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Knowledge on IT Tools Based on AI Maturity – Industry 4.0 Perspective

P. Niewiadomski[a], A. Stachowiak[b]*, N. Pawlak[b]

[a]*University of Zielona Górai, Faculty of Economics and Management*
[b]*Poznan University of Technology, Faculty of Engineering Management, Chair of Production Engineering and Logistics, Poznań, Poland*

Abstract

The world is moving extremely fast towards creating a superintelligence that will go far beyond human capabilities. Proper use of this superintelligence in enterprises will result in developing conditions in which their potential is fully exploited. In the context of the above, research has been undertaken to recognize the level of knowledge maturity in the domain of IT tools based on the artificial intelligence algorithm. In other words, it is about recognizing whether the enterprise knows IT tools supporting management operating on the basis of the artificial intelligence algorithm. It was assumed that in the fourth generation industry era such tools should be implemented by Polish manufacturers operating in the agricultural machinery sector. To assess the level of business knowledge of IT tools based on AI algorithms maturity the self-evaluation questionnaire was developed and the research was conducted among manufacturers of parts, subassemblies and ready-made agricultural machines.

*Keywords:*maturity, knowledge, knowledge management, AI, Industry 4.0, agricultural machines industry

1. Introduction

Contemporary producers have to operate in a specific, turbulent environment. Permanent social, political and economic changes have contributed to the fact that hitherto valid and commonly used methods of mass production and management strategies adjusted to them are not applicable in the present times. There is a new economy with three essential attributes - it is global, it favors intangible resources (ideas, information, connections and knowledge) and is strongly interconnected. These three characteristics constitute a new kind of market and society rooted in the ubiquitous network of connections. The global trend that enabled coming of the next revolution was primarily the increase in the amount of available data and computing capabilities. Thanks to them, it was possible to manage company's resources better, plan production and manage the entire life cycle of the product. Data analytics gave companies the opportunity to deepen cooperation with suppliers, as well as better responding to customer needs [1].

* Corresponding author. Tel.: +48-692-446-716
E-mail address: niewiadomski@zpcz.pl, agnieszka.stachowiak@put.poznan.pl, natalia.pawlak@put.poznan.pl

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When observing business practice, it can be noticed that the current use of information systems in management in enterprises is insufficient. This is for two reasons. First of all, the functionalities of the IT systems available on the market are sometimes so complicated that a lot of enterprises have serious difficulties adapting their processes to them and subsequent mapping of analyzes in a given IT tool. Secondly - in the course of a detailed analysis of manufacturing processes that require reliable and up-to-date data, it may also turn out that the functionality of IT systems is insufficient in a given case, which necessitates the use of additional IT tools or dedicated systems supporting these sub-processes that require the most detailed data. In connection with the above, it should be emphasized that there is a growing demand for systems that will enable not only current running of the company, but also support strategic decisions.

The interest of engineers in human intelligence has resulted in the research into the functioning of the neural mechanisms of the human brain. Developing such research tools as: connectionism, expert systems, artificial neural networks, fuzzy logic, genetic algorithms, hybrid systems, leads towards developing advanced artificial intelligence. The development of information technologies using artificial intelligence enabled effective support and partial automation of the decision making process. Data stored in typical transaction systems is characterized by high detail, usually reflecting fragments of a specific field of activity, while aggregated data is needed to plan or consider development strategies. Additionally, the problems related to different data formats, completeness and reliability of the data themselves, their transformation to the required form or with insufficient efficiency of creating advanced reports intensify the need to develop technology based on artificial intelligence methods and techniques [2].

In the context of the above, research has been undertaken, the main goal of which was to recognize the level of knowledge of IT tools based on the artificial intelligence algorithm maturity. In other words, it is about recognizing whether the enterprise knows IT tools supporting management, operating on the basis of the artificial intelligence algorithm. Authors believe that in the fourth generation industry such tools should be known and implemented by Polish manufacturers operating in the agricultural machinery sector. To assess the level of business knowledge maturity in the domain of IT tools based on the artificial intelligence algorithm, self-evaluation questionnaire was developed; the research was carried among manufacturers of parts, subassemblies and ready-made agricultural machines.

The following observations were made before the research was launched:

- IT tools supporting management and based on artificial intelligence algorithms are not clearly comprehended by entrepreneurs;
- There are barriers that limit entrepreneurs willing to implement and develop IT tools supporting management and based on artificial intelligence algorithm
- The literature offers partial approach to managerial tools based on artificial intelligence.

