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Smart Railway Platform with Train Arrival Detection

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ABSTRACT
Indian Railways contributes a major share in our country's economy. It helps to mobilize goods and passengers throughout the nation, contributing a remarkable part to India's development. Public safety is of utmost important in the transportation sector, particularly in stations. One of the main disadvantages of Indian railway stations during peak hours, it becomes more rush and difficult for senior citizens and Persons with disabilities (PWD) to use the staircase and elevators. So, they are crossing the platforms through tracks and they walk much distance from one end to another end, and during the time of crossing, accidents may occur. After analyzing the problem statement, a Smart Railway Platform (SRP) is proposed in response to the difficulties faced by senior citizens and PWD. This creative design uses a microcontroller-driven retractable bridge connecting the two main platforms. The advanced sensors detect the approaching and departing trains, and it communicates through RF technology to Arduino and servo motor, resulting in the opening and closing of the mobile bridge. The SRP aims to improve the safety of passengers and also make them more comfortable, which is especially advantageous for persons with mobility issues.

KEYWORDS
RF Technology, Mobile bridge, Sensors, Smart Railway Platform

1. INTRODUCTION

Recent studies and social analytics have highlighted a major shortcoming in the Indian Railway system: the challenges faced by the elderly and PWD when navigating overhead steps. The current infrastructure for accessing or changing platforms typically involves the use of footbridges, escalators, and elevators [1]. However, this setup is quite challenging for individuals who are elderly or have physical disabilities, as it often requires them to navigate long distances and undergo strenuous movements. Additionally, footbridges are typically situated at the far ends of platforms, making the process even more cumbersome. As such, there is a need for a more inclusive and accessible system for individuals with mobility challenges [2].

The proposed solution seeks to simplify the process of crossing railway tracks by eliminating the necessity for stairs or elevators. Addressing frequent accidents at railway stations, the proposed system aims to automate track crossings for pedestrians, making the system more user-friendly [3]. The proposed SRP system is integrated into the station's infrastructure. Sensors, strategically placed on the tracks, detect a train's proximity to the station, governing the system's operations accordingly. The platform design ensures automatic deployment and retraction of mobile bridge, minimizing accident risks and enhancing overall station safety. This paper delves into SRP system tailored to ensure safety and accessibility for older adults and PWD, with a comparison on various frameworks used for train detection, detailed exploration of the design and operational specifics.

In this, we had summarized as follows: Section 2 narrates the few existing frameworks used for train detection. Section 3 describes the proposed solution, working principle and design. Section 4 describes the results and discussions. At last section 5 highlights the future scope of our work along with the conclusion.

2. EXISTING FRAMEWORKS FOR TRAIN DETECTION

In Acoustic-Based Train Arrival Detection [4], microphones used to capture both train sounds and ambient noise. With the aid of binary audio classifiers, background noise is filtered, leaving only the train's sound, which then determines its position. Upon completion of this detection, users are alerted, which is used in railway gate crossings. Major drawback in this system is noise variability due to weather and background noise. In another system titled AI based Surveillance Method for Railway Passengers Crossing [5], cameras and sensors combined with artificial intelligence are placed at railway crossings. These systems can autonomously initiate alerts, including audio warnings. These alerts can be directed to users, nearby trains, or other vehicles approaching the crossing. Weather Conditions such as heavy rain, fog or snow can challenge the effectiveness of AI systems in detecting objects and ensuring railway safety.

Petri net mathematics [6] explored to enhance information dissemination about train approaches at crossings. Within this framework, different states symbolize components like an incoming train, the status of crossing gates and control signals. Events such as an incoming train or gate closure are represented by transitions in the Petri net. This involves more complex system and harder implementation. An Intelligent Video Analysis System [7] Station harnesses the capabilities of AI and video analytics to booster safety and operational efficiency at train stations. It offers real-time data and can autonomously react to various situations, enhancing the passenger experience and aiding in station management. The activity of people who cause damage to a particular bridge was only checked.

Ahmed et al., proposed a system by integrating Internet of Things (IoT) to help in controlling unmanned railway gates. Here, distance is measured and alerts are sent to other vehicles [8].

