# ТЕЗИ СТЕНДОВИХ ДОПОВІДЕЙ ТА ВИСТУПІВ УЧАСНИКІВ КОНФЕРЕНЦІЇ

# HIGHLIGHTS OF REPORTS AND PRESENTATIONS OF PARTICIPANTS TO THE CONFERENCE

analysis of the impact of neighboring elements, damage dynamics);

– localization at the facility and determination of the cause (use of logic and diagrams, method of separation (Half-Split), measurements).

After the fault has been fixed, certain checks are carried out to confirm that the system has been fully restored and is safe to operate.

The use of modern information and communication technologies can improve the technical diagnostics of railway automation systems, particularly in terms of fault detection. A Telegram bot can significantly improve fault detection (localization) in railway automation systems by acting as a mobile interface for diagnostic systems and a communication tool for staff. The Telegram bot will provide the following functions:

– mobile access to diagnostic data (instant damage notification, request for current device parameters, access to the history of changes in the status of objects);

– support in decision-making (Decision Support) (knowledge base of possible causes of damage, simplified step-by-step diagnostics based on a diagnostic tree, photo reports for further analysis);

– communication and reporting (centralized reporting with automatic sending to leadership, sharing of information about faults between relevant specialists, automatic reminders about scheduled maintenance).

In general, the use of modern information and communication technologies, in particular bots, will help improve the diagnostics of railway automation systems, speed up the search for faults, and increase traffic safety when repairing damage.

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## THE ARTIFICIAL INTELLIGENCE IN RAILWAY SYSTEMS. CURRENT STATUS AND FUTURE PROSPECTS

Artificial Intelligence (AI) is a pivotal technology reshaping numerous industries, with the railway sector being no exception. Modern railway systems grapple with multifaceted challenges, including the optimization of operational complexities, enhancement of safety protocols, assurance of infrastructural reliability, and elevation of passenger service quality. AI technologies provide robust tools to address these issues, bridging the gap between theoretical models and practical implementation. This paper presents a comprehensive systematic review of the current state of AI applications within railway systems. The analysis is founded on 139 scholarly articles published between from 2010, encompassing seven key sub-domains: maintenance and inspection, traffic planning and management, safety and security, autonomous driving and control, revenue management, transport policy, and passenger mobility.

The analysis of research distribution reveals a significant imbalance in the scientific community's focus. The vast majority of publications are concentrated in the field of maintenance and inspection, accounting for 57% (81 articles) of the reviewed literature. This emphasis is driven by the direct economic impact of predictive maintenance, which facilitates reduced operational costs and minimizes service disruptions. The second most researched area is traffic planning and management, with a 25% share (34 articles), where AI methods are employed to solve complex optimization problems.

Other critical domains have received considerably less attention. Research in safety and security (8%), autonomous driving and control (5%), and passenger mobility (5%) is notably less frequent. A critical finding is the complete absence of scholarly work on AI applications in strategic areas such as revenue management and transport policy. This gap highlights a substantial untapped potential for future research.

The technological landscape is also heterogeneous. The maintenance domain is dominated by Machine Learning (ML) techniques, particularly Deep Learning (DL) and Computer Vision (CV). Models like Convolutional Neural Networks (CNNs) are effectively used for the automated detection of defects in railway components such as rails, sleepers, and fasteners. In contrast, the field of traffic planning favors Evolutionary Computing, such as Genetic Algorithms (GA), and Reinforcement Learning (RL) to address NP-hard scheduling and real-time adjustment tasks. The domain of autonomous operation, especially the development of Automatic Train Operation (ATO) systems, is also advancing rapidly, as confirmed by specialized reviews.

This review indicates that while research into AI applications in railways is still in its nascent stages across most sub-domains, it demonstrates significant potential to revolutionize the industry. Key findings point to the predominance of maintenance-related topics, a trend attributable to data accessibility and clear economic

advantages. Concurrently, significant research gaps have been identified in the areas of revenue management and transport policy.

For the successful future integration of AI, it is imperative to address several fundamental challenges. Firstly, data-related problems, including ensuring data quality, accessibility, and standardization, as well as developing methods to work with limited or imbalanced datasets (e.g., for rare events like accidents). Secondly, the development of hybrid approaches that merge AI with traditional optimization methods to solve multifaceted problems. Thirdly, the growing importance of intelligent cybersecurity amidst the increasing digitalization and automation of railway systems. Addressing these challenges will pave the way for creating safer, more efficient, and sustainable railway transportation for the future.

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## SMART HOME SYSTEM DESIGN

Modern smart home systems are rapidly developing due to the integration of Internet of Things (IoT) and Artificial Intelligence (AI) technologies. Creating an adaptive environment using the Artificial Internet of Things (AIoT) to improve the comfort, safety, and energy efficiency of living space is the main task of smart home systems [1-2]. The current problem is the selection or creation of such an architecture of a smart home system that provides a certain autonomy of the system, but allows the user to intervene in the system as needed. Analysis of typical scenarios of everyday life of smart home users with subsequent control of lighting, temperature and humidity, air quality, water supply, energy supply, and security makes it possible to build a coordinated functioning of a significant number of smart things in a smart home.

The purpose of the work is to analyze possible solutions for using existing platforms to create a smart home system, justify the choice of a particular platform and design a smart home system that prioritizes flexibility and innovative solutions and allows the use of machine learning algorithms to build smart home control scenarios. The functioning of the designed system should correspond to the strategy of intuitive interaction with system users. In other words, the smart home system should be a good assistant, but not create unnecessary problems for system users.

This paper examines the ecosystems of three typical smart home architectures as ESPHome, Apple Home, and Google Home and identifies the advantages of the ESPHome architecture for creating a flexible and scalable smart home system.

The features of a smart home system built on the basis of ESPHome are:

1. The ESPHome ecosystem can be a standalone system, or be part of a larger Home Assistant ecosystem, allowing for the connection of devices and services not only compatible with ESPHome.
2. The ESPHome ecosystem is an open source system.
3. The system developer on ESPHome (administrator) can control both the hardware and software of the system. Edge computing based on machine learning can be implemented.
4. The control part of the system can be distributed (no hub required), or can use the hub of the Home Assistant ecosystem. ESPHome devices can function as autonomous IoT devices.
5. Dependence on external Internet connections is minimized. Local API and MQTT are used for communication, including with Home Assistant.
6. To form the microcontroller software in ESPHome, a Python-based firmware generator is used, which processes a YAML configuration file to create its own customized C++ firmware. The firmware is installed on ESP-based microcontrollers, after which the devices operate independently.
7. Access of the ESPHome-based smart home system to cloud environments is possible, and