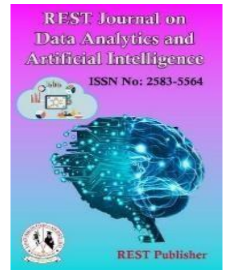
REST Journal on Data Analytics and Artificial Intelligence
Vol: 4(1), March 2025
REST Publisher; ISSN: 2583-5564
Website: http://restpublisher.com/journals/jdaai/
DOI: https://doi.org/10.46632/jdaai/4/1/15



Train Accident Avoidance Using Piezo Sensors

***Kanakari Akshay, Mendu Ashwitha, Y. Sanjay Goud, Nallamothu Raghu**
School of Engineering Anurag University, Hyderabad, India.
**Corresponding Author Email: kankariakshay@gmail.com*

Abstract. *Train accidents due to boulders have been a disastrous event causing damage to lives of many people. In India many railway tracks have been laid in the regions of Mountains and Ghats. In the rainy season the rocks will detach from the mountains and fall on to railway tracks. Because of no information of boulders on the railway tracks the train accidents may occur causing damage to lives of people. To prevent from this issue, we have developed a project "Train Accident Avoidance Using Piezo Sensors" which helps in intimating the train driver about the boulder on the track and making them stop the train before any disastrous event occurs. In this project we are using the economic piezo electric sensors (pressure sensors) connected to the ESP32 microcontroller so that the values of sensors are monitored and if any unusual varying in the values is produced due to boulder, we can immediately send the notifications to the train driver to stop the train and prevent the train from accident.*

Keywords: *General Purpose Input Output, Light Emitting Diode, Structured Query Language, User Interface, Integrated Development Environment, Electronic Stability Device, Internet of Things*

1. INTRODUCTION

Train accidents, particularly in hilly areas, can result in significant human and economic losses. While derailments and collisions between trains are common, a less frequent but equally devastating type occurs due to boulders falling onto railway tracks. These accidents, although rare, cause severe damage because train drivers have no prior warning of rocks obstructing the tracks, making it nearly impossible to prevent such incidents. To address this challenge, the project titled "Train Accident Avoidance Using Piezo Sensors" proposes a solution to detect the presence of boulders on railway tracks. Piezoelectric sensors are designed to sense pressure or mechanical stress caused by falling rocks, generating an electrical signal that can alert railway authorities or train operators in real-time, potentially preventing accidents and ensuring passenger safety [1-3]. Boulders rolling onto tracks is a unique issue in hilly regions where landslides and rockslides are common. Despite the unpredictable nature of these events, piezo sensors offer a reliable means to detect the physical pressure caused by debris. The system works by installing sensors along the tracks in vulnerable areas. When a rock lands, the sensor experiences mechanical deformation, producing an electric signal proportional to the stress applied [4-5]. This signal is transmitted to a control center, which notifies operators to take preventive actions, such as slowing down or stopping the train, reducing the risk of a collision. This solution can also be integrated with other railway safety mechanisms, forming a comprehensive accident prevention strategy that enhances railway safety in hilly terrains. The main objective of the project is to intimate the driver about the rocks on the railway track. To do this we are using the economic piezo sensors in our project along with one of the most trending microcontrollers called ESP32. The hardware connections are made to the microcontroller by connecting piezo sensors as input and connecting LEDs and piezo buzzers as output. When it comes to software part, we are using Arduino IDE to display the values read by the microcontroller and use them to help microcontroller to take the actions on the output. The software support is also given by the NoSQL cloud data base called "Firebase" which is powered by the Google.

