Industry 5.0 and human capital

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Abstract. Industry is a key factor in economic development. We are on the approach of a new paradigm - Industry 5.0. This study briefly discusses the main driving forces and means that contribute to the introduction of this new paradigm, then examines the role of man in it, as well as human responsibility and control, in comparison with the classic robots and cobots, which the new Industry is talking about. In conclusion, the main features and the problems of Industry 4.0 and innovations related to the transition to Industry 5.0, as well as the ethical component of the transition and the formation of a human capital as a core value.

1 Introduction

Humanity is actively experiencing the fourth industrial revolution, also called «Industry 4.0», which is based on the massive introduction of information technologies in various fields of Industry, process automation and the spread of artificial intelligence technologies. This, in turn, offers a number of benefits both for ordinary workers and business owners, as well as for the country's economy as a whole:

- Increasing competitiveness due to the rapid growth and development of groundbreaking products.
- Increased productivity due to production facilities and process automation.
- Safety of workers due to the robotization of processes that provide harm to humans.

As Industry 4.0 evolved, a concept called the Industrial Internet of Things (IIoT) emerged, which consists of Internet-connected machinery and services that process the data that the equipment produces. IIoT brings together technology, computing processes, analytics, and enterprise workers to improve the efficiency of manufacturing processes. With IIoT, industrial companies can digitize processes, modify business models, and increase productivity and efficiency while reducing costs, which is the basis of the concept under consideration.

Despite its appeal, Industry 4.0 has its downsides. Process optimization has greatly reduced the importance of humans in many tasks across industries, causing considerable concern and protest among workers.

We are on the approach of Industry 5.0, which, in turn, will help bring back the importance of humans in production and create human-machine synergy. However, Industry

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5.0 focuses not only on the ability of workers to cooperate with robots, but also on the flexibility of production processes and their impact on the environment.

The research paper proposes to consider the main concepts that characterize Industry 5.0 and the role of human in it.

2 The problems of the Industry 4.0 and the principles of transition to Industry 5.0

The scale of economic, environmental and social problems faced by humanity is only growing every year. Industry 5.0 is a relatively new concept and at the moment there is some uncertainty about what it will bring and how it will affect business and production. Technologies will be more complex than those that humanity has faced before, and people need to prepare for these changes.

Before considering the transition to Industry 5.0, it is necessary to understand what is wrong with Industry 4.0 and why it should be upgraded. The desire to increase industrial productivity and simultaneously reduce production costs has led to the active introduction of automation in all its manifestations. Integration of computing, network and physical processes within a common cyber–physical system is, by and large, Industry 4.0 or the Fourth Industrial Revolution.

We can highlight a number of problems that Industry 4.0 brings to the table:

• Huge investment needed. The transformation of an enterprise to the level of the fourth industrial revolution, the connection of all its devices to the industrial Internet of Things, requires significant material investments, which are needed both for the remuneration of specialists, research, and for the purchase of technical components that allow solving the problem. At the same time, it is necessary to thoroughly analyze all the risks in order not to suffer huge losses. In addition, if we consider the economic side of the issue, small business cannot afford such investments, and large business occupies an increasing part of the market, which can lead to potential monopolization, which is not a positive aspect for the development of the economy.

- Lack of sufficient confidentiality. In the era of big data, an important aspect for the development of an enterprise is the collection and analysis of this very data from the consumer, which allows you to find out his needs, desires, satisfaction. But such an approach from the client's point of view can be perceived as a threat to privacy. The cornerstone of security is bridging the gap and eliminating misunderstandings between the consumer and the manufacturer, since confidentiality is also an important aspect for the customer.
- Lack of necessary security. One of the most difficult aspects of the introduction of Industry 4.0 is the problem of security, since it is directly related to the security and protection of information technologies, the need to provide the enterprise with protection from the introduction of criminals and competitors. The concept of the Industry and, in particular, the industrial Internet of Things, assumes access of devices to a global computing network (WAN) or a local area network (LAN), which, in turn, allows for the possibility of cyber attacks and even cyber theft at the enterprise, which can negatively affect the reputation of the company in the eyes of customers and to attract large losses. The solution may be to hire specialists in the field of information technology, information security and data encryption, which brings us back to the problem of large investments.
- Errors in the operation of automated devices and software. Of course, such errors will always be present and difficult to get rid of, but in the transition to a new Industry, this problem will be especially relevant, because disruptions in the operation of cyber-physical systems are inevitable at first. Misconfigured enterprise LANs, device malfunctions and similar problems can affect the stability and stability of technology, and rob the company of some of its profits

by reducing the productivity of getting work done. Some of this can be done by bringing in specialists, but there's not enough to do on your own. It is necessary to take into account all the difficulties for the continuous and uninterrupted work of the enterprise, timely control the operational state of the network and remove the anomalies as soon as they appear, or better yet - proactively - before they happen. Only continuous monitoring can help with this, the mechanism of which has not yet been developed within the Industry 4.0.