The following assumption were made for the research purposes:

A1) Key management support tools - based on the artificial intelligence algorithm –described in the literature do not have to be identical and consistent with the indications of the sector's experts.

A2) Management support tools based on the artificial intelligence algorithm should be adapted to the market requirements and the specificity of the adopted business model.

A3) Only entrepreneurs and managers as well as representatives of science, characterized by a high level of general and sectoral knowledge, are subjected to expert and survey research, which is to ensure the reliability of research

The work is the result of analysis of literature on the subject and individual research on the scientific and practical ground. It also results from numerous discussions with representatives of the sector under research. It is the result of many professional meetings, consultations and exchange of experiences. The considerations contained in the publication are located in the social sciences, and more specifically in the sciences of management and quality, in the area of computerization in business management.

2. AI algorithm – Industry 4.0 perspective

Artificial intelligence is defined as the field of computer science, which deals with methods, techniques of symbolic inference by a computer and symbolic representation of knowledge used during such inference [3]. In artificial intelligence methods, the data processing is transferred to knowledge processing.

The main task of research on artificial intelligence is the construction of machines and computer programs capable of realizing selected functions of the mind and human senses that are not subject to numerical algorithmization.

Artificial Intelligence (AI) can be captured in short as ‘solving tasks like humans do’. The concept is more than sixty years old as the term was coined at Dartmouth in 1956 by McCarthy and colleagues [4]. At that time, a new science field was envisioned for AI as “science and engineering of making intelligent machines.” (see [5], [6]).

Today smart technologies are changing every aspect of human lives, from the way they work, to health care, education, travel and transportation. Nowadays, most of the production processes are partly or entirely based on automation and robotics devices equipped with selected mechanisms of AI. Dedicated manufacturing processes based on CAM (Computer-Aided Manufacturing) aimed at the implementation of specialized orders (Smart Factory), are supported by control devices that have the ability to recognize the very complex and individual features of items. Such quality control will be based on machine learning algorithms, gaining experience and looking for potential defects in the entire product class [7]. Another production domain in which artificial intelligence algorithms are already applied is solving complex optimization problems concerning material flow planning and management [8], [9]. For this purpose, it is necessary to identify and locate the product in real time. The current RFID system will be supported by Industrial Internet of things (IoT) elements using the 5G network with high operational requirements[10], [11], [12].

It is believed, that by 2025 the processes and enterprises will be smart and to a great extent automated. They will benefit from AI technology that simulates the nuances of human behavior [13].

Nevertheless, AI implementation outside of the tech sector is at an early, often experimental stage. Few firms have employed it at scale. In McKinsey survey of 3,000 AI-aware C-level executives, across 10 countries and 14 sectors, only 20 percent said they currently use any AI related technology at scale or in a core part of their business [9].

According to Accenture AI could double annual economic growth rates by 2035 by changing the nature of work and creating a new relationship between people and machines, in which people are firmly in control and technology increasingly adapts to our wants and needs.

Accenture has identified three channels through which AI can reverse the cycle of low profitability across industries: intelligent automation, labor and capital augmentation, and innovation diffusion [14].

What is the future of artificial intelligence in 4.0 industry? According to Deloitte, another industrial revolution will be based on close cooperation of people with machines equipped with cognitive capabilities. This is what the authors of the report "Exponential technologies in manufacturing" concluded after examining the opinion of leaders in the area of new technologies and production directors in the largest companies operating on the global market. According to the authors of the report, human and artificial intelligence will be complementary to each other – providing a unique value resulting from its strong, unique sides. Tedious, repetitive activities will be performed by the machines, while the employees of flesh and blood will take care of what is creative, requiring critical thinking, prediction and a dose of sensitivity. What is also important for the labor market is the fact that robots cannot do without maintenance, and so far they are completely dependent on human. The more machines, the more repairs and, consequently, more employees needed [15].

The advanced machine learning algorithms, easy-to-use interfaces and manual control systems that can be used to teach a robot to perform specific tasks will contribute to development of co-bots to perform new tasks and operate in a variety of work environments. The programming is done by memorizing sequences of movements made by man and does not require conventional coding. Such machines are already available on the market, they are able to move so as not to pose a threat to people, and for safety reasons they are equipped with special protectors. For the same reason, the strength with which they perform tasks has been severely limited. They will probably become more and more common solution in the future [15].

3. Material and method

The goal of the research was to recognize the level of knowledge on IT tools based on AI algorithm maturity. Research, which was referred to the era of the fourth generation industry, was conducted from the perspective of manufacturing companies operating in the agricultural machinery sector. The research scheme is depicted in Figure 1.