In concept named Automated Footbridge [9] across Platform, the platform is designed to automatically extend when a train nears and retract as it leaves. This is facilitated by IR or Ultrasonic sensors placed strategically on the track. Once a train intersects with these sensors, a microcontroller activates the platform's operations. Here, the range of detection is low and the communication method is not effective. Muthumari et al., proposed a Pedestrian crossing between platforms designed to utilize IR sensors for detecting train movements. Based on this data, a microcontroller signals a stepper motor to either open or close the bridge platform. When the platform detects an arriving train using an Ultrasonic Sound sensor, it retracts. After a train leaves, it extends after a short delay. Throughout this process, passengers are kept informed via LED indicators and an audible buzzer. Installing GPS in all trains is not possible for maintenance [10].

There are various types of systems or methods available for train detection such as Acoustic-Based Train Arrival Detection, Artificial Intelligence-Based Surveillance Systems, Petri net mathematics, Intelligent Video Analysis Systems, IoT, and automated footbridges. After thoroughly reviewing and analyzing the different research papers, it can be concluded that each solution offers unique benefits, but it had certain shortfalls. Even though research done in this field, an efficient train detection method is not yet evolved. Table 1 shows the detailed Information of Frameworks used for train detection along with its inference. To overcome the drawbacks of these detection systems, SRP system is proposed.

The primary aim of SRP system is to real time detection of trains and also to automate mobile bridge in between platforms to avoid rail passengers related accidents and to increase passenger safety

Table. 1. Detailed information of frameworks used for train detection

Author/ Year	Framework	Techniques used	Inference
Wei-Ho Tsai et al., IEEE Access, 2022	Convolutional Neural Networks utilized for Train Arrival Detection Using Acoustic method.	Deep Learning and GPS	Noise Variability due to weather and Background Noise.
Pavel Sikora et al., IEEE Sensors Journal, 2021	AI Based Surveillance method for Railway passenger Crossing.	Artificial Intelligence	Weather Conditions such as heavy rain, fog or snow can challenge the effectiveness of AI systems in detecting objects and ensuring railway safety.
S T Boltayev et al., IEEE (EIConRus), 2022	Improving the way of passing data pertaining the approach of trains near railway crossings.	Petri Net Mathematics	More complex system and harder implementation.
Shuoyan Liu et al., IEEE (ICSP), 2022	Intelligent Video Analysis Method for Railway Station.	Deep learning	The activity of people who cause damage to a particular bridge was only checked.
T. Rahman et al., IEEE (ICISET) 2018	Controlling Multiple Unmanned Railway Gates and Bi-directional Train Tracking with Alarming System operating with the concept of IoT.	Internet of Things (IoT)	Any failure in IoT components, sensors or communication networks could result in a catastrophic accident. IoT systems are Vulnerable to cyber-attacks.
Kajal Hareshwar Bari et al., IJERT, 2020	Automated Footbridge Across Platform at Railway Station	Embedded system, Ultrasonic sensors and NFC	The range of detection is low and the communication method is not effective.
M.Muthumari et al., IJERT, 2019	Auto Railway Platform Control using sensors	GPS and Zigbee communication technology	Installing GPS in all trains is not possible for maintenance.
Chirag Sanjay Suryawanshi et al., IJERT, 2021	Environmental Adaptive Automatic Railway Platform	Embedded system with specific IR	Accuracy is low because the system detects all objects that cross the sensor.
M Zawodny et al., Sensors, 2023	Train Detection to Improve Closing Time of Level Crossing	radar/LIDAR	Works only when no interference in the system.
Ali Mustafa et al., Springer, 2022	Railway Accident Detection by Real Time Mobile Communication	LTE and GPS modules	The maintenance and installation of LTE modules are very high.

3. PROPOSED SOLUTION

The proposed SRP system aims to facilitates seamless crossing between two platforms as mentioned in Fig. 1. This system functions through two primary stages: train identification and pathway activation. The train's position and direction are detected via hall effect sensor and vibration. The values by the sensors are transmitted from the transmitter to the receiver. The controller connected to the receiver reads the message from the transmitter and decides to open or close the smart mobile bridge. It includes a data collection unit and a processing segment. When a train nears the station, the sensors detect and passes the data to the receiver. Subsequently, the microcontroller directs a command to the piston, prompting the pathway to open as mentioned in the Fig. 2. To assist passengers, a voice module and an information display are integrated into the setup, indicating the platform is close. When the train passes the station, the sensor detects and passes the information to the receiver. The controller reads the information and opens the mobile bridge for the access of people and using the voice module and display board indicating that the platform is open as show in Fig. 1.

