AUTOMATIC RAILWAY TRACK CRACK DETECTION SYSTEM USING IOT

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Abstract - *The objective of this initiative is to tackle the widespread problem of railway accidents in India, which frequently lead to fatalities as a result of faults in railway tracks, especially fractures. The suggested remedy is using GPS systems in conjunction with sensor technology to pinpoint the exact position of railway track cracks. The Node MCU IoT module is used by the system to gather data from the sensors and send it to the cloud for processing and archiving. At89s52 microcontroller is utilized to supervise the system's overall operation, guaranteeing the smooth integration and synchronization of diverse components. Through real-time crack detection and cloud-based transmission of this information, railway authorities can quickly implement preventive actions like temporary closures or track maintenance to reduce the likelihood of accidents.*

Key Words: *At89s52 microcontroller, IR Sensor, Node MCU, IOT Cloud, GPS Module*

1.INTRODUCTION

Certainly, the railway system in India, while being one of the most affordable and efficient modes of transportation, does face significant challenges, particularly regarding safety. The occurrence of accidents resulting in loss of lives and injuries underscores the need for modernization and enhanced safety measures within the railway infrastructure.

To address these issues, our model proposes the development of a modernized and secure transportation system. This system would incorporate advanced technologies and methodologies to ensure the safety of passengers and prevent accidents. One crucial aspect is the implementation of predictive maintenance systems that can detect potential issues such as track cracks caused by natural changes in physical and chemical properties. By utilizing sensors and monitoring systems, our model aims to continuously assess the condition of railway tracks and identify early signs of wear, damage, or potential hazards. This proactive approach allows for timely maintenance and repair, significantly reducing the risk of accidents caused by track defects. Moreover, our model advocates for the integration of cutting-edge safety features such as automated signaling systems, collision avoidance technology, and real-time monitoring of train operations. These advancements not only enhance safety but also improve the overall efficiency and reliability of the railway network.

Furthermore, our model emphasizes the importance of comprehensive training programs for railway personnel to ensure proper implementation and maintenance of the proposed safety measures. Fig-1 depicts the crack in the railway track. By fostering a culture of safety and accountability, we aim to create a transportation system that prioritizes the well-being of passengers and minimizes the occurrence of tragic accidents on Indian railways.

Fig -1: Crack in Railway Track

In our proposed system, we implement an infrared (IR) sensor as the primary component for crack detection along railway tracks. The IR sensor is strategically placed to monitor the track's surface continuously. When a crack is detected, the IR sensor triggers the system to initiate further actions. Upon crack detection, the system activates a GPS module integrated into the setup. The GPS module accurately determines the geographical coordinates of the location where the crack is detected. These coordinates provide precise information about the exact spot on the railway track where maintenance or repair is required.

Next, the system employs an IoT framework, utilizing Node MCU as the intermediary device. Node MCU collects the crack detection data and the corresponding GPS coordinates. It then establishes a connection to the cloud infrastructure for data transmission. The cloud platform receives the crack detection data along with the GPS coordinates from Node MCU. This information is processed and stored securely in the cloud database. Additionally, appropriate alerts or notifications can be generated and sent to concerned authorities or railway personnel in real-time. By leveraging this integrated approach, railway authorities can swiftly respond to crack detections, allowing for timely maintenance or repair actions to be taken. This proactive measure significantly reduces the risk of accidents and enhances overall railway safety for passengers and goods transportation.

2. WORKING

The main objective of the project is to develop a system capable of detecting cracks along railway tracks using an IR sensor and transmitting the detected crack coordinates to the cloud via a GPS module. The block diagram depicted in Fig-2 illustrates the key components and their interconnections within the system.

IR Sensor: The IR sensor serves as the primary crack detection component. It is positioned strategically along the railway track to continuously monitor its surface for any cracks or abnormalities. When a crack is detected, the IR sensor triggers the system to initiate further actions.

