A COMPREHENSIVE REVIEW OF AUTOMATED GATE CONTROL, AIRBAG SYSTEMS AND SMOKE DETECTORS IN ENHANCING RAILWAY SAFETY

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***Abstract*—The RAILSAFE initiative is a groundbreaking endeavor focused on revolutionizing railway safety through the advancing of innovative technologies. At its core is the Automated Wireless Railway Gate Control System, a sophisticated solution utilizing sensors and wireless technology to streamline railway crossings. This system ensures timely gate closure, significantly reducing collision risks and improving overall safety. Complementing this, the initiative introduces the Machine Learning Fire Detection and Alert System, which rapidly identifies smoke or fire patterns along railway tracks. The system's immediate alerts enable swift responses, fortifying passenger safety and minimizing the risk of fire incidents on the railway network. In inclusion to these measures, the RAILSAFE initiative incorporates an Airbag System within trains, strategically deployed to activate in the occurrence of a collision or derailment. These onboard airbags prioritize passenger well-being, providing a proactive safety layer and minimizing the potential consequences of such incidents. The seamless integration of these cutting-edge components establishes a synergistic safety ecosystem, reshaping the landscape of railway safety through the combination of advanced technologies and automation. By addressing critical safety challenges at multiple levels, the RAILSAFE initiative aims to set new standards in railway safety, ensuring a secure and resilient travel experience for passengers in the phase of diverse safety concerns .**

Keywords—Automatic wireless gate control, Smoke detector using ML, Airbag system

I. INTRODUCTION

The RAILSAFE initiative emerges as a pioneering force in the advancing of railway safety, introducing a transformative amalgamation of cutting-edge technologies to create a comprehensive and proactive safety ecosystem. At its forefront, the Automated Wireless Railway Gate Control System redefines the dynamics of railway crossings. This system, marked by the integration of advanced sensors and wireless technology, orchestrates precise and timely gate closures. By doing so, it not only minimizes the potential for collisions but also lays the foundation for an elevated standard of safety in rail operations.

Complementing this technological marvel is the Machine Learning Smoke or Fire Detection and Alert System, an intelligent solution designed to infuse a layer of foresight into railway safety. Leveraging machine learning CNN algorithm ,this system swiftly analyzes and identifies smoke or fire patterns within the train. These intelligent systems, trained on diverse datasets, offer real-time analysis, swift detection, and immediate alert generation. By combining cutting-edge machine learning with railway safety, this advanced technology not only fortifies passenger well-being but also establishes a proactive framework for managing fire incidents across the entire railway network.

Taking safety to a heightened dimension, the RAILSAFE initiative introduces an Airbag System within trains, strategically positioned to activate in the occurrence of a collision or derailment. These strategically deployed airbags prioritize passenger well-being, representing a proactive safety layer designed to minimize injuries and potential consequences in the face of unforeseen incidents. The integration of this onboard airbag system underscores the initiative's commitment to a multifaceted safety approach that spans from prevention to protection.

Collectively, these interconnected components form a synergistic safety ecosystem, reshaping the landscape of railway safety through a harmonious blend of advanced technologies and automation. The RAILSAFE initiative transcends the conventional boundaries of safety measures by presenting a unified vision that addresses critical challenges comprehensively. It is not merely a collection of disparate technologies; rather, it is a holistic and transformative endeavor aimed at setting new benchmarks in railway safety standards. As the initiative unfolds, it seeks to instill confidence in passengers by ensuring a secure and resilient travel experience. By embracing innovation and embracing a proactive safety stance, the RAILSAFE initiative stands as a testimony to the continuous evolution of railway safety.

II. LITERATURE SURVEY

The study distills the survey's outcomes, offering a concise summary that encapsulates key findings and insights derived from the research in a tabular format, providing a comprehensive overview of relevant research works. The table encompasses crucial details such as the name of the study, author(s), publication year, research objectives, and key advantages and disadvantages identified in each work.