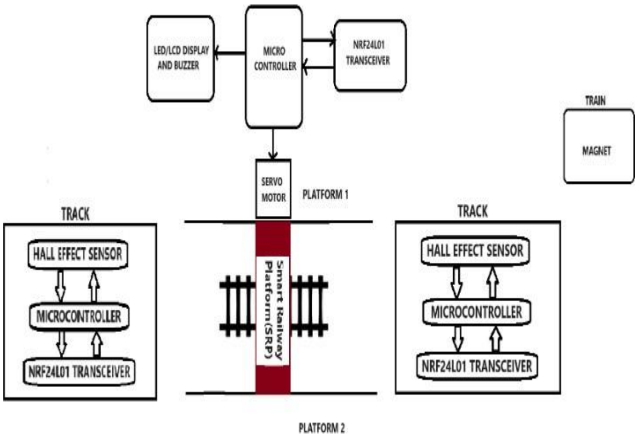

Fig. 1. Bridge open phase

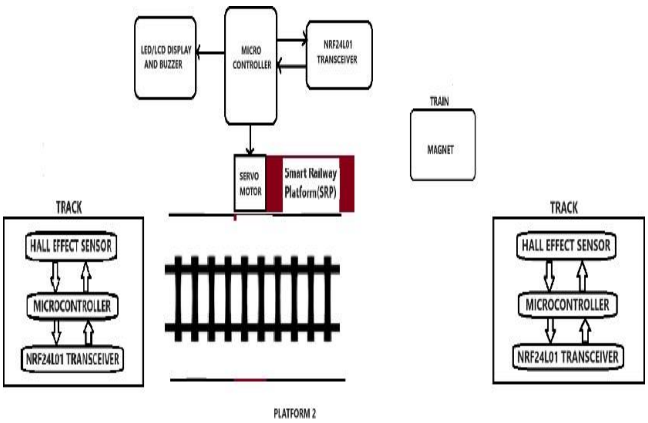

Fig. 2. Bridge closed phase

In case of emergencies, the platform can be manually operated by the station master to close the mobile bridge. The system remains shut down until it receives the command to enable the automatic process. Once it receives the instruction, it functions as an automated mobile bridge.

3.1 Working Principle

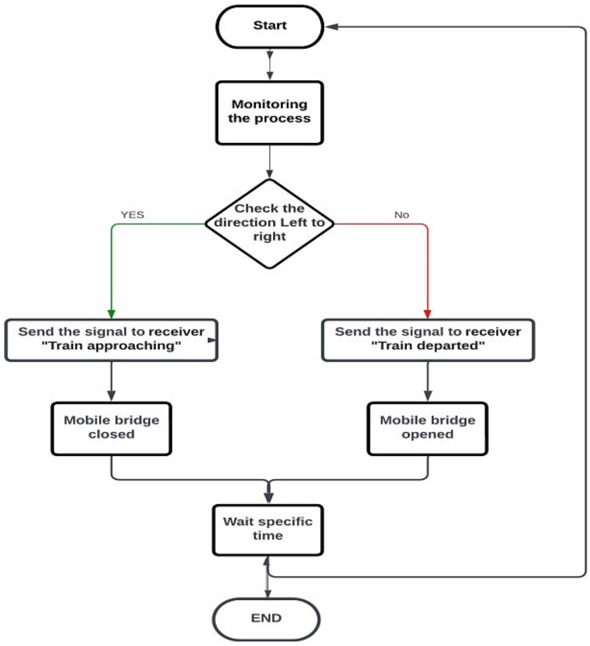

Fig. 3 Flow Chart of work flow

A. Steps Involved in SRP System

The SRP operates through four distinct steps to ensure efficient functionality as mentioned in Fig. 3. Let's delve into each:

1) Train Arrival and Departure Detection: Both Hall effect sensor and vibration sensor are placed near the tracks to identify an incoming or departing train to the station. Where these sensors are placed 4 kilometers away from the stations, upon sensing a train, a signal about its movement is relayed to the controller.