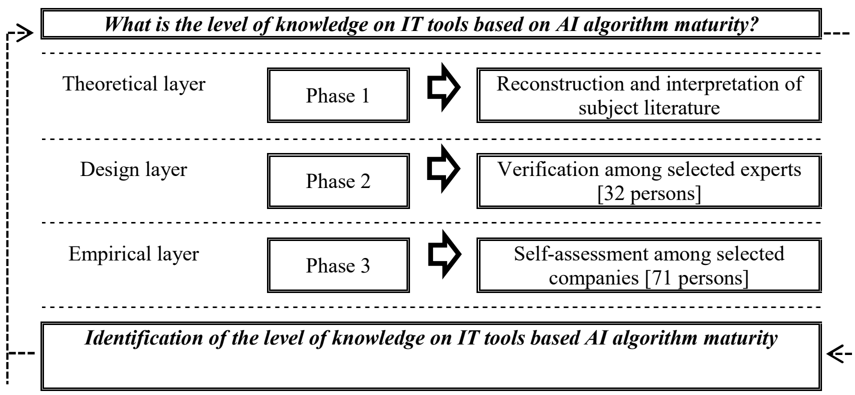

Fig. 1. Research scheme Source: Own study based on the research

The fourth industrial revolution is a concept regarding the use of automation and data processing and exchange [1], as well as the implementation of various new technologies allowing the development of the so-called cyber-physical systems and introducing innovation to production methods [16], [17], [18]. In order to comprehensively address the subject matter, the literature on the subject of new technologies was recognized, including the Internet of Things [19], [20], cloud computing [21], [22], [23], [24], Big

Data analysis [25], artificial intelligence as well as incremental printing, augmented reality [26] or co-bots [27].

The analysis of the literature was used to define the catalogue of tools, potentially representing IT tools based on AI algorithm, that was subject of verification by the group of selected experts.

It has been assumed that the most important criterion for experts selection will be practical application of knowledge. In the context of the above, the experts were practitioners of management (29 people). However, representatives of academia (3 people) were also invited to express their views.

Exploration of the literature and discussion among experts was aimed at compiling a research tool in the form of an assessment sheet.

Participants of the study individually identified tools that in their opinion should be used in the assessment of the maturity of knowledge on IT tools based on the artificial intelligence algorithm. Having phenomenological character (based on experience) - expert research allowed to recognize opinions, feelings and associations, which were caused in the analyzed case by a number of factors referring to the problem of IT tools based on the artificial intelligence algorithm.

Based on expert opinion, guidelines for quantitative research have been established. As a result of the research, the accuracy of language selection was verified; it was important to verify what are the terms used by practitioners. These studies, to a great extent, have facilitated the researchers' closeness to the natural world of the respondents, understanding their attitudes and language, which greatly helped to carry out quantitative research properly while ensuring full understanding of the phenomena investigated among potential respondents.

The basic survey (self-assessment) was conducted on a sample of 71 enterprises representing the agricultural machinery sector.

The respondents were the owners (45.07%) and managers (54.93%) representing: micro - 9 people (12.68%), small - 25 people (35.21%), medium - 31 people (43.66%)) and large - 6 people (8.45%) production companies operating in the agricultural machinery sector. 7.04% of population surveyed were people under 30 years old, 33.80% were between 31-40 years old, 26.76% between 41-50 years old, 23.94% between 51-60 years old and 8.45% over 60 years old. Considering only the group of owners (32 people), more than 40.63% were over 50, the age of 34.38% was in the range of 41-50 years, while 25% of the owners were under 40 years of age. In the case of managers, as many as 25.64% of the respondents were over 50, the age of 20.51% was in the range of 41-50 years, while 53.85% was under 40 years of age. Among the respondents, the majority were secondary and university graduates (62 people), 43.75% of the owners were university graduates, 31.25% -high school/secondary school graduates, and 25% - vocational school graduates. In the case of managers, 69.23% of respondents were university graduates, 28.21% high school/secondary school graduates, and 2.56% vocational school graduates.

To conduct the research, the five levels scale of maturity was implemented, with the levels of maturity characterized by knowledge and experience with AI tools (table1).

