ТЕЗИ СТЕНДОВИХ ДОПОВІДЕЙ ТА ВИСТУПІВ УЧАСНИКІВ КОНФЕРЕНЦІЇ

HIGHLIGHTS OF REPORTS AND PRESENTATIONS OF PARTICIPANTS TO THE CONFERENCE

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Ph.D., Associate Professor **T.S. Hryshechkina**
Ukrainian State University of Science and Technology
(Dnipro, Ukraine)

ACCOUNTING FOR DEPENDENT FAILURES IN A TECHNICAL SYSTEM

The issue of accounting for dependent (interrelated) failures in complex technical systems of railway transport is considered. Dependent failures, in particular those caused by common causes (operational, design, or environmental), result in an excessive concentration of malfunctions and underestimation of reliability estimates when classical independent models are employed. An approach to the systematic accounting of such failures is proposed.

Current research focuses on three areas: (1) modeling dependencies between components (multivariate distributions, copulas, Bayesian networks, common cause failure models — CCF); (2) methods of data collection and processing to identify event correlations (event logs, SCADA/CBM data, time series); (3) practical approaches to integrating information into maintenance systems (CMMS/ERP, condition-based maintenance analytics).

Based on the research carried out in [1], it has been shown that the use of models that take into account dependent failures allows for more accurate prediction of intervals between failures, optimization of maintenance intervals, and reduction of the risks of mass failures of elements of a complex technical system. Criteria for classifying dependencies between elements and a procedure for identifying group events have been developed.

An information and analytical system consisting of three levels has been proposed:

Data collection: unified event log, telemetry from sensors, repair records; time stamps.

Processing and detection: pre-processing modules (filtering, normalization), event correlation algorithms (temporal correlation, spatial-topological relationships), clustering and CCF pattern detection; application of mathematical apparatus using recurrent relations on sets to assess dependencies.

Analytics and integration into O&M: interface for engineers with recommendations for preventive measures, automatic triggers for changing repair priorities, reports for logistics planning.

The implementation of a dependent failure accounting system increases the accuracy of diagnostics, allows for the adjustment of maintenance policies, and reduces the risk of simultaneous multiple failures of elements of complex technical systems. Further research should focus on testing algorithms in real operating conditions and optimizing modeling coefficients, taking into account local failure statistics.

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Oleksii Lazariev
Ukrainian State University of Railway Transport
Viktor Lazariev
Kharkiv National University of Radio Electronics
Oleksandra Lazarieva
V.N. Karazin Kharkiv National University

IMPROVEMENT OF TECHNICAL DIAGNOSTICS OF RAILWAY AUTOMATION SYSTEMS

In the current conditions of martial law and a shortage of staff for the timely maintenance of railway automation systems, improving the technical diagnostics of these systems is a relevant task. Technical diagnostics of railway automation systems are classified according to several criteria [1]:

– by purpose and functionality (performance monitoring, technical condition assessment, fault detection (localization), residual life prediction);

– by object of diagnosis (component level, node level, system level);

– by timing (scheduled (periodic) diagnostics, continuous (non-stop) diagnostics, operational (emergency) diagnostics, test diagnostics);

– by level of automation (manual (visual), automated).

Modern railway automation systems strive to use continuous automated diagnostics at all levels to minimize the human factor and detect malfunctions before they lead to traffic safety violations [2].

Finding (locating) faults in railway automation systems is a critically important and highly organized process that combines automated monitoring and actions by maintenance staff.

In modern signaling control systems (especially microprocessor-based ones), this process is divided into several stages:

– detection and registration of faults (automatic recording, dispatcher control, hardware journal of object status changes);

– remote preliminary localization (analysis of damage reports, parameter checks, power supply checks, 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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Ph.D. **S.O. Zmii, V.O. Sotnyk, A.A. Melikhov**
Ukrainian State University of Railway Transport (Kharkiv), Mipro OY (Tallinn, Estonia)

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