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Proposed Dual Approach for Rail Track Crack Detection

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ABSTRACT
The Indian rail network covered a route length of 68,442-kilometre and a total track length of 1,23,236-kilometre as of March 2019 [1]. This makes it one of the largest rail networks in the world. Inherently maintaining such a big rail network poses problems. This paper describes an automated approach to make the crack, misalignment detection and reporting process easier thereby increasing passenger convenience and potentially averting accidents caused due to derailment.
Keywords – Crack Detection, STM32 microcontroller, Infrared Sensor, Ultrasonic Sensor, GSM, GPS

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I. INTRODUCTION

In the year 2017-2018, The Indian railway moved 8,286 million passengers operating

13,452 passenger trains daily [1]. These statistics combined with the prodigious length of the rail network make maintaining the rail tracks a difficult task. The current process of track inspection for repairs is carried out manually requiring large man power. Manual inspection when done on a small scale can be effective, however when the system to be covered is large such that as the Indian rail network it can be an inefficient process posing several disadvantages. Manual inspection is heavily reliant on the experience of the personnel and their ability to perform optimally. This may not be true all the time. Consequently, the number of rail accidents in India for the year 2017-2018 stood at 72. Out of these 53 were attributed to derailment of trains. Further, 60 (83.33%) of these 72 accidents were due to human failure [1]. Hence we can conclude that human deployment is an unpredictable and unreliable means to inspect tracks.

To combat the problem of maintaining tracks, several methods have been proposed. One such approach involves the use of Image processing and machine vision while another implements Ultrasonic and Infrared sensors to detect cracks. Crack reporting systems include, the Internet of Things (IOT) approach to upload the acquired data to the cloud to log it. Another system consists of using a Global System for Mobile (GSM) module to use its ubiquitous Short Message Service (SMS) to deliver crucial positional information to the safety authority.

Our approach combines the best aspects of the proposed methods till date while also adding new features which will enhance the process of crack, misalignment detection and reporting.

II. LITERATURE REVIEW

(i) IMAGE PROCESSING

The image processing approach to crack detection involves capturing high resolution images of the track surface through one or multiple high speed cameras mounted at different angles. The rail tracks are identified by employing the canny edge algorithm and Hough transform. Pre-processing techniques are done to improve contrast. The local normalisation and adaptive histogram equalisation have been deployed as image enhancement techniques [2] . Also, binary segmentation by adaptive thresholding is used for crack segmentation [2]. After the detection stage of the algorithm, the detected defects are further post-processed with image cleaning morphological operations. Then the following geometrical properties of each defect are extracted: length (maximum distance between any two points along the boundary of the defect), the orientation of the defect (orientation about x axis), area, and perimeter. Connected components are obtained from the complete area of the track image. If there is discontinuity then there is a crack otherwise no crack detected [2].

(ii) IR TRANSMITTER AND RECEIVER

In this implementation, cracks are detected by using an IR transmitter and receiver assembly. The principle involved in this approach is that light reaching the IR receiver is proportional to the magnitude of the crack i.e. when maximum light transmitted by transmitter reaches the receiver, the crack intensity is more [3]. The IR transmitter will be attached to one side of the rails and the IR receiver to the opposite side. During normal operation, when there are no cracks, the light from transmitter does not fall on the receiver due to intactness of the track and hence the detected value is low. When there is a crack, radiation from the transmitter falls on the receiver, the received value increases and the amount by which it increases is proportional to the intensity of the incident signal. Larger the received value, the greater is the size of the crack.

(iii) Ultrasonic Transmitter And Receiver

Ultrasound refers to sound waves which have a frequency greater than twenty kilo Hertz. This approach is based on the fact that the speed of sound is different in air and steel. The ultrasonic transmitter and receiver are mounted vertically above the track. The transmitter constantly emits ultrasound waves which reflect off the track and reach the receiver. If there are no cracks in the track. The reflected wave will reach the receiver in a shorter time interval as compared to the situation of a crack where the ultrasonic waves would travel through the air filling the crack and hence taking longer to reach the receiver. Depending on the time interval of the received signal, the severity of the crack can he determined.

(iv) HALL EFFECT SENSOR

A Hall effect sensor is a device that is used to measure the magnitude of a magnetic field [9]. Its output voltage is directly proportional to the magnetic flux linked to it. A magnet such as neodymium magnet is used to magnetise the rail tracks. The sensors then measured any change in flux caused by defects [4]. In presence of any railway track crack the magnetic flux changes. This data is used to classify that point as a crack.

Table 1: Summary of methods for crack detection proposed till date

Sr no.	Method	Strength	Weakness
1	Use of image processing to identify cracks.	Automatic, reduces the chances of human error, multiple sets of data collected	Requires high-resolution and costly camera, results can be altered due to environ-mental factors
2	Use of Hall Sensor for detecting and Internet of Things	Can perform remote sensing, actuating and monitoring capabilities	Heavily dependent on internet connection, Hall sensors provide much lower measuring accuracy, sensors can drift significantly, requiring compen-sation.
3	Infrared Sensor used for crack detection along with GSM and GPS [8].	Reduces chances of false detections, low power consumption, on time data operation and minimum analysis time, can detect missing nut and bolt.	Can fail to detect deeply set cracks.
4	Use of ultrasonic sensor along with GSM and GPS [7].	Ultrasonic sensor has high frequency, high sensitivity and high penetrating power therefore it can easily detect the external or deep objects.	Cannot detect motion and missing nut and bolt.

