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THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE DEVELOPMENT OF RAILWAY TRANSPORTATION

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Abstract: Artificial intelligence (AI) has been a revolutionary force in modern transportation systems. In recent years, AI has played an important role in the development of railway transportation. This paper explores the role of AI in railway transportation and the potential impact it may have on the industry. The paper begins by discussing the different types of AI technologies that are being used in railway transportation. It then examines the advantages of AI in railway transportation, including improved safety, increased efficiency, and reduced costs. Finally, the paper discusses the challenges associated with implementing AI in railway transportation and concludes with a discussion of future developments in this area.

Keywords: *Artificial Intelligence, AI, railway transportation, railway industries, Digital Automatic Coupling (DAC)*

1. INTRODUCTION

Railway transportation is one of the oldest and most important modes of transportation in the world. Over the years, it has played a vital role in the transportation of people and goods, and it continues to be an important part of the transportation system. However, the railway industry is facing many challenges, including increasing competition from other modes of transportation, aging infrastructure, and safety concerns. To address these challenges, the railway industry is turning to artificial intelligence (AI) technologies to improve its operations and provide better service to its customers. AI has the potential to revolutionize railway transportation, and this paper will explore the role of AI in the development of railway transportation.

2. METHODOLOGY

Types of AI technologies used in railway transportation:
There are several types of AI technologies that are being used in railway transportation. One of the most important is machine learning. Machine learning is a type of AI that allows machines to learn from data without being explicitly programmed (Borsodi & Takács, 2022). Machine learning is being used in railway transportation to develop predictive maintenance models, which can help prevent breakdowns and reduce downtime. Another important type of AI technology is computer vision. Computer vision is a type of AI that allows machines to recognize and interpret visual data, such as images and video (Fedorko, 2021). Computer vision is being used in railway transportation to develop intelligent video surveillance systems, which can help improve safety and security (Ulewicz, et al., 2019).

3. RESULTS

3. 1. Advantages of AI in railway transportation

There are several advantages to using AI in railway transportation. One of the most important is improved safety. AI technologies, such as predictive maintenance models and intelligent video surveillance systems, can help identify potential safety hazards and prevent accidents before they occur. Another advantage is increased efficiency. AI technologies can help optimize railway operations, reducing delays and improving service to customers. Additionally, AI can help reduce costs by reducing the need for manual labour and optimizing resource allocation.

AI can support research and development in the railway industry in several ways, including:

- Predictive modelling and simulation: AI can help researchers develop predictive models and simulations that can simulate different scenarios and outcomes. For example, machine learning algorithms can be used to analyse data from railway systems, such as train schedules, traffic patterns, and weather conditions, to predict potential issues and improve the efficiency of railway operations.
- Data analysis and decision-making: AI can help researchers and engineers analyse large amounts of data to make informed decisions. Machine learning algorithms can be used to identify patterns and correlations in the data,

allowing researchers to make predictions and recommendations based on the data.
- Autonomous systems: AI can be used to develop and optimize autonomous systems for railway operations. For example, AI can be used to develop algorithms that allow trains to operate autonomously, reducing the need for human intervention.
- Optimization of resources: AI can be used to optimize the use of resources in railway operations. Machine learning algorithms can be used to analyse data on train schedules, maintenance schedules, and other operational data to identify areas where resources can be optimized, such as reducing downtime or increasing efficiency.
- Risk management: AI can help researchers and engineers identify potential risks in railway operations and develop strategies to mitigate them. For example, machine learning algorithms can be used to analyse data on train accidents and incidents to identify patterns and potential risks.

Overall, AI can be a valuable tool for supporting research and development in the railway industry, helping to improve efficiency, safety, and reliability in railway operations.

3. 2. Digital Automatic Coupling (DAC)

It is important to note, however, that one of the most important steps to properly exploit the new opportunities is digital transformation. An essential element of this is the implementation of digital automatic coupling devices on wagons.
Digital Automatic Coupling (DAC) technology can improve the efficiency of railway transportation in several ways:
- Faster and more efficient coupling: DAC technology allows for faster and more efficient coupling and decoupling of train cars. This can reduce the time required for loading and unloading cargo and improve the overall efficiency of railway operations.
- Improved safety: DAC technology can improve safety by providing more accurate and up-to-date information about train car positions and movements. This can help reduce the risk of collisions and other accidents (Takács, 2023), (Mekonnen, et al., 2023).
- Real-time monitoring: DAC technology can allow for real-time monitoring of train car positions and movements, allowing control centres to make more informed decisions about train schedules, routes, and other operational details. This can help reduce delays and improve the overall efficiency of railway operations.

- Increased capacity: DAC technology can increase the capacity of train cars by allowing for more precise coupling and decoupling. This can help reduce the number of train cars required to transport a given amount of cargo, improving efficiency, and reducing costs.
- Improved maintenance: DAC technology can improve maintenance operations by providing real-time information about train car components and performance. This can help maintenance teams identify potential issues and make repairs more quickly, reducing downtime and improving efficiency.

