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For lecturers, researchers, postgraduates, students, and professionals.

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IoT TECHNOLOGIES FOR ENVIRONMENTAL MONITORING OF FREIGHT TRANSPORT

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Modern freight transport is an integral part of the global logistics system, but its impact on the environment is becoming increasingly evident. According to the European Environment Agency, the transport sector accounts for over 25% of all CO₂ emissions in Europe. This problem is incredibly relevant for Ukraine as well. In light of growing demands to reduce environmental impact and improve transport energy efficiency, the implementation of innovative technologies is an urgent necessity. One promising solution is the creation of an IoT system for monitoring the environmental sustainability of freight transport.

The urgency of addressing this issue is further underscored by the global commitments to combat climate change, such as the Paris Agreement, which seeks to limit global temperature rise by reducing greenhouse gas emissions. Freight transport, as a key contributor to CO₂ emissions, has become a focal point for both policymakers and industry leaders. The integration of advanced technological solutions into transport systems is not only a response to environmental challenges but also a strategic move toward meeting international sustainability goals.

Additionally, the growing economic and technological interdependence among countries makes it essential for national logistics systems to align with global standards of environmental performance. Ukraine's strategic location as a transit hub between Europe and Asia positions it uniquely to leverage innovative IoT systems [1]. By adopting advanced monitoring and optimization technologies, Ukraine can enhance its role in international logistics while addressing pressing environmental concerns.

The primary goal of the development is to create a system capable of not only providing real-time control of transport's environmental performance but also offering recommendations to enhance its operational efficiency.

The main objectives are:

- collect data on harmful emissions, fuel consumption, and engine performance;
- analyze the collected data in real-time;
- detect anomalies and generate optimization recommendations;
- automatically generate reports in compliance with international environmental standards.

Methods and technologies from sensors to cloud platforms. To achieve the set goals, the system integrates modern hardware with powerful analytical platforms and user-friendly interfaces.

I. Hardware.

- emission sensors (detect levels of CO₂, NO_x, C_mH_n, and other harmful substances).
- GPS trackers (monitor routes, speed, and movement conditions).

- fuel sensors (provide fuel consumption control and identify possible leaks).
- weather sensors (consider the impact of external factors (temperature, humidity)).

II. Cloud Platform.

The system utilizes cloud technologies such as AWS or Google Cloud to process large volumes of data in real-time. Using machine learning algorithms, the system forecasts equipment conditions and generates route optimization recommendations.

III. User Interfaces.

Web and mobile applications provide convenient access to data, enabling managers and operators to monitor the transport's condition and plan its operation. Integration with ERP systems and logistics platforms via API makes the system even more functional.

The implementation of the IoT system contributes to achieving significant results in various industries. Logistics companies, for instance, gain the ability to control emission levels in real-time, optimize fuel consumption, and detect technical issues early. In the construction industry, this allows for reducing the environmental impact of heavy machinery and enhancing economic efficiency.

The development and implementation of IoT systems come with certain technical challenges. One of them is ensuring the accuracy of sensor operation in challenging conditions, such as low temperatures or high air pollution. Special materials and technologies are used to enhance equipment reliability. Another challenge is integrating IoT systems with outdated infrastructure. In response, adapters and universal APIs have been developed to ensure compatibility.

The proposed IoT system offers significant prospects for sustainable development. Its scaling and enhancement, particularly integration with automated fleet management systems, will further reduce the negative impact of transport on the environment. Future research will focus on improving data analysis algorithms and developing new forecasting methods.

Conclusion. Integrating IoT technologies into freight transport is not only a means to reduce environmental impact but also a tool to enhance company efficiency. A system combining modern sensors, cloud technologies, and machine learning algorithms has the potential to become a key element in the environmental transformation of the transport sector. Implementing such innovations is an important step toward a sustainable future.

Reference: 1. Ziuziun V., Parasiuk L. «IoT in the transportation sector: opportunities and challenge,» XLIII International scientific and practical conference «Modern Challenges and Achievements of the Scientific Community of the 21st century» (October 16-18, 2024) Narva, Estonia. International Scientific Unity, 2024. – P. 65-70 <https://doi.org/10.70286/ISU-16.10.2024>