UDC 004.77

INTERNET OF THINGS TECHNOLOGIES FOR INDUSTRIAL PROCESS OPTIMIZATION

Jargalova D.
bachelor's degree, Mirzo Ulughbek National University of Uzbekistan (Tashkent, Uzbekistan)

ТЕХНОЛОГИИ ИНТЕРНЕТА ВЕЩЕЙ ДЛЯ ОПТИМИЗАЦИИ ПРОМЫШЛЕННЫХ ПРОЦЕССОВ

Жаргалова Д.Т.
бакалавр, Узбекистанский национальный университет имени Мирзо Улугбека (Ташкент, Узбекистан)

Abstract

The article explores the potential of Internet of Things (IoT) technologies for optimizing industrial processes. Key IoT advantages, such as real-time data monitoring, enhanced equipment condition control, and predictive maintenance, are described. Emphasis is placed on predictive maintenance using machine learning methods to forecast failures and schedule preventive actions. Additionally, energy efficiency improvements and inventory management optimization enabled by IoT are discussed. The conclusion highlights IoT's importance for industrial digital transformation and improving business competitiveness.

Keywords: Internet of Things, industry, predictive maintenance, energy efficiency, process optimization.

Аннотация

В статье рассматриваются возможности использования технологий Интернета вещей (IoT) для оптимизации промышленных процессов. Описаны основные преимущества IoT, такие как мониторинг данных в реальном времени, улучшение контроля состояния оборудования и поддержка прогнозного обслуживания. Особое внимание уделяется прогнозному обслуживанию, основанному на методах машинного обучения, позволяющему предсказывать неисправности и проводить профилактические работы. Также обсуждаются аспекты повышения энергоэффективности и оптимизации управления запасами с помощью IoT. В заключении подчеркивается значимость IoT для цифровой трансформации промышленности и повышения конкурентоспособности предприятий.

Ключевые слова: Интернет вещей, промышленность, прогнозное обслуживание, энергоэффективность, оптимизация процессов.

Introduction

Internet of Things (IoT) technologies are increasingly being applied in industry, providing opportunities for automation, monitoring, and analysis of production processes. IoT enables devices to exchange data, forming an interconnected network that helps optimize production lines, equipment management, and quality control processes. This technology is becoming the foundation for creating "smart" manufacturing systems capable of responding rapidly to real-time changes, thereby enhancing efficiency and reducing costs. One of the key advantages of IoT in the industrial sector is the ability to continuously collect and analyze data on equipment conditions and production processes. By using sensors and other IoT devices, parameters such as temperature, humidity, machinery speed, and many other indicators that can affect product quality can be monitored. This

data is used to create predictive models that help prevent breakdowns and production downtime. Thus, IoT contributes to the development of predictive maintenance systems that minimize risks and extend equipment lifespan.

The aim of this article is to explore ways to apply IoT for optimizing industrial processes and analyzing their effectiveness. The article will examine examples of IoT usage in manufacturing, as well as methods that facilitate automation, enhance management accuracy, and improve product quality control.

Main part

The implementation of IoT in manufacturing enterprises allows for real-time data collection regarding equipment performance and production processes. This is achieved by installing sensors and connected devices on key equipment elements that record parameters such as temperature, vibrations, wear level, and other indicators. For instance, vibration sensors can detect early signs of bearing or motor failure, allowing the enterprise to conduct preventive maintenance and avoid downtime. IoT systems enable the monitoring of key parameters of production equipment, such as temperature, vibration, noise level, and pressure.

Figure 1 shows the growth of IoT device usage in industrial applications over the past five years. This demonstrates the increasing adoption of IoT technologies in manufacturing processes.