The firebase UI is so friendly so that we can use this as a control center for monitoring the values [6-7]. All the sensors which are placed in the different locations can be monitored through the single screen. We are also developing a mobile application with the help of the software which will be a lightweight application that can be downloaded by the driver and he will get alerts about the rocks in that particular application. The main intention of the project is to intimate the driver about the rocks at the very least expense. Therefore, we are using the economic piezo sensors as an input. The sensors will take the input based on the rocks on the railway tracks and send them as electrical signals to the microcontroller. The microcontroller acts as logic device and if the values are greater than the threshold, the output will be delivered by sending alerts to the train pilot. Along with this, we will also switch on LEDs and piezo buzzer to alert the driver about the rocks. By doing this, we can prevent the train accident due to rocks and help in saving many people lives [8]. We have chosen “INTERNET OF THINGS” as the domain for our project. The IOT can be defined as physical objects (or groups of such objects) with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks [9]. Nowadays, IOT is used in every domain possible and it is trending technology that has a very high importance in the future. In a basic way, IOT can be said as the sensors and the actuators connected to the mediator device which helps as an interface for the hardware and the software tools. The mediator device is called the microcontroller [10]. The microcontroller has the basic GPIO pins to which the inputs and outputs devices are connected and the microcontroller will take charge in controlling these devices based on the software code that we have written. The microcontroller is the most important device because the connection to internet will be done through this device and it sends data to cloud and send alerts through the mobile application [11].

2. LITERATURE SURVEY

[12] examined the various applications of sensors like IR sensor, fire sensor in practice and illustrated the importance of accident preventions. This paper helps us to evaluate and analyse the existing benefits and challenges of using those sensors in the IOT domain. They countered the benefits of ZigBee module which is for transmission of data, microcontroller for sending messages to LCD, IR sensors for heat and to detect obstacle near curves. They also examined the model to check the feasibility then it is found that in the range test maximum distance between transmitter and receiver for safer transmission is about 50 meters but it is insufficient range for remote stations. This also has certain drawbacks such as scalability, performance, usability, secure identity, a lack of incentives, and adaptability. [13] analysed and categorized some of the pros and cons of Automatic Gate Control using IoT. The main intension of this review is to automate the entry and close of gates at a railway crossing since it is a threat to the public if it is not closed properly while train is crossing. The railway gates are closed automatically using IR sensors, the DC motor may automatically close and opens the gate. [14] elements employed in this system of paper includes microcontroller, continuity sensor and RF transmitter and receiver. It is a literature review of wireless prevention of accident which is communicated by transmitting and receiving waves of radio frequency module. Here electromagnetic coupling is used for associate and discharge of the railway compartments in current is drawn using solar panels and piezo electric crystal. The drawback of this work is that RF module covers only up to 2km hence it is difficult to stop at that nearby situation. [15] the goal of this study is to show how efficient the collision of train can be avoided and gate protection system applied can be verified. The authors propose that wireless network can be used for communication on both hardware and software of train module. They concentrated more on practical implementation and characteristics of integrating compression type pressure sensors and prevents the accident of two train running on the same track. As a result [16] on Socio Economic Impacts Of occurrences on Railways, it is research taken for making account of socio-economic benefits joined with safety and reliability for the economic analysis. They have included a key element in which is to compare solving way of socio-economic phenomenon that signifies impact of sub divisions of difficult approaches. The key constraint is that the assessment of encouraged protection and definitive measures of railway architecture after its reconstruction. [17] in this article takes a thorough look at implications for prevention can be used in the railway industry. In the current state of the art, they’ve discovered a variety of use cases for railway accidents in railway field such as, indepth analysis over 10 years in CANADA for physical barrier approach. The growth of prevention of train accidents has taken place in different tiers. The first tier is the indepth provisional survey of suicides. The second tier is to facilitate adjusted security approaches to identify locations and behavior of people who sacrifice their lives by accidents and suicides. [18] aim is to analyze accidents due to breakage of track. In this review they utilized a vibration sensor for identifying the cracks. In railway tunnel lights will power off and on when train go in and go from the tunnel with utilization load cell and shifting circuitry for energy with help of IR sensor which can be used in boogie. Though different technologies have similar functionalities, there are differences in terms of wireless sensor network of real time visualization and in prevention

of railway accidents. According to this study, it is noticed that the application of internet of things in the railway industry remains in the unapplied stage and there is a need for low power real time embedded for observing managing and energy consumption has been verified thoroughly. [18] analyzed track circuit reliability assessment for preventing railway accidents using train detection devices, a decentralized application. This paper is the first method to merge subsisting knowledge in the technological and theoretical. occurrences that handles the electrical conduct of the wheel contact to ingress organizing the actions and equipment helped to make sure standard of electrical contact in severe states [19-22].