Table1. Maturity scale. Source: Own study based on the research

Level	Description	Characteristics
5	**Very high** knowledge of AI tools maturity	Very high level of knowledge and ability to use the tool, application, algorithm or information system based on the artificial intelligence algorithm.
4	**Fairly high** knowledge of AI tools maturity	Tool, application, algorithm or IT system based on the artificial intelligence algorithm known and used; however, there are opportunities to improve knowledge and use.
3	**Sufficient** knowledge of AI tools maturity	Tool, application, algorithm or IT system based on the artificial intelligence algorithm known and used; however, there are opportunities to improve knowledge and use.
2	**Low** knowledge of AI tools maturity	The principle, method or tool based on the artificial intelligence algorithm is poorly recognized.
1	**Very low** knowledge of AI tools maturity	Tool, application, algorithm or IT system based on the algorithm of artificial intelligence practically unknown.

The respondents were asked to assess their knowledge maturity with respect to the identified AI tools, applications and systems with the maturity scale presented in the table 1. The results of the research are presented in the next chapter. The authors are aware of the fact that on ordinal scales, the average value of a given feature should not be taken into account. Nevertheless, in the research methodology, it is used in the questionnaires and thanks to it one can get an answer regarding the degree of acceptance of a given phenomenon or view. Therefore, it is appropriate and can be used in this research.

The next stage of the conducted research is a description of the results obtained and their interpretation.

4. Research results

Research results are presented in the form of the table, in which AI tools, applications and systems important from managers perspective are listed. The experts were asked to assess their maturity knowledge and the number and percentage of indications of a given knowledge maturity level are presented in the table, followed by the average knowledge maturity calculated.

Table 2. Knowledge maturity characteristics. Source: Own study based on the research

Nr	*Tools, applications, systems based on AI*	Realization(% of indications)					
		1	2	3	4	5	
1.	Means of production and automatic devices operating on the principle of self-regulation and working without human intervention or with limited human participation	-	3,0	6,0	25,0	37,0	4,35
		-	4,2%	8,5%	35,2%	52,1%	
2.	IT tools enabling integrated product design	-	3,0	6,0	36,0	26,0	4,20
		-	4,2%	8,5%	50,7%	36,6%	
3.	Tools supporting communication with the client (elements of relationship marketing)	-	2,0	8,0	28,0	33,0	4,30
		-	2,8%	11,3%	39,4%	46,5%	
4.	Modules of dynamic management of the progress path in production correlated with the customer's order (flexible client panel, statuses, notifications, tools for feedback, etc.)	1,0	3,0	12,0	33,0	22,0	4,01
		1,4%	4,2%	16,9%	46,5%	31,0%	
5.	Tools supporting electronic customer service (elements of transactional marketing); standards for handling exchanges, returns and complaints	1,0	3,0	10,0	33,0	24,0	4,07
		1,4%	4,2%	14,1%	46,5%	33,8%	
6.	Integrated tools supporting analyzes in the field of production controlling, including analysis and budgeting of production costs, budget implementation and budget deviations; profitability of investments (resources)	1,0	3,0	13,0	35,0	19,0	3,96
		1,4%	4,2%	18,3%	49,3%	26,8%	
7.	Tools that help eliminate errors and guarantee continuous quality increase	1,0	5,0	15,0	33,0	17,0	3,85
		1,4%	7,0%	21,1%	46,5%	23,9%	
8.	Internal logistics systems (product location, signage, input buffer, service, and output)	1,0	4,0	11,0	37,0	18,0	3,94
		1,4%	5,6%	15,5%	52,1%	25,4%	
9.	Applications enabling management of production equipment	2,0	7,0	22,0	31,0	9,0	3,54
		2,8%	9,9%	31,0%	43,7%	12,7%	
10.	Applications that imply the functionality of dynamic product database management (list of goods, groups and product lines) with the possibility of integration with the production and supply department	1,0	5,0	12,0	38,0	15,0	3,86
		1,4%	7,0%	16,9%	53,5%	21,1%	
11.	Applications for contracting purchases	2,0	5,0	21,0	33,0	10,0	3,62
		2,8%	7,0%	29,6%	46,5%	14,1%	
12.	Applications in the field of warehouse handling (codification, cataloging, bar codes, data collectors, data terminals, data flow automation)	-	1,0	7,0	41,0	22,0	4,18
		-	1,4%	9,9%	57,7%	31,0%	
13.	Systems for automatic handling of product defects at the level of assortment management (ie mistakes, errors, poor product quality, incorrect markings, etc.)	2,0	6,0	14,0	34,0	15,0	3,76
		2,8%	8,5%	19,7%	47,9%	21,1%	
14.	Applications supporting communication and information flow (correlation of data from correspondence with data from systems)	2,0	5,0	17,0	31,0	16,0	3,76
		2,8%	7,0%	23,9%	43,7%	22,5%	
15.	Applications integrated with external systems of forwarding companies that support logistics (semi-automatization or / and full automation of the order distribution process with an element of customer communication support, e.g. secondary statuses from operators	1,0	7,0	18,0	32,0	13,0	3,69
		1,4%	9,9%	25,4%	45,1%	18,3%	
16.	Calculation algorithms enabling production planning taking into account the availability of tools required to carry out the production process at a given time	1,0	4,0	10,0	35,0	21,0	4,00
		1,4%	5,6%	14,1%	49,3%	29,6%	
17.	Applications for multidirectional data processing in a warehouse (minimum stock levels, doming of materials and raw materials, label management, statuses, etc.) Implementing the functionality of dynamic management of inventory updates	1,0	3,0	9,0	36,0	22,0	4,06
		1,4%	4,2%	12,7%	50,7%	31,0%	
18.	Platforms of orders, products, statistics panels, analytics panels,	1,0	4,0	10,0	37,0	19,0	3,97