2) Data transmission: Post detection, the values collected by the sensors are processed by the controller and are transmitted by a transmitter module nRF24L01 to the receiver in the station.

3) Data Reception and Bridge Action: After capturing the sensor's data, the receiver processes the information to find out the direction of the approaching train. If the train is arriving at the station, it notifies people that the bridge is about to close. The servo motor then closes the bridge which is attached with platform. Once the train has departed, it notifies people that the bridge is open for use, and the bridge opens.

4) Safety Verification and Alerts system transmission: A pivotal safety feature involves the use of an ultrasonic sensor to identify obstructions or individuals potentially caught between smart railway platforms. Upon detecting unusual objects, an alert, like a buzzer, is activated to caution the public and avoid accidents. Additionally, an LCD displays important visual messages and directions for the passengers.

During critical situations, the station master has the authority to manually control the platform, shutting down its automated features until the system receives the go-ahead to resume normal automated operations. Once cleared, the platform returns to its automated functionality. At this time the algorithm mentioned in Fig. 3 is paused and starts working in the process as mentioned in the workflow in Fig. 4.

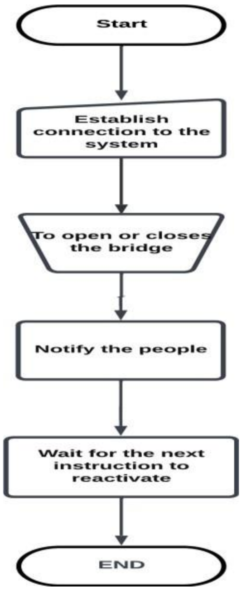

Fig. 4. Work flow in emergency

In the above process, the station master is directly connected to the smart railway platform's controller via Wi-Fi. This allows him to manually operate the platform in emergency situations. Once the platform is manually closed, it will not open or close automatically as mentioned in Fig. 3 and stops the workflow, then starts workflow as mentioned in Fig. 4, until it receives a signal or information to resume automatic operation. The station master also has the ability to halt the automatic process and reactivate it as per the situation's demands. By this working principle and algorithm, the smart railway platform ensures efficient functionality and safety**.**

3.2 Design

A. Train Detection and Data Transmission (Transmitter part)

- Hall effect sensors and Vibration sensors [Range:10Hz – 50Hz]➞ detect an incoming or departing train.
- Controller ➞ Process the sensor data and relay a signal about the train's movement.
- nRF24L01 ➞ Transmit this data.

B. Smart Platform Action and Safety Verification (Receiver part)

- nRF24L01 ➞ Capture and process the sensor's data.
- Controller ➞ operates the servo motor.

C. Safety Verification

- Ultrasonic sensor ➞ detects any obstructions or individuals in a smart railway platform.
- LCD board and speaker ➞ If an unusual object is detected, activate an alert and display important visual messages and directions