Title	Authors	Year	Objectives	Advantages	Disadvantages
Automated Railway Crossing System: A Secure and Resilient Approach.[1]	A. Golder, D. Gupta, S. Roy, M. A. Al Ahasan and M. A. Haque	2023	This study helps in Monitoring the system by checking any obstacle that gets stuck in the track and communicates with the railway signal to change it appropriately to alert and stop the train.	The ultrasonic sensors and GSM technology are replaced with RF transmitter/receiver pair to identify the approaching train, It will gradually decrease the effects of railroad accidents and improves safety in unmanned level crossings at less expenditure	The train is detected using IR sensors and the information about the train is intimated to the gate through GSM service.
Development of Automatic Railway Train Safety System. [2]	R. S. Tour, S. S. Narwade, A. R. Sathe and N. N. Ghuge,	2023	Introducing an advanced smoke detection system to enhance railway safety by addressing fire risks from electrical issues, wood materials, and collisions, mitigating potential incidents more effectively.	The whole framework is significantly more viable. The smoke sensor needs to fast closeness to the hotspot for brisk identification while the smoke identifier needs to keep as high as could reasonably be expected.	False Alaram, It has a range restrictions-for large areas, a wireless system can have an issue with transmitting information to the main control panel.
An Intelligent Image Fire Detection Approach Based On Deep Convolutional Neural Network. [3]	A. K. Vishwakarma and M. Deshmukh	2023	We developed a superior fire detection model on custom datasets, outperforming state-of-the-art algorithms. Utilizing multipath convolutional layers with diverse filters enhances local and global feature learning for effective image-based fire detection.	Our fire detection model, surpassing state-of-the-art algorithms, excels with multipath convolutional layers on custom datasets. Enhanced local and global feature learning ensures superior image-based fire detection, mitigating unpredictable social and economic impacts..	Challenges include potential overfitting on specific datasets, limited scalability, and dependency on quality and diversity of training data for optimal performance.
Smoking Detection and Alarm in Multiple Scenes Based on Deep Learning [4]	Tian Wu; Li Ling; Gui Wu; Jun Tao	2022	Introducing a method for smoking detection and alarm in diverse settings using the YOLOv5 deep learning model. Achieves 70.8% accuracy, surpassing others in speed and size for efficient deployment in urban monitoring systems.	The proposed YOLOv5-based method achieves 70.8% accuracy, excelling in recognition speed and compact size, ideal for rapid deployment in urban monitoring systems.	Potential limitations in challenging scenarios. Further real-world testing needed to ensure adaptability and reliability. Considerations for false positives and privacy concerns are essential.

Title	Authors	Year	Objectives	Advantages	Disadvantages
A Novel Robotics and MEMS Artificial Intelligence based Train Safety Device [5]	Shabaz Anwaz Sheikh; Harikumar Naidu	2021	This paper addresses railway accidents caused by unmanned crossings and suicidal individuals on tracks. Introducing an innovative Airbag Robot, employing MEMS technology, prevents injuries, track damage, and delays. MATLAB simulations affirm its effectiveness in mitigating accidents and facilitating timely train stops.	Introducing an Airbag Robot using MEMS technology prevents injuries, track damage, and delays caused by unmanned railway crossings and suicidal individuals.	Potential limitations in extreme scenarios. Further real-world testing needed to ensure the reliability and adaptability of the Airbag
Automation of Railway Gate Control with Obstacle Detection and Real-Time Tracking in the Development of Bangladesh Railway. [6]	Kuraish Bin Quader Chowdhury, Moshiur Rahman Khan, Md. Abdur Razzak	2020	This presents an automatic railway gate control system with real-time tracking, monitoring and obstacle detection for Bangladesh Railway. Implemented using microcontroller and various sensors, the system aims to enhance efficiency, safety, and quality in the railway system.	Efficient automatic rail gate control. Real-time train monitoring. Obstacle detection for enhanced safety.	Challenges in practical implementation, including sensor distance optimization and speed-related issues. Refinement needed for real-world deployment.
Design Of Smoke Detection And Alarm System Based On Lora. [7]	Zong Li, Shaopeng Li, Jianxiang Liu*, Ling Li, Chunliang Guo, Long Xu	2020	The paper presents a cost-effective LoRabased smoke detection system with improved anti-interference. It enables periodic data reporting, abnormal alarms, and optimizes hardware for power efficiency. Additional details on challenges and LoRaWAN specifics could enhance the paper.	Utilizes LoRa wireless communication for long-distance transmission. Low power consumption design with periodic data reporting. Effectively reduces system power consumption.	Limited information on practical implementation challenges. Specifics of LoRaWAN technology implementation could be explored further.
Fire Safety And Alerting System In Railways. [8]	P. Arun Mozhi Devan, M. Priyanga, G. Manisha, K.G.T. Rajarajeswari, K. Sangeetha.	2018	The paper proposes a railway fire safety system using GSM, gas/smoke sensors, LM35, and automated fire suppression for enhanced safety.	Longer communication using GSM. Utilizes gas/smoke sensors and LM35 for effective fire detection. Automated fire suppression with CO2 extinguishers.	Potential challenges with sensor calibration and false alarms. System effectiveness may vary in different environmental conditions. Further refinement for real-world deployment

