International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 04 | Apr 2023 www.irjet.net p-ISSN: 2395-0072

# Railway Track Geometry Surveying System

**Jaiswal Mamta Navratan[1], Raorane Sakshi Sanjay[2], Vardam Nihar Sanjay[3], Vasistha Mukti Ramesh[4], Prof. Nandkishor Narkhede[5], Prof. Santosh Kamble[6]**

[1,2,3,4] *Students, Department of Electronics EngineeringShah and Anchor Kutchhi EngineeringCollege Mumbai 400088, India*
[5,6] *Professors, Department of Electronics EngineeringShah and Anchor Kutchhi EngineeringCollege Mumbai 400088, India*

---

**Abstract-** *This paper represents design and implementation of Railway Track Geometry Surveying System. On Railway tracks, any time the track strikes due to weather conditions, floods, earthquake, cyclone, etc. accidents happen. Nowadays most of the systems have some limitations, for example if a bridge or track is damaged, then that information goes to railway authority people, they notify and inform the corresponding trains which will take more time informing them.*

*So, to avoid delays and save time, our proposed system will immediately notify and inform the current train coming on the track through wireless medium using GPS and GSM module. This project is useful for avoiding the accident due to track geometry changes.*

***Keywords*: *GSM Module, ESP32 Microcontroller, ESP32 Camera, GPS Module, Ultrasonic Sensor, Railway Tracks.***

## I. INTRODUCTION

The Indian railways provide the most affordable and convenient mode of passenger transportation, catering to both long-distance and suburban traffic. However, the occurrence of accidents on railways is often attributed to factors such as railway track crossings, uneven tracks, and undetected cracks. Therefore, there is a pressing need for robust, efficient, and safe technologies for detecting cracks in railway tracks and ensuring proper alignment.

Our project proposes a dynamic approach to railway track geometry and crack detection, utilizing sensor technology and a GPS tracking system. The ESP32 microcontroller is employed to control and coordinate the activities of the device. This innovative solution aims to send alert messages along with the geographical coordinates of the detected cracks, enabling prompt action to rectify the issue and ensure track safety.

## II. METHODOLOGY

This section discusses about hardware and software used, development and working of the proposed system.

### A. Hardware Specifications

1. **ESP32**: The ESP32 microcontroller is a cost-effective System on Chip (SoC) that is ideal for Internet of Things (IoT) systems requiring connectivity. It is equipped with Wi-Fi and Bluetooth capabilities, making it a versatile choice for building IoT applications. In comparison to the ESP8266, which is suitable for Wi-Fi connectivity only, the ESP32 offers additional features such as high-resolution ADCs, DACs, serial connectivity, and more.

The ESP32 microcontroller includes the ESP-WROOM-32 module, two rows of IO pins (15 pins on each side), a micro-USB connector for power and programming, enable and boot buttons for reset and flashing, and power and user LEDs (red and blue, respectively, connected to GPIO2). These features make the ESP32 microcontroller a unique and powerful choice for IoT projects.