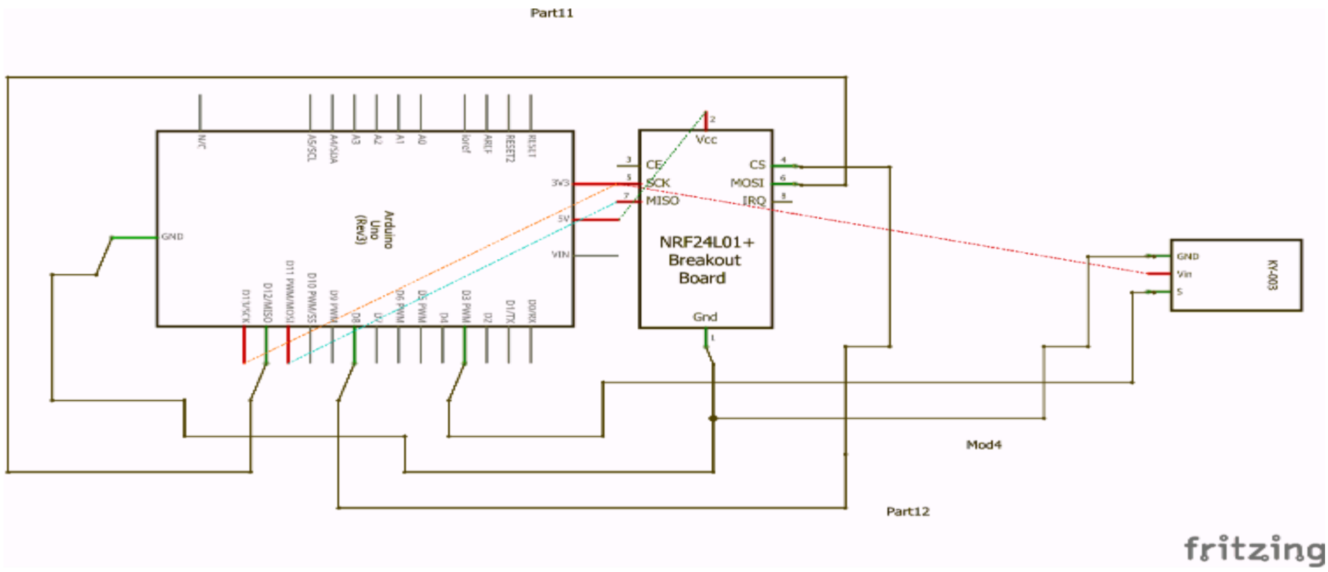

Fig. 5. Transmitter Schematics

As mentioned in the above algorithm the system consists of two parts. Where transmitter part is connected with the sensors and the transmitter module with a controller as per the connections shown in Fig. 5 and the controller is programmed using Arduino ide. The nRF24L01 module is crucial as it guarantees a consistent communication link between the sending and receiving units.

The receiver part is subdivided into two parts as mentioned in the algorithm. First, the transmitted data is received by the receiver nRF24L01 module in the railway station, and then the data is transmitted to the controller. The controller processes data and operates the servo motor according to the received value. As mentioned in Fig. 6 the connections are made with a controller, receiver module and servo motor. The transmitter and receiver are connected in same channel for seamless connection and to avoid interference with other signals or channels.

