Digital technologies Industry 4.0

Dmitry A Kurasov

Kurgan State University, Kurgan, Kurgan region, 640020, Russia
naukka@mail.ru

Abstract. Digital technologies contributed to the emergence of Industry 4.0 and are drivers of the fourth industrial revolution. The modern principles of Industry 4.0 radically change the traditional rules of production and competition. The paper provides an analysis of digital technologies and an assessment of their joint impact on the transformation of industry.

Keywords: Digital, Industry 4.0, Fourth industrial revolution.

1 Introduction

Soviet digital technology Industry 4.0, variation in the work of various authors, precursors: Internet of Things, Internet of Services, mobile devices, advanced interfaces between human and computer, 3D printing/additive manufacturing, intelligent sensors (sensors), Data Science, Augmented Reality and Virtual Reality/wearables, cloud services [1].

At the national level, according to national and regional industrial digitalization initiatives (on digitizing industry), the following programmes and initiatives are being implemented: Industrie 4.0 Oesterreich (Austria); Made different - Facts of the future (Belgium); Prumysl 4.0 (Czech Republic); Industrie 4.0 (Germany); Manufacturing Academy of Denmark (MADE, Дания); Industria Conectada 4.0 (Spain); Alliance pour l'Industrie du Futur/Nouvelle France Industrielle (Франция); IPAR4.0 National Technology Initiative (Hungary); Industria 4.0 and Fabbrica Intelligente (Italy); Digital For Industry Luxembourg; Smart Industry (Netherlands); Smart Industry (Slovakia); Industria 4.0 (Portugal); Smart Industry (Sweden).

2 Internet of Things and of Services, mobile devices

The Internet of Things (IoT) in figure 1 is defined as a network of physical objects supported by the Internet, the purpose of which is to integrate each object for their interaction through embedded systems, network communications, server computing and applications [2]. IoT and implementation of this technology in numerous industries allows objects, including intelligent sensors, machine controllers and other digital technology objects, to communicate with each other, collect and access data, as well as interact with users, other systems and applications, creating intelligent connected environments. The use of IoT significantly increases the communication capabilities between system objects, allowing the implementation of more intensive and expanded data flows. The implementation of IoT in industry can consist in the use of application packages [3] to solve technical calculations.

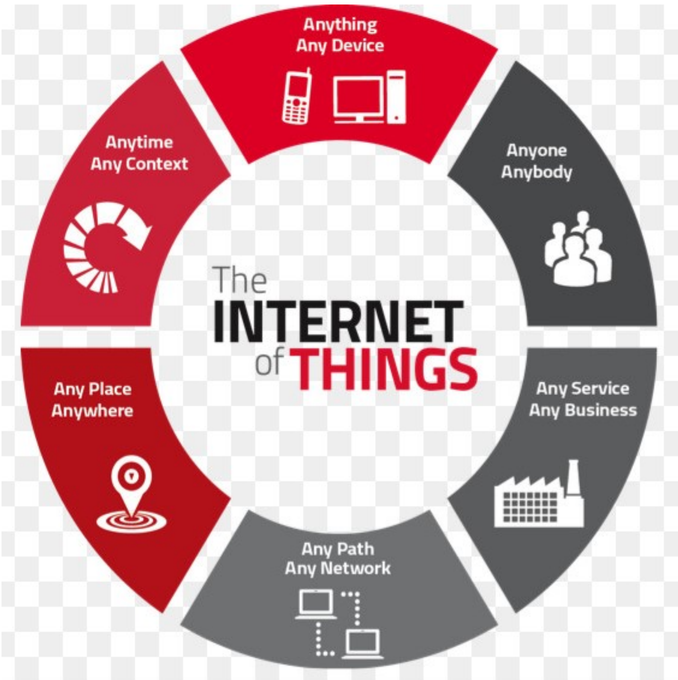

Fig. 1. Internet of Things concept.

Industrial Internet of Things (IIoT) is a subset of the Internet of things which belongs to such heavy industries as production, power, oil, gas, agriculture, etc. The diverse objects of the enterprise interconnected by means IoT get to generate a huge number of data ("big data") at high speed.

Internet of Things features: obtaining a huge amount of data; tracking the location of things accurate calculation of the route of travel; improving the environmental friendliness of production; remote management of mobile devices complication of interaction with devices; guessing desires with smartphones; a revolution in data exchange.

