IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A REVIEW ON RAILWAY TRACK FAULT DETECTION USING ML ALGORITHMS

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Abstract—Railway track faults pose a significant risk to train operations, leading to accidents and potential loss of life and resources. Manual inspection methods are time-consuming and prone to errors. To address this issue, a novel approach using a camera mounted on trains for real-time track fault detection is proposed. This system employs image processing techniques to analyze the camera data and identify any faults present on the tracks. The proposed approach leverages an innovative system where a webcam is strategically mounted on a toy train moving along a miniature track. As the toy train progresses, the webcam captures real-time images of the track's surface. The system integrates image processing techniques with Arduino-based hardware. Upon detection of a crack, a robust alarm system is triggered, alerting users to the potential hazard. Simultaneously, the toy train undergoes an automatic halt, ensuring immediate attention to the identified crack. The proposed system offers a cost-effective and efficient solution for early crack identification, mitigating potential risks and contributing to the advancement of railway track monitoring technologies. Additionally, temperature data logging is implemented to monitor the environmental conditions along the railway track. With this technology, train operators can proactively address track faults and take necessary actions to ensure the smooth functioning of the railway system.

Keywords— Arduino, Machine Learning, MATLAB, Webcam.

I. INTRODUCTION

India, with one of the largest railway networks globally, boasts the lifeline of the nation - the Indian Railways. This colossal network, spanning over 67,000 kilometers and connecting remote villages to bustling metropolises, is a testament to the intricate tapestry of the Indian transport system. However, operating and managing this vast and diverse railway ecosystem comes with its unique set of challenges.

The Indian Railways grapples with the complexities arising from its sheer scale and diversity. The network caters to an incredibly vast and diverse demographic, from the urban sprawls of major cities to the rural hinterlands. Managing this diversity while ensuring efficiency, safety, and accessibility poses a formidable challenge. The multitude of terrains, ranging from the Himalayan foothills to the arid plains and coastal regions, further complicates the task of maintaining a seamless and reliable railway network.

The crux of this system lies in the application of advanced image processing techniques using MATLAB. These techniques enable the system to promptly identify cracks on the track. The significance of this approach lies not only in its technical ingenuity but also in its potential for cost-effective, miniature-scale implementation.

Upon detecting a crack, the system activates an alarm, indicating the presence of a potential hazard. Simultaneously, the toy train halts automatically, emphasizing the integration of safety measures into the detection process. This amalgamation of image processing, alert systems, and automation sets the stage for an efficient and proactive approach to track monitoring.

The advantages of this system are manifold. Firstly, it reduces the time and effort required for track maintenance, as faults can be detected in real-time, allowing for immediate action to be taken. Secondly, the system can detect subtle faults that may be missed by human inspectors, ensuring a higher level of accuracy in fault identification. Thirdly, by utilizing pre-processed data, the system can be implemented without disrupting train operations, making it highly practical and efficient.

This real-time fault detection system not only enhances the safety of train operations but also minimizes the risk of accidents caused by track faults. The integration of machine learning models ensures accurate and reliable fault detection, reducing the chances of false alarms. With this technology, train operators can proactively address track faults and take necessary actions to ensure the smooth functioning of the railway system.

II. LITERATURE REVIEW

Siddiqui et al, proposed a paper that explains the autonomously identify railway track faults using acoustic analysis and localization. The microphone and GPS sensor mounted on RPi positioned near the wheels of the cart was used to record the sound and send acoustic signal and a GPS location every five seconds to a remote cloud. 98.4% accuracy was achieved through MLP. Manual inspection was not necessary and achieved 98% accuracy with more types of faults detected.[1]

Ya-Wen et al, deliberated a paper that explains the GoPro Hero7 Black video camera was mounted on a maintenance vehicle. The camera features are 4k quality, lightweight, waterproof, shock-proof, dust resistant and GPS recording. The captured images (60 FPS) were transmitted to the backend deep learning server over 4G or Wi-Fi for fastener identification along with GPS position. Yolo v3 was used for fastener identification and classification with 89% precision and 95% recall rate.[2]