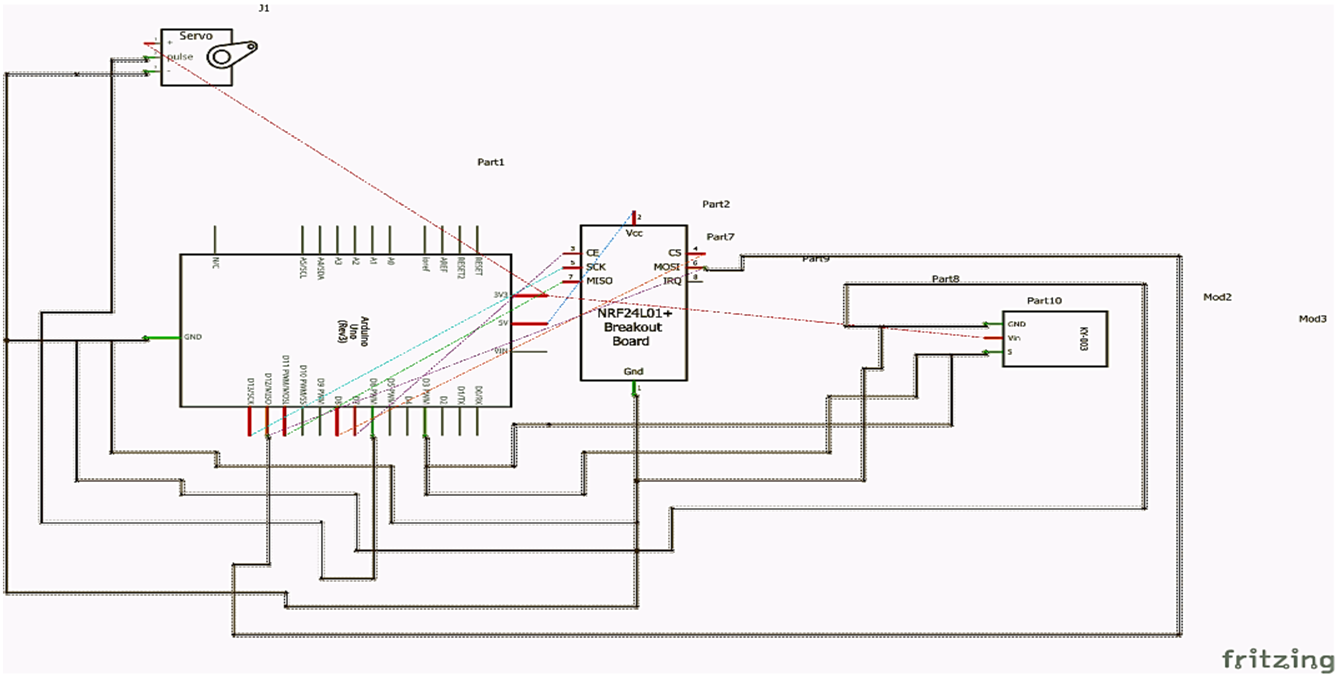

Fig. 6. Receiver Schematics

The other part of the receiver consists of an ultrasonic sensor and LCD display which is integrated with the SRP to avoid accidents and help passengers to guide them to access the platform in a safer way.

4. RESULT AND DISCUSSIONS

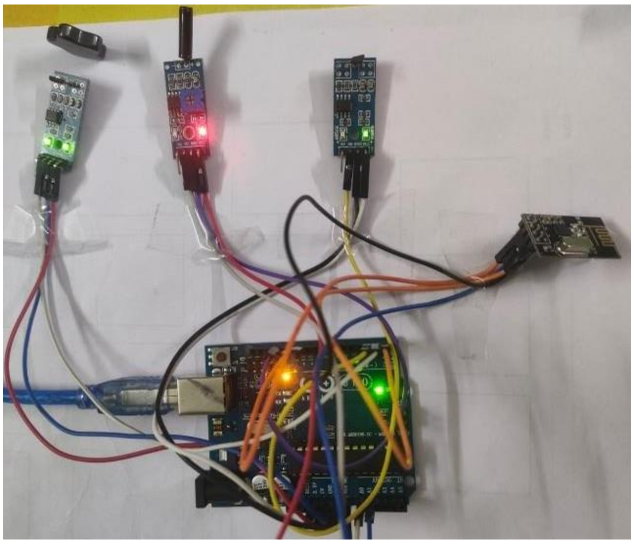

Fig. 7. Setup of Transmitter module

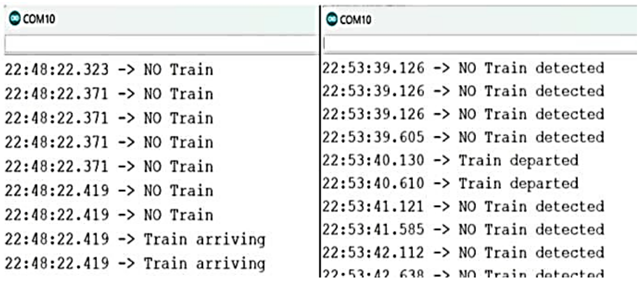

Fig. 8. Detection of the train

After setting up the transmitter module as per Fig. 7, the output is recorded. This data, representing the arrival and departure times of the train, is stored in the system as shown in Fig. 8. These values are then transmitted to the receiver for the operation of the SRP system.

In addition, values from a vibration sensor are also recorded, which confirm the detection of the train. These values are graphically represented as shown in Fig. 9. Since our system employs two types of sensors: Vibration sensor for train detection by the frequency received by the sensor and where it ranges from 10Hz to 50Hz [it differs based on the type of the train and speed]. Hall effect sensor for direction detection. This approach enhances the accuracy of detection and minimizes the possibility of system failure.

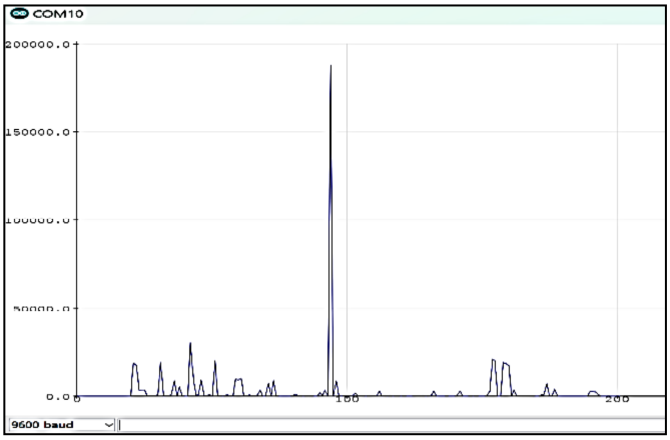

Fig. 9. Vibration sensor values

The receiver module, as depicted in Fig. 10, receives values from the transmitter and implements operations in the servo motor. This module is also connected to an LCD display and speaker to provide instructions and guide passengers. A special system is incorporated into the receiver module, optimized to be operated via Wi-Fi by the station master in emergency situations. While the station master cannot operate the transmitter module, the values read by the sensors can be regularly monitored for maintenance purposes.