Internet of Services (IoS) acts as a gateway between consumers and manufacturers [4]. An important element of this concept is that devices and people can act as a supplier and consumer, which includes the case of the supply of services by one device to another. The service IoS applies to both information technology products and traditional products. Consumers of these products receive services provided by the manufacturer through the products themselves connected to the Internet. IoS extends the range of service distribution channels and enhances communication between the manufacturer and the consumer. For example, Tesla's innovative automotive technology allows owners to update their car's software through overnight updates on the Internet.

Mobile devices. One of the important properties of mobile devices is their ability to provide communication for objects and people moving in space. This connection creates the conditions for their integration into an industrial automation system based on IoT technologies and human-machine interfaces IoT. Mobile devices strengthen Industry 4.0 in manufacturing, and the use of mobile devices in production sites and beyond is essentially the next activator of Industry 4.0 after IoT. IIoT, mobile devices and IoS will change every sector of industry and play a huge role in it.

Mobile devices used in the enterprise can have MES, ERP, PLM applications installed on them, etc. Such devices are useful in production conditions in such situations as the performance of construction and installation work, their monitoring and quality control of execution at complex technical facilities. For example, installation of equipment, pipelines, routes of ventilation systems, power supply, control and alarm systems at shipbuilding facilities. In this case, quick receipt of working documentation at the site, the use of mobile augmented reality tools to carry out markup and compare the actual spatial configuration of the installed physical system with the visual reference model of technical documentation will significantly increase economic efficiency. The modern megatrend 5G and IIoT can take Industry 4.0 to a new level.

Advanced human-computer interfaces. As Industry 4.0 takes industry to a new level, there is a need for new types of interfaces to ensure uninterrupted interaction of all involved persons, improve accuracy and speed of problem resolution. New interfaces need to be more sophisticated to increase efficiency and remoteness of operations, especially when workers interact with technologies in difficult industrial conditions. Since operators are involved in the production process, the human-machine interface of the system should provide a way of communication in which commands can be easily entered. Based on these requirements, new types of man-machine interfaces are created, which include advanced touch interfaces, voice interfaces, sign interfaces, and AR/VR glasses.

3 Additive Manufacturing and intelligent sensors

Additive Manufacturing (AM) or 3D printing is the process of creating objects from three-dimensional digital models by adding a corresponding layer of material after the previous layer [5]. This technology minimizes raw material waste and allows the manufacture of complex molds without tools and cutting tools. In addition, additive manufacturing stimulates the production of personalized goods on demand, as well as custom building strategies. Many steps, such as engineering, planning, and manufacturing, are required to convert raw materials into traditional products. 3D printing qualitatively changes and reduces the number of these stages. This is most pronounced in products with complex geometry. AM is currently used in a number of industries, including aerospace, automotive, biomedical, instrumental, jewelry, food, etc. In intelligent factories of the future, where all processes are connected by the Internet of Things, AM will contribute to greater decentralization, flexibility and individualization of production processes.

Existing 3D printing machines make products in various ways: chemical agent (binder), extruder (molten yarn) or laser (sintering/melting). The use of materials includes the use of metals, polymer composites, ceramics, wood, fibers and composites, concrete and many others [6].

The use of 3D printers and 3D scanners has opened up unique possibilities for reproducing the most complex spatial forms, objects, engineering structures and mechanisms in many areas of science and production - for example, in the aerospace, automotive, oil and gas industries, aircraft engineering, instrument engineering, design, mechanical engineering, metalworking, medicine, jewelry.

Intelligent sensors. Existing sensor technologies used by measurement, control and automation systems are mainly based on physical measurement. Shape and distance measurements are crucial for robots; flow and temperature measurements are widespread in process control. Sensors cover such areas as heating, air conditioning and ventilation systems, refrigeration equipment, technological processes, monitoring and forecasting maintenance of equipment, hydrostatic level in tanks and management of raw materials, availability and quality of raw materials, frequency characteristics of vibration, pressure drops, detection of unauthorized access, speed and acceleration of movement, etc.

The next step in the development of sensor technology will be the creation of sensors for spectral scanners of materials. The collection by such sensors of qualitative and quantitative information on chemicals and materials and its entry into the database in real time will significantly improve automatic management solutions. For example, the use of spectral scanner sensors in pipeline collective transport systems for liquid hydrocarbons.

