Railway Accident Prevention and Safeguarding the Tracks using Lora Technology

Pratheeba C[1,*], Gokulapriya S[2,] Mythili R[3,] Sindhuvarshni K[4,]
[1]*Assistant Professor, Department of Electrical and ElectronicsEngineering,*
Nandha Engineering College (Autonomous), Erode, India.[2]

ABSTRACT: In this modern world, railway transportation plays an indispensable role in societal connectivity. Indian railway uses various technologies for transportation schedules and safety factors. Even though there are a lot of accidents and loss of resources.Railway track damages, obstacles, and signal issues are the major reasons for train crashes. After a train accident, significant impact occurs on people, the train's interior, exterior, and the tracks, the recovery process is prolonged and costly. Those unexpected accidents can be prevented by train safeguarding devices using LoRa technology. This technology is used for real-time wide-range communication without any signal issues. This device detects the obstacle inside the track using an Ultrasonic sensor and detects the crack that appears on the train track using an Infrared sensor. If any obstacles or cracks are present inside the track this system will alert us and the train stops automatically when an accident possibility occurs. In this device, the LoRa transmitter sends the real-time status of the train to the operating station via the Internet of Things. In addition, to avoid accidents in barrier-lifting areas which are connected to a LoRa receiver is used for awareness of the status of the train and automatic operation of the barrier-lifting gate.

KEYWORDS -- Railway transportation – LoRa technology – PIC microcontroller – Infrared sensor – Ultrasonic sensor – Internet of Things (IoT) – Barrier lifting gate – Real-time communication – Railway safety – Crack detection – Obstacles detection – Swift response mechanism.

I. INTRODUCTION

Railway transportation is crucial for connecting people and cargo, fostering economic growth, and improving mobility in modern societies. Despite its benefits, safety concerns persist due to factors like track issues, obstacles, and communication faults. Our project addresses these concerns by implementing LoRa (Long Range) technology for wide-range real-time communication between trains and operating stations. PIC microcontrollers serve as central processing units, managing data flow and executing control commands.

Various sensors, including ultrasonic and infrared, contribute to early hazard detection, triggering alarms and automatically stopping trains to prevent accidents. The LoRa receiver inbarrier lifting areas receives real-time train updates, closing gates to secure railway passages during movement.

IoT modules form the communication backbone, enabling seamless data exchange between system components. This integration of IoT technology, LoRa communication, PIC microcontrollers, and sensors empowers railway operators with accurate, responsive data for monitoring and managing train operations. Through this holistic approach, our project strives to significantly enhance railway safety, mitigating risks associated with track issues, obstacles,and communication failures.

Figure 1. Obstacles in railway track

Figure 2. Animal Crossing on railway track

II. LITERATURE SURVEY

This [1] paper focuses on preventing train collisions through an embedded system integrated with ultrasonic sensors. Despite existing collision avoidance systems, challenges like cost andlimited range persist. We propose an efficient embedded system with ultrasonic sensors to predict and prevent collisions, addressing these challenges. The system detects obstacles usingsensors and microcontrollers, facilitating faster track inspection without manual intervention. This approach enhances railway safety and operational efficiency.

In [2] presents a rail safety system for smart cities using real-time mobile communication. It employs sensors, an LTE module, a microcontroller, and a motorized gate for accident detectionand prevention. Train detection is via ultrasonic sensors, with GPS and LTE modules for accident detection. Two-way communication enables control room interaction. Automated doors close upon sensor detection of rail movement. Prototype testing validates systemeffectiveness, substantiating its reliability for smart city implementation. This [3] explores implementing Intelligent Transportation Systems (ITS) in railway-level crossings, addressing safety concerns. It proposes a dual sensor module combining 79GHz FMCW radar and CCTV,offering superior accuracy and cost-efficiency. The evaluation compared radar, camera (Yolov5), and manual detection under varied weather. Radar excelled in adverse conditions, detecting 5 additional objects. Findings emphasize the radar's effectiveness, crucial for enhancing safety in railway level crossings.