Bhagyalakshmi et al, proposed a paper that explains a solar powered electric vehicle was deployed on the railway track that was controlled by Raspberry pi (Rpi). Ultrasonic sensors, vibration sensors and image processing were used for the detection of faults. GSM and GPS module, interfaced with Arduino UNO microcontroller board was used for communication. SMS was sent to the control unit. The test for 15 images. 10 out of 12 faulty images were detected properly and all the three healthy images were detected as fault free trial. The inspection vehicle was mainly powered by solar hence lowering carbon footprints.[3]

AlNaimi et al, deliberated a paper that explains a robot deployed on the rail-track that captured images from both sides of the track. Image processing was done on the rail-track while inspection using Two Dimensional Convolutional Neural Networks (2DCNN) and only defected rail-track images were stored and sent to the cloud. Once an abnormal image was detected, its location was mapped and sent along with the image to the cloud. 97% accuracy was achieved through 2DCNN.[4]

Chowdhry et al, proposed a paper that explains a system were battery was mounted on the rotor of the excitation rotor and an accelerometer was connected to the Node MCU. Continuous forced vibration was applied in order to produce continuous vibration on track. Hilbert transform was used to calculate the amplitude obtained from the accelerometer. Results were, if the amplitude of the track is more than 5 dB it is a damaged track and it needs to be repaired or replaced, immediately, or if the amplitude of the track ranges between 2.9 dB to 5 dB it is recognized to suffer from drainage issues and it requires a proper inspection and any track reading below 2.9 dB falls in the category of intact track.[5]

Ghosh et al, deliberated a paper that explains to compare the performance of two mathematical methods such as Fast Fourier Transformation (FFT) and Discrete Wavelet Transformation (DWT) widely used to detect faults on railway tracks. The accelerator sensors were deployed on the axle-box of service trains to measure the acceleration of the vibrations produced by the running train. Both methods were used to estimate the track faults. Using FFT, 100% of corrugations and 90.53% of cracks were detected, while using DWT, 99.33% of corrugations and 99.85% of cracks were detected.[6]

Akhila et al, proposed a paper that explains image processing and deep neural network -based CNN model was used for detecting the faulty images in the railway crack detection. The inspection process was performed by collecting the images of railway tracks by Otsu segmentation model mainly used in railway surface detection. It reduced the consumption of hardware resources. And improved prediction accuracy effectively.[7]

Shah et al, deliberated a paper that explains the advent of IoT-based smart inertial measurement units, Muhafiz, a prototype, an automated and portable Track Recording Vehicles (TRV) with a novel design based on axle-based acceleration methodology for rail track fault diagnosis. The wheels of TRV were designed in such a way that the minimal marginal railway faults that can result in the train derailment could be analyzed. Low cost, low-power, wireless, and real-time IoT-based sensing system along with a customized TRV replacing the manual production of features. Muhafiz was 87% more efficient than the traditional push trolley- based TRV mechanism.[8]

Wei et al, proposed a paper that explains the track and fastener positioning method based on variance projection and wavelet transform was introduced. After that, a bag-of visual-word (BOVW) model combined with spatial pyramid decomposition was proposed for railway track line multi-target defect detection with a detection accuracy of 96.26%. Secondly, an improved YOLOv3 model named Track Line Multi-target Defect Detection Network (TLMDDNet), integrating scale reduction and feature concatenation, was proposed to enhance detection accuracy and efficiency.[9]

Patil et al, discussed a paper that explains an automated system based on microcontroller and sensors to overcome the problem of faults in tracks and to identify the moving object or animal on the tracks was presented. The system designed was an autonomous robot consisting of PIR and Ultrasonic sensors, coupled with GPS and GSM for providing the real time alert. The approach allowed for large-scale implementation with very little initial investment. The conventional, commercially disposable testing equipment also has an additional disadvantage, it is heavy.[10]