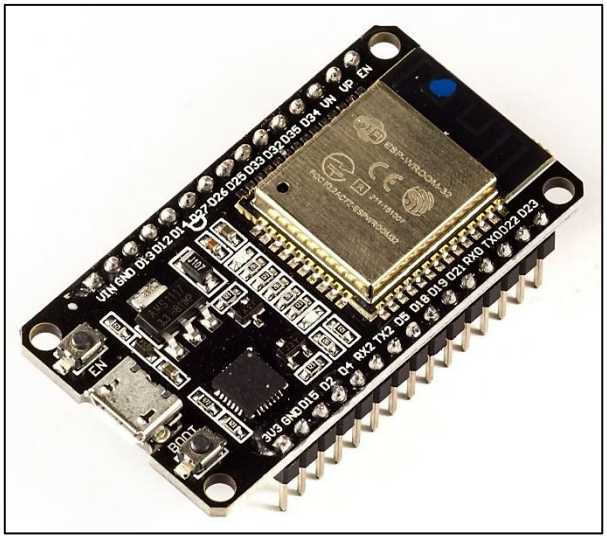

Fig.1 ESP32 Microcontroller

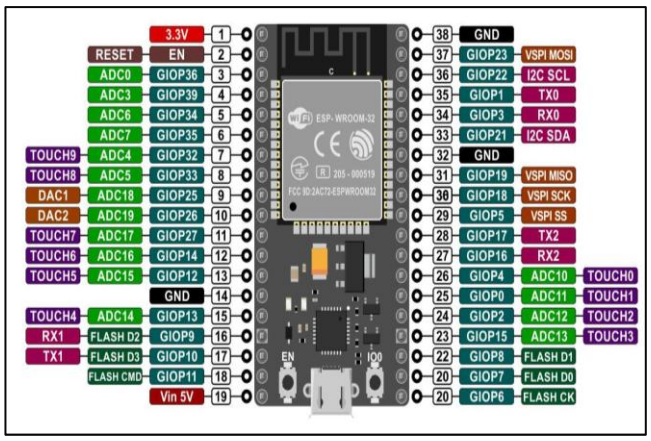


Fig. 2 ESP32 Pin Diagram

1. **GSM Modem:** A GSM modem is a wireless modem designed to work with a GSM wireless network. It operates similarly to a dial-up modem, with the main difference being that a dial-up modem uses a fixed telephone line, whereas a GSM modem uses radio waves for sending and receiving data. Similar to a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier to function properly.

A GSM modem can be an external unit or a PCMCIA card (also known as a PC Card) that can be inserted into a PC. An external GSM modem can be connected to a PC using a serial cable, USB cable, Bluetooth, or Infrared. Just like a GSM mobile phone, a GSM modem also requires a SIM card from a wireless carrier for operation.

GSM modems are controlled by AT commands issued from a PC, similar to how a compatible modem is controlled. These modems support an extended set of AT commands, which are defined in the GSM standards.

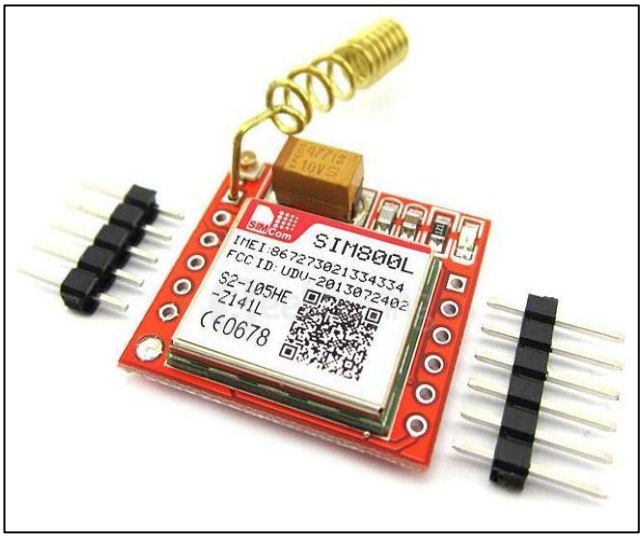


Fig. 3 GSM Modem 800L

2. **GPS Modem**: The Global Positioning System (GPS) is a worldwide, satellite-based, radio navigation system that was developed by the U.S. Department of Defense for military purposes. It provides precise location information for vehicles regardless of their location, time, or weather conditions. The system comprises 24 satellites in orbit around the Earth, constantly monitored by earth stations. These satellites transmit signals that can be detected by GPS receivers installed in vehicles, allowing for highly accurate determination of their location.

So, how does GPS work?

Each GPS satellite broadcasts radio signals that enable GPS receivers in vehicles to estimate the satellite's location and the distance between it and the vehicles. The receivers then use these measurements to calculate the vehicles' precise location on Earth, converting the calculations into geodetic latitude and longitude coordinates. To pinpoint a vehicle's position, a receiver typically requires signals from at least three GPS satellites.