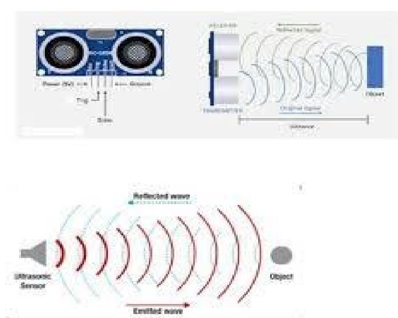

Figure . Ref [1]

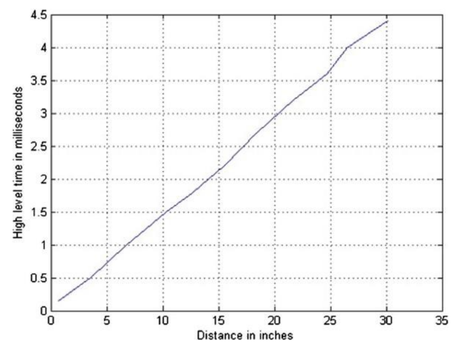

Figure . Ref [2]

In [4] A train brake system utilizes a vacuum to stop trains in case of obstacles on the track, with a simulation model employing fuzzy logic to prevent collisions. Despite brakes, a Micro Electro Mechanical System (MEMS) deploys an airbag upon impact, safeguarding humans and preventing track damage. This innovative MEMS technology, coordinated via fuzzy logic, enhances safety without disrupting train schedules, offering a viable solution to mitigate train-related injuries. This [5] presents a walking aid cane robot for the elderly and visually impaired,incorporating force sensors in the handlebar for movement control. An ultrasonic sensor detectsobstacles, while a MEMS sensor detects falls. A driver circuit manages movement, and a GSMmodule sends alerts to the user's phone. Various sensors, including EEG, enhance safety by providing real-time information about the user's status and surroundings, reducing accidents. This [6] introduces a LoRa channel access method for a single-channel, high-speed moving LoRa gateway to gather sensing data from railroad-installed end devices. It employs control messages to coordinate communication between the mobile gateway and static sensors. Compared to LoRa WAN, our approach demonstrates superior performance in packet error rateand throughput in real-world mobile environments. This highlights the advantages of a LoRa gateway-aware solution over LoRa Wan's non-awareness approach.

The [7] paper introduces TRINETRA, a sensor-based system for railway track obstacle detection, integrating camera, RADAR, and IR LASER. It aids trains in zero visibilityscenarios like fog and rain. The prototype includes a camera for a long-range view display to the loco pilot, RADAR for continuous obstacle detection, and an IR illuminator for monitoring in zero visibility. Testing showed effective obstacle tracking. [8] Utilizing computer vision andpattern recognition, we propose a novel framework for railway safety risk assessment. A supervised CNN is employed to identify risks in dynamic and complex railway stationenvironments. The model detects fall, slip, and trip events, providing more accurate motion data for early intervention and generalizability across various locations and risk types. In this

[9] An IoT-based railway track fault detection robot employs Laser transmitters, Raspberry Pi 3, GPS, GSM modules, and image processing. Laser identifies cracks, while the camera captures images for analysis. GPS provides coordinates to Raspberry Pi 3, which sends alerts via GSM to authorized contacts, facilitating timely

maintenance interventions. The [10] presents a robust railway crack detection scheme employing IR and ultrasonic sensors, facilitated by Atmega162 microcontroller and GSM modem. Each train is equipped with individual GPS modules for communication with the head office, allowing real-time monitoring of train locations. The system employs IR sensors to detect cracks on tracks and ultrasonic sensors for object detection. Upon detection, alerts are sent to the railway authority, contributing to accident prevention. The compact, software-controlled system demonstrates the potential for broader industrial, research, and commercial applications, leveraging advanced technology for enhanced safety and efficiency in railway operations.[11] The paper presents a complex signaling and blocking system for enhancing railway track crossing safety. A probabilistic model incorporates vehicle and pedestrian dynamics to assess crossing conditions. Safe crossing probability is determined via a lognormal distribution-based dynamic model. Equipment includes speed monitoring, pedestrian sensors, and automated alarm/blocking mechanisms for enhanced safety. [12] Our Smart Railway Crossing Surveillance System utilizes train passage data to display gate status, track closure times, and monitor traffic density and intrusions. This automated solution improves efficiency and safety, outperforming human- managed systems, and offering cost-effective traffic regulation and accident prevention at railway crossings.