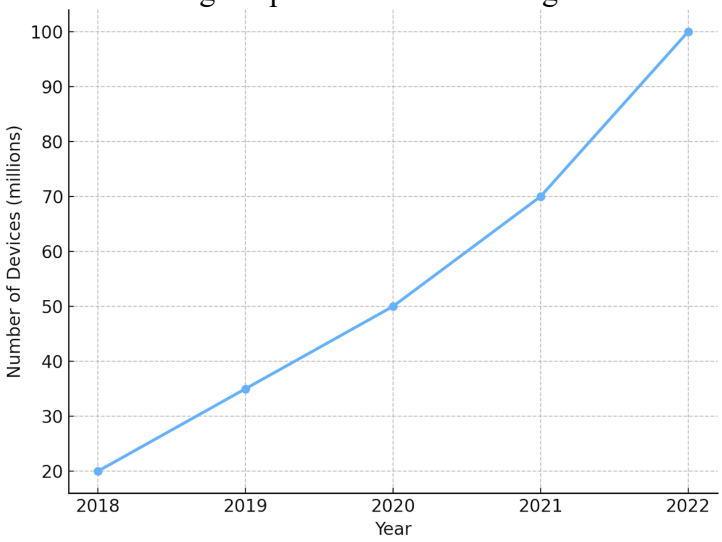

Figure 1. Growth of IoT device usage in industry

As shown in Figure 1, the number of IoT devices used in industrial settings has grown significantly, reaching 100 million by 2022. This trend reflects the increasing reliance on IoT for data collection and analysis.

Temperature sensors help monitor equipment, preventing overheating, which is especially important for reliably operating machinery. Vibration sensors allow for the timely detection of potential failures associated with mechanical wear of components [1]. Noise level control helps comply with safety standards, which is crucial for ensuring comfortable working conditions. Pressure is also continuously monitored to maintain optimal production conditions and exclude deviations that may affect product quality. IoT collects this data in real-time, allowing enterprises to monitor and analyze key performance indicators of production processes.

Another important function of IoT is supporting predictive maintenance systems based on historical data analysis. Predictive maintenance allows for early identification of potential equipment issues and timely preventive actions. Such systems utilize machine learning algorithms to analyze accumulated data and predict the likelihood of failures. This helps reduce repair costs and minimize downtime, which is particularly important for industrial enterprises with continuous production cycles [2]. Additionally, IoT facilitates the optimization of inventory management for raw materials and components. Connected devices can track the number of materials available in real-time and automatically generate orders when supplies approach minimum levels. This reduces the likelihood of production disruptions due to material shortages and allows for more efficient purchasing planning, eliminating excess storage costs.

Another significant area is enhancing energy efficiency. IoT allows for the monitoring of electricity consumption at each stage of production and identifies areas with the highest costs. For example, data analysis can optimize the operating schedule of energy-intensive equipment, reducing energy consumption during low-demand periods [3]. This approach helps lower electricity costs and aligns with modern environmental standards. The use of IoT also significantly improves product quality control systems. By installing sensors on production lines, it is possible to track product parameters in real-time, such as dimensions, weight, temperature, or density, and promptly identify deviations from standards. Implementing such systems allows for the timely detection and correction of defects at early stages, thereby improving the quality of the finished products and reducing the amount of waste.

Predictive maintenance using IoT

One of the significant advantages of implementing IoT in industrial production is the opportunity to realize predictive maintenance based on accumulated data analysis [4]. By utilizing data collected from sensors, IoT systems can predict potential equipment failures before they actually occur. This enables optimization of preventive maintenance scheduling and avoidance of unscheduled downtimes that can lead to financial losses. Predictive maintenance is achieved through the application of machine learning methods and statistical analysis. Analyzing historical data regarding equipment conditions helps identify patterns indicating the likelihood of breakdowns. For instance, data regarding temperature and vibrations may signal increased wear of bearings or other moving parts. Such models allow for the planning of necessary maintenance actions in advance, reducing repair costs and extending equipment operating life. Moreover, predictive maintenance aids in resource optimization. Through an automated fault prediction process, enterprises can more effectively allocate labor and materials, avoiding excess inventory and unnecessary repairs. Implementing IoT and predictive models creates a flexible maintenance system that takes into account the current state of equipment and adapts to real production conditions [5].