- Modernization of the labor market. With the arrival of Industry 4.0, manufacturing employment must change on a global level. Due to the automation of many processes at all stages of the product lifecycle, a certain part of the workforce will be dismissed as unnecessary. And some of the remaining people will need to be retrained to acquire the skills to work in an already automated enterprise. An impressive sector of the labor market will have to come into line with the new principles of production. A partial solution to this problem may be the introduction of new forms of education for employees right in the enterprise, expanded mentoring and training systems.
- An uncertain future and the uselessness of production workers. Due to the automation of most factors of production, many employees are rendered useless and lose their jobs, which, in turn, causes enormous concern and even protests among people against robotization. It is unclear to the worker whether he can compete with robots in smart manufacturing and what his role is now. The skills he has trained for his entire life can be replaced by a machine at a moment's notice. And despite the fact that Industry 4.0 nurtures great potential in economics, investment, research, and technological advances, it diminishes the merits of humans, thereby causing negative attitudes toward itself in general and robotics in particular, thereby slowing down technological development and progress.

After considering these problems, we can conclude that it is necessary to make a number of changes, which, in the end, will rid us, though not of all, but of most of the problems. And most importantly - will increase the importance of man, reducing a large number of risks and discontent. After all, man is at the head of this world, without him there would be none of this, which means we cannot simply exclude him from further development. There must be a close interaction between man and machine, a widespread increase in the level of trust in technology. All of this can be done within the framework of the new industrial revolution or Industry 5.0.

In April 2021, during an international scientific conference on the problems of economic and social development, the concept of Industry 5.0 was proposed, implying the synergy of human intelligence and technological perfection of the machine, creating on their basis a collective intelligence, which will develop technology, modernize humans and avoid technological singularity [1].

A similar viewpoint was put forward at the Aveva world digital event on June 17, 2021: «Combining the capabilities of connected Industry 4.0 technologies with the human-centered approach of Industry 5.0 will pave the way for the harmonious interaction of human intelligence with cognitive computing» [2].

Therefore, the new Industry will incorporate all aspects of Industry 4.0, as well as complementing itself with the following changes:

- Robots will expand to «Collaborative Robots» (cobots), that not only perform fast and accurate tasks, but also have safety functions to protect the person performing tasks together, therefore, accurate and controlled metrics are required to perform such safety functions as key performance indicators [3].Increased productivity due to production facilities and process automation.
- There will be a new role in industrial production – the director of robotics, who will be responsible for making decisions regarding interactions with the robot. Such people should have a deep understanding of robotics and have a positive impact on the management of

production processes and the protection of the environment from the negative effects of new technologies.

- Reducing network latency and congestion by developing a global network of sensors at each manufacturing. To implement such a network, it is necessary to develop a common structure for transmitting and storing information that allows working with different types of big data, which, in turn, will open up the possibility of high-quality and transparent management of all production processes.
- Monitoring of the entire manufacture using a complete simulation of each device and a global network of digital twins. These are digital copies of physical objects, such as products, processes, or systems. Digital twins differ from other related concepts in the level of data integration between physical and digital counterparts, since they are fully integrated with real-time data exchange [4]. Combined with advanced visualization and modeling technologies, technologies such as digital twins are designed to increase the productivity of all sectors of any Industry.
- Trackers that enable real-time asset and process tracking pave the way for online optimization of the production process. When combined with technologies such as the Internet of Things and machine learning, they can also lead to reduced material loss, theft prevention and unfair asset management.

In addition to the above aspects, there are also other nuances that should be considered in the transition to a new Industry. To meet today's challenges, the focus should not only be on enterprise profits, but also on environmental, social costs and benefits. To comply with this, the integration of the perspectives of sustainable development, flexibility, and human-centered model should be at the core [5].

3 The role of human in the Industry 5.0

The human-centered approach focuses on basic human interests and needs. Instead of adapting employees' skills, we use technology to adapt processes to their needs. This also ensures workers' rights, autonomy and human dignity.

Technological innovations do not allow to fully provide a sufficient degree of personalization required by customers. Personnel working in production remain a significant part of it, allowing to use and improve the potential of technology [6]. After all, only humans are capable of generating the kind of creative ideas that can lead to product development with personalization in mind.

With the arrival of Industry 5.0, the employee finds himself in a new role in the enterprise; he is seen as part of the investment for the owners of the enterprise. This approach allows both the employer and the employee to develop, because the hiring company is interested in investing in the skills, abilities and well-being of the employees, in order to achieve common goals. Human capital becomes a core value.