Motor Driver and Motor: The motor driver and motor are likely utilized as part of a mechanism to facilitate movement along the railway track. This movement could be for the purpose of deploying the IR sensor along the track or for any other operational requirements of the system.

GPS Module: The GPS module integrated into the system provides accurate geographical coordinates of the location where the crack is detected. These coordinates are essential for precisely identifying the location of the crack along the railway track.

Cloud Connectivity: Once a crack is detected and the corresponding GPS coordinates are obtained, the system utilizes cloud connectivity to transmit this information to the cloud infrastructure. This communication enables the real-time sharing of crack detection data with relevant stakeholders and authorities.

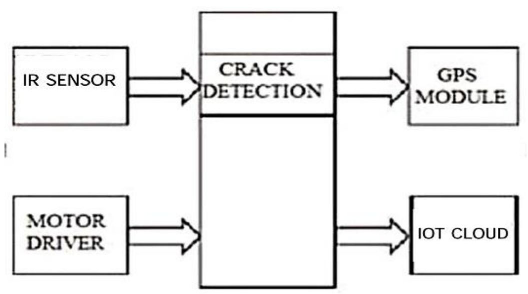


Fig -2: Crack

Overall, the system aims to enhance railway safety by enabling the timely detection and communication of cracks along railway tracks, thereby facilitating prompt maintenance to mitigate the risk of accidents.

3. SELECTION OF SENSOR

Selecting the appropriate sensor for a specific application can indeed be a challenging task, and in the case of detecting cracks along railway tracks, it's crucial to choose a sensor that offers high efficiency and reliability. After careful consideration and evaluation, the decision was made to utilize an infrared (IR) sensor for this project due to several reasons:

Suitability for Surface Detection: IR sensors are well-suited for surface detection applications, making them ideal for detecting cracks along railway tracks. They can effectively identify changes or irregularities in the surface texture, such as cracks, which is essential for ensuring accurate detection.

Sensitivity to Changes in Surface Temperature: Cracks on railway tracks can cause temperature variations due to factors like friction and stress. IR sensors are sensitive to changes in surface temperature, allowing them to detect these variations caused by cracks more effectively.

Non-contact Operation: IR sensors operate in a non-contact manner, meaning they do not physically touch the surface being monitored. This feature is advantageous for railway track monitoring as it minimizes wear and tear on the sensor and reduces the risk of damage or malfunction.

Cost-effectiveness: IR sensors are generally cost-effective compared to other types of sensors with similar capabilities. This aspect is crucial, especially for projects with budget constraints or scalability considerations.

Robustness and Durability: IR sensors are known for their robustness and durability, making them suitable for deployment in harsh environmental conditions typically encountered along railway tracks, such as temperature variations, dust, and vibration.

By selecting an IR sensor for crack detection, the project team aims to ensure the efficient and reliable operation of the system while effectively addressing the challenges associated with railway track monitoring. This choice aligns with the project's objectives of enhancing railway safety through timely detection and communication of cracks for proactive maintenance and repair actions.

