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Review of the Cybersecurity Impact and Limitations of the Use of Artificial Intelligence in Transport

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***Abstract*—Artificial intelligence opens new opportunities for adding value to industry, transport, and society. New technologies are everywhere and are becoming increasingly established in many aspects of life. AI applications are endless to discuss, develop, and deploy. This study looks at the most used applications of artificial intelligence in transport. On the other hand, cybersecurity is also a growing technical and technological concept. Many companies engaged in the development of technical and technological solutions with applications in transport have incorporated information technology into their business. This requires companies and organizations to implement more security measures. The need to protect data and information increases the requirements for cybersecurity, and it is also believed that artificial intelligence substantially impacts cybersecurity. Machine learning is already heavily induced in the latest technologies supporting cybersecurity. The article reviews the literature and explores the overall impact of artificial intelligence on cybersecurity.**

Keywords*— *Artificial Intelligence, Cybersecurity, Road Transport, Railway Transport.

I. INTRODUCTION

The development of artificial intelligence provides new opportunities for generating and managing processes and gives additional value to industry, transport, and society as a whole [1]. New technologies provide more and more opportunities for AI to find applications in many aspects of life. These applications are practically endless to discuss, develop, and implement in many areas. However, in transport, aspects of reliability and security are fundamental, especially regarding people's safety and health.

This study was provoked and aims to look at the most used applications of artificial intelligence in transport. On the other hand, cybersecurity is also a growing technical and technological concept. Many companies engaged in the development of technical and technological solutions with applications in transport have incorporated information technology into their business. This requires companies and organizations to implement more security measures. The need to protect data and information increases the requirements for cybersecurity, and it is also believed that artificial intelligence substantially impacts cybersecurity. Machine learning is already heavily induced in the latest technologies supporting cybersecurity. The article reviews the literature and explores artificial intelligence's overall impact on transport cybersecurity [2].

II. MATERIALS AND METHODS

As a basic definition, AI is connected to all machines acting in a way that seems intelligent [3] or exhibiting characteristics typical of human reasoning. However, this definition suffers from the lack of a universally accepted definition of "intelligence." Later, a new definition was developed based on the Turing test [4]: A machine is considered intelligent if it is indistinguishable from a human during interaction with an impartial observer.

More structured, detailed definitions are also known in [5]-[8] as they attempt to capture the broad nature of AI and its potential coverage. In some areas, such definitions sound too abstract, which means they are less likely to be widely accepted. Generally, standard definitions are characterized by a decrease in adoption, which leads to a lack of general agreement on what AI is.

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According to [9], the closest definition of AI suitable for next-generation transport and transport engineering is AI is the discipline that brings together all the aspects that allow an entity to determine how to perform a task and/or make a decision based on the experience gained through sample observation and/or interaction with the environment, as well as possibly competing or collaborating with other entities.

This definition is based on the need to highlight the following aspects that are crucial when considering the application of AI in the field of transportation:

1) to be able to learn from examples (i.e., not to be a program code to solve a problem);

2) possibly working in an environment in conjunction with other objects;

3) performing a task that requires intelligence if performed by a human;

4) omits trivial automatism;

5) It can be either hardware or software (or hybrid).

The above allows us to deduce the connection between some of the most common concepts related to AI, including Deep Learning, Machine Learning, and AI itself.

Machine learning is a subfield within AI focused on techniques that can learn from examples and improve with experience without being explicitly programmed for a task. Within ML, artificial neural networks are borrowed from the structure of the human brain: ANNs have a layered structure of interconnected neurons (perceptrons) that interact with each other to perform a task. In recent years, technological evolution has made it possible to build more and more complex ANNs, such as the so-called. Deep Neural Networks are a class of ANNs with multiple layers of neurons, allowing them to extract functions from the data automatically. DNN enables DL, which "allows for the so-called. Computational models to be composed of multiple processing layers and to learn data representations with multiple levels of abstraction [10]."

