Integrated use of IT - technology in the construction industry

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Abstract. A number of new IT technologies are now developing successfully: Cloud Computing, Border Computing, Internet of Things, Digital Twins, Machine Vision, Big Data, Deep Learning. The list is constantly updated, as this direction is developing very dynamically. Experience shows that the best effect is achieved when several new IT technologies are used in one technical solution. Often, new solution in the IT area is an incentive to use other modern solutions: the introduction of the Internet of Things required the transition to a new Internet protocol IPv6, the use of wireless networks in the Smart House caused the need to use the technology of ZigBee. The way the combination is very much dependent on the subject area. In some cases, it is effective to combine IT technologies with advanced advances in other technics areas. For example, "Machine Vision" can be used in unmanned aerial vehicles (drones) in the construction and operation of high-rise buildings, bridges, etc. The work explores the complex use of IT - technology in the construction industry.

1. Introduction
Recently there are new directions IT: the Internet of Things, digital twins, machine vision, etc.. It is safe to say that, firstly, these areas can be used in the construction and operation of buildings, secondly, in practical implementation should take into account the specifics of the construction industry, thirdly, to improve efficiency can be used several new IT technologies. In this regard, a number of questions need to be answered: where (in the field of construction) specific technologies can be used, in what combination of their rational application, the economic side of the question, how affects the specifics of the construction industry on specific IT solutions. This article addresses the above-mentioned range of issues and provides practical recommendations that can be useful in the construction and operation of facilities.

2. Materials and Methods
Let's start with the technologies that can be used in conjunction with Internet of Things technology. This technology includes IIoT, the industrial Internet of Things. [1,2]. IIoT technology differs from IoT technology in that the latter involves household applications: light, heating, surveillance cameras, etc. Both technologies are based on the use of radio frequency communication tools to communicate physical objects with each other and with the external environment. The term "Internet of Things" and the acronym IoT are often used in both directions (IoT and IIoT).

At first glance, the use of IoT is nothing new, as previously automated building status control systems used wireless sensors. However, in the internet of things technology systemically worked out
a number of issues, found effective techniques and tools that bring the solutions Smart House [3], control of the state of the building, etc. to a qualitatively higher level.

The Internet of Things involves a significant number of remote sensors, these sensors contain a large amount of diverse information. This information can be effectively processed with Big Data’s new intelligent technology [4-9], which, in addition to sensor information, allows for the data contained in the technical documentation, building operating conditions, etc. When implementing Big Data, you should use cloud computing [10] to reduce costs. Thus there is a chain of new IT technologies: IoT – Big Data – Cloud computing (Figure 1):

Figure 1. The chain of new technologies.

Part of the calculations (for reasons of information security and to optimize computation) is appropriate to be done “on the spot”, i.e. to use Edge computing [11]. Thus, the chain of new IT technologies has a look: IoT - Big Data - Cloud computing - Edge computing.

One of the reasons preventing IoT development is the problem of address space. Indeed, the number of devices connected to the global network has now very large. Using the existing version of the Internet protocol IPv4, it became difficult to identify sensors in the Internet space. As a solution, it was proposed to use Internet of Things technology in conjunction with a new version of the Internet protocol IPv6, which largely removed the restriction on the address space of sensors.

Another example of the involvement of progressive technologies in the implementation of the Internet of Things is the use of new wireless protocols. Indeed, when using wireless communications, high speed and information security have traditionally been at the forefront. Wi-Fi solutions were based on IEEE 802.11 standards, such as IEEE 802.11ac and IEEE 802.11ax, which provide high transmission speeds. On the Internet of Things was in demand another standard - IEEE 802.15.4 and protocols based on it ZigBee, MiWi, etc. These protocols are characterized by low energy consumption, reliable work in low-speed conditions, adaptability, and the ability to organize themselves.

The use of the Internet of Things in conjunction with another new technology, the Digital Twin [12] is very promising. A Digital Twin is a digital copy of a physical object or process that helps optimize the efficiency of a physical object or business process.

In the context of this research, a digital twin can be presented as a model of an already constructed facility (e.g., a special warehouse for storing a certain type of building materials) that contains information about the site and is regularly updated in the process of physical use. As a result of the processing of information, it is possible to identify additional opportunities to improve the quality of the facility (in our case of the warehouse): to make adjustments to the ventilation system, support the desired temperature and humidity. The Digital Twin stores a large amount of diverse data. This allows you to do smart analysis with Big Data and identify additional ways to improve the quality of the object.
With today's approach, sensors are the main component in the Internet of Things. Thus, the combination of Internet of Things technologies - Digital Twin provides an effective solution at the modern level. The chain of IT technologies used for this case is shown in Figure 2.