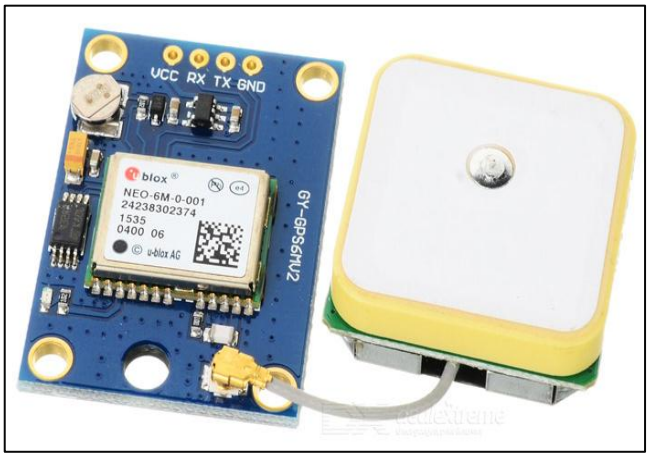


Fig. 4 GPS Modem Neo-6m

3. **Accelerometer (MEMS Sensor):** The ADXL335 is a compact, slim, and energy-efficient 3-axis accelerometer that provides voltage outputs for measuring acceleration. With a minimum full-scale range of ±3 g, it is capable of detecting both static acceleration due to gravity in tilt-sensing applications and dynamic acceleration caused by motion, shock, or vibration.

One of the unique features of ADXL335 is its user-selectable bandwidth, which can be adjusted using capacitors at the XOUT, YOUT, and ZOUT pins. This allows for customization to suit the specific requirements of the application, with bandwidth options ranging from 0.5 Hz to 1600 Hz for the X and Y axes, and 0.5 Hz to 550 Hz for the Z axis.

In addition to its versatile performance, the ADXL335 also offers three analog outputs for XYZ axis, providing voltage levels that correspond to acceleration values. For example, when powered with 3V, an output voltage of 1.5V indicates zero g acceleration. This makes ADXL335 a reliable choice for various acceleration sensing applications, with its unique features and performance capabilities.

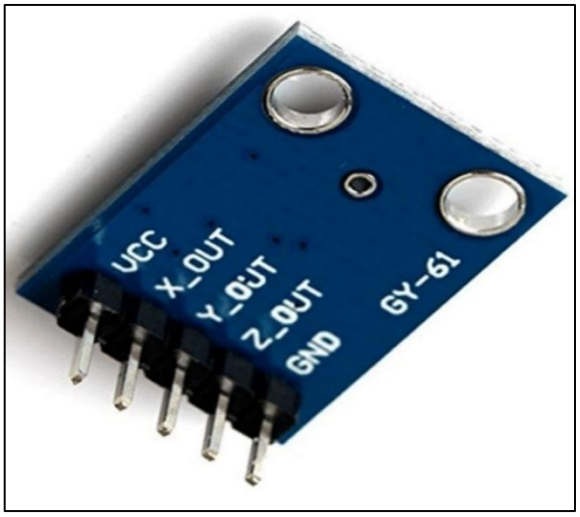


Fig. 5 ADXL335 Accelerometer

4. **ESP32-CAM:** The ESP32-CAM is a cost-effective development board based on the ESP32 microcontroller, featuring an onboard camera and compact size. Designed for IoT applications, prototype constructions, and DIY projects, this board integrates Wi-Fi, traditional Bluetooth, and low-power BLE, powered by two high-performance 32-bit LX6 CPUs.

With its 7-stage pipeline architecture and on-chip sensors, including a Hall sensor and temperature sensor, the ESP32-CAM offers flexibility and versatility. Its main frequency can be adjusted from 80MHz to 240MHz, making it suitable for a wide range of applications. The board is fully compliant with Wi-Fi 802.11b/g/n/e/i and Bluetooth 4.2 standards, enabling it to function as a standalone network controller or as a networking module for existing devices.

The ESP32-CAM finds application in various IoT scenarios, such as home smart devices, industrial wireless control, wireless monitoring, QR wireless identification, and wireless positioning system signals. With its wide range of capabilities and compact design, the ESP32-CAM is an ideal solution for diverse IoT applications, providing flexibility, performance, and cost-effectiveness.


Fig.6 ESP32 Camera

5. **OLED**: Unlike LCD technology, Organic Light-Emitting Diode (OLED) displays do not necessitate a backlight and are deemed as the ultimate technology for the upcoming era of flat panel displays. The composition of OLED displays consists of an ultra-thin organic film comprising numerous layers situated between an anode and cathode, both made up of electric conductive transparent Indium Tin Oxide. This multi-layered organic film comprises a Hole Transporting Layer, an Emission Layer, and an Electron Transporting Layer.