The development of communication and information systems has led to the creation of so-called Intelligent Transport Systems, and computing systems and resources have opened new opportunities for intelligent solutions for traffic safety, comfort, and transport efficiency. Artificial intelligence is widely used to optimize traditional data-driven approaches in various research areas. A typical example is the application of the Vehicle-to-Everything system in land transport, which, combined with AI, collects and analyzes information from various sources, expanding the driver's perception and predicting traffic situations to avoid potential accidents [11]. In the same case, V2X communications are based on the sharing of information between:

- Vehicle-to-Infrastructure;
- Vehicle-to-Vehicle;
- Vehicle-to-Pedestrian;
- Vehicle-to-Self;
- Vehicle-to-Road side units

V2X communications are related to the following three aspects of management:

- efficiency and speed of movement, optimal routes, and minimization of traffic;
- safety, security, and comfort of travel and transportation;
- energy efficiency and ecology.

One important V2X use case is traffic information. Vehicle apps can use this information to intelligently perform tasks such as clearing congestion, making better use of electric vehicle charges, minimizing fuel consumption, and improving location-based services. The traffic dataset can be obtained from multiple sources, such as CCTV cameras, induction loops, information services, and vehicles. Designing highly accurate traffic forecasting algorithms using conventional traffic estimation techniques is challenging.

There are known overview studies dedicated to the application of AI in railways, all of which focus on a specific aspect of an application. For example, in [12], an overview of the latest applications of big data analytics in the context of railway engineering and transport has been carried out.

The [13] also provides a study of the available and potential use of AI in railway assets.

The [14] reviews and evaluates data-driven approaches applied in train dispatching management, which are grouped into statistical methods, graphical models, and ML.

[15] proposes a study on recent applications of ML in railway maintenance based on a taxonomy of existing literature.

Another study provided an overview of the applications of visual inspection technology based on image processing in the railway industry [16].

The [17] contains a systematic revision of the forecasting of urban spatiotemporal data flow; existing ML-based methods for urban flow forecasting are monitored, with some discussions about the difficulties and some ideas in this direction.

The [18] provides an overview of the rail system's sustainability, with a focus on quantitative approaches. The review discusses sustainability metrics and approaches, as well as data-driven and optimization-based approaches. Several growing future scientific topics are also identified.

The researchers [19] present a study of recent approaches to the problems of online rescheduling of rail traffic, including dynamic and stochastic aspects. According to the authors' conclusion, models based on optimization are the most used approaches.

In general, the use of AI in railways is an area that is to be developed more dynamically. On the one hand, there is a broad perspective on the application of AI. On the other hand, it is necessary to consider them in a complex way (including an accompanying analysis of the different sub-areas of the railway sector) [20]-[22].

The railway sector is a particularly relevant example of the possibility of a significant degree of automation of processes and the development of various targeted AI applications for railway systems, analysis of their models and distributions, etc. Given its specificity, AI applications can be distinguished into seven subfields, which can be defined as follows [23]:

Maintenance and Inspection covers all preventive and corrective activities designed to keep the system or subsystems in good operational condition. These activities are essential to avoid deterioration with possible safety consequences due to improper maintenance.

Safety and security are paramount for any transport system, as passengers expect transport to be safe and secure. Transport safety and security refers to all activities and means to reduce the risks of both unintentional and intentional causes of accidents that may directly or indirectly cause injury to persons and/or damage to physical assets.

Autonomous Driving and Control includes applications oriented toward creating trains capable of operating automatically without any (or only limited) human intervention and approaches aimed at optimizing the energy consumption of moving rolling stock. The International Association of Public Transport defines five Grades of Automation in terms of the operation of trains ranging from GoA0, meaning there is no automation, to GoA4, which awaits trains capable of operating automatically without onboard staff/driver. A more in-depth review of research and development of automatic train operation in rail transport can be found in [24].

Traffic Planning and Management combines all activities with effective and efficient capacity management, scheduling and control of rail operations, and resource allocation and management. This includes traffic forecasting and rescheduling, analysis of passenger and freight rail transport, assessment of traffic demand and capacity, train and crew timetables, and optimal use of rolling stock and energy to increase passenger and freight transport efficiency and competitiveness.

Revenue Management is the application of disciplined analytics that predict consumer behavior at micro-market levels and optimize product availability and price to maximize revenue growth.

Transport Policy deals with the development of a set of strategies and programs, which are established by governments and regulators, to achieve specific objectives related to social, economic, and environmental conditions and the functioning of the transport system.

Passenger Mobility refers to the movement of people using any means of transport. In this context, it refers to rail transport and the following characteristics of mobility: time taken to reach the destination; affordability and Accessibility, as rail options need to be affordable to ensure a successful transport service; and Safety, which is a fundamental prerequisite for rail mobility.