Nr	*Tools, applications, systems based on AI*	Realization(% of indications)					
	control panels	1,4%	5,6%	14,1%	52,1%	26,8%	
19.	Applications of the social media and Social Media channels	1,0	3,0	10,0	29,0	28,0	4,13
		1,4%	4,2%	14,1%	40,8%	39,4%	
20.	Applications supporting decision making and introducing modern technologies in the field of production (eg. expert systems, Business Intelligence, ICT systems, remote work systems, process automation, etc.)	3,0	6,0	12,0	33,0	17,0	3,77
		4,2%	8,5%	16,9%	46,5%	23,9%	
21.	Modules supporting the virtual display of the offer	3,0	6,0	10,0	33,0	19,0	3,83
		4,2%	8,5%	14,1%	46,5%	26,8%	
22.	Applications for managing the rotation of materials and raw materials in relation to the commercial offer and commodity flows (obtaining priority effect on the market, diversification, uniqueness / exclusivity, etc.)	2,0	4,0	10,0	34,0	21,0	3,96
		2,8%	5,6%	14,1%	47,9%	29,6%	
23.	Control and measurement modules and apparatus	2,0	3,0	10,0	33,0	23,0	4,01
		2,8%	4,2%	14,1%	46,5%	32,4%	
24.	Modules for dynamic processing and management of material order flow (placing / acceptance of orders, service and implementation, verification and control)	1,0	5,0	9,0	32,0	24,0	4,03
		1,4%	7,0%	12,7%	45,1%	33,8%	
25.	Shopping platforms with suppliers' and logistic services systems	2,0	3,0	8,0	33,0	25,0	4,07
		2,8%	4,2%	11,3%	46,5%	35,2%	

In the era of shortage of executive staff, the ability to transfer the entire function of managing the manufacturing process to specialized devices, most often to computers, gains special importance, while partially leaving some scope of executive functions to people. Following the indicated trend, the surveyed enterprises show a relatively high level of maturity in the knowledge of modern technologies and automatic devices (CNC numerically controlled machines, welding robots, conveyors, feeders) operating on the principle of self-regulation and working without human participation or with its limited participation (average rating 4.35, 52.1% indications of 5th level of maturity). Proper tools save costs, make people's work easier, minimize the risk of errors, give new opportunities, optimize and automate customer service processes. The effect of implementing the right tools to support communication with the customer is the increase in sales, which contributes to an increase in revenues and profitability of the company. That is why knowledge is so important. Enterprises are aware of the fact that new conditions require them to prepare and implement strategies for multi-channel communication with the client and the use of modern marketing automation and call / connect center tools; they indicate high level of knowledge maturity in this area (average rating 4.30, 46.5% indications of 5th level of maturity). The new conditions are the challenge for the sales departments, but at the same time an excellent opportunity for fully personalized customer service. Attention is drawn to the need to implement IT tools that enable integrated product design; enterprises demonstrate knowledge, awareness and extensive experience in this area (average rating 4.20, 36.6% indications of 5th level of maturity).

Customer service is the ability to meet the requirements and expectations of customers mainly regarding the time and place of ordered deliveries, using all available forms of logistic activity, including storage. Errors in warehousing logistics often result in the loss of customers for competition. In order to avoid them, it is necessary to implement tools supporting warehouse service in terms of four main dimensions: time, reliability, communication and convenience. IT systems supporting the work of a warehouse in Poland are used in almost every enterprise, and their importance is constantly growing due to the economic growth, also associated with increased trade in goods. There are completely new challenges and needs. The answer to such needs are systems operating on the basis of the artificial intelligence algorithm. However, the availability of the systems, their effectiveness, and above all the knowledge about their implementation is very diverse, in the case of the surveyed enterprises relatively mature (average rating 4.18, 31.0% indications of 5th level of maturity).