The sensor platform is only one part of the industrial system. Its full potential can be realized only when used together with IoT, cloud technologies and machine learning.

4 Big data and science, Augmented and Virtual Reality

Big data analytics. Big data science Industry 4.0 in figure 2 is the use of digital technologies for data management and analysis. Big data can be considered in four dimensions: volume, diversity, value and speed. Industrial big data is characterized by a variety of composition and a high degree of distribution of sources [7], which include a wide range of types of technical devices, product lifecycle, enterprise operation, supply chains and external cooperation.

Big data industry analytics examines knowledge models with support for descriptive or predictive and prescriptive modeling, complex event handling, alert generation and triggers for actions, visualization of generated reports.

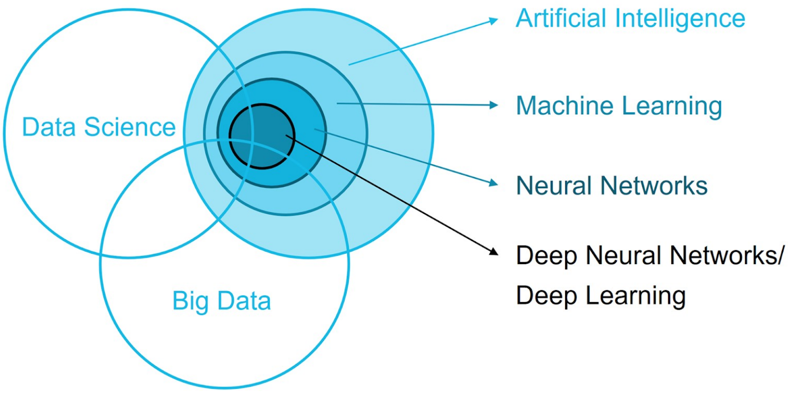

Fig. 2. Big data and science concept.

The modern market for big data analytics technology platforms is already unusually wide and includes products such as SAP Aleri Streamihg, Oracle Complex Event Processing, TIBCO BusinessEvents IBM WebSphere Business Events for processing complex events, and for creating visualization reports - IBM Watson Analytics, FusionCharts InfoSoft Global, Qlik View, etc.

Data Science professionals solve four main problems: converting the original "raw" data into a form suitable for analysis; data analysis itself; interpretation of data; application of data to practice.

Augmented Reality (AR) [8] creates a visual representation of the real human environment, complementing it with a virtual one. Augmented reality works in real time in the human environment and allows people to interact with both real and virtual objects that are integrated in the view and connected to each other [9]. Industrial Augmented Reality (IAR) is the application of augmented reality to support the industrial process.

Today, five main areas of application of AR in industry are defined: human and robot collaboration, maintenance, assembly, repair, training, product quality control and structure monitoring. In the field of human and robot systems, AR is used to create effective interfaces for interacting with industrial robots. In maintenance, assembly and repair, AR improves the productivity and quality of work. During the training process, users can find a powerful solution in AR to increase the level of their skills. During product quality control and in monitoring of buildings and other complex technical facilities, supervisors can notice any inconsistencies of the created object/product to the reference electronic image using powerful and universal AR systems.

Virtual Reality [8] (VR) is an efficient technology that creates interactive 3D worlds that exist in a given scenario and are controlled in real time. Everything in these worlds is subject to the main rule is imitation of reality. Everything in these worlds is subject to the main rule is imitation of reality.

When creating virtual reality programs, you need to take into account their properties [10].

Plausibility is the ability to maintain a user's sense of reality. Interactivity is user interaction with the virtual environment. Machine generation is use high-performance hardware. Accessibility to study is an opportunity to explore the virtual world with a high level of detail. The effect of presence is the involvement of both the brain and the body of the user in the process. The presence of all the listed properties in the virtual world allows you to create a high-quality virtual reality with full immersion in it.

There are several types of virtual reality: VR with a full immersion effect; VR with a floor immersion effect; VR without immersion; VR with joint infrastructure; VR based on Internet technologies.

Cloud computing. The implementation of enterprise systems in the environment of Industry 4.0 places high demands on the resources of computer systems. The increase in such requirements led to the emergence of the term Cloud Computing. The conventional interpretation of the term cloud computing defines it as the availability on demand of computer system resources, especially data warehouses and computing power. This term is commonly used to describe data centers accessible over the Internet. Big clouds often have functions spread across multiple locations. The cloud server closest to the user in terms of connection is called an edge server.