4. METHODOLOGY

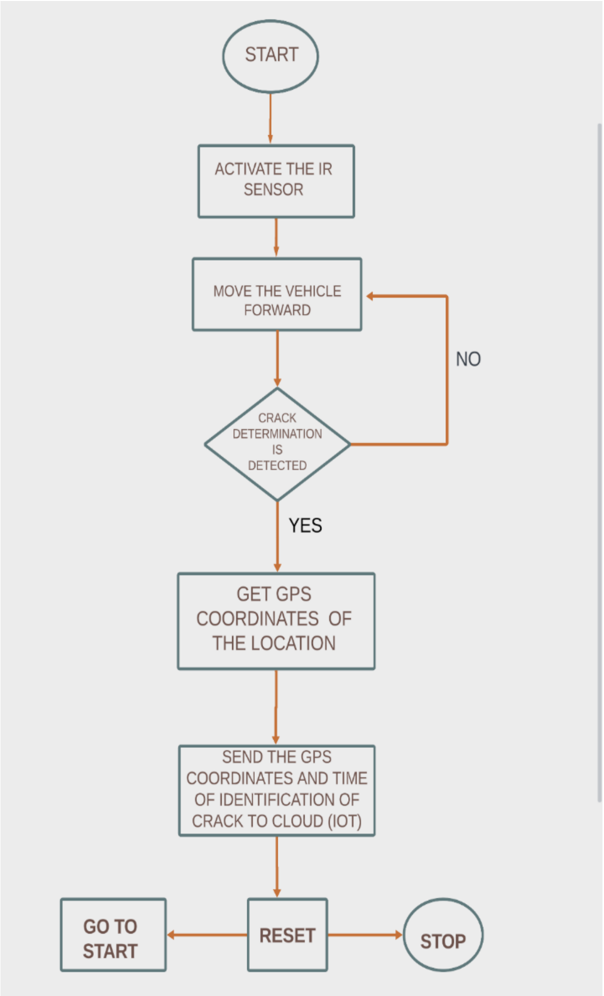


Fig -3: Work Flow Block Diagram

The Fig 3 depicts the work flow diagram of the model

The process begins as follows:

a) The car moves forward and begins to detect the crack.

b) If the crack is not detected, it moves continuously.

c) If the crack is detected, the GPS module sends a signal to obtain the coordinates.

d) The coordinates are received by the GPS receiver where the signal is sent by transmitter.

e) The At89s52 microcontroller controls the system's overall operation.

f) After receiving the coordinates, the data, including the location and time of detection of crack is stored.

5. MODEL IMPLEMENTATION AND COMPONENTS

The primary aim of this model is to efficiently detect faults on railway tracks, particularly cracks, through regular inspections. The system employs a vehicle propelled by a motor and motor driver assembly. Detection of cracks is achieved using infrared (IR) sensors, while the precise location of the faults is determined via a GPS module. By integrating these technologies, the model ensures comprehensive coverage of the railway network, facilitating early identification and timely maintainance of track defects. This proactive approach enhances railway safety and operational reliability, mitigating the risks associated with track failures. Furthermore, the automated nature of the system reduces reliance on manual inspections, improving efficiency and reducing labor costs. Overall, the model represents a significant advancement in railway track maintenance, offering a reliable and scalable solution for ensuring the integrity and safety of rail infrastructure.

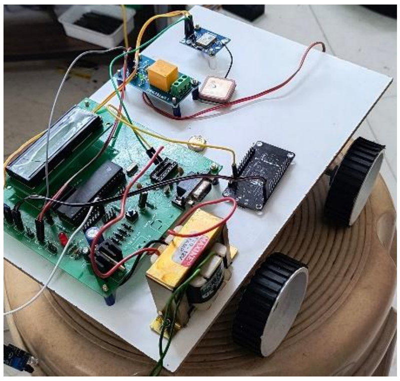


Fig 4 -: Working Model Diagram

The fig -4 depicts the working model of our model

5.1. AT89S52 MICROCONTROLLER

An 8-bit chip that is widely used is the AT89S52 microcontroller made by Atmel. With its 256 RAM bytes, 32 I/O pins, and 8KB of Flash memory, it can be used in a variety of embedded applications. Its architecture, which is compatible with the 8051, allows it to support a wide range of peripherals and communication protocols, enabling flexible designs for consumer electronics, automotive systems, and industrial automation.

Fig 5 -: AT89S52 Microcontroller

5.2. NODE MCU

An open-source development kit and firmware called Node MCU is useful for creating Internet of Things applications. It makes it simple to prototype Internet of Things devices by integrating with a scripting language based on Lua and using the ESP8266 WiFi module. Its integrated USB-to-serial connectivity makes troubleshooting and programming easier. Numerous sensors and actuators are supported by Node MCU , enabling a wide range of IoT applications. Because of its compatibility with the Arduino IDE, a large developer community can provide tutorials and libraries. Furthermore, both experts and enthusiasts can use Node MCU due to its tiny form factor and inexpensive cost, which speeds up the development and implementation of Internet of Things solutions for home automation, sensor monitoring, and other applications.