Among the companies seeking contact with clients, the interest in the social media increases. While there is no doubt that skillful activities conducted on the basis of social media support sales, what is the knowledge level in this area? The widespread presence of social media in the practice of the surveyed enterprises is a manifestation of relatively well-established knowledge in the applications that give the opportunity to interact with the participants, thus becoming a space for community development (average rating 4.13, 39.4% indications of 5th level of maturity). Nevertheless, the challenges faced by social media researchers, such as the combination of the quantitative and qualitative aspect, or the problem of complexity and the selection of indicators, prove the need to constantly expand knowledge in this area.

Building a customer relationship requires the use of a system that will also provide the user (manufacturer) with the necessary feedback on the basis of which he will be able to make strategic decisions. E-commerce has created an effective platform for producers to obtain information, which forced them to constantly gain knowledge on the possibilities of using tools that support electronic customer service, including exchanges, refunds and complaints (average rating 4.07; 33.8% indications of 5th level of maturity).

Until recently, purchasing systems were the domain of a small group of professional buyers. Meanwhile, electronic offer inquiries and purchase auctions improving work, increasing the transparency of purchases and enabling measurable savings, often significantly exceeding the expectations of users have become commonplace. The trend of digitization of purchasing processes is unstoppable, of which entrepreneurs are aware of the significant knowledge in the field of the possibility of using tools supporting procurement processes (average rating 4.07, 35.2% of indications of 5th level of maturity).

Striving for optimal stock levels is a constant search for a compromise between two opposing needs. On the one hand, enterprises want to maintain constant and free access to the raw materials they need, on the other hand, they try to minimize the costs associated with their possession and storage. In effective warehouse management, the key element is the ability to instantly collect, control and present reliable information about them. Implementing the functionality of dynamic management of stock updates requires the implementation of warehouse management systems, of which entrepreneurs know more and more (average rating: 4.06, 31.0% of indications of 5th level of maturity). In the era of industry 4.0, inventory management is of particular importance. Attention is given to ensure maximum availability at a minimum cost. This forces the necessity to implement modules for centralization and automation of inventory management. That is why the algorithm, which adapts selectively the optimal stock level of individual materials in order to minimize lost sales cost is being used more and more often. Attention is drawn to the relatively high level of knowledge and awareness regarding the possibility of using an application that will automate both generation of orders to suppliers and internal orders (average rating of 4.03, 33.8% of indications of 5th level of maturity). Therefore, it is crucial to implement a dynamic track management module in production with the customer's order (flexible client panel, statuses, notifications, feedback tools, etc.), which in turn is conditioned with "mature" knowledge on the basis of which the manufacturer will be able to take strategic decisions on its implementation (average rating 4.01, 31.0% indications of 5th level of maturity).

A common way to support production control is the use of hierarchical information systems built on the basis of various decision support tools, integrated with common databases. In enterprises, there is currently growing interest in computational algorithms enabling production planning taking into account the availability of tools required to carry out the production process at a given time. Manufacturers face a complex decision problem consisting in answering the question of how much and when to produce in order to minimize the cost of setup. The entrepreneurs seem to have specific knowledge, required when using production planning tools implemented in contemporary integrated management systems (average rating 4.00, 29.6% indications of 5th level of maturity).

In order to guarantee availability of information throughout the enterprise, the database should be synchronized with partial resources in other systems. Therefore, knowledge of comprehensive and open to integration sales platforms (orders, statistics panels, analytics panels, control panels) that enable integration with the production department is important (average rating 3.97, 26.8% indications of 5th level of maturity). The need for analytical and forecasting information, which can be the basis for assessing the state of the enterprise, in all aspects of its operations, is undeniable regardless of the size or nature of the production enterprise. Enterprises aware of their controlling needs should make the decision about computerization. Attention is drawn to the need to broaden knowledge on integrated tools supporting analyzes in the field of production controlling (average rating 3.96, 26.8% indications of 5th level of maturity).

It is important from the marketing 4.0 point of view to achieve the effect of priority, diversification, uniqueness or exclusivity on the market. Therefore, attention is paid to the knowledge of applications that enable the management of material and raw materials turnover in relation to the commercial offer and goods flows (average rating 3.96, 29.6% indications of 5th level of maturity), including software supporting internal logistics management.