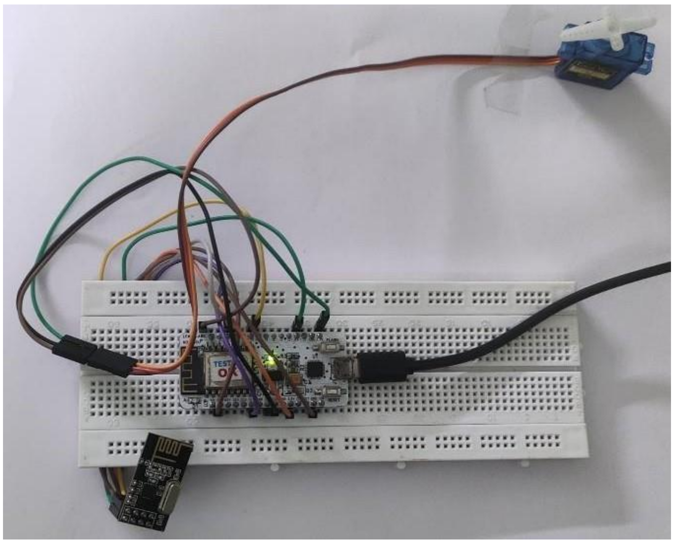

Fig. 10. Setup of Receiver module

Table. 2. Detailed analysis of srp with existing works

S.No	Framework	Drawbacks	Advantages of SRP
1.	Auto Railway Platform Control using sensors	Reduced accuracy because it detects all objects crossing the sensor.	In SRP, vibration sensors and hall effect sensors are used to detect the train and its direction accurately.
2.	Sensor Based Smart Railway Accident Detection and Prevention System for Smart Cities Using Real Time Mobile Communication	The maintenance and installation of LTE modules is very high.	RF technology i.e. Transmitter and receiver are used.
3.	Train Detection to Improve Closing Time of Level Crossing	Works only when there is no interference in the system. It needs to process more data	The processing of sensor values and data is comparatively less and faster.
4.	Convolutional Neural Networks utilized for Train arrival detection using acoustic method	There are no options in emergencies	It can be operated by the station masterin emergency by connecting with Wifi.

In table II, the detailed analysis of SRP with existing frameworks are tabulated. In SRP, vibration sensors and halleffect sensors are used to detect the train and its direction accurately, the processing of sensor values and data is comparatively less and faster and it can be operated by the station master in emergency by connecting with Wi-Fi.

5. CONCLUSION

In this research paper, initially we integrate the prevailing shortfalls in the existing method, and depending on the demand in railway industry for control of on-site equipment, data collection and centralized management suggests the construction of SRP under railway infrastructure. In this proposal of constructing the system with RF Module's capabilities, train detection handled efficiently. The mobile bridge adjusts the position based on whether a train is arriving or departing. Notably, even once a train reaches one platform, the mobile bridge remains in place for a brief period. This feature ensures that passengers running slightly behind schedule can still catch their train. The proposed model is developed to strengthen the management of humanized, intelligent and centralized SRP system, that will enhance the safety of railway passengers and service level of railway infrastructure. Ultimately, this innovation diminishes the potential hazards faced by passengers when switching platforms.

6. FUTURE SCOPE

Implementing machine learning algorithms can optimize the scheduling of movable bridges based on historical data, passenger traffic patterns, train schedules and maintenance techniques are used to ensure continuous operation of SRP.

The Application Programming Interface (API)-Integration is can augment the functionality of the SRP by integrating it with a train tracking application using the Railway API. This integration may empower the SRP to precisely identify the exact platform.

To enhance user experience and provide real-time updates on the operation of the SRP, display boards can play a crucial role in maintaining efficient communication and ensuring a smooth, user-friendly railway experience.

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