[13] Addressing the necessity of 3D multi-object detection and tracking in computer vision, this paper presents deep learning methods tailored for applications like robotics, autonomous driving, and augmented reality. The focus is on overcoming challenges posed by object diversity, lighting variations, and occlusions to enable precise decision-making. [14] Railway operations necessitate precise trackside weather monitoring. Conventional cellular networks lack comprehensive rail line coverage due to cost constraints. We propose a LoRa mesh-5G integrated network, leveraging 5G for backhaul and LoRa mesh for extended coverage, enhancing safety and efficiency in rail operations. [15] Automatic rail gate control system withobstacle detection and real-time train tracking implemented in Bangladesh Railway using Arduino Nano, IR Sensor, Flame Sensor, Ultrasonic sensor, Servo Motor, DC Gear Motor, andwireless communication. Aimed at enhancing safety and efficiency by leveraging both traditional and modern technologies for railway development.

Unsupervised convolutional autoencoder models are explored for railway obstacle detection due to limited labeled data and unknown obstacle classes. Utilizing various loss functions, activations, and optimizers, Multi-Criteria Decision Making evaluates model performance. The score measures reconstruction differences to rank models, achieving up to 68% average gap score. [17] Utilizing affine transformation to address semantic misalignment, and introducing a fusion module (DMF) to reconcile spectral imbalance, we present YOLOv5s-DMF, an efficient railway intrusion detection network. YOLOv5s-DMF reduces MR by14.23% via decoupled head and boosts mAP@0.5 by 5.7% and mAP@0.5:0.95 by 4.1% compared to existing methods. [18] Introducing a lightweight fault-detection technique for autonomous vehicle object tracking, leveraging a user-directed observer design pattern. It monitors predicate validity over algorithmic state variables to enhance fault detection withoutcompromising system programmability. Real-world railway domain evaluations demonstrate up to 24.4% overall reliability improvement over replication, rising to 43.9% in specific phases.

PROPOSED SYSTEM

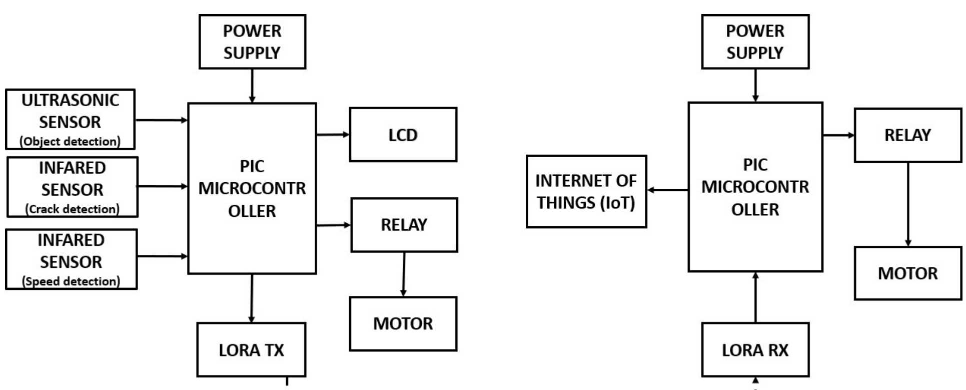

Figure 5. Proposed Work

This new system wants to make train travel safer by using LoRa (Long Range) technology. It'sall about stopping accidents caused by problems on the tracks, like damage, obstacles, or signalfailures. They're putting together IoT gadgets, PIC microcontrollers, and a bunch of sensors tokeep an eye on things in real time. This way, they can spot trouble early and do something about it fast. All these pieces work together to make sure trains can spot dangers on the tracksquickly.

