TIC3151
Artificial Intelligence

Assignment

Tutorial Section:TT4L
Group Number: G2

ID	Name	Email Address
1201101003	Chia Yu Zhang	1201101003@student.mmu.edu.my
1201100514	Yap Zhi Toung	1201100514@student.mmu.edu.my
1191201569	Too Yee Shuen	1191201569@student.mmu.edu.my
1191201404	Tee Eng Leong	1191201404@student.mmu.edu.my

Question 1

1. Introduction

Artificial intelligence (AI) has become a game-changing technology in various industries, and the railway sector is no exception. AI has the potential to revolutionize the way railways operate, maintain their assets, and deliver services to customers. From enhancing safety to improving efficiency, AI has the power to transform railway operations and bring significant benefits to the industry.

In recent years, there has been a growing interest in applying AI in railway operations and management. With the advent of big data, IoT sensors, and advanced analytics, railways can leverage AI to make better decisions, optimize resources, and improve customer experience. AI-powered systems can also help railways predict and prevent equipment failures, detect anomalies, and reduce downtime, leading to significant cost savings.

The purpose of this report is to analyze 20 research papers and provide insights into the potential of AI in the railway industry, its current adoption, and the challenges and opportunities associated with its implementation. The report will focus on the problems faced by the industry and the techniques used to overcome them with the help of AI. It aims to serve as a resource for stakeholders in the railway industry, providing a comprehensive understanding of AI's potential and its impact on the workforce.

2. Descriptive Statistics

In total, there are 20 papers mentioned: 17 published in journals and magazines, and 3 published in conferences. The distribution of publication years is as follows: 3 papers in 2023, 7 papers in 2022, 6 papers in 2021, 2 papers in 2020, and 2 papers in 2018.

Author	**Safety and risk assessment**	**Infrastructure maintenance and efficiency**	**Operations and Optimization**	**Infrastructure and Construction**	**Communication and Control System**	**Data Analysis and Prediction**
Alawad et al. (2020), Arslan et al. (2022), Liu et al. (2021) , Najeh et	X					

al. (2021), Yan et al. (2023)						
Asalkhanova et al. (2022), Bai et al. (2021), Popov et al. (2022)		X				
Li et al. (2020), Rößler et al. (2021), Xu et al. (2021)			X			
Huang et al. (2023), Paneiro et al. (2018), Polyanskiy et al. (2022), Wang et al. (2022)				X		
Yu et al. (2021), Zhou et al. (2022), Zhang et al. (2018)					X	
Mirbod et al. (2023),						X
Bešinović et al. (2022)	X	X	X		X	X

Table 1: Challenges and problems solved by researchers

Table 1 shows the challenges and problems solved by different researchers. In a comprehensive review of the literature, five papers were identified to address the problem of safety risk and assessment. Additionally, four papers focused specifically on the topic of Infrastructure and Construction. Three papers were dedicated to exploring issues related to Infrastructure maintenance and efficiency, Operations and Optimization, and Communication and Control Systems. Furthermore, one paper delved into the field of data analysis and prediction. Notably, the paper by Bešinović et al. (2022) encompassed all five problem areas, namely safety risk and assessment, Infrastructure maintenance and efficiency, Operations and Optimization, Communication and Control Systems, and data analysis and prediction. This collection of research papers provides a comprehensive understanding of the challenges and potential solutions across various domains within the field of infrastructure.

Author	Convolutional neural network (CNN)	Artificial Neural Networks (ANN)	Data Mining	Machine Learning	Physics-based models and machine learning	Graph-based topological analysis	Reinforcement Learning	Optimization Algorithm	Statistical econometric technique	Long short-term memory (LSTM)
Arslan et al. (2022), Polyanskiy et al. (2022), Paneiro et al. (2018), Popov et al. (2022)	X									
Arslan et al. (2022), Paneiro et al. (2018), Popov et al. (2022)		X								
Asalkhanova et al. (2022), Mirbod et al. (2023), Polyanskiy et al. (2022)			X							
Rößler et al. (2021)				X						
Huang et al. (2023), Yu et al. (2021), Zhang et al. (2018)					X					
Liu et al. (2021)						X				
Xu et al. (2021)							X			
Bešinović et al. (2022), Li et al. (2020), Xu et al. (2021)								X		
Wang et al. (2022)									X	
Najeh et al. (2021)	X									X
Yan et al. (2023)	X						X			

Table 2: Artificial Intelligence techniques used by researchers

Table 2 depicts the information about different Artificial Intelligence techniques used in work related to railway. The literature review covered various techniques in machine learning and data analysis. Convolutional Neural Networks (CNN) and Artificial Neural Networks (ANN) were each explored in four papers. Data Mining, Physics-based models with machine learning, and Optimization Algorithms were investigated in three papers each. Reinforcement Learning was the focus of two papers, while other techniques such as Graph-based topological analysis, Statistical econometric techniques, and Long short-term memory (LSTM) were covered individually. Notably, Najeh et al. (2021) used CNN and LSTM, and Yan et al. (2023) utilized CNN with Reinforcement Learning. These papers provide valuable insights into different approaches within machine learning and data analysis.