Cigarette Smoke Detectors for Non-Smoking Areas in the Building[9]	Sancha Panpaeng; Phattharamon Phanpeang; Ekkasit Metharak	2018	This study designs cigarette smoke detectors using Gas Sensor (MQ-2) and NodeMCU V2 (ESP8266-12e) to alert staff through LINE API, ensuring quick response in spaces under 20 square meters	Efficient smoke detection in small spaces using Gas Sensor (MQ-2) and NodeMCU V2, alerting staff promptly through LINE API.	Limited applicability to larger areas due to size constraints, potentially hindering comprehensive smoke detection in spacious environments.
An Improved Object Detection Method Based On Deep Convolution Neural Network For Smoke Detection [10]	Junying Zeng; Zuoyong Lin; Chuanbo Qi; Xiaoxiao Zhao; Fan Wang	2018	This paper introduces an enhanced object detection method, leveraging deep CNNs, to improve smoke detection accuracy. Substituting feature extractors and optimizing parameters yield a 56.04% mAP on the smoke detection dataset, demonstrating superior results in both accuracy and speed.	Revolutionizing smoke detection with improved object detection using deep CNNs, achieving 56.04% mAP on the smoke detection dataset, surpassing traditional methods in accuracy and speed.	Despite advancements, challenges may persist in open spaces. Further research needed to enhance adaptability for comprehensive smoke detection in diverse environments.
A secure railway crossing system using IoT. [11]	E. A. Reddy, I. Kavati, K. S. Rao and G. K. Kumar	2017	This paper introduces an IoT-based railway gate control system for automatic operation, enhancing safety by reducing accidents at level crossings. Real-time communication and a mobile app provide efficient gate control and driver convenience..	The Automatic Railway Gate Control using IoT, which control the Railway Gate, Signals, Buzzer and also send same data on the Mobile Application.	The ultrasonic sensor include Limited testing distance, inaccurate readings and inflexible scanning methods.
Development Of Airbags For Locomotive Crew Protection. [12]	Dr.Abdullatif Zaouk, Mr.Srinivasan Kasturi, Mr. S.K.Punwani, Dr.Harishanker Nagarajan	2006	The paper discusses the development of airbags optimized for specific conditions faced by locomotive operators. It includes finite element simulations and fullscale collision tests for crew injury mitigation.	Significant reduction in head, chest, and lower abdomen injuries with airbag protection	Technical challenges, including the need for longer airbag inflation duration and adaptation for both belted and unbelted crew members. Specific fabric characteristics are required.

III. CONCLUSION

In conclusion, the presented project focuses on the automation of railway level crossing gates, fire detection using computer vision, and the execution of airbag technology for automotive safety. The manual operation of level crossing gates by gatekeepers is prone to delays and traffic congestion, which can be mitigated by the proposed automated system using infra-red sensors and Arduino control. The integration of computer vision and image processing techniques in fire detection offers a more reliable alternative to traditional methods like infrared sensors and smoke detectors. By analyzing visual characteristics such as brightness, spectral texture, spectral flicker, and edge trembling, the system can discriminate fires from other stimuli, minimizing false alarms and providing a more accurate and timely response to potential fire incidents. In the realm of automotive safety, the airbag system serves as a crucial restraint device designed to rapidly inflate during a collision, mitigating injuries by absorbing and distributing the impact force. The advancing of this life-saving technology depends on correct implementation and adherence to safety protocols. Overall, the project showcases the possibility of automation, computer vision, and advanced safety technologies in enhancing efficiency, reducing accidents, and safeguarding lives. The successful implementation of these systems marks a significant step forward in improving transportation safety and emergency response mechanisms.