To achieve continuous improvement in the new synergy aspects of management, the potential of technology and the human mind should be integrated with the PDCA cycle (Fig. 1) as it:

- Widely known to the public, thereby generating (greater receptivity) greater trust among users.
- Contains briefly outlined basic management concepts.
- Has a cyclical view that implementation and system transitions should be gradual [6].

Fig. 1. PDCA cycle.

The cyclical continuation of the four steps leads to a spiral of constant customer satisfaction at lower costs. With the regular repetition of the cycle, there is a constant improvement in quality and ensuring the development and growth of the enterprise's economy [7]. The use of advanced technologies requires software and hardware, taking into account the constant import substitution of software and technical solutions: modern CNC technological equipment, built-in and integrated control systems, highly efficient structural and functional materials of technological solutions, technologies and the organization of high-tech production [8] and the interaction of all this with a person.

Using the PDCA cycle allows you to expand the interaction between process control and information about these processes. This approach not only develops and implements a management system, but also certifies it in accordance with the requirements of ISO 9001 series standards, which allows the use of developments at any enterprises in accordance with the legislation.

By integrating human capital with the PDCA cycle, by managing the necessary process data through the implementation of digital and adaptive mismatch tools, the availability of flexible adaptive communication, dynamic changes in the priorities for management processes and the application of information security requirements, it is possible to optimize and improve all processes and aspects of management and production. Continuing to consider the concept of a new Industry, it is necessary to address the topic of artificial intelligence, both in it and in technological development in general.

In [9], the authors present a neuro-economic model of the Industry 5.0 concept, headed by artificial intelligence, which combines neuro-digital, socio-economic and other types of ecosystems. It is this model that allows combining all the possibilities of the already mentioned Industry 4.0 together with a human-centered approach, thereby taking human capital as the basis and elevating it, which, in turn, will facilitate managing the technological development of all mankind.

The 2019 UN Human Development Report brought up the possibility of transforming labor markets, particularly with regard to how automation and artificial intelligence can replace humans [10]. Thanks to the development of Industry and society as a whole, such problems will no longer exist. Since humans have creativity, a desire for personal responsibility for work results, and a certain amount of education, and robots have a perfect command of technology and the ability to do monotonous work, together they will form a perfect synergy, which will make decisions as efficiently as possible [11].

The saturation of the market with collaborative robots will help bring fundamental changes in the social structure of society and the distribution of its resources. The information model of the transition from Industry 4.0 to Industry 5.0, which is the absolute transformation of human capital, is shown in Figure 2.

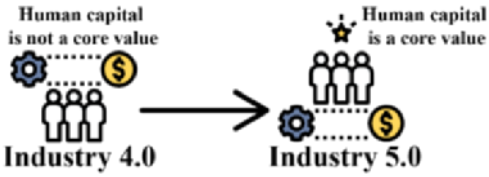

Fig. 2. Model of transition from Industry 4.0 to Industry 5.0.

The elevation of human capital to an absolute is a crucial aspect, both for one's perception and attitude toward work and for economic growth. In [12] the relationship between human capital and economic growth is discussed. General and professional education, health care, migration, and access to information are considered the most important forms of human investment.

Education and training in the workplace provides an increase in the volume of human capital. Health protection and healthcare increases the intensity and amount of use of human abilities, by reducing mortality and morbidity of mankind. Possession of information and migration contribute to the movement of a person to regions where human labor is paid in the best way, thereby contributing to other regions to increase wages due to a shortage of employees, which also contributes to the development of the economy.

Like physical capital and material opportunities, the formation of human capital requires significant investments both from the individual himself and from the whole society, and for this it is necessary to understand the benefits of investing in development. For an individual, the benefit is to increase his own income and increase the standard of living, and for society – to increase the level of the national economy and the economic development of the country as a whole.

Since it is recognized that man is the main social wealth [13], to the extent that the economic progress of society directly depends on human development. The socio-economic environment requires the development and implementation of innovative approaches to the development and use of human capital, namely [14]:

- Creation of a system of human needs focused on achieving a balance of social, economic and environmental interests.
- Development of a system of labor motivation aimed at activating the innovative behavior of employees and the development of their respective competencies.
- The introduction of non-standard forms of employment in the activities of organizations, which is a promising tool for the use of human capital.

All this is partially or completely provided during the transition to Industry 5.0.

4 Human responsibility and control

Considering the processes of transition to a new industry and the formation of human capital at the head of industry 5.0, it is necessary to touch upon such a concept as individual responsibility of a person, which is inherent only to him. This will help to understand the importance of the implemented changes and highlight the shortcomings of industry 4.0, which does not pay enough attention to human capital.

According to [15], there is corporate social responsibility (CSR), which includes economic, legal, ethical and discretionary expectations imposed by society on the organization at a given time. Compliance with CSR ensures the continuous development of the organization, which, in turn, drives the country's economy. It should be understood that for an effective strategy of such responsibility, ethics, along with personal responsibility of a person, plays a major role.