3. DATASET

Initialization

- Initialize the piezo sensors on railway tracks.
- Set up a communication protocol for data transmission (e.g., MQTT, WebSocket).
- Define thresholds for pressure detection to identify potential rock falls.

Continuous Monitoring

- Start a loop to continuously monitor the sensor data.
- While the system is active:
- Read data from all piezo sensors.
- For each sensor, perform the following checks:
- If pressure exceeds the defined threshold:
- Record the timestamp and sensor ID.
- Mark the sensor as "active" for pressure detection.

Pressure Detection Logic

- If any sensor is marked as "active":
- Log the event with details (sensor ID, timestamp, pressure level).
- Send an alert notification to the railway staff via the communication protocol.
- Initiate the emergency stop process for approaching trains.

Emergency Stop Procedure

For each approaching train:

- Check the current position and speed of the train.
- If the train is within a predefined safety distance from the detected pressure event:
- Send an emergency stop signal to the train.
- Activate safety alarms in the train control system.
- Update the train's status to "Emergency Stopped."

Notification to Railway Staff

Generate a detailed report for railway staff that includes:

- Sensor ID and location.
- Time of detection.
- Severity of pressure change.
- Status of trains in the vicinity.
- Send the report through the communication system to designated personnel.

Post-Event Analysis

Once the situation is resolved:

- Reset the sensors to normal monitoring mode.
- Conduct an analysis of the incident for safety improvements.
- Update system parameters if necessary (e.g., pressure thresholds, notification protocols).

End Process

- Return to the continuous monitoring state.
- Ensure all systems are operational and ready for the next detection.