Injecting appropriate electrical voltage into the OLED display initiates the injection of holes and electrons from the anode and cathode, respectively, which then combine to produce excitons. Subsequently, electroluminescence takes place, which is the glowing effect observed in OLED technology.

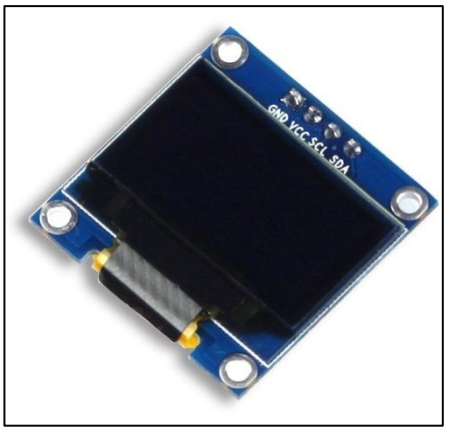


Fig.7 0.96 OLED

6. **Ultrasonic Sensor:** The principle behind ultrasonic sensors involves the use of ultrasonic waves to measure distance. The sensor emits an ultrasonic wave from its head and then receives the reflected wave from a target. By measuring the time elapsed between the emission and reception of the waves, the sensor is able to calculate the distance to the target.

Ultrasonic sensors operate by transmitting a sound wave at a frequency beyond the range of human hearing. The transducer within the sensor acts as both a transmitter and receiver of the ultrasonic sound. In many cases, including our ultrasonic sensors, a single transducer is used to emit a pulse and receive the echo.

To determine the distance to a target, the sensor measures the time lapse between the emission and reception of the ultrasonic pulse. This unique method allows for accurate distance measurement using ultrasonic technology.

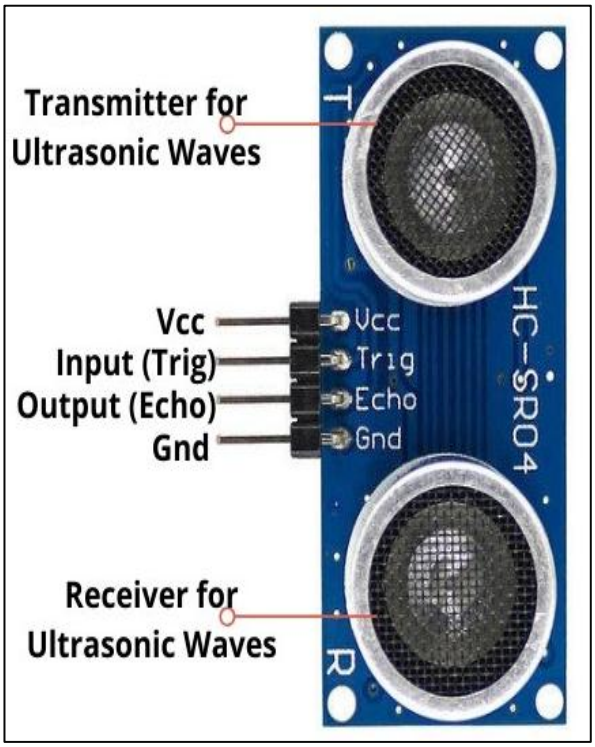


Fig.9 Ultrasonic Sensor

## 2. Software Specifications

1. **Arduino IDE:** The Arduino IDE is a freely available open-source software used for writing and uploading code to Arduino boards. It provides an Integrated Development Environment (IDE) that is compatible with various operating systems including Windows, Mac OS X, and Linux. The Arduino IDE supports programming languages such as C and C++, making it a versatile tool for Arduino programming.

In the context of Arduino programming, the code written in the Arduino IDE is commonly referred to as a sketch. To upload the sketch to the Genuino or Arduino board, it needs to be connected to the IDE. The sketches are saved with the file extension '.ino', which is specific to Arduino programming. The Arduino IDE simplifies the process of writing and uploading code, making it accessible to both beginners and experienced developers in the Arduino community.