The study [25] systematizes scientific research, as shown in Fig. 1, where the information on the studies included in each sub-field of railway transport shall be presented.

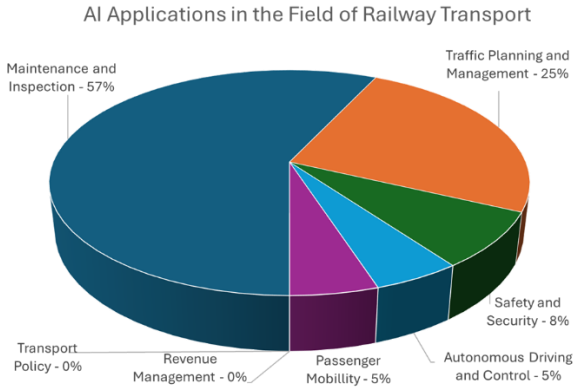

Fig. 1. AI Applications in the Field of Railway Transport.

"Maintenance and Inspection" is the main component, which makes up about 57% of the surveys: more than twice as many documents in "Traffic Planning and Management" and seven times as many documents in the field of "Safety and Security." Documents in the field of "Autonomous Driving and Control" as well as "Passenger Mobility" account for 5% each. So far, there is no open research interest in the "Revenue Management" and "Transport Policy" subfields.

The application of artificial intelligence in transport projects is a complex task that requires a comprehensive concept [26],[27]. The reasons are mainly related to the degree of use of information technology in transportation and the cost of AI. The creation of AI is directly related to significant engineering effort and cost.

Artificial intelligence is increasingly used in all modes of transport, but it is entering the sector with a slowdown. The biggest problem facing technologies related to artificial intelligence is the collection of data and its classification in order for the learning process to be effective. The goal is not to hinder the development and penetration of artificial intelligence but to prevent the risks of its use.

The application of artificial intelligence in managing transport projects is a complex and multi-parameter task, requiring data on traffic, the environment, transport events over time, etc. The data and information are accumulated, processed, and analyzed, which then form the basis for improving the performance of artificial intelligence.

The use of artificial intelligence in project management is a topical scientific problem that several authors consider methodological [28]-[32]. The issues discussed are a special case related to the design and construction of transport infrastructure, but this will, in any case, be an important element of the overall task and the challenges to its implementation.

Artificial intelligence is increasingly used in the management of transport projects. However, the most serious challenge for the technologies used is still collecting, analyzing, and classifying data to make the learning process more efficient [33].

Most of the transport projects are in the construction of transport infrastructure. The application of artificial intelligence in managing projects for the construction of transport infrastructure is mainly related to documentary analysis, remote analysis, forecasting, analysis of subcontractors, etc. The project architecture shows the team's relationships, tasks, and milestones in these cases. Artificial intelligence can be successfully used to account for this interaction and improve overall project management. The rapid development of artificial intelligence technologies implies improving the management of transport infrastructure projects.

The modernized version of the four-stage model for transport infrastructure planning requires planning based on long-term forecasts of expected traffic, applying mathematical models [34],[35]. The extended four-stage transport model is shown in Fig. 2. It also includes an "Artificial Intelligence" module, through which the accumulated data and trends are processed and analysed.

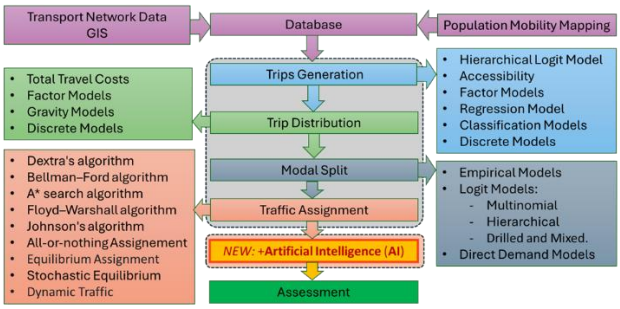

Fig. 2. A modernized version of the four-stage transport model for transport infrastructure planning.