4. RESULTS AND DISCUSSIONS

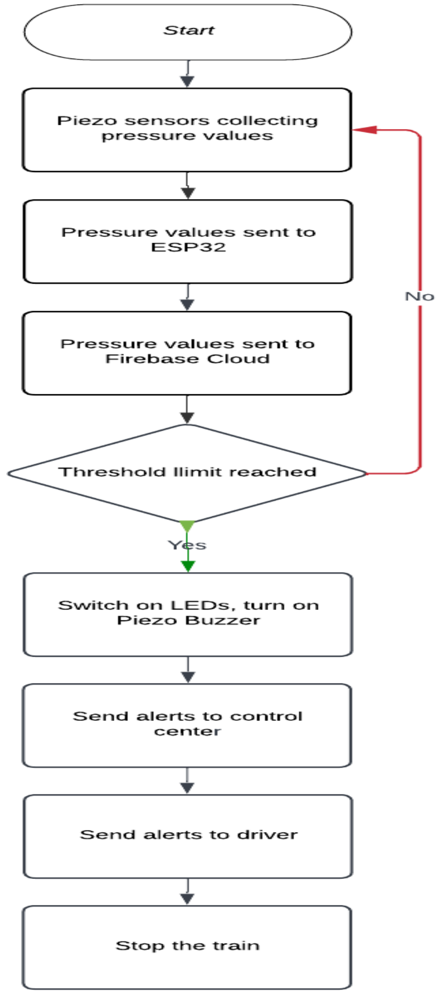


FIGURE 1. Flow Process Diagram

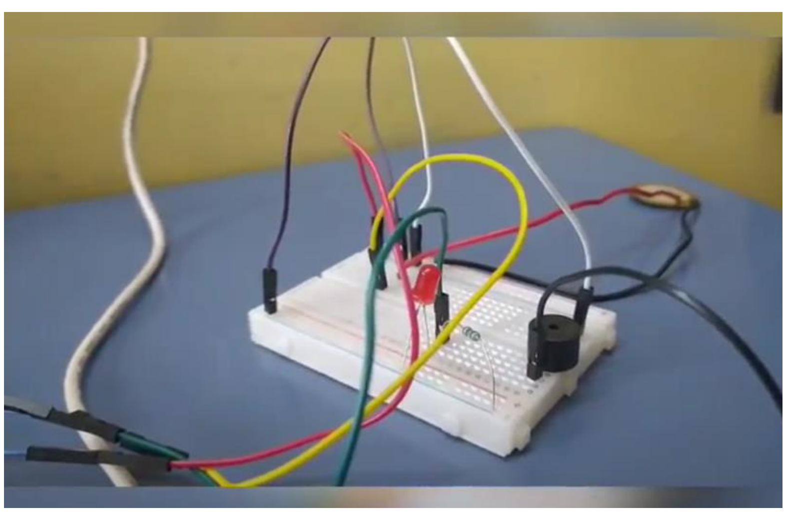


FIGURE 2. Connection of components

FIGURE 3. Display indicating no rocks and all areas clear

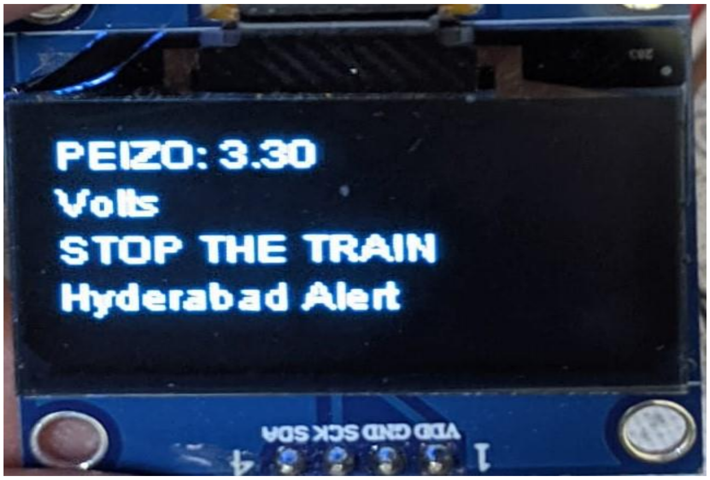


FIGURE 4. Display indicating to stop the train

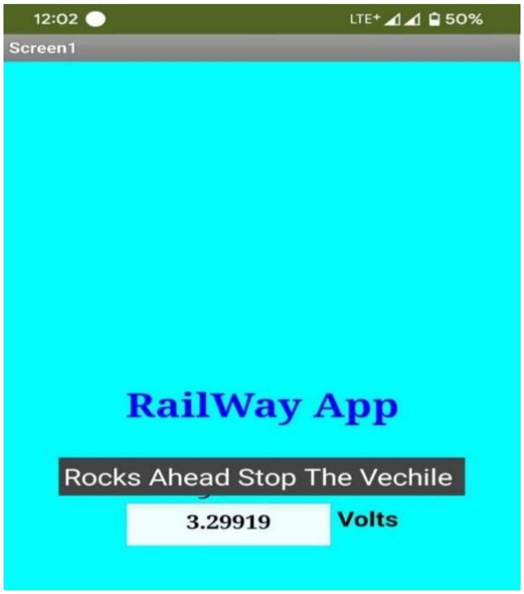


FIGURE 5. Mobile Application interface indicating to stop the train

5. RESULT ANALYSIS

The result analysis of the train accident-avoidance system using piezo sensors reveals its potential to significantly improve railway safety in hilly areas by detecting falling rocks on the tracks. During testing, the piezo sensors displayed high sensitivity to even minor pressure changes, allowing for the early detection of hazards. This sensitivity is crucial for identifying objects that could pose a threat to moving trains. The system proved to be accurate in distinguishing between minor debris and serious obstructions, minimizing false positives while ensuring that genuine hazards were not missed. This balance between sensitivity and accuracy made the system highly reliable in real-world scenarios. In terms of response time, the system performed impressively. Once the sensors detected pressure from falling rocks, the notification system activated swiftly, immediately alerting railway staff. This prompt communication allows staff to take preventive action, such as slowing down or stopping the train, to avoid accidents. Additionally, in situations where the system was configured to automatically trigger emergency brakes, the response was nearly instantaneous. This ensured that trains could be halted in time to prevent collisions, offering an additional layer of safety. The system was tested under various conditions to assess its reliability in different environments, and it consistently performed well. Whether during inclement weather or on uneven terrain, the piezo sensors remained functional and maintained accurate detection. This robustness indicates that the system could operate continuously without major interruptions, making it a dependable solution for real-time monitoring. Furthermore, its integration with existing railway infrastructure was seamless, which makes the system a practical option for large-scale deployment. Overall, the train accident-avoidance system using piezo sensors demonstrated its ability to detect hazards quickly and reliably, making it a viable solution for preventing accidents in areas prone to rockfalls. Its high sensitivity, accurate detection, fast response times, and consistent reliability under various conditions suggest that it could play a critical role in enhancing rail safety.