Humans have responsibilities and ethical qualities that are available only to them and not to anyone else. Although questions about the ethics and morality of robots and automatic agents have been investigated before, the possibility of such machines can still not be rightly evaluated.

As automation and robotics capabilities grow, perhaps the most important issue to consider is the need to rethink responsibility [16]. Absolutely all robots, be they cobots or other cyber-physical artificial intelligence systems, regardless of their level of autonomy, social awareness, or ability to learn, are merely entities created by humans to achieve certain ends.

Research in the field of artificial intelligence shows that ethics and artificial intelligence are connected at the following levels [17]:

- Ethics by Design: the technical/algorithmic integration of ethical reasoning capabilities as part of the behaviour of artificial autonomous system.
- Ethics in Design: the regulatory and engineering methods that support the analysis and evaluation of the ethical implications of AI systems as these integrate or replace traditional social structures.
- Ethics for Design: the codes of conduct, standards and certification processes that ensure the integrity of developers and users as they research, design, construct, employ and manage artificial intelligent systems.

However, although all of the above links ethics with artificial intelligence, it does not add to this intelligence the responsibility that is so necessary for creating principles, morality, ensuring productivity and error-free production.

When considering the duties and responsibilities of digital productions and machines, a direct comparison can be made with another group of nonhuman sentient beings, such as wild and domestic animals. Conceptually they have much in common and can provide insight into nonhuman responsibilities. Peter Singer pointed out that «animals are treated like machines that turn food into flesh» [18].

Many animals are raised by humans to perform certain duties in human society (for example, guide dogs). In many cases, they are also specially bred (with certain genotypes, phenotypes and traits) and subsequently trained to perform specific tasks. Similarly, digital intelligent manufacturing and robots are specially designed, built and subsequently programmed to perform specific tasks.

Wild animals have moral codes, and many animals demonstrate «social homeostasis» through their social interactions. They have been shown to exhibit «wild justice» [19] where they express emotion, flexible behavior, reciprocity, empathy, trust, and tangible duty.

How realistic is it for a robot to possess similar traits in the future? From a purely ethical point of view, the question of morality does not depend on the type of origin of the individual. The question of animal rights has many well-established viewpoints, and there is a tacit consensus that, on a practical level, a utilitarian approach is taken to grant rights to animals wherever possible [20]. Nevertheless, there is a tacit recognition that animals have a moral responsibility that requires consideration of their moral worth.

However, any direct moral comparison of robots and artificial intelligence to animals can be problematic. The source of such moral action must be distinguished from an assessment of the responsibility of automated industries and robots as compared to that of humans. Here it is crucial to highlight a particularly significant property of individual human responsibility. It is the ability, through one's own responsibility, to correct a mistake made, which one is inclined to do all the time.

A mistake that can be made at any stage of production activity, if it has not resulted in a fatal outcome, can be corrected. But this is only possible with human participation in the observation and control of production automation.

By weaving personal responsibility into the fabric of Industry 5.0, we find a qualitatively different level of scrutiny at every stage of the technological pipeline. Updating PDCA cycle (Fig. 3), we refine each of its characteristic stages to include additional control through personal responsibility and ethics.

Fig. 3. Updated PDCA cycle.

By weaving personal responsibility into the fabric of Industry 5.0, we find a qualitatively different level of scrutiny at every stage of the technological pipeline. Updating PDCA cycle (Fig. 3), we refine each of its characteristic stages to include additional control through personal responsibility and ethics.

Each point of responsibility is thus a coordinate of personal quality control of the production or product. It is generally accepted that human involvement creates risks of inappropriate interference in an automated process due to so-called human factors. But it is human intervention in an automated, technologically sophisticated process that will avoid long-term, uncontrollable failures, broaden the strategic vision of production, and prevent questionable assessments and decisions.

5 Conclusions

If Industry 4.0 emphasized the combination and integration of technologies, where formal and systemic methods are crucial to realize its benefits [21], and intelligent production plays a central role [22]. Industry 4.0 has paved the way for the development of socio-environmental sustainability functions such as energy sustainability, harmful emissions, reduction and improvement of social welfare [23]. However, there is organizational resistance, both at the employee and middle management level, in the path of production development, which significantly hinders the implementation of Industry 4.0 technologies [24].

On the contrary, Industry 5.0 will allow to overcome social resistance, not simply involving a person in the organizational and production process, but giving him a defining value to this process. The creative potential of specialists in cooperation with efficient, intelligent and precise machines will give an increase in the quality of resource-saving, ecological, user-friendly production solutions in comparison with Industry 4.0 [25].

Industry 5.0 will bring many new things to our world and make human-machine communication a reality. The fundamental principle of Industry 5.0 is that robots will support

rather than replace humans, thereby helping to take decision-making and efficiency to a new level.

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