The working process of the system begins with continuous monitoring using ultrasonic sensorsfor object detection and infrared sensors for identifying track cracks. The collected data is thentransmitted in real-time through LoRa technology, providing updates on the train's status to the operating station. In the event of an obstacle or track crack, the system triggers alarms, leadingto an automatic stoppage of the train to prevent potential accidents. Additionally, the LoRa receiver positioned in barrier-lifting areas facilitates the automatic closure of barrier-lifting gates for enhanced safety during train movement. This project proposes a comprehensive solution aimed at enhancing railway safety, enabling continuous monitoring, real-time communication, and automatic response mechanisms. These collective efforts contribute to preventing accidents and ensuring a safer and more efficient railway transportation system. In critical situations, such as the presence of obstacles or track cracks, the system responds by triggering alarms and selectively stopping the train, thus enhancing overall safety measures.

III. EXPERIMENTAL SETUP

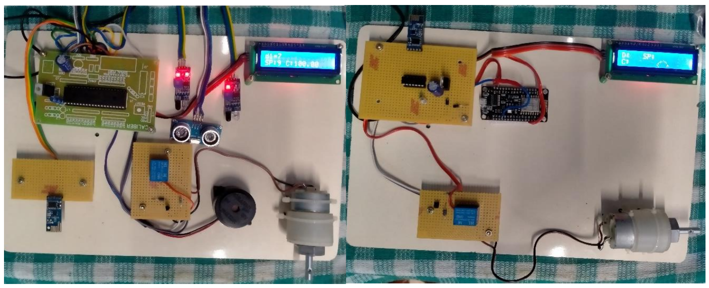

Figure . Experimental Setup

In safeguarding against train accidents using LoRa technology, our hardware implementation involves utilizing a PIC microcontroller for debugging and control purposes. LoRa is utilized for wide-range communication. During the simulation, we replace the potentiometer in the sensor. In the hardware setup, sensors are deployed for detecting obstacles and cracks. Specifically, we employ two sensors, an ultrasonic sensor for detecting obstacles on the train track and an infrared sensor for detecting train cracks. Additionally, a speed sensor is responsible for controlling and monitoring train speed. These sensors are fixed in front of the train. We utilize an IoT module to store information, while a virtual terminal is employed for monitoring obstacles and crack ranges. In places where there are no people around, like at unmanned railway crossings, we use LoRa devices to automatically open and close the barriergates. Finally, the LCD shows the parameters.

IV. RESULT AND DISCUSSION

The "Safeguarding the Tracks" system detected an object on the railway, initiating horn soundsat 60% likelihood of collision and halting the train at 80% likelihood. It also detected track cracks, stopping the train at 80% risk. The system communicates with road crossing receivers,closing barriers upon detection of hazards, and ensuring synchronized safety measures. This integration enhances transportation efficiency while reducing accidents, showcasing advanced technology's efficacy in railway safety. In summary, the system prevents accidents with:

- Horn sound initiation at 60% likelihood
- Train halting at 80% likelihood
- Barrier closure at road crossings upon detection of hazards.

Figure 8. Object detection graph Figure 9. Crack detection graph

V. CONCLUSION AND FUTURE SCOPE

In conclusion, the concept of "Safeguarding the Tracks" provides a reliable and efficient solution for enhancing railway safety through the use of advanced technology. By utilizing a combination of object and crack detection sensors, along with real-time communication between the track and train, potential hazards can be identified and addressed on time.

Implementing this concept can greatly improve the overall safety of railways, making it an essential consideration for any modern rail transportation system. LoRa system is proposed for railway safety, setting a foundation for safer operations. Plans include AI integration for predictive analysis, bolstering risk anticipation. Advanced obstacle detection algorithms to fortify safety measures. Using 5G for quicker communication and possibly adding remote control features for emergencies.

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