Overall, DAC technology can help improve the efficiency, safety, and reliability of railway transportation by providing faster and more efficient coupling, real-time monitoring, and more accurate information about train car positions and movements.

However, while there are clear benefits to be gained from the uptake of DAC, it may not be widely adopted in the near future. The cause is that rail transport is fragmented. Separate departments are responsible for traction, passenger transport, the carriage of goods and infrastructure management. As these outsourced companies are economically independent, there is no collective interest. Passenger and cargo wagons would have to be installed with DAC equipment, so the costs would logically be assigned to these divisions. But the profit is expected to be made by the infrastructure provider. It is reasonable that the companies that operate and service the wagons do not want to spend around 20.000 EUR per wagon, as they will never make a profit for them. At the same time, the company that maintains and handles the infrastructure does not want to spend on upgrading wagons owned by another company.

Another difficulty is that the profitability of old cargo wagons is very uncertain.

To solve the problem, companies in each area need to work together, but none of them are interested in doing it separately. But its social utility is unquestionable, so top-down legislation can provide the solution.

It is important to note that this investment makes no sense in small increments, and the benefits can only be realised if everyone switches to the new systems at approximately the same time. Of course, this is most important in terms of international traffic.

It is also important that a standardized coupling device is introduced.

In the same way as the economic benefits (Evans, 2013), we can also see that this is the only way to maximise the potential of artificial intelligence.

The resulting increase in capacity could also significantly reduce the volume of passenger and cargo traffic on the roads, which would also lead to a reduction in emissions (Török & Sipos, 2022).

While digitalization has the potential to bring many benefits to railway transportation, there are also some potential threats that need to be addressed. Here are some of the key threats of digitalization in rail transport (Török, 2023):

- Cybersecurity risks: As railway systems become more interconnected and reliant on digital technology, they may become more vulnerable to cyber-attacks. This could include attacks on the railway's IT systems, control systems, or even the trains themselves. Cybersecurity threats could disrupt railway operations, compromise passenger safety, and cause significant financial losses.
- Reliance on technology: While digitalization can improve the efficiency and reliability of railway services, it also means that railway operators become more reliant on technology. This means that if there is a technology failure, there could be significant disruptions to railway operations.
- Job displacement: The use of digital technology could lead to job displacement in the railway industry, as automation and AI take over some roles that were previously done by humans. This could have a significant impact on workers and their communities.
- Data privacy concerns: As digitalization generates large amounts of data about railway passengers and operations, there are concerns about how this data is collected, stored, and used. There is a risk that this data could be misused or hacked, leading to privacy violations and other negative consequences.
- Infrastructure challenges: Digitalization requires significant investments in IT infrastructure and communication networks, which can be expensive and time-consuming to implement. Railway operators may need to upgrade their infrastructure to support digitalization, which could lead to disruptions during the implementation phase.

It is therefore important to recognize the potential threats of digitalization in rail transport and take steps to mitigate them. This includes investing in cybersecurity, ensuring appropriate training and support for workers, addressing privacy concerns, and carefully managing the implementation of new digital technologies.

3. 3. Challenges associated with implementing AI in railway transportation

Despite the many advantages of AI in railway transportation, there are also several challenges associated with its implementation. One of the biggest challenges is the cost of implementing AI technologies. Implementing AI requires significant investment in hardware, software, and personnel. Another challenge is the lack of standardization in the industry. There is a need for standardized data formats and communication protocols to enable the integration of different AI systems.

Finally, there are also concerns around privacy and security. Intelligent video surveillance systems, for example, raise concerns about the use of personal data and the potential for abuse.

4. Conclusion

In conclusion, AI is playing an increasingly important role in the development of railway transportation. The advantages of AI, including improved safety, increased efficiency, and reduced costs, make it a promising technology.

4. 1. Future developments in AI in railway transportation

Despite the challenges, the future of AI in railway transportation is promising. AI technologies are expected to continue to play an important role in the development of railway transportation, with new technologies and applications emerging over time. One area of particular interest is the use of AI in autonomous trains. Autonomous trains have the potential to revolutionize railway transportation, improving safety and efficiency while reducing costs. Another area of interest is the use of AI in customer service, with chatbots and virtual assistants being developed to improve the customer experience.

5. Summary

Railway transportation has been a vital mode of transportation for both people and goods for many years, but it faces numerous challenges such as competition from other modes of transportation, aging infrastructure, and safety concerns. Artificial intelligence (AI) technologies have the potential to revolutionize railway transportation by improving efficiency, reducing costs, and increasing safety. Machine learning and computer vision are some of the AI technologies used in railway transportation. AI can support research and development in the railway industry in several ways, including developing predictive models and simulations, analysing data, developing autonomous systems, optimizing resources, and risk management. Digital automatic coupling (DAC) technology can further improve the efficiency of railway transportation by providing faster and more efficient coupling, improved safety, real-time monitoring, and increased capacity. However, the fragmentation of the railway industry may limit the adoption of DAC technology in the near future.

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