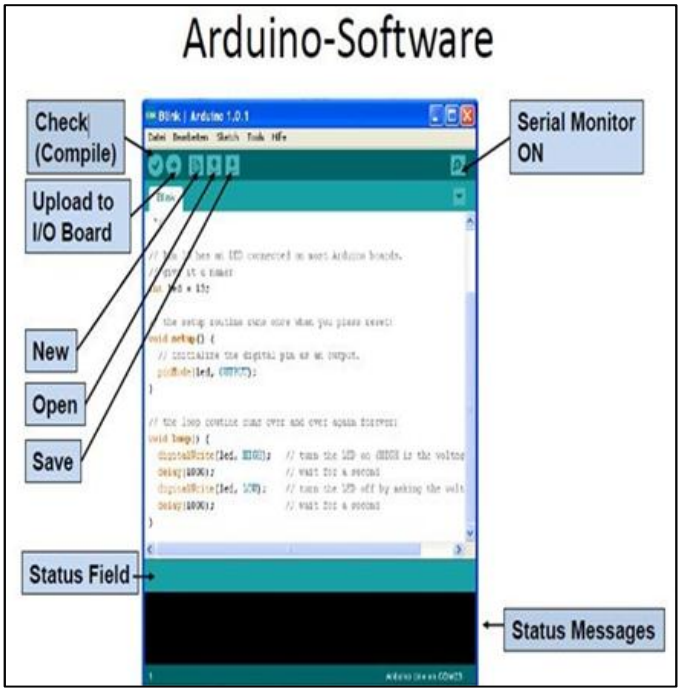


Fig. 8 Arduino IDE software

2. **PCB Design:** In our PCB design process, we utilized the Express PCB software, which was downloaded from the internet. This user-friendly software provided a simple and straightforward approach to create PCB layouts for our project.

The manufacturing of printed circuit boards (PCBs) involves several distinct steps. These steps include creating the circuit diagram, designing the PCB layout, creating the PCB artwork, transferring the pattern onto the board, etching the board, cleaning it, and finally drilling holes as needed. Each step plays a crucial role in the overall PCB manufacturing process, and careful attention is paid to ensure that each step is executed accurately and efficiently.

## III. WORKING

i. **Bend Detection of Track:** In our railway track geometry system, we utilize a MEMS sensor to monitor the direction of the system. If the system detects any bend in the track through the MEMS

sensor, a message is promptly sent to the user specifying the exact location of the bend. The MEMS sensor is connected to the controller board, and any changes in its values are detected when a bend is detected in the track. All these sensors are connected to the appropriate GPIO pins on the controller board.

The controller board utilizes UART read to collect data from the GPS module, enabling us to accurately determine the location of the bend in the track.

ii. **Crack Detection**: In our railway track crack detection system, we utilize ultrasonic sensors to detect cracks on the track. If no echo sound is received by the ultrasonic sensor, it indicates the presence of a crack on the track. However, if an echo sound is received, it indicates that no crack is detected. The output of the ultrasonic sensors is then fed to a microcontroller, which is also connected to GPS and motor driver IC.

By employing ultrasonic sensors in our system, we are able to effectively detect cracks on the railway track by analyzing the echo signals. The microcontroller acts as the central processing unit, receiving and analyzing the output from the ultrasonic sensors, and coordinating with the GPS and motor driver IC. Once a crack is detected, the system sends an SMS notification through the GSM module, providing real-time information about the location of the crack to ensure prompt action can be taken.

## IV. BLOCK DIAGRAM

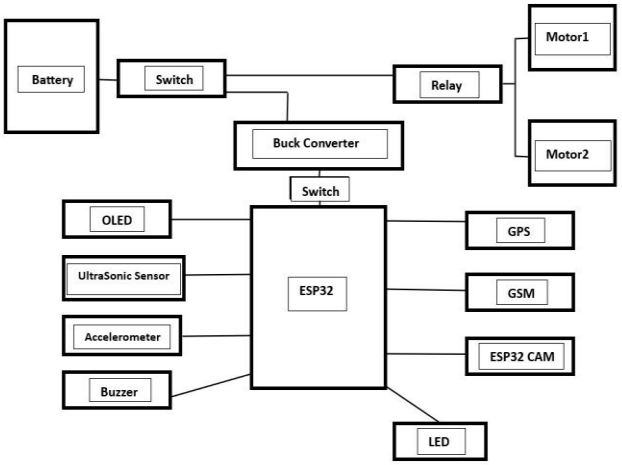


Fig.10 Block Diagram

## V. FUTURE SCOPE

The future scope of railway track geometry systems is promising, as advancements in technology continue to drive innovation in the field. Here are some potential future developments:

- Integration of Artificial Intelligence (AI) and Machine Learning (ML): Railway track geometry systems can leverage AI and ML algorithms to analyze large amounts of data collected from sensors and other sources. This can enable more accurate and automated detection of track alignment issues, cracks, and other anomalies, as well as predictive maintenance capabilities for proactive repairs and maintenance scheduling.

