of Earth's long wavelength thermal radiation. But the higher values of wavelength thermal radiation λ give smaller values of the Earth's thermal emission capacity - $E(W/m^2)$.

The Fig. 6 represents the values of emission capacity (longwave radiation) as the function of the values of planetary albedo. The graphics from Fig. 7 show that if the value of planetary albedo is increasing as the dependence of various geographical locations, then the wavelength radiation (W/m^2) is decreasing. This is the same form of the dependence both for January and August.

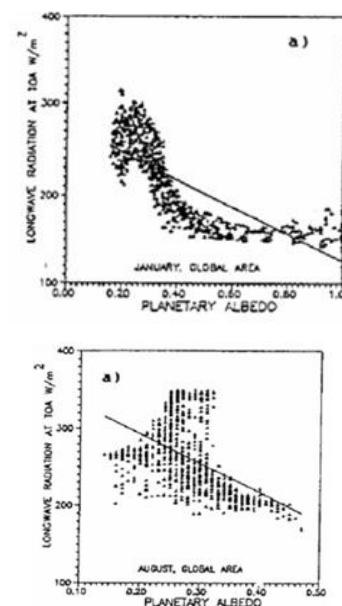


Fig. 6 The dependence of Earth's thermal emission capacity as the function of planetary albedo [16].

The connection of the data from Fig. 6 with those from Fig. 3 and 4 gives the same statement: Higher is the value of albedo then smaller is the value of the effective temperature and in its turn the smaller is the value of the emission capacity.

Taking into consideration the expression (6) and the values of T_{eff} the following dependence $E=f(A)$ is represented on Fig. 7.

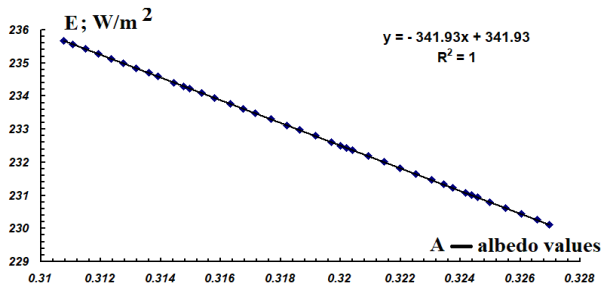


Fig. 7 The decreasing values of Earth's emission thermal capacity as the function of Earth's albedo [source: the recent paper based on the data from [14]].

The linear form of the dependence $E=f(A)$ from Fig. 7 is similar to the same dependence which is represented on the Fig. 6.

The combinations of the expressions (3), (4) and (6) give the following:

$$E = \frac{I_{sc}}{4} - \frac{I_{sc}}{4} \cdot A \quad (9)$$

The expression (9) is a linear function of $E=f(A)$

In fact this linearity of the expression (10) is proven by the dependence $E=f(A)$ of the Fig.8. The correlational calculations of the Fig. 8 show the best fitting with the linear dependence ($R^2=1$)

The coefficients of linear dependence $y = -ax+b$ of the expression (9) are:

$$a \equiv -\frac{I_{sc}}{4}; \quad b \equiv \frac{I_{sc}}{4}; \quad a = -341,93; \quad b = 341,93$$

$$\text{Then: } \frac{I_{sc}}{4} = 341,93 \Rightarrow I_{sc} = 1367,72 \quad (10)$$

The obtained result of the Sun constant $I_{sc} = 1367,72$ validates in general the correctitude of the suggested calorimetrical method which is described by the expressions (2) and (5).

So, the Earth's albedo is increasing with time and the effective temperature is decreasing respectively. The decreasing of the effective temperature can be explained by the decreasing of the irradiation of the Earth's surface. In its turn, the reduction of irradiation of the Earth's surface is explained by the higher degree of the absorption of solar energy by the polluting green house gases with higher concentrations. The fact that the recalculation of the solar constant by the application of the suggested calorimetric method coincides with that theoretical one denotes the validity and correctness of the suggested method. A very important result is obtained which shows that the increase of albedo values leads to the decrease of the thermal emitted radiation capacity $E(W/m^2)$ and in its turn to the increase of the wavelength of the Earth's thermal radiation. The calculated values of the wavelengths by the Wien's displacement law allows to represent the graphic of the dependence of the wavelengths as the function of albedo values - $\lambda=f(A)$ (Fig. 8)

The maximum of the emission according to the Wien's displacement law moves in the direction of longer values of wavelengths as the albedo values increase. The degree of darkness (dimming) of Earth depends on the value of the infrared wavelength. The longer is the wavelength ($\lambda > 10 \mu m$), then the

greater the degree of darkness (dimming) of Atmosphere-Earth system.

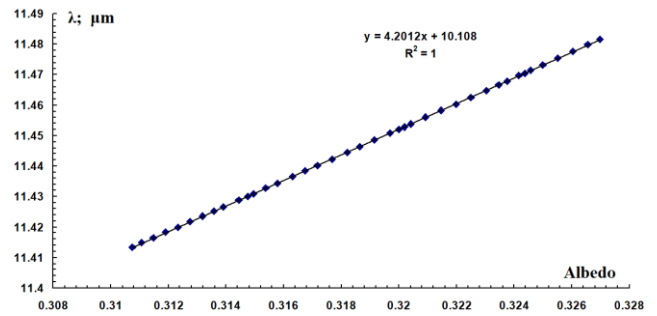


Fig. 8 The outgoing wavelength radiation as the function of albedo

The interconnection between the wavelengths and albedo values can be seen on the Fig. 9.

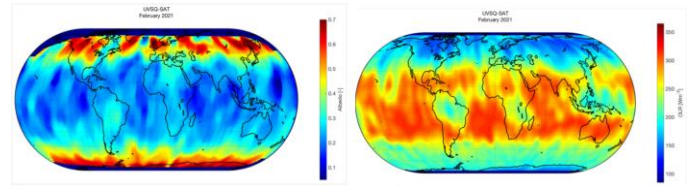


Fig. 9. The interconnection of outgoing longwave radiation and albedo values [19]

The extracted values of albedo and energy (W/m^2) are represented on the Table 2.

Table 2. The outgoing longwave radiation of Earth

A	E; W/m^2	T_{eff} ; K	E_{th} ; W/m^2	λ ; μm
0.2	280	270.696	304.444	10.7020
0.6	160	227.627	152.222	12.7269
0.3	270	261.808	266.389	11.0653
0.7	110	211.831	114.167	13.6760
0.35	270	257.002	247.361	11.27227
0.15	300	274.83	323.472	10.54107
0.7	120	211.831	114.167	13.6760
0.25	230	266.363	285.417	10.8761

The values of energies of outgoing longwave radiation $E(W/m^2)$ as the function of albedo is represented on the Fig. 10.

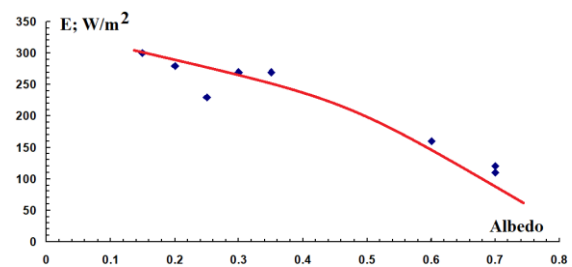


Fig. 10 The values of energies of outgoing longwave radiation as the function of Albedo (based on the data from the Table 2)

The known values of effective temperatures T_{eff} from the Table 2 allow again recalculating the values of energies of outgoing longwave radiation E_{th} and to compare with the real ones.

The representation of the dependence $E_{th}=f(E)$ is represented on Fig.11. The correlational calculations show the strong link between data and the calculated values of E_{th} are of the same order as E .

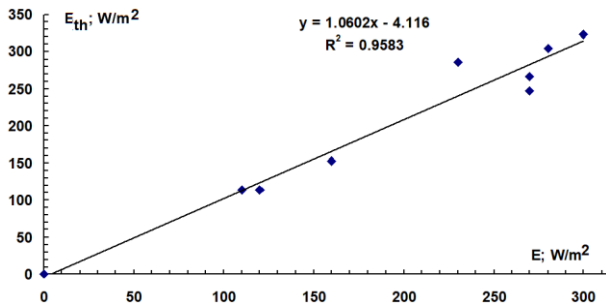


Fig. 11 The reciprocal interconnection of the data E and E_{th} (based on the data from the Table 2)

According to Wien's displacement law the wavelengths are calculated (Table 2). The dependence of $\lambda=f(A)$ is represented on Fig. 12.