Fig 6 -: Node MCU

5.3. IR SENSOR

An infrared (IR) sensor picks up infrared radiation that things release into space. It is made up of a receiver that picks up the infrared radiation and an emitter that emits it. The infrared radiation is blocked by an object that enters the sensor's detection range, which modifies the output of the receiver. Infrared sensors are widely utilised in many different applications, such as remote control systems, object and motion detection, proximity sensing, and more. They are used in robotics, automated doors, burglar alarms, and security systems. Because of their adaptability, affordability, and dependability, they are essential to modern technology for use in both consumer and industrial settings.

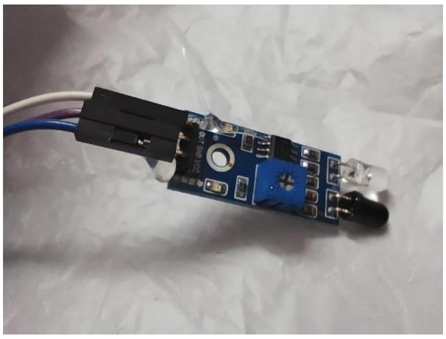


Fig 7 -: IR Sensor

5.4. GPS MODULE

A GPS module, also known as a global positioning system module, is a device that uses signals from satellites in orbit above the Earth to pinpoint its exact location as well as its velocity and time. It usually consists of a processing unit, an antenna, and a receiver. The latitude, longitude, and altitude of the module are determined by the receiver by gathering signals from several satellites. These modules are commonly utilised in many different applications, such as fitness trackers, drones, cellphones, and automobile navigation systems. They enable users to navigate, track assets, carry out location-based services, and conduct surveys by providing precise positioning information. Since GPS modules provide accurate and up-to-date location data for a variety of uses, they have become indispensable in today's technological world.

Fig 7 -: GPS Module

5.5. RELAY

Relays are electrically operated switches that mechanically regulate the switching mechanism through the use of an electromagnet. Usually, an iron core with a coil of wire coiled around it is used. When the core becomes energised, a magnetic field is created that pulls an armature to make or break electrical contacts. Relays are widely utilised in many different applications, including as home appliances, automobile systems, telecommunications, and industrial automation. They allow low-power signals to reliably manage high-power devices by establishing isolation between the control and load circuits. Diverse types of relays, including reed relays, solid-state relays, and electromechanical relays, are suitable for diverse applications depending on attributes including dependability, power handling capacity, and switching speed.

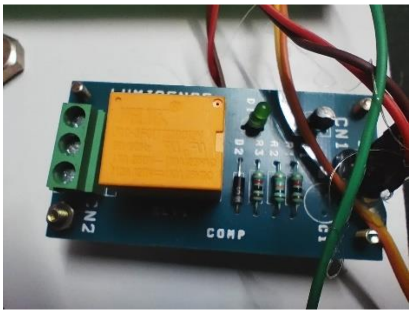
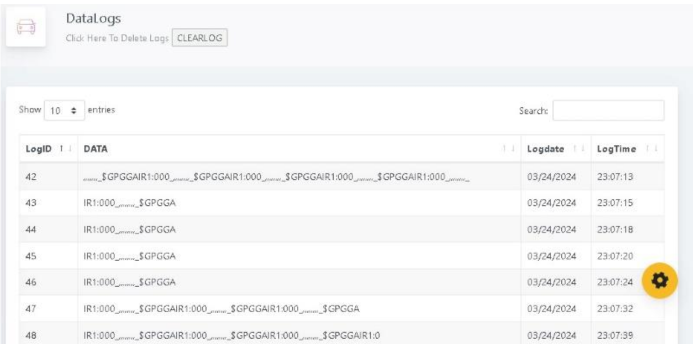


Fig 8 -: Relay

DATA STORAGE IN CLOUD(IOT)

Our model is instrumental in identifying cracks, and once detected, the coordinates are transmitted to the cloud through a GPS module. Figures 9 and 10 illustrate both the time of crack detection and provide a graphical representation of how the data is transmitted to the cloud.