3. Limitations

The efficiency of suggested remedies in actual railway systems is frequently dubious in research articles because of a lack of empirical validation. The railway system lacks synergy between its various components, which makes it difficult to design comprehensive solutions. Many times, practical limitations like expense and stakeholder resistance go unnoticed. Data security and privacy issues are not sufficiently handled. To be implemented successfully in railway systems, more detailed and practical research is required.

4. Future Work

Future research in railway transportation can encompass a range of important areas. One aspect involves investigating the implementation of AI systems, with a focus on testing prototypes for predictive maintenance, scheduling, and control, while also evaluating their feasibility and effectiveness in real-world railway systems. Another critical area of research involves addressing ethical and legal considerations associated with using AI systems in rail travel, including the development of regulatory frameworks and addressing ethical concerns related to security, privacy, and equity. Additionally, research efforts can be directed towards exploring data management strategies that optimize the cleaning, analysis, and integration of data from diverse sources such as train and rail sensors, with the aim of enhancing overall system performance. Furthermore, studies can be conducted on designing user-friendly interfaces and understanding the integration of AI systems into existing railway procedures and operations, taking into account the important aspect of human-machine interaction. Lastly, research can explore the integration of AI systems with other modes of transportation, with a focus on achieving seamless intermodal connectivity and advancing transportation networks.

5. Recommendations

The recommendation for the railway industry is to invest in AI-powered technologies for train control, scheduling, and predictive maintenance to improve efficacy, safety, and cost-efficiency. By

creating frameworks with regulatory agencies, it is essential to handle ethical and regulatory issues. To collect, store, clean up, and analyze data from many sources and increase the effectiveness of AI systems, it will be crucial to develop solid data management systems. The advantages of AI in rail transportation will also be increased by making investments in tools that promote effective human-machine interaction and multi-modal integration with other transportation stakeholders.

6. Conclusion

In conclusion, the adoption of AI in the railway sector has revolutionized operations, offering advantages including improved passenger experience, autonomous operations, and predictive maintenance. Through autonomous systems, AI improves safety, enables effective maintenance procedures, and offers individualized services. However, issues like data privacy and ethical issues must be resolved. Overall, AI has made railroads a more secure, effective, and customer-focused source of transportation.

7. Reference

Alawad, H., Kaewunruen, S., & An, M. (2020). A Deep Learning Approach Towards Railway Safety Risk Assessment. *IEEE Access*, *8*, 102811–102832. doi:10.1109/ACCESS.2020.2997946

Asalkhanova, T., Karpov, I., & Kolisnichenko, E. (2022). Development of Strategies for Analysing the Factors which Influence the Organization of Routine Railway Track Maintenance. *Transportation Research Procedia*, *61*, 582–587. doi:10.1016/j.trpro.2022.01.094

Arslan, B., & Tiryaki, H. (2020). Prediction of railway switch point failures by artificial intelligence methods. *TURKISH JOURNAL OF ELECTRICAL ENGINEERING & COMPUTER SCIENCES*, *28*(2), 1044–1058. doi:10.3906/elk-1906-66

Bai, T., Yang, J., Xu, G., & Yao, D. (2021). An optimized railway fastener detection method based on modified Faster R-CNN. Measurement, 182, 109742. doi:10.1016/j.measurement.2021.109742

Bešinović, N., De Donato, L., Flammini, F., Goverde, R. M. P., Lin, Z., Liu, R., … Vittorini, V. (2022). Artificial Intelligence in Railway Transport: Taxonomy, Regulations, and Applications. *IEEE Transactions on Intelligent Transportation Systems*, *23*(9), 14011–14024. doi:10.1109/TITS.2021.3131637

Fink, O., Zio, E., & Weidmann, U. (2013). Predicting time series of railway speed restrictions with time-dependent machine learning techniques. *Expert Systems with Applications*, *40*(15), 6033–6040. doi:10.1016/j.eswa.2013.04.038