The problem of managing a huge amount of product information and the possibility of their transparent presentation is a significant challenge in the context of the industry4.0. It is crucial to make product information important for the customer efficiently - preferably in the form of a positively distinguished competition. Significant savings potential and streamlining of purchasing, production and sales processes opens up a wider recognition and implementation of the software platform for managing product and catalog information to enterprises. Although IT systems in this area are known and widely used, there is a possibility to improve knowledge in terms of their functioning and implementation. (average rating 3.86, 21.1% indications of 5th level of maturity).

In the Industry 4.0, planning of actions and the response to irregularities is very important in order to ensure maximum availability at a minimum cost. Attention is drawn to the necessity of a wider recognition of tools supporting the elimination of errors and guaranteeing a continuous increase in quality and a system of automatic handling of product defects at the level of inventory management. This will allow elimination of mistakes, errors, poor product quality, incorrect markings, etc.

From the Industry 4.0 point of view, multi-directional communication and information flow, including correlation of data from correspondence with data from systems is important. Therefore, it is reasonable to implement a module that gives the opportunity of electronic exchange of documents between counterparties according to EDI (Electronic Data Interchange) standard. In the face of fourth generation industry attention is paid to the need to gradually implement applications that provide the ability to integrate with forwarding computer systems in generating printouts according to specific templates, generation of individual shipment labels for each of the shippers, or automatic settlement of collection amounts. Attention is drawn to the need to implement applications that enable management of production equipment [1]. A tool, application or IT system based on the artificial intelligence algorithm is well known and used in the indicated areas; nevertheless, there are opportunities to improve knowledge about the possibility of their use and use, which is a key message of the philosophy of continuous improvement.

5. Conclusion

Contemporary ideas, concepts and theories stress the role of knowledge in effective enterprise management. Numerous research on the interdependence between the level of knowledge maturity and enterprise development contribute to the development of theoretical and empirical achievements, while generating consistent results regarding the direction and strength of this relationship. Hence, the development of an appropriate method for assessing the maturity of domain knowledge and, on this basis, its assessment, should be the subject of research; confirms the desirability of their implementation. The development of technology leads to the situation in which knowledge about tools, applications or information systems based on the artificial intelligence algorithm becomes an indispensable attribute of all activities and intentions; knowledge possession determines the conduct and effectiveness of undertaken activities.

In order to implement and maintain modern systems using the artificial intelligence algorithm, on which the idea of Industry 4.0 is based, not only knowledge in the field of management, but also automation or IT is needed. As these fields become more and more intertwined, it will be necessary to train interdisciplinary specialists - management engineers.

An important barrier related to the implementation of solutions specific to Industry 4.0 will not only be the acquisition of the right technology, but - related to this - the need to acquire new knowledge. Therefore, the authors undertook research which main goal was to recognize the level of knowledge maturity in the domain of IT tools based on the artificial intelligence algorithm. In other words, it was about finding out whether IT tools based on AI supporting management are recognized and implemented.

The conducted assessment was an excellent opportunity to verify the views held in the context of participant observation. The results of the research confirmed the authors' belief that knowledge in the domain of IT tools based on the artificial intelligence algorithm, however high, in some areas still needs to be improved. The observations and interviews conducted by the authors predispose them to stating that in the majority of surveyed entrepreneurs, in their activity, they perceive the necessity to implement modern IT solutions supporting management; they see the threat of not knowing about the available applications, tools or systems.

The authors are aware of the fact that the presented areas of evaluation do not fully cover the discussed issues, but it is important that they become any indication and basis for those who want to assess the level of knowledge maturity in their company. The authors hope that the development will affect the development of management and quality sciences.

References

[1] Nogalski B., Niewiadomski P., Szpitter A., Przemysł czwartej generacji a strategiczne działania dostosowawcze polskich wytwórców sektora maszyn rolniczych (Industry 4.0 in the context of strategy ddevelopment in the agricultural machinery sector), „Przegląd Organizacji", nr 11, (2018).

[2] Niewiadomski P., Determinanty elastyczności funkcjonowania przedsiębiorstwa produkcyjnego sektora maszyn rolniczych (The determinants of flexibility of manufacturing enterprise functioning in agricultural machinery . Wydawnictwo Politechniki Poznańskiej, Poznań (2016).

[3] Pacholski L. Systemy ekspertowe i sztuczna inteligencja (Expert systems and Artificial Intelligence), Wydawnictwo Politechniki Poznańskiej, (2012), 19-20.