- Mobile and Wearable Solutions: Mobile and wearable technologies can be integrated into railway track geometry systems, allowing maintenance crews to access real-time data and perform inspections on the go. This can increase flexibility, speed, and accuracy in track inspections, leading to more efficient maintenance processes.

- Autonomous Inspection Systems: Autonomous inspection systems, such as drones or robotic vehicles, can be utilized for railway track inspections, reducing the need for manual inspections and enhancing safety. These systems can collect data from various sensors and cameras, providing detailed and accurate information about track alignment and cracks.

## VI. RESULT & DISCUSSION

The railway track geometry system in our project utilizes both ultrasonic sensors and MEMS sensors to detect cracks and bends on the track. The values obtained from these sensors are then passed to the controller board for further processing. Additionally, the GPS module is used to track the location of abnormal conditions on the track, and the coordinates are also passed to the controller board from the GPS module. Finally, an SMS is sent to the user through the GSM module to notify them about the detected abnormal condition.

Our proect presents a cost-effective and robust solution to the problem of railway track geometry surveying. The method employed is unique as it combines simplicity with novel ideas. Detailed technical and design aspects are discussed, along with a proposed railway track geometry surveying system. The implementation results are based on the utilization of simple components such as a GPS module, GSM modem, and MEMS-based track detector assembly. This project showcases the successful implementation of these components to achieve an efficient and effective railway track geometry surveying system.

## VII. CONCLUSION

In conclusion, the railway track geometry system is a valuable tool that aids in ensuring the alignment and integrity of railway tracks. By employing advanced

technology, such as sensors, laser measurement, and data analysis, this system enables accurate and efficient inspection of railway tracks, identifying potential issues such as misalignment and cracks. It provides timely feedback to maintenance crews, allowing for prompt repairs and preventing potential accidents or delays.

The implementation of a railway track geometry system can significantly improve the safety, reliability, and efficiency of railway operations, reducing the risk of accidents and minimizing downtime. In summary, the railway track geometry system is a crucial asset for railway maintenance and operation, supporting the safe and reliable transportation of passengers and goods on rail networks.

Furthermore, the railway track geometry system offers several benefits, including cost savings by identifying issues early and preventing costly repairs or replacements. It also helps extend the lifespan of railway tracks by detecting and addressing alignment problems and cracks in their early stages, preventing further deterioration. Additionally, the railway track geometry system enhances safety by reducing the risk of derailments and accidents caused by misaligned tracks or cracks. It also improves operational efficiency by minimizing track maintenance disruptions, optimizing train speeds, and reducing wear and tear on rolling stock. Overall, the railway track geometry system is a valuable tool for maintaining track quality, ensuring safe and efficient railway operations, and enhancing the overall performance of railway networks.

## VIII. REFERENCES

[1] P. Lad and M. Pawar, "Evolution of railway track crack detection system," 2016 2nd IEEE International Symposium on Robotics and Manufacturing Automation (ROMA), Ipoh, Malaysia, 2016, pp. 1-6, doi: 10.1109/ROMA.2016.7847816.

[2] Josef Fuchs, Gabor Müller, Kamil Sazgetdinov, Erich Wipfler, Ingolf Nerlich. (2023) A methodology for alignment of measured rail profiles in turnouts as a basis for reliable vehicle/track interaction simulations. Vehicle System Dynamics 61:3, pages 821-837.

[3] Bhat, Shreetha & Karegowda, Dr & Noushad, Iqbal. (2021). Smart Railway Track Monitoring System.

[4] 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.

[5] D.Narendhar Sigh and D. Naresh, "Railway Track Crack Detection And Data Analysis", vol. 5, no. 4, pp. 1859-1863, 2017.

[6] George Mathew, Mebin & A, Parvathy & Justus, Saji & Anil, Ajan. (2017). Automatic Rail Fault Track Detection for Indian Railways. 10.1109/CESYS.2017.8321251.