The idea is to create large data sets related to transport, logistics operations, vehicles, types of cargo, cargo volume, speed of freight flows, carriers, routes, infrastructure, and workload by hours, days, and seasons to be used by artificial intelligence. The data collected is of different types – text, numbers, photos, video, voice, etc. It has been found that the most researched data are those related to transport accidents to improve safety [36]. In these cases, with the help of tools and techniques for analyzing text data and images, artificial intelligence can detect previously hidden problems. It should be noted that with flexible management of transport projects with an artificial intelligence application, higher efficiency is achieved [37],[38].

The transport sector is a complex system consisting of many coordinated business logic and processes to ensure a continuous, high-quality, and safe transport process. It is this complex information infrastructure consisting of many hardware and software elements, including the ability to use AI, that makes it sufficiently vulnerable to unintentional or deliberate negative information impacts that can disrupt operations, compromise sensitive data, and even threaten public safety, according to the classic scheme given in the figure below:

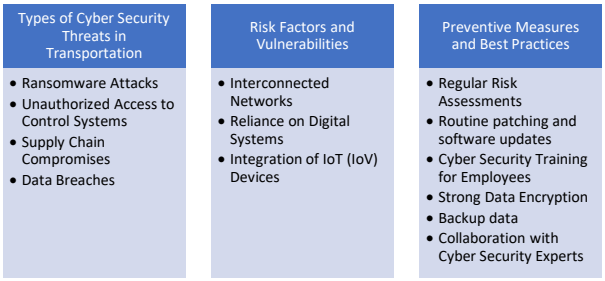

Fig. 3. Typical scheme for presenting cyber threats, risk factors and prevention in transport.

III. RESULTS AND DISCUSSION

The analysis of the work in the current study shows that AI can revolutionize the transportation sector, but it comes with challenges and considerations. In this regard, the following can be summarized regarding the use of AI in transport:

Benefits of AI in Transportation

AI improves traffic management, predictive maintenance, and logistics optimization, making transportation systems more efficient.

AI can improve safety by enabling autonomous driving, reducing human error, and improving traffic monitoring and accident detection.

AI helps optimize routes and reduce fuel consumption, creating a more sustainable transportation ecosystem.

Challenges and risks of using AI

AI involves collecting vast amounts of data and raising privacy questions.

AI systems can mistakenly recognize pedestrians or other vehicles, leading to potential accidents.

Implementing AI in transportation requires robust regulatory frameworks to ensure safety and ethical use.

Key Areas of AI Application

AI supports features such as perception, localization, mapping, scheduling, and control in self-driving cars.

AI improves intelligent traffic management systems, improving traffic and reducing congestion.

AI optimizes logistics operations, from route planning to predictive maintenance.

From a future perspective, the role of artificial intelligence in transportation is expected to grow, with advances in machine learning and IoT (IoV) leading to further innovation. However, addressing the challenges and risks associated with AI is crucial for its successful integration into the transport sector.

IV. CONCLUSION

This article summarizes and systematizes the problem of the application of artificial intelligence in the field of road transport, particularly railway transport, as an illustrative example of a high degree of automation of its management and functioning. Categorization has been made into seven railway sub-areas: maintenance and inspection, safety and security, autonomous movement and control, transport planning and management, revenue management, transport policy, and passenger mobility. This is an important step towards adopting AI in transportation, as it systematically provides a detailed and in-depth summary of available research focuses.

In this regard, the following conclusions are presented:

- AI reveals its strong impact on various activities related to forecasting. For example, in the field of maintenance and inspection, AI-enabled damage/defect predictions have been extensively studied. Similar situations are also found in areas such as forecasting the flow of transport passenger mobility and traffic situation forecasting in real-time traffic management.
- The use of intelligent systems provides additional support to improve maintenance operations, resulting in increased safety.
- AI can support optimization models to address large-scale real-life issues in planning, traffic management, maintenance, and inspection scheduling.
- AI applications can use a wide range of data from sensors, visuals/footage, and traffic movement logs, making AI's capabilities in transportation extremely diverse.
- Special emphasis is placed on the application of artificial intelligence in the management of transport projects, which is a complex and multiparametric task that requires extensive data on traffic, the environment, transport events over time, etc.
- Regarding Cybersecurity impact and limitations in transport, a scheme for the presentation of cyber threats, risk factors, and prevention is given.

AI is attracting increasing research interest, and therefore – it is realistic to expect that a greater focus on AI-based scientific and applied research will characterize the future of transport engineering, as well as its planning and management.

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