![Figure 2](image.png)

**Figure 2.** The chain of new technologies that includes a Digital Twin.

Let's now look at the direction related to the intellectual processing of information. Data Mining was one of the first in this field. This technology involves in-depth analysis of data (e.g. building maintenance data) to identify previously unknown regularity useful from a practical point of view. The technology uses serious mathematical methods based on the application of tree solutions, artificial neural networks, associative memory, fuzzy logic, etc. The important condition for the successful use of Data Mining is the visual representation of results, it allows people to use the technology without special mathematical training. Many of Data Mining's methods have been in demand in later IT technologies, particularly Big Data technology.

Big Data technology was appeared due to the need to quickly process large amounts of heterogeneous, often poorly structured information. Often this technology is characterized with three V - Volume, Velocity, Variety (Figure 3).

![Figure 3](image.png)

**Figure 3.** Interpretation of Big Data technology in the form of 3 V.
Big Data is based on intelligent mathematical methods - machine learning, artificial neural networks, etc. Most of the methods have moved from Data mining, others - crowdsourcing, mixing and integration appeared in Big Data, which allowed to consider this technology as an independent direction.

Big Data technology can be successfully used in conjunction with other IT technologies, which allows to effectively solve a number of problems in the construction industry. Big Data's relationship with other IT technologies is shown in Figure 4.

![Figure 4. Big Data's relationship with other IT technologies.](image)

Big Data's relationship with IoT and Digital Twin was previously considered. As for Machine Vision [13,14] technology, the useful effect of using Big Data can be shown in a simple example. One of the important areas of use of machine vision in construction is the control of welded structures. The quality of welded structures (size edges, seams, etc.) is subject to strict requirements, regulated by the relevant documents. Since Big Data allows you to quickly process large amounts of different data, in addition to the information generated by the machine vision system, you can take into account the information contained in technical documentation and regulatory documents.

Big Data can be used effectively in the situation center. The Situation Center is a separate room equipped with visualization devices (a set of monitors, including a large screen), modern telecommunications (fast Internet, video conferencing devices, wired and wireless communication channels, etc.) intelligent information processing tools [15]. The use of the situation center is economically justified in the construction and maintenance of large-scale facilities - high-rise buildings, large bridges, etc.

Big Data's technical implementation uses new IT solutions: Cloud computing and Edge computing (see above). Since the interaction of these two technologies goes beyond the Big Data theme, it should be considered separately.

Consider the combination of two technologies - Cloud computing and Edge computing. In cloud computing, a complex network infrastructure for computing (servers and other hardware) is hidden from the user.) These resources can be dynamically modified, which saves costs significantly. Another advantage of the cloud approach is the use of new versions of software products, the ability to access from any device connected to the Internet, the ability to work with data of several remote users, etc. Disadvantages include: the issue of information security when dealing with the "cloud", especially with regard to sensitive and private data; a large load on the data channel, a possible delay in obtaining processing results, etc.

Edge computing technology allows significantly "smooth" the flaws inherent in Cloud computing. Information security is enhanced because storage about the processing of a piece of data (including sensitive data) is done in the same place where data streams are generated. This significantly reduces the load on the data channel, you can carry out operational analytics without waiting for the results from the data center. Such a delay is in some cases undesirable or even unacceptable. For example, in
process automation systems or in a situation center, if there is a force majeure situation at a construction site.

Thus, cloud and border computing complement each other, and the effectiveness of their application is determined by the extent to which the functions are properly distributed between the two technologies. Consider the technologies used in machine vision systems. Previously, it was noted the effectiveness of combining technologies "Machine vision - Internet of Things" (for example, to control construction cracks). Here we will consider a promising direction - the use of a combination of technologies "Machine Vision - Deep Learning."

Deep learning is part of a broader family of machine learning methods based on artificial neural networks with representation learning. This IT technology uses a deep neural network that contains many hidden layers. Among the experts on this issue formed a conceptual image of deep learning in the form of a subset of machine learning and machine learning as a subset of artificial intelligence (Figure 5).

![Conceptual Image of Deep Learning](image)

**Figure 5.** Conceptual image of deep learning.

Thus, deep learning is part of the artificial intelligence direction, develops and improves artificial intelligence techniques, while achieving qualitatively new results in a number of areas, including machine vision.

Here are two fundamental points:

- Deep learning techniques open up new possibilities and new horizons for the use of machine vision.

- Deep learning is quite a resource-intensive technology. It requires powerful GPUs, high-performance graphics cards, large amounts of memory, etc.

 given the trends of modern IT technologies, the first point is more important, so the combination of machine vision and deep learning seems very promising. Such equipment, in particular, can be used to solve an important and responsible task - control the condition of high-rise buildings, large bridges and other large-scale construction projects.

New IT technologies are particularly promising when combined with cutting-edge solutions from other areas. Here are examples from the construction industry: unmanned aerial vehicles (drones) equipped with machine vision - to monitor the state of high-altitude objects, renewable energy sources - for use in a smart home and smart city, etc.