DataLogs
Click Here To Delete Logs CLEARLOG

Show 10 entries Search:

LogID	DATA	Logdate	LogTime
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Fig 9 -: Detection of crack

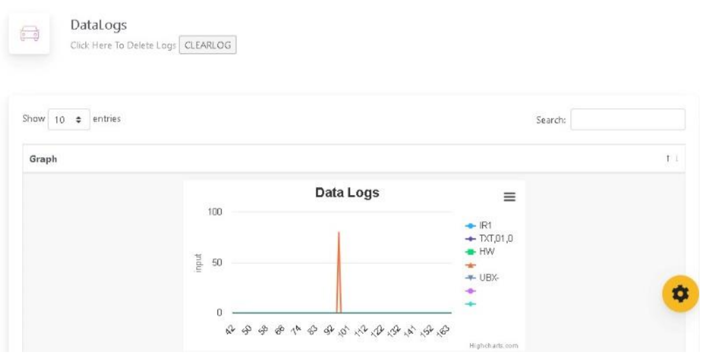

Fig 10 -: Graphical representation of detection of crack

6. CONCLUSION

In conclusion, the initiative to address the pervasive issue of railway accidents in India through the integration of GPS systems, sensor technology, and IoT modules presents a comprehensive and proactive approach to enhancing railway safety. The focus on real-time crack detection, facilitated by the collaboration of these technologies, offers a promising solution to mitigate the risks associated with track faults, particularly fractures, which often lead to fatalities.

By leveraging GPS systems in tandem with sensor technology, the initiative aims to accurately identify the precise locations of railway track cracks, enabling swift intervention by railway authorities. The utilization of Node MCU IoT modules for data gathering and cloud-based transmission ensures seamless communication and efficient processing of critical information. Additionally, the incorporation of At89s52 microcontrollers supervises the overall operation, ensuring smooth integration and synchronization of diverse components.

The significance of this Initiative lies in its ability to provide railway authorities with timely and actionable insights, empowering them to implement preventive measures such as temporary closures or immediate track maintenance. By leveraging real-time data and cloud-based infrastructure, authorities can proactively address potential risks, thereby reducing the likelihood of accidents and enhancing overall railway safety standards.

Furthermore, the initiative's emphasis on collaboration and technological innovation underscores a proactive approach towards addressing complex challenges within the railway sector. By harnessing the power of emerging technologies, such as IoT and cloud computing, the initiative demonstrates a commitment to leveraging modern solutions to safeguard passenger lives and improve transportation infrastructure.

In essence, the integration of GPS systems, sensor technology, IoT modules, and microcontrollers represents a transformative step towards enhancing railway safety in India, signaling a shift towards proactive risk management and the adoption of innovative solutions to address longstanding challenges within the transportation sector.

REFERENCES

[1] A. Rizvi, P. Khan and D. Ahmad, "Crack Detection In Railway Track Using Image Processing", International Journal of Advance Research, Ideas and Innovations in Technology., vol.3, no. 4, 2017.

[2] S. Srivastava, R. Chaurasia, S. Abbas, P. Sharma and N. Singh, "Railway Track Crack Detection Vehicle", International Advanced Research Journal in Science, Engineering and Technology, vol. 4, no. 2, pp. 145-148, 2017.

[3] K. Bhargavi and M. Janardhana Raju "Railway Track Crack Detection Using Led-Ldr Assembly “, International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), vol. 3, no. 9, pp. 1230-1234, 2014.

[4]B. Siva Ram Krishna, D. Seshendia, G. Govinda Raja, T. Sudharshan and K. Srikanth, "Railway Track Fault Detection System By Using IR Sensors And Bluetooth Technology", Asian Journal of Applied Science and Technology (AJAST), vol. 1, no. 6, pp. 82-84, 2017.