Clouds can be limited to a single organization (enterprise cloud) or accessible to many organizations (public cloud). The public cloud can be used under outsourcing conditions in the following versions: software as a service (SaaS), platform as a service (PaaS), desktop as a service (DaaS), database as a service (DBaaS), infrastructure as a service (IaaS), data as a service (DaaS), etc.

Foggy calculations are used to reduce time delays, reduce instability, and increase safety. Nebulous calculations refer to the processing power for analyzing data and control functions based on large amounts of data obtained by IoT devices (IoT). The nodes that perform such processing are typically located on the same LAN as the IoT devices and typically have storage capacity and computing capabilities.

5 Conclusion

As a result, the following conclusions can be drawn. Digital technology products and products currently mastered by the industry do not yet realize all the opportunities described by the academic community. For example, the benefits of using intelligent sensors digital spectral material scanners for the oil and gas industry can potentially actually transform the sector of the collective oil pipeline market, but such technologies have not yet been created. Another example of a promising yet unrealized digital technology is AR and VR for use in industrial and civil construction and shipbuilding at the stages of design, construction of facilities, installation, assembly, monitoring of work progress and technical acceptance.

Many of the existing digital developments are experimental and exist in the form of research prototypes. The time required to develop digital technology from the creation of the first prototype to the launch of the product is approximately 20-25 years. For example, the capabilities of new commercial products, such as Siemens Solid Edge, allowing designers to create digital layouts for visual analysis of large assemblies that reduce the number of expensive physical prototypes, were demonstrated in research prototypes back in the mid-1990s, in particular by the EDS virtual reality laboratory. The digital technology products released on the market are more likely to be the first experimental samples that solve private local problems, which are too early to perceive as full-fledged digital blocks of Industry 4.0. Therefore, it is safe to say that both the creation and practical implementation of full-featured digital technology products and the full-scale implementation of Industry 4.0 will take a long time.

In the context of the transformation and transition of industry to complex production and technological systems of Industry 4.0, the task of monitoring the state of elements and processes of digital and production technologies is significantly complicated. At the same time, there is a need to create methods and tools for conducting large-scale integrated monitoring, diagnostics and management of the entire range of Industry 4.0 technologies.

Industry 4.0 is slowly but surely entering our world. Industry 4.0 will make it possible to reach a new level of human development and quality of life. It will change the attitude of people and people themselves.

References

1. Martinov, G.M.: Digital manufacturing technologies according to the concept of industry 4.0. Automation in industry, 5, 3-5 (2019).
2. Wopata, M., Rickert, J., Lueth, K., Scully, P.: Industry 4.0 and Smart Manufacturing Market Report 2018-2023. IoT Analytics, 373 (2018).
3. Kurasov, D.A. Mathematical modeling system MatLab. Journal of Physics: Conference Series, 1691(1), 9 (2020).
4. Reaney, T., Hadid, B.: Industry 4.0. Research paper LMAC Consulting, 29 (2020).
5. Horst, D., Duvoisin, C., Vieira, R.: Additive Manufacturing at Industry 4.0: a Review International. Journal of Engineering and Technical Research (IJETR), 8, 3-8 (2018).
6. Dilberoglu, U., Gharehpapagh, B., Yaman, U., Dolen, M.: The role of additive manufacturing in the era of Industry 4.0. Procedia Manufactring, 11, 545-554 (2017).
7. Wang, J., Zhang, W., Shi, Y., Duan, S.: Industrial Big Data Analytics: Challenges, Methodologies, and Applications Submitted to IEEE Transactions on Automation Science and Engineering, 13 (2018).
8. Kurasov, D.A., Podvalnay, E.F.: Using innovative virtual reality (VR) education technologies in training and industry. Innovative knowledge-based technologies: reports of the VII International Scientific and Practical Conference, 190-92 (2020).
9. Riascos, R., Levy, L., Stjepandic, J., Frohlich, A.: Digital Mock-up Concurrent Engineering in the 21 st Century: Foundations, Developments and Challenges. London: Springer Verlag, 355-88 (2016).

10. Ivanov, A.S.: Virtual reality and its prospects Innovative technologies: theory, tools, practice, 2, 225-27 (2014).