3. Results
The work explores the complex use of IT - technology in the construction industry. First, the range of problems that are solved with the help of Internet of Things technology has been investigated. It was explored the possibility of combining IoT and Big Data technologies. Thanks to Big Data's capabilities, remote sensor information can be taken into account, data contained in technical documentation, documents regulating building conditions, etc. When implementing Big Data, you should use cloud computing to reduce costs. Thus, to get the result, a chain of new IT technologies is built: IoT - Big Data - Cloud computing.
There is a prospect of using the Internet of Things in conjunction with another new IT technology, Digital Twin. It is noted that the main difference between a digital twin and an information model is the ability to aggregate information from sensors installed on a physical object. It is stated that the use of a digital twin allows to improve the efficiency of the real physical object, given a specific example from the field of construction.

The methods and concepts underlying Big Data technology have been explored. It is noted that a number of methods - artificial neural networks, associative memory, etc. have moved from Data mining technology, others - crowdsourcing, mixing and integration appeared in Big Data, which allowed to distinguish this technology as an independent direction. It is stated that to effectively solve a number of problems in the construction industry, Big Data technology can be used in conjunction with other IT technologies: IoT, Digital Twin, Machine Vision, Situation Center. The implementation of Big Data can be carried out on the basis of Cloud Computing technology - this allows to significantly reduce costs and apply this technology not only on large construction sites, but also to use in smaller projects. For a more balanced technical solution, cloud computing can be supplemented with Edge (Peripheral) Computing.

The rational combination of two IT technologies - Cloud Computing and Edge (Peripheral) computing - has been investigated. It is pointed out that Cloud Computing can significantly reduce costs and respond flexibly to changing computing needs. This allows you to use many IT applications not only for the construction of high-rise buildings, large bridges, etc., but also on smaller construction sites. Edge Computing technology minimizes the flaws inherent in Cloud Computing: information security improves, data transfers to Data Center are not delayed. Such a delay is in some cases unacceptable - for example, when processing information in a Situation Center in the event of a force majeure situation at a construction site or in some systems of automation of processes. It is stated that cloud and boundary computing complement each other, effectiveness is determined by the extent to which functions are properly distributed between the two technologies.

The technologies used in machine vision systems are considered. In particular, the topic of "Deep Learning" - a new direction in the field of artificial intelligence - is touched upon. It is noted that Deep Learning develops and improves artificial intelligence techniques, which significantly improves processing efficiency in a number of areas, including Machine Vision. The prospect of this technology in the construction area is indicated, specific examples are given.

It is noted that new IT technologies are particularly effective when combined with advanced solutions from other areas. Examples are given: the use of unmanned aerial vehicles (drones) equipped with machine vision to monitor the state of high-altitude facilities, the use of renewable energy sources in a smart home and smart city.

References
[1] Olivier Hersent, David Boswarthick, Omar Elloumi. The Internet of Things: Key Applications and Protocols. — Willey, 2012. — 370 p
[2] L.Chernyak. IoT platform. Open systems. DBMS, 2012. № 7.
[3] Urban Sensor Data Streams: London 2013 // IEEE Internet Computing: 2013. Vol. 17. №. 6. p. 1.
[4] Alexandr Konikov, Ekaterina Kulikova and Olga Stifeeva. Research of the possibilities of application of the Data Warehouse in the construction area. MATEC Web of Conferences 251, 03062 (2018)
[5] Konikov A., Konikov G. Big Data is a powerful tool for improving the environment in the construction business. IOP Conference Series: Earth and Environmental Science, 2017, vol. 90, p. 012184.
[6] A.I. Konikov. Study of a number of aspects of using Big Data technology in construction, BST Journal, 2019, №2, p. 28-29.
[7] Nikolay Ivanov and Maxim Gnevanov. Big data: perspectives of using in urban planning and management .MATEC Web of Conferences 170, 01107 (2018)
[8] Valpeters M., Kireev I., Ivanov N., 2018. Application of machine learning methods in big data analytics at management of contracts in the construction industry. MATEC Web of Conferences, 170, 01106

[9] Gnevanov M. V., Ivanov N. A. Big Data technology - using in urban planning // Industrial and Civil Engineering, 2018. № 4. p. 83-87.

[10] Maximov K.V. The effectiveness of the use of cloud computing: methods and models of evaluation //Applied computer science, 2016. № 1(81), p.106-113.

[11] Peripheral calculations (Edge computing). TADVISER. Government.Bisiness.IT. 2019. №11 – 7. https://www.tadviser.com

[12] Jack Reid and Donna Rhodes, Digital system models: An investigation of the non-technical challenges and research needs, Conference on Systems Engineering Research, Systems Engineering Advancement Research Initiative, Massachusetts Institute of Technology, 2016.

[13] Computer vision: technologies, market, perspectives. TADVISER. Government.Bisiness.IT. 2019. №6 - 26. https://www.tadviser.com

[14] Lukyanica A.A, A.G. Shishkin. A.G. Digital video processing. M.: “AY-ES-ES-PRESS”. - 2009. 518 p.

[15] Konikov A.I. Situational Control Center buildings// Industrial and Civil Engineering, 2018, № 7. p. 84-87.