III. PROPOSED SYSTEM

The proposed system here is an integration of two methods studied and reviewed. It aims at freeing the Railway Management System from the hurdles of manual and visual inspection as it takes care of any crack on the track and detects any missing bolt between the tracks. It also detects any misalignment between two sections of the rails. The system uses simple yet effective hardware modules to provide accurate results while being cheap and quick. It puts into use a dual crack detection methodology to ensure optimum record of real-time data.

The microcontroller STM32F103 plays a pivotal role in this system. The STM32 is a 32-bit microcontroller family which is based on the ARM processor core, particularly the Cortex-M series [5]. It integrates with a wide range of modules, offers high performance and as per requirements, provides real-time data handling and processing capabilities along with a low power and low voltage operation.
The MCU receives information from various sensors and modules and processes the data in the following steps: -
1) Crack detection will be done with the help of Infrared transmitters and receivers placed parallel to the track on either side and Ultrasonic sensor placed directly above.
2) In case a crack is detected, the location data from the GPS module will be stored and using the GSM module an alert with the location and severity of the problem will be sent to the Railway control station.

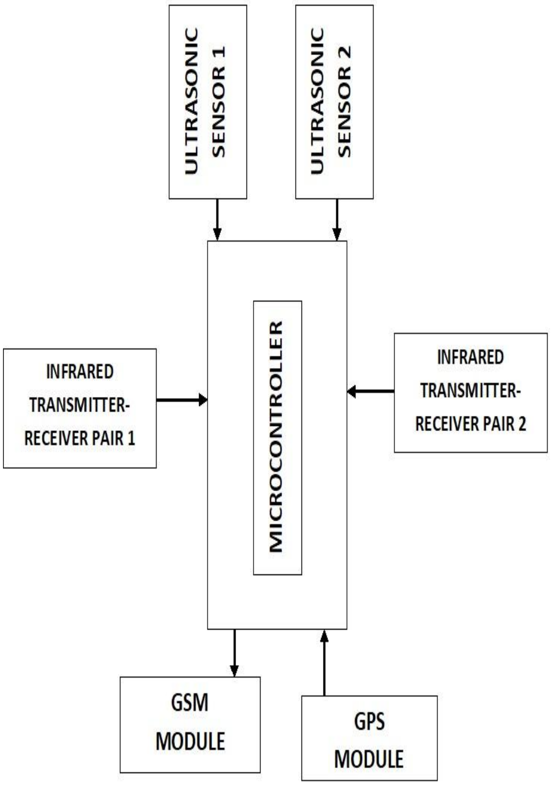

Figure 1: Block Diagram of proposed system

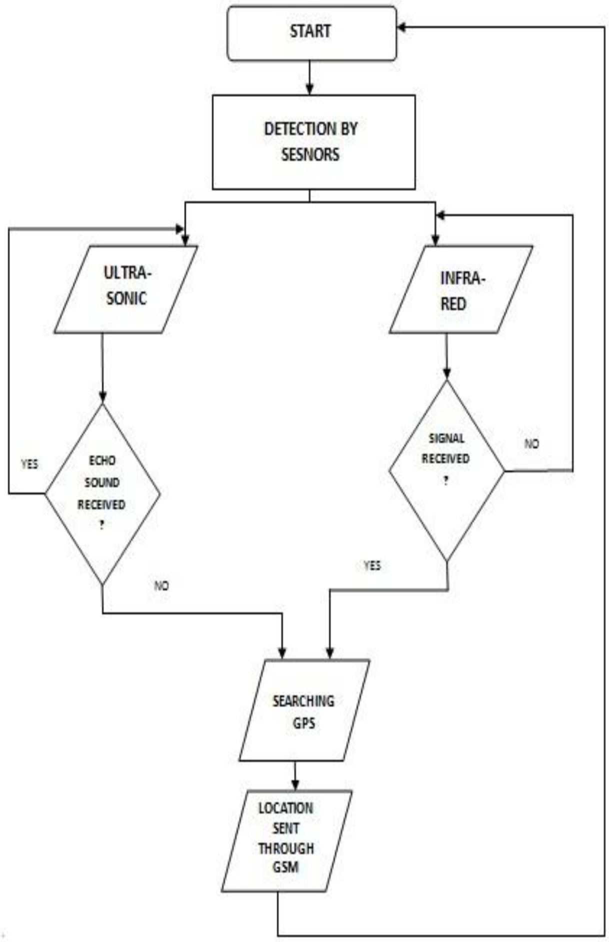

Figure 2: Flowchart of proposed system

The components selected for the proposed system are based on the following considerations and advantages offered by them:

1. STM32 is used as a microcontroller here in order to reduce the load on the battery, