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VIEW OF THE OPPORTUNITIES OF INDUSTRY 4.0

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Abstract: The Fourth Industrial Revolution is inducing significant changes in both the manufacturing and service sectors. The main purpose of the Industry 4.0 concept is to reduce the outsourcing of the European industrial production and to help to shift towards higher added value production. Using the Industry 4.0 technologies and the associated various methods and procedures the flexibility of the systems can be greatly increased. The aim of this article is to provide a literature overview of the possibilities and optimization of the production related to Industry 4.0.
Keywords: Industry 4.0, production, logistics, optimization, cyber-physical system

1. INTRODUCTION

The development is shown by the process of interconnection of machines and devices, integration of the economy into large-scale intelligent information systems.

The most important task of the industrial sector is the cost-effective manufacturing, but for this it is necessary to have a material and information flow system that facilitates and supports this. This is unimaginable today without advanced IT systems and tools. The processes are characterized by digitization, networking and, last but not least, an increasing degree of automation.

Using robots and highly automated processes can provide the most obvious solution to replace the human labor. The Internet and various wired and wireless connections integrate units and equipment into a network, revolutionizing the process management.

The development of technology and the availability of the Internet have created the possibility for companies and the industrial processes, machines and people within companies to be organized into networks. Digitization and data management are the heart of the Fourth Industrial Revolution. If production processes are optimized in the whole value chain, the flexibility, speed, quality, productivity of production processes will increase and downtime will decrease [1].

The driving force of this newest industrial revolution is the Internet, where not only humans but also machines can communicate with each other in a cyber-physical system. The industry 4.0 creates the concept of gentelligent product and production [2]. The Fourth Industrial Revolution is a fusion of technologies that blurs the boundaries between the physical, digital and biological spheres [3].

The Industry 4.0 affects the entire enterprise value chain, it can extend beyond the boundaries of the company covering the entire supply chain, the supply network. This requires networked technological tools and new procedures, what require new capabilities from the company, and may even require the development of new business models [4].

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The product lifecycle is shortened due to the rapidly changing customer needs, so the product and the manufacturing technologies needs constant innovation. Not only the product needs to be renewed but flexible and optimized production technology needs to be developed to meet the ever-changing customer needs. As very high number of product variants are produced, all of which require unique setup, identification and tracking.

All of this can be accomplished through digitization and networking for the enterprise of the Industry 4.0. Simulations and rapid prototyping (e.g. additive production) shorten the development phase and time to reach market while fast and flexible production lines produce only as much as the customer wants. Production data is immediately available, allowing to make decisions that result in efficiency and high quality.

Industry 4.0 has the greatest impact on production, but the methods and procedures used may be different. Sensors can be used to detect and signal deviations in the production process, while a number of statistics and evaluations can be made using the data collected and can be useful in scheduling maintenance to reduce downtime. The machines can be connected to a large network. Thanks to the advanced architecture and control, the machine park can be transformed flexibly and quickly if the production requires. The production support can take new forms like using augmented reality, such as the use of smart glasses, which can be a useful at several stages of the production process.

When the ICT technologies became common in the manufacturing processes in the manufacturing industry the technological innovation cycles are also evolving. The shortening of product information cycles induces a continuous adjustment of production capacities: new materials must be evaluated and processed according to their added value, preferably with new production technologies. The new technologies and services needed to be integrated into the solutions, and the capabilities needed to be continuously developed. The development of a new product may require the design and construction of entirely new production equipment. To ensure adequate supply and efficiency, the company's own value-added network must be expanded, and related developments must be constantly monitored.

The ever-shorter investment cycles and increased expectations for flexible manufacturing platforms require value-added rolling product lifecycle management. Effective rolling design provides greater planning security [5].

2. Literature Overview

2.1. Methodology

After selecting the topic to be reviewed, the related literature sources must be identified in the first step, and after reading and analysing the collected literature, the summary can be made [6].

After defining the research question and defining the relevant database(s) related to it, a keyword search was used as the most common method to identify the literature. The main topic can be selected by reviewing summaries of the articles, reducing the number of resources. After selecting the methodology of the analysis of the articles and summarizing the main scientific results, the less researched areas and bottlenecks can be mapped [7].

Among the possible databases (Google Scholar, ResearchGate, Science Direct, Scopus, Web of Science, etc.) Scopus was chosen. The search included three terms and their combinations, the terms were: "industry 4.0", "optimization" and "production" (Table I.).

Table I.

The results of the search

Query string	Result
TITLE-ABS-KEY ("production")	2 787 042 documents
TITLE-ABS-KEY ("optimization")	1 420 142 documents
TITLE-ABS-KEY ("optimization" AND "production")	108 040 documents
TITLE-ABS-KEY ("industry 4.0")	3 828 documents
TITLE-ABS-KEY ("industry 4.0" AND "production")	1 461 documents
TITLE-ABS-KEY ("industry 4.0" AND "optimization")	285 documents
TITLE-ABS-KEY ("industry 4.0" AND "optimization" AND "production")	155 documents

2.2 Descriptive analysis

The Scopus database contains 78 review articles for the term "Industry 4.0" in which the following keywords can be found most often: Industry 4.0 (56), Embedded Systems (15), Internet of Things (12), Big Data (10), Industrial Revolutions (9), Manufacture (8), Cyber Physical System (7), Smart Factory (7). The keywords Production and Optimization can be found 0 and 1 times [8]. According to this, it can be stated that it is worth reviewing and summarizing the literature on the 3 keywords selected. In the following, the 155 literature sources that yielded results for all three keywords will be reviewed (Figure 1.).

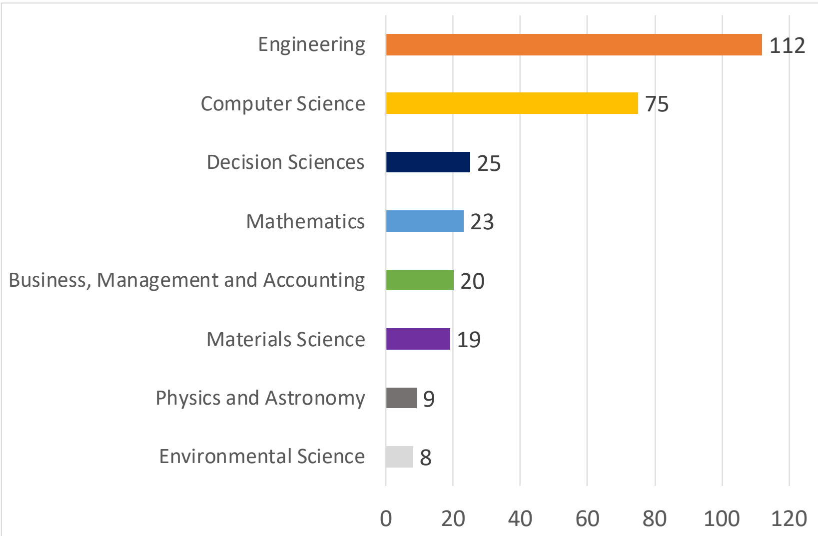

Figure 1. Grouping by topic

Due to the novelty of the term "Industry 4.0", the articles on the chosen topic have all been written recently (Figure 2). The earliest of them was published barely 5 years ago [9]. The number of articles published in each year is constantly growing, which shows the growing importance of the topic.

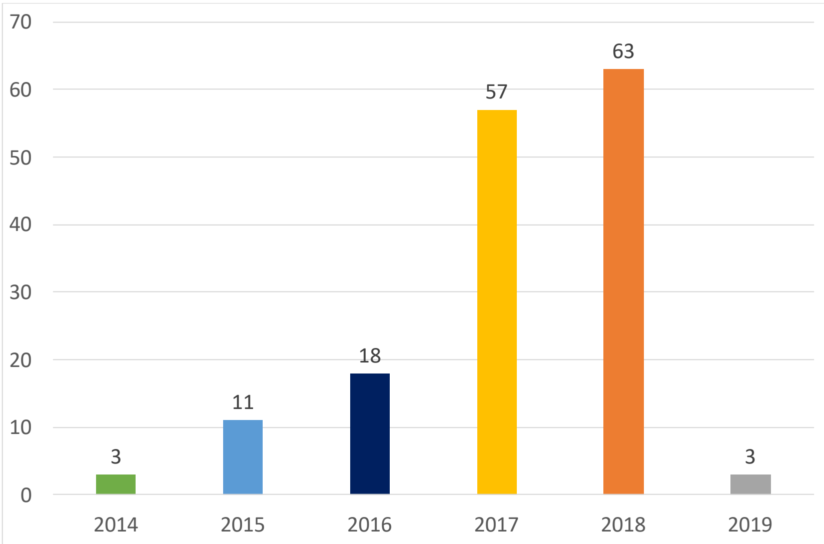

Figure 2. Number of articles published

The distribution of the most commonly used keywords is illustrated by the following two figures broken down by year.

Figure 3 shows the number of occurrences of keywords, while Figure 4 shows their proportion in the proportion of publications published in the given year (and included in the research).

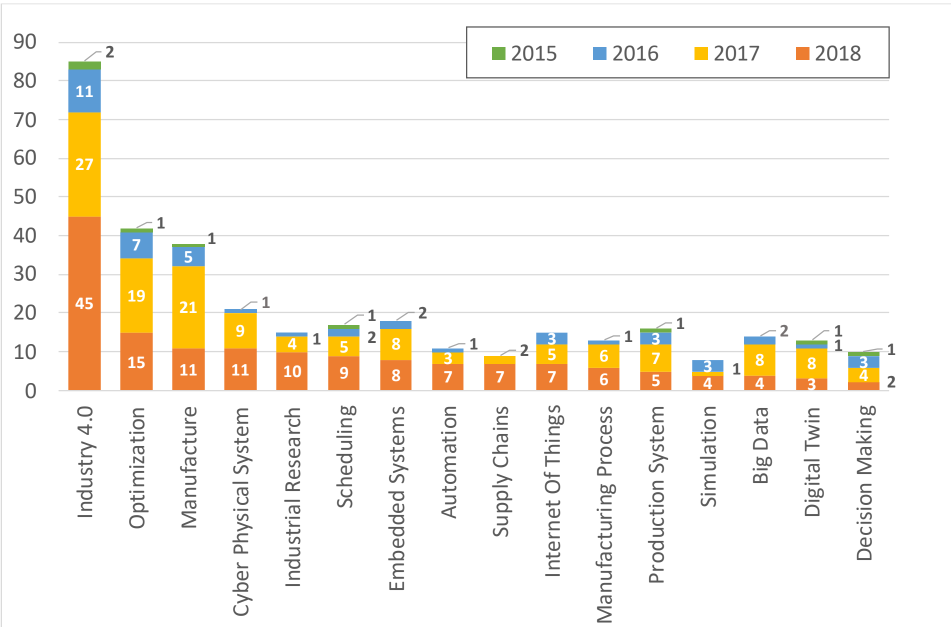

Figure 3. Keyword occurrences

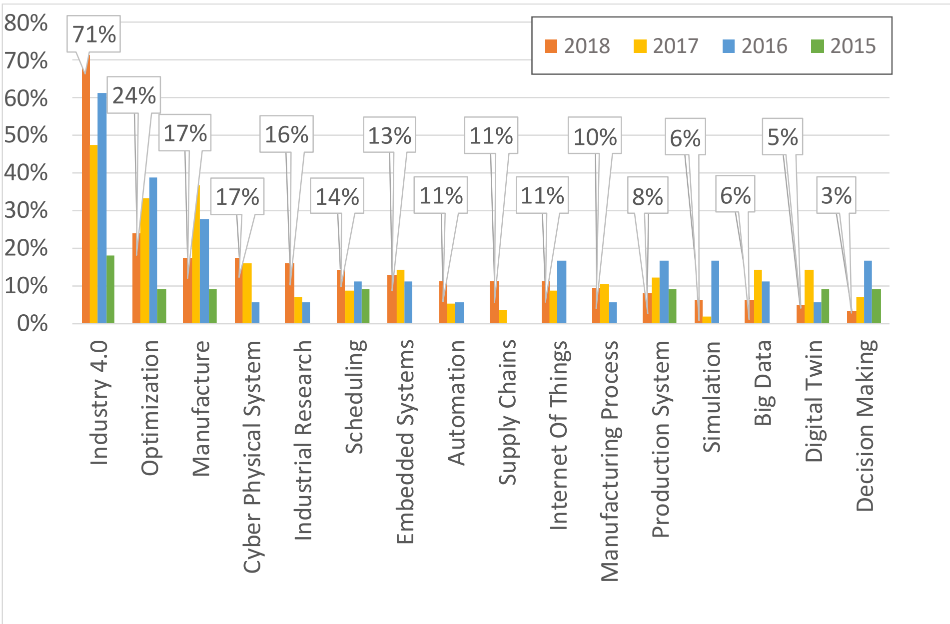

Figure 4. Keyword occurrence frequency

The publications included in the analysis were written in three languages: English (146), German (9), Russian (2), we will narrow the research to English.

Publications can also be grouped by document type (Figure 5). The analysis is limited to articles and conference papers that included "industry 4.0" and "optimization" as keywords. The number of documents to be reviewed was thus reduced to 97.

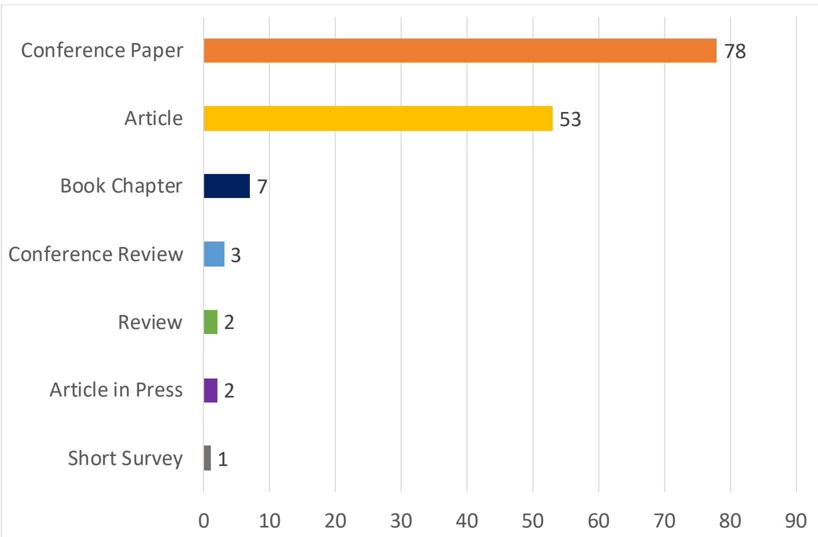

Figure 5. Grouping by document type

2.3 Content analysis

The presence of the workers will not cease in the cyber-physical systems with automated solutions, the work areas will change. The integration of the human workers into the system can be helped by trend estimates for future work areas [10]. The developments should focus on solutions that reduce the relative proportions of labor costs, energy costs and machine costs. In the case of the production of non-woven fabrics, this can be achieved on the one hand using self-optimizing machines and on the other hand by the use of systems that allow the safe processing of large amounts of data generated during production. In the case of the production of non-woven fabrics, this can be achieved on the one hand using self-optimizing machines and on the other hand using systems that allow the safe processing of large amounts of data generated during production. [11]. In current CPSs data can be collected from the production equipment. The data collected shows the operating status of the equipment. The MTConnect is a data collection protocol that is becoming increasingly popular for machine tools. Additional data can be collected using Computer Production Management System (MES). The data collected by MTConnect and MES are usually located in separate systems. Using Android devices and cloud computing the MTConnect data can be linked to production data [12].

Recording, storing, and analysing data will become increasingly important. Complex IT systems have only been partially implemented, especially among SMEs. There is a need for a learning concept that allows participants to become familiar with the technologies required, for example the difficulties of implementing the Digital Twin (DT), and the benefits of using it [13].

For small and medium-sized enterprises with low automation production, it is not enough to know information consisting only of time-dependent position data. A comprehensive picture of the production system can only be obtained by taking into account additional information on the movement of workers and the means of production. Maximum consistency of cyber-physical processes with the real model must be ensured by multimodal data collection and evaluation. As the database of SME production data is generally inadequate for the implementation of the Digital Twin due to the heterogeneity and quality, sensor-based tracking and machine vision data collection should also be implemented [14]. Using camera-based sensor technologies makes the processes of logistics and production systems more efficient and economical. Combining different data sources leads to process improvements. Production and logistics data augmented with sensor data can be used to optimize the CPS control [15]. The three pillars of CPS are production line (production), logistics and facilities (building automation). A new group has been identified based on advanced data processing, IoT-based M2M protocol, and machine learning and knowledge training algorithms using a cloud-based platform. This digital functionality is necessary for the real-time information sharing and automation interaction of subsystems from product design to logistics system [16]. Compliance with QoS (Quality of Service) requirements can be improved by reducing component latency and increasing their reliability. Graph-based analysis and optimization of IoT and CPS systems is key to better exploiting the potential of the technology [17]. Graph analysis and optimization of IoT and CPS systems is key to better exploiting the potential of the technology [17]. Textile manufacturers also have to struggle with the tendency for series sizes to decrease while the number of product variants increases. One option to respond to changing market trends is to use CPPS (Cyber-Physical Production Systems) and cognitive machines. A self-optimizing routine allows the weaving machine to independently calculate the optimal parameters, reducing the set-up time by a quarter compared to manual set-up [18]. Diversification of customer needs, rising labor costs, rising costs of energy resources characterize the manufacturing industry. To solve the problems, intelligent manufacturing systems (SMS) are being developed. Smart Manufacturing (SM) connects procurement, production, logistics, services and products to the network and controls the entire production in real time. The CPS enables manufacturing to optimize product development and take full control of the production system through real-time information exchange and the Internet of Things connected to cloud systems (IoT) [19]. The introduction of Industry 4.0 and the rapid development of manufacturing of cyber-physical systems, as well as the growing demand for small-scale and personalized products, represent a major challenge to traditional manufacturing systems. An ontology-based resource reconfiguration method can be used to meet production requirements for fast iteration and to achieve agile and efficient production resource allocation [20]. An ontology-based approach can improve equipment intelligence while reducing energy consumption and increasing production efficiency [21]. Due to the complexity and uncertainty arising from the constant change in customer needs, the design activity of a manufacturing system (MS) can be considered a wicked problem. The AI based design assistants leverage people's cognitive ability to deal with uncertainty and creativity, using the greater computational strengths of AI to analyse large amounts of data [22]. The smart factory is based on the concept of Industry 4.0, denoting technologies and concepts related to cyber-physical systems and the Internet of Things. The smart factory is based on the concept of Industry 4.0, denoting technologies and concepts related to cyber-physical systems and the Internet of Things. In smart factories, computer physical systems monitor physical processes, create a virtual instance of the physical world, and make decentralized decisions. CPSs communicate and collaborate with each other in real time. The architecture of the smart shop floor can be divided into a physical layer, a communication layer and a logical layer. During communication between the physical layers, the communication layer transforms the message, the scheduling decisions of the autonomous intelligence agents in the logical layer are passed to the physical entities, the physical layer executes scheduling commands and simultaneously updates its status to the logical layer for dynamic scheduling [23]. Not so long ago, IT services were assigned to individual servers, resulting in complex maintenance and lower levels of reliability. Today, services running in cloud infrastructures are dynamically and automatically assigned to servers, all of which has led to reduced maintenance and improved reliability. For similar reasons, tasks cannot be performed efficiently without the resource sharing of CPS applications. Developers, installers, and maintainers are unable to keep up with emerging needs as their complexity increase at an ever-increasing rate. The question arises as to whether virtualization of CPS infrastructure can provide a solution based on the model of the IT industry [24]. The intelligent monitoring of vital process parameters (VPP) and the quality development and vision of Zero Defect Manufacturing (ZDM) together ensure that every step of the process chain will meet the standards. Thanks to the sensors and the monitoring system, all events of the CPS system can be documented in detail during the processes [25]. The manufacturing industry needs the highest quality products and services to maintain its competitiveness in the consumer market. Industry 4.0 also offers significant opportunities in quality management through the concepts of Smart Factory, cyber-physical system and IoT [26]. Virtual commissioning (VC) could be one of the main applications of future simulation solutions in the automotive industry. In case of a new component integration, before any physical changes are made in the factory, a simulation can be run and, if successful, the device can send feedback to perform the reconfiguration process in a real factory environment [27].

Using the CPS, DT and Big data creates the basis for the decision-making autonomy and self-regulation of the manufacturing plant's machines. The combined CPS-DT architecture allows for strategy-level optimization of resource flows [28]. The lack robustness and inaccuracy of digital twins can be a major concern, especially when self-developed manufacturing systems and the matching digital twins interfere with each other in the manufacturing workflow and threaten the proper behaviour of manufacturing systems. Using software circuit breakers, the problem can be handled [29]. The Industry 4.0 paradigm is characterized at all levels of manufacturing processes by the autonomous behaviour of manufacturing units and their interconnection. A key concept in this area is the semantic interoperability of the systems. Formal concept analysis (FCA) can be applied in various scientific fields, such as artificial intelligence and machine learning. The FCA approach can be adapted to structure knowledge and optimize collaboration within CPS [30]. Improvements in data monitoring and data processing in CPS result not only in the optimization of predictive equipment maintenance, but also in the possibility of integrating new control techniques [31]. To schedule multi-machine preventive maintenance, the decision-making process can be divided into two decision levels (local and global corporate). This decentralization allows distributed computing, resulting in reduced runtime. Large-scale problems can be solved without compromising on the accuracy of the solution [32].

3. Summary

The Institute of Logistics of the University of Miskolc was one of the first to be involved in the research of the logistics aspects of Industry 4.0. This is indicated by the number of publications produced by the Institute's staff over the past few years. Among these, the following main areas of research are highlighted: the development of innovative business models suitable for the operation of sustainable supply chains, with special regard to outsourcing opportunities [33]; design and modelling aspects of milkrun-based in-plant supply processes in the automotive environment [34]; the application of artificial intelligence methods in the design and management of logistics processes, with special regard to the cyber-physical production environment [36]. In this study, a brief overview and analysis of articles published in the last five years on Industry 4.0 was provided. In the following research papers, a more in-depth analysis will be performed based on this literature base.

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