III. PROBLEM STATEMENT

The maintenance of railway tracks is a crucial task that ensures the safety and efficiency of the transportation system. However, traditional methods of track maintenance are reactive and inefficient, leading to higher costs and increased risk. One of the main challenges in track maintenance is the detection and classification of faults, which can be subtle and difficult to identify. The objective is to develop an automated system that can quickly and accurately detect faults or abnormalities on the tracks, enabling immediate action to prevent accidents. The system should improve the efficiency and reliability of fault detection, reduce human effort and time required for inspections, and provide data-driven insights for better track maintenance.

IV. OBJECTIVES

The main objective of the approach is to detect cracks on a railway track in real time so as to ensure the safety of the passengers and the railway system.

- Develop an AI ML algorithm to detect cracks in images captured by a USB webcam.
- Interface Arduino Uno with a webcam for image capture and processing.
- Utilize an L293D module and robot chassis setup to simulate a train engine.
- Implement a temperature sensor interfaced with Arduino for continuous temperature data logging.
- Create a MATLAB application for image capture, crack detection, and temperature data visualization.

V. MOTIVATION

The motivation behind this research stems from a critical intersection of technology, safety, and play, with a focus on miniature railway systems. The traditional charm of toy trains has not only captured the imaginations of enthusiasts but also serves as an educational tool for many. However, the safety aspects of miniature rail transport often receive less attention. This research is motivated by the desire to introduce cutting-edge technologies, such as Webcam interfacing and machine learning, to address safety concerns on toy train tracks.

The absence of advanced safety mechanisms in miniature railways has prompted the exploration of innovative solutions to enhance the overall safety and efficiency of these systems. The potential application of the webcam, coupled with a real-time processing unit like the Arduino, MATLAB and a machine learning algorithm, offers a unique opportunity to revolutionize safety measures in miniature rail transport. This project is motivated by the aspiration to infuse intelligence into these miniature systems, mitigating risks associated with track anomalies and elevating the overall user experience. By addressing the safety challenges of miniature railways, this research aims to contribute to a safer and technologically enriched transportation experience, not only for enthusiasts but also for educational and recreational purposes.

In essence, this research is motivated by the belief that the fusion of advanced technologies with miniature railways can usher in a new era of safety, innovation, and enjoyment, aligning with the evolving landscape of intelligent transportation systems.

VI. CONCLUSION

The integration of a MATLAB model with a n Arduino and webcam for railway track crack detection constitutes a groundbreaking solution with multifaceted benefits. This innovative approach ensures accurate identification and classification of track defects, leveraging the high-resolution data acquired through webcam. The use of Arduino as a computing platform enables real-time monitoring, facilitating prompt decision-making and intervention. This cost-effective system not only reduces maintenance expenses but also minimizes downtime by detecting cracks early, thereby optimizing railway operational efficiency. The modular design ensures adaptability to various railway configurations, making it a scalable and versatile solution. Beyond financial advantages, the technology significantly elevates safety standards by preventing accidents associated with track defects, enhancing the overall reliability of transportation infrastructure. This comprehensive system represents a paradigm shift in railway maintenance, offering a proactive, scalable, and efficient alternative to traditional inspection methods. As a result, it is poised to revolutionize the industry, setting new standards for the integration of artificial intelligence and sensor technologies in ensuring the safety and sustainability of railway networks.

ACKNOWLEDGEMENT

We convey our sincere thanks to Rajya Vokkaligara Sangha, Bangalore and our guide Dr. Hema Jagadish, Associate Professor, Department of Information Science and Engineering, Bangalore Institute of Technology, without whose direction, this would not have been possible. We also express our gratitude to our team members whose team participation resulted in successful completion of the paper.

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