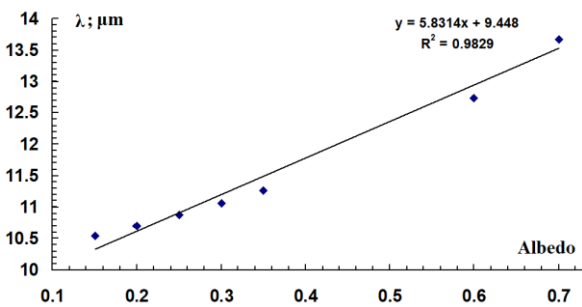


Fig.12 The dependence of wavelengths of outgoing radiation as the function of Albedo (based on the data from the Table 2)

There is a following statement about the global dimming: "Global dimming is the reduction of global direct irradiance at the Earth's surface that has been observed since systematic measurements began in the 1950s. The effect varies by location, but worldwide it has been estimated to be of the order of a 4–20% reduction"[20]. The recent study of global dimming states the following: "Scientists have noticed the planet becoming increasingly dark for several decades now, and it's only recently been connected to climate change."[21] From physical point of view the degree of the dark is related to the notion of effective temperature. Higher is the effective temperature then higher is the degree of the dark.

Another study also states that the global dimming is related by the presence of aerosols in the atmosphere: "It is thought that global dimming is probably due to the increased presence of aerosols particles in Earth's atmosphere, caused by pollution, dust, or volcanic eruptions." [22] It means in general that the process of global dimming and global warming exist at the same time concomitantly. This concomitant existence is stated by the following: "Some scientists now consider that the effects of global dimming have significantly masked the effect of global warming and that resolving global dimming may therefore lead to increases in future temperature rise".[23]

Another research states some main peculiarity: "The 2001 study by researchers at the Scripps Institution of Oceanography concluded that the imbalance between global dimming and global warming at the surface leads to weaker turbulent heat fluxes to the atmosphere. This means globally reduced evaporation and hence

precipitation occur in a dimmer and warmer world, which could ultimately lead to a more humid atmosphere in which it rains less." [24] In general the aerosol pollutants have higher capacity of the reflection of Sun radiation which is stated as follow: "The particles reflect and absorb sunlight, less sun rays reach Earth surface layers, thus resulting in cooler water and land surface temperatures, and also less cloud formation, subsequently dampening the development of hurricanes." [25] In general, the capacity of emissions and reflections are various for various geographical locations. Globally, it is observed that with the increasing of the albedo values, the emission capacity of Earth decreases.

The results obtained by the application of the suggested quantitative method generally check the state which is presented in the above mentioned literature about the dimming process, albedo effect and in connection with it the results are checked by the state of climatic processes in the atmosphere as well as by the examples of the presence of pollutants aerosols in the atmosphere.

Conclusions

The World is living in a critical period of the atmospheric change due to of the variations in the concentrations of green house gases. The large scientific societies and the annual socio-political congresses are focused on the solving of the global problem of the annual increase in the average temperature of the atmosphere. One way out of this situation is to reduce carbon dioxide emissions. The first steps are already being taken with great effort, nevertheless that the economies of the countries will cost millions of losses.

This paper has applied the thermodynamic calorimetric model of the quantitative expression that contains the values of the variations of the masses of carbon dioxide and oxygen and this model is connected to the expression of the effective temperature of Earth. The dimming process of Earth is related to the decreasing values of effective temperatures of Earth. The dependence is obtained from physical point of view, that if the values of planetary albedo is increasing then the emission capacity of Earth is decreasing and in its turn the effective temperatures are decreasing.

Thus the suggested calorimetric method describes both the greenhouse effect and the dimming processes which is described by the albedo value with the results coinciding with the real ones. If the amounts of pollutants decrease then the green house anthropogenical effect will be within the normal limits as well as the dimming processes.

The obtained values of the effective temperature of Earth's thermal radiation by the application of the suggested calorimetric method are real and the validity is confirmed by the check of the calculation of the solar constant that coincides with that theoretical one. The dimming processes which are described in the mentioned literature are explained exactly with the phenomenon of the thermal radiation of the Earth by the approximation of the "black body". The most important moment is the explanation of these phenomena by the suggested calorimetrical method, namely with the increase of the global values of albedo, then the dimming effect of the Earth is increased.

The practical importance of this suggested method consists in the application of the quantitative calculation of the effective temperature for various geographical regions by the known value of the emitted energy which is measured by technical means. In its turn, the measured value of the energy by technical means of the thermal radiation of the Earth E (W/m²) allows to calculate the albedo values for the respective geographical place and then can be compared with the real albedo that can be measured by technical means. It is clear that the values of effective temperature, thermal radiation energy and albedo vary from one geographical location to another. This quantitative relation of the effective temperature can be successfully applied to the process of measuring the thermal energy (W/m²) emitted by the respective geographical place.

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