6. CONCLUSION

By the end of this project, we successfully developed a system that can help prevent accidents caused by boulders falling onto railway tracks, particularly in hilly regions where landslides are common during the rainy season. The system utilizes cost-effective piezoelectric sensors to detect mechanical stress from falling rocks, generating electrical signals that alert train operators or railway authorities in real-time. This enables timely preventive actions, such as slowing down or stopping trains to avoid collisions. The equipment used is affordable, durable, and can be implemented in any location where such accidents are frequent, making it accessible to a wide range of railway systems. Beyond detection, the project integrates various alert methods for drivers, from visual and audio warnings to potentially linking with automatic braking mechanisms. Moreover, the continuous monitoring of pressure along vulnerable areas provides valuable data for long-term safety planning and preventive maintenance. Overall, this project presents a practical and scalable solution to enhance railway safety, offering a reliable method for preventing accidents caused by boulders while ensuring passenger and infrastructure protection.

REFERENCES

[1]. V. Ruiz, A. S ´anchez, J. F. V ´ elez, and B. Raducanu, ´ "Automatic image-based waste classification," in International Work-Conference on the Interplay Between Natural and Artificial Computation. Springer, 2019, pp. 422–431.

[2]. J.-w. Feng and X.-y. Tang, "Office garbage intelligent classification based on inception-v3 transfer learning model," in Journal of Physics: Conference Series, vol. 1487. IOP Publishing, 2020, p. 012008

[3]. Manoranjan Dash, Design of Finite Impulse Response Filters Using Evolutionary Techniques - An Efficient Computation, ICTACT Journal on Communication Technology, March 2020, Volume: 11, Issue: 01

[4]. H. Wang, Y. Li, L. M. Dang, J. Ko, D. Han, and H. Moon, "Smartphone-based bulky waste classification using convolutional neural networks," Multimedia Tools and Applications, vol. 79, no. 39, pp. 29 411–29 431, 2020.

[5]. M. Yang and G. Thung, "Classification of trash for recyclability status," CS229 Project Report, vol. 2016, 2016

[6]. Manoranjan Dash, N.D. Londhe, S. Ghosh, et al., "Hybrid Seeker Optimization Algorithm-based Accurate Image Clustering for Automatic Psoriasis Lesion Detection", Artificial Intelligence for Healthcare (Taylor & Francis), 2022, ISBN: 9781003241409