REFERENCES

[1] A. Golder, D. Gupta, S. Roy, M. A. Al Ahasan and M. A. Haque, "Automated Railway Crossing System: A Secure and Resilient Approach," *2023 IEEE 14th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON)*, New York, NY, USA, 2023, pp. 0247-0253, doi: 10.1109/UEMCON59035.2023.10315973

[2] R. S. Tour, S. S. Narwade, A. R. Sathe and N. N. Ghuge, "Development of Automatic Railway Train Safety System," 2023 9th International Conference on Electrical Energy Systems (ICEES), Chennai, India, 2023, pp. 5-8, doi: 10.1109/ICEES57979.2023.10110041.

[3] A. K. Vishwakarma and M. Deshmukh, "An Intelligent Image Fire Detection Approach Based On Deep Convolutional Neural Network," 2023 14th International Conference on Computing Communication and Networking Technologies (ICCCNT), Delhi, India, 2023, pp. 1-6, doi: 10.1109/ICCCNT56998.2023.10307489.

[4] T. Wu, L. Ling, G. Wu and J. Tao, "Smoking Detection and Alarm in Multiple Scenes Based on Deep Learning," 2022 34th Chinese Control and Decision Conference (CCDC), Hefei, China, 2022, pp. 6212-6217, doi: 10.1109/CCDC55256.2022.10033747.

[5] S. A. Sheikh and H. Naidu, "A Novel Robotics and MEMS Artificial Intelligence based Train Safety Device," 2021 2nd International Conference on Smart Electronics and Communication (ICOSEC), Trichy, India, 2021, pp. 1-5, doi: 10.1109/ICOSEC51865.2021.9591761.

[6] K. B. Q. Chowdhury, M . R . Khan and M. A. Razzak, "Automation of Rail Gate Control with Obstacle Detection and Real Time Tracking in the Development of Bangladesh Railway," 2020 IEEE 8th R10 Humanitarian Technology Conference (R10-HTC), Kuching, Malaysia, 2020, pp. 1-6, doi: 10.1109/R10-HTC49770.2020.9356986.

[7] Z. Li, J. Liu, C. Guo, S. Li, L. Li and L. Xu, "Design of Smoke Detection and Alarm System Based on LoRa," 2020 Chinese Automation Congress (CAC), Shanghai, China, 2020, pp. 5086-5090, doi: 10.1109/CAC51589.2020.9326322.

[8] P. A. M. Devan, G. Manisha, K. G. T. Rajarajeswari, M. Priyanga and K. Sangeetha, "FIRE SAFETY AND ALERTING SYSTEM IN RAILWAYS," 2018 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), Bangalore, India, 2018, pp. 535-539, doi: 10.1109/RTEICT42901.2018.9012364.

[9] S. Panpaeng, P. Phanpeang and E. Metharak, "Cigarette Smoke Detectors for Non-Smoking Areas in the Building," 2018 22nd International Computer Science and Engineering Conference (ICSEC), Chiang Mai, Thailand, 2018, pp. 1-4, doi: 10.1109/ICSEC.2018.8712773.

[10] J. Zeng, Z. Lin, C. Qi, X. Zhao and F. Wang, "An Improved Object Detection Method Based On Deep Convolution Neural Network For Smoke Detection," 2018 International Conference on Machine Learning and Cybernetics (ICMLC), Chengdu, China, 2018, pp. 184-189, doi: 10.1109/ICMLC.2018.8527037.

[11] E. A. Reddy, I. Kavati, K. S. Rao and G. K. Kumar, "A secure railway crossing system using IoT," 2017 International conference of Electronics, Communication and Aerospace Technology (ICECA), Coimbatore, India, 2017, pp. 196-199, doi: 10.1109/ICECA.2017.8212795.

[12] A. Zaouk, S. Kasturi, S. K. Punwani and H. Nagarajan, "Development of airbags for locomotive crew protection," Proceedings of the 2006 IEEE/ASME Joint Rail Conference, Atlanta, GA, USA, 2006, pp. 115-120, doi: 10.1109/RRCON.2006.215301.