Challenges and risks of IoT implementation in industrial production

Despite the significant benefits of IoT in industrial production, its implementation faces several challenges and risks that must be considered. One of the main challenges is ensuring data security and protecting against cyber threats. IoT systems collect and transmit vast amounts of data, often involving sensitive information related to production processes. Unauthorized access or data breaches can lead to production disruptions, financial losses, and intellectual property theft. Therefore, implementing robust security measures, such as encryption and secure data transfer protocols, is essential to safeguard IoT infrastructure in industrial environments [6].

Another challenge is the high initial cost associated with IoT deployment. Installing sensors, upgrading equipment, and establishing data storage and analysis systems require significant financial investments, which may be prohibitive for small or medium-sized enterprises. Moreover, ongoing maintenance and updates to IoT infrastructure can also contribute to costs [7, 8]. To address this, companies need to evaluate the return on investment by considering long-term benefits such as reduced downtime, increased productivity, and lower operational costs, which can offset the initial expenses over time [9].

Finally, IoT implementation demands a skilled workforce capable of managing and analyzing data generated by interconnected devices. Training personnel to work with IoT systems and interpret data analytics is critical for maximizing the value of IoT. Additionally, integrating IoT into existing production workflows may require adjustments and adaptations, as legacy systems may not always be compatible with IoT technologies. Addressing these challenges requires comprehensive planning and a phased approach to IoT deployment to minimize disruption and maximize benefits for industrial enterprises.

Conclusion

The implementation of IoT technologies in industrial production opens up significant prospects for improving efficiency and quality of production processes. IoT allows enterprises to collect real-time data, which enhances equipment condition monitoring and provides opportunities for predictive maintenance. This contributes to reduced downtime and lower repair costs, enabling enterprises to

operate more efficiently. Predictive maintenance, supported by IoT, is becoming an integral part of industrial asset management, as data analysis allows for anticipating potential failures and conducting preventive maintenance at the right time. Such technologies, including machine learning methods, ensure equipment longevity and reduce the risk of emergency situations, which is particularly important for high-load enterprises with continuous production cycles. The use of IoT also aids in resource optimization and reduces costs for energy and materials. Monitoring energy consumption metrics and inventory status enables more accurate management of production processes and minimizes expenses. Thus, IoT is a key element facilitating digital transformation and enhancing the competitiveness of industrial enterprises.

References

1. Gordienko E.P. Internet of Things: history of emergence and prospects for application // Actual problems and prospects for the development of transport, industry, and economy of Russia ("TransPromEx-2023"). 2023. P. 40.
2. Petrov V.Yu., Rudashevskaya E.A. Internet of Things technology as a promising modern information technology // Fundamental Research. 2017. No.9-2. P. 471-476.
3. Kupriyanovsky V.P., Namiot D.E., Drozhzhinov V.I., Kupriyanovskaya Yu.V., Ivanov M.O. Internet of Things in industrial enterprises // International Journal of Open Information Technologies. 2016. Vol. 4. No.12. P. 69-78.
4. Cherapanov N.V. Industrial Internet of Things in enterprises // Innovations and Investments. 2019. No.10. P. 151-154.
5. Paskova A.A. Integration of artificial intelligence technologies and industrial Internet of Things // Issues of sustainable development of society. 2020. No.4-2. P. 607-612.
6. Xu S., Chen J., Wu M., Zhao C. E-commerce supply chain process optimization based on whole-process sharing of internet of things identification technology // Computer Modeling in Engineering & Sciences. 2021. Vol. 126. No.2. P. 843-854.
7. Chui M., Loffler M., Roberts R. The internet of things. McKinsey Global Institute. 2010.
8. Huang X. Quality of service optimization in wireless transmission of industrial Internet of Things for intelligent manufacturing // The International Journal of Advanced Manufacturing Technology. 2020. Vol. 107. No.3. P. 1007-1016.
9. Soori M., Arezoo B., Dastres R. Internet of things for smart factories in industry 4.0, a review // Internet of Things and Cyber-Physical Systems. 2023. Vol. 3. P. 192-204.