[7]. H. Panwar, P. Gupta, M. K. Siddiqui, R. MoralesMenendez, P. Bhardwaj, S. Sharma, and I. H. Sarker, “Aquavision: Automating the detection of waste in water bodies using deep transfer learning,” Case Studies in Chemical and Environmental Engineering, p. 100026, 2020.
[8]. F. Shaikh, N. Kazi, F. Khan, and Z. Thakur, “Waste profiling and analysis using machine learning,” in 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA). IEEE, 2020, pp. 488–492
[9]. O. Adedeji and Z. Wang, “Intelligent waste classification system using deep learning convolutional neural network,” Procedia Manufacturing, vol. 35, pp. 607–612, 2019
[10]. S. Zhang and E. Forssberg, “Intelligent liberation and classification of electronic scrap,” Powder technology, vol. 105, no. 1-3, pp. 295–301, 1999.
[11]. C. Liu, L. Sharan, E. H. Adelson, and R. Rosenholtz, “Exploring features in a bayesian framework for material recognition,” in 2010 IEEE computer society conference on computer vision and pattern recognition. IEEE, 2010, pp. 239–246
[12]. E. Strollo, G. Sansonetti, M. C. Mayer, C. Limongelli, and A. Micarelli, “An AI-Based approach to automatic waste sorting,” in International Conference on HumanComputer Interaction. Springer, 2020, pp. 662–669.
[13]. S. M, S. M, S. Doss and P. K. P, "Deep Learning based Waste Material Classification," 2023 IEEE Silchar Subsection Conference (SILCON), Silchar, India, 2023, pp. 1-6
[14]. Manoranjan Dash, “Modified VGG-16 model for COVID-19 chest X-ray images: optimal binary severity assessment,” International Journal of Data Mining and Bioinformatics, vol. 1, no. 1, Jan. 2025, doi: 10.1504/ijdmb.2025.10065665.
[15]. R. Faria, F. Ahmed, A. Das and A. Dey, "Classification of Organic and Solid Waste Using Deep Convolutional Neural Networks," 2021 IEEE 9th Region 10 Humanitarian Technology Conference (R10-HTC), Bangalore, India, 2021, pp. 01-06
[16]. Nikhil Kumsetty, Amith Nekkare, November 15, 2022, "TrashBox", IEEE Dataport CCHANG, "Garbage Classification,"Kaggle, 2018.
[17]. P. S. Silpa et al., "Designing of Augmented Breast Cancer Data using Enhanced Firefly Algorithm," 2022 3rd International Conference on Smart Electronics and Communication (ICOSEC), Trichy, India, 2022, pp. 759-767, doi: 10.1109/ICOSEC54921.2022.9951883.
[18]. Vytla, V., Ramakuri, S. K., Peddi, A., Srinivas, K. K., & Ragav, N. N. (2021, February). Mathematical models for predicting COVID-19 pandemic: a review. In Journal of Physics: Conference Series (Vol. 1797, No. 1, p. 012009). IOP Publishing.
[19]. S. K. Ramakuri, C. Chakraborty, S. Ghosh and B. Gupta, "Performance analysis of eye-state charecterization through single electrode EEG device for medical application," 2017 Global Wireless Summit (GWS), Cape Town, South Africa, 2017, pp. 1-6, doi:10.1109/GWS.2017.8300494.
[20]. R. S. Kumar, K. K. Srinivas, A. Peddi and P. A. H. Vardhini, "Artificial Intelligence based Human Attention Detection through Brain Computer Interface for Health Care Monitoring," 2021 IEEE International Conference on Biomedical Engineering, Computer and Information Technology for Health (BECITHCON), Dhaka, Bangladesh, 2021, pp. 42-45, doi: 10.1109/BECITHCON54710.2021.9893646.
[21]. K. R. Sravanth, A. Peddi, G. S. Sagar, B. Gupta and C. Chakraborty, "Comparison of Attention and Meditation Based Mobile Applications by Using EEG Signals," 2018 Global Wireless Summit (GWS), Chiang Rai, Thailand, 2018, pp. 260-265, doi: 10.1109/GWS.2018.8686634..