[4] Pan, Y. Heading toward Artificial Intelligence 2.0. Engineering (2016), 2, 409–413.

[5] Norman, D. Design, Business Models, and Human-Technology Teamwork. Res.-Technol. Manag. (2017), 60, 26–30.

[6] Hamet, P.; Tremblay, J. Artificial intelligence in medicine. Metabolism (2017), 69, 36–S40.

[7] Polityka Inside, Iloraz sztucznej inteligencji, Potencjał AI w polskiej gospodarce, (eng. Potential of AI in Poland. Quotient of Artificial intelligence), Warszawa (2018) (www.politykainsight.pl/nowa/badania, accessed on 2/02/2019.

[8] Fertsch M., Oleśków-Szłapka J., Pawłowski G., An Optimization Approach for Scheduling and Lot Sizing Problems in Electromechanical Industry Using GA-Based Method. In: Burduk A., Mazurkiewicz D. (eds) Intelligent Systems in Production Engineering and Maintenance – ISPEM 2017. ISPEM 2017. Advances in Intelligent Systems and Computing, Springer, Cham, 637 (2018)140-150.

[9] McKinsey&Company, Artificial Intelligence. The next digital frontier?, (2017).

[10] Kizza J.M., Guide to Computer Network Security, Computer Communications and Networks, Springer International Publishing AG (2017) (DOI 10.1007/978-3-319-55606-2_24).

[11] Schneider S., Understanding The Protocols Behind The Internet Of Things, ElectronicDesign, (2013).

[12] Maia Tanajura Ellefsen A.P., Oleśków-Szłapka J., Multi-agent systems: A case study that explores challenges, trends and future perspectives in terms of IoT, AI and 5G technology, Proceedings of 28th European Conference on Networks and Communication, (preprint).

[13] Gartner, The road to enterprise AI, (2018). DOI: 10.13140/RG.2.2.34573.44006.

[14] Purdy M., Daugherty P., Accenture, How AI boost Industry profits and innovation, (2017).

[15] https://www2.deloitte.com/us/en/pages/manufacturing/articles/advanced-manufacturing-technologies-report.html

[16] Lee J. Bagheri B., Kao H., A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems, „Manufacturing Letters", Vol. 3, 1 (2015), 18-23.

[17] Kagermann H., Chancen von Industrie 4.0 nutzen, [in:] T. Bauernhansl, M. Hompel, B. Vogel-Heuser (eds.), Industrie 4.0 in Produktion, Automatisierung und Logistik. Anwendung, Technologien und Migration, Springer Fachmedien, Wiesbaden, (2014), 603-614.

[18] Lee E., Cyber Physical Systems: Design Challenges, 11th IEEE Symposium on Object Oriented Real-Time Distributed Computing (ISORC), 1 (2008), 363-369.

[19] Atzori L., Iera, A., Morabito G., The Internet of Things: A survey, „Computer Networks", 54(15), (2010), 2787-2805.

[20] Zuehlkea D., SmartFactory - Towards a factory-of-things, „Annual Reviews in Control", 34(1), (2010), 129–138.

[21] Xu X., From cloud computing to cloud manufacturing, „Robotics and Computer Integrated Manufacturing", 28(1), (2012), 75-86.
[22] Subashini S., Kavitha V., A survey on security issues in service delivery models of cloud computing, „Journal of Network and Computer Applications", 34 (1), (2011), 1-11.
[23] Valilai O.F., Houshmand, M., A collaborative and integrated platform to support distributed manufacturing system using a service-oriented approach based on cloud computing paradigm, „Robotics and Computer Integrated Manufacturing", 29(1), (2013), 110–127.
[24] Wang X.V., Xu X.W., An interoperable solution for Cloud manufacturing, „Robotics and Computer Integrated Manufacturing", 29(4), (2013), 232-247.
[25] Lee J., Kao H-A, Yang S., Service innovation and smart analytics for Industry 4.0 and big data environment. „Procedia CIRP", 16, (2014),3–8.
[26] Stadnicka D., Antonelli D., Implementation of augmented reality in welding processes, „Technologia i Automatyzacja Montażu", 4, (2014), 56-60.
[27] Stadnicka D., Antonelli D., Discussion on lean approach implementation in a collaborative man-robot workstation, Sixth International Conference on Business Sustainability 2016 „Management, Technology and Learning for Individuals, Organisations and Society in Turbulent Environment", November 16-18, (2016). Póvoa de Varzim, Portugal