Huang, G., Wu, G., Yang, Z., Chen, X., & Wei, W. (2023). Development of surrogate models for evaluating energy transfer quality of high-speed railway pantograph-catenary system using physics-based model and machine learning. *Applied Energy*, *333*, 120608. doi:10.1016/j.apenergy.2022.120608

Liu, J., Schmid, F., Li, K., & Zheng, W. (2021). A knowledge graph-based approach for exploring railway operational accidents. *Reliability Engineering & System Safety*, *207*, 107352. doi:10.1016/j.ress.2020.107352

Li, Z., Zhang, Q., Ren, Y., Sun, Y., Miao, C., & Duan, J. (2020). High-speed Railway Timetabling Model based on Transfer Optimization. *2020 IEEE International Conference on Artificial Intelligence and Information Systems (ICAIIS)*, 162–166. doi:10.1109/ICAIIS49377.2020.9194932

Mirbod, M., & Dehghani, H. (2023). Smart Trip Prediction Model for Metro Traffic Control Using Data Mining Techniques. *Procedia Computer Science*, *217*, 72–81. doi:10.1016/j.procs.2022.12.203

Najeh, T., Lundberg, J., & Kerrouche, A. (2021). Deep-Learning and Vibration-Based System for Wear Size Estimation of Railway Switches and Crossings. *Sensors*, *21*(15). doi:10.3390/s21155217

Paneiro, G., Durão, F. O., Costa e Silva, M., & Falcão Neves, P. (2018). Artificial neural network model for ground vibration amplitudes prediction due to light railway traffic in urban areas. *Neural Computing and Applications*, *29*(11), 1045–1057. doi:10.1007/s00521-016-2625-9

Polyanskiy, A. (2022). Stages of Intellectualization of Engineering and Technical Support of Railway Construction. *Transportation Research Procedia*, *61*, 574–581. doi:10.1016/j.trpro.2022.01.093

Popov, K., De Bold, R., Chai, H.-K., Forde, M. C., Ho, C. L., Hyslip, J. P., … Hsu, S. S. (2022). Big-data driven assessment of railway track and maintenance efficiency using Artificial Neural Networks. Construction and Building Materials, 349, 128786. doi:10.1016/j.conbuildmat.2022.128786

Rößler, D., Reisch, J., Hauck, F., & Kliewer, N. (2021). Discerning Primary and Secondary Delays in Railway Networks using Explainable AI. *Transportation Research Procedia*, *52*, 171–178. doi:10.1016/j.trpro.2021.01.018

Wu, D., Zhu, G., & Ai, B. (2010). Application of artificial neural networks for path loss prediction in railway environments. *2010 5th International ICST Conference on Communications and Networking in China*, 1–5.

Wang, C., Chen, J., Li, B., Chen, N., & Wang, W. (2023). Impact of high-speed railway construction on spatial patterns of regional economic development along the route: A case study of the Shanghai–Kunming high-speed railway. *Socio-Economic Planning Sciences*, 101583. doi:10.1016/j.seps.2023.101583

Xu, J., & Ai, B. (2021). Artificial Intelligence Empowered Power Allocation for Smart Railway. *IEEE Communications Magazine*, *59*(2), 28–33. doi:10.1109/MCOM.001.2000634

Yan, D., Li, K., Zhu, Q., & Liu, Y. (2023). A railway accident prevention method based on reinforcement learning – Active preventive strategy by multi-modal data. *Reliability Engineering & System Safety*, *234*, 109136. doi:10.1016/j.ress.2023.109136

Yu, H., Li, S., & Yu, J. (2021). Intelligent Monitoring and Control System for underground mine rail transportation based on communication-based train control (CBTC) system and AI computing. *2021 IEEE 2nd International Conference on Big Data, Artificial Intelligence and Internet of Things Engineering (ICBAIE)*, 704–707. doi:10.1109/ICBAIE52039.2021.9389946

Zhou, T., Zhang, H., Ai, B., Xue, C., & Liu, L. (2022). Deep-Learning-Based Spatial–Temporal Channel Prediction for Smart High-Speed Railway

Communication Networks. *IEEE Transactions on Wireless Communications*, *21*(7), 5333–5345. doi:10.1109/TWC.2021.3139384

Zhang, M., Zhang, Q., Lv, Y., Sun, W., & Wang, H. (2018). An AI based High-speed Railway Automatic Train Operation System Analysis and Design. *2018 International Conference on Intelligent Rail Transportation (ICIRT)*, 1–5. doi:10.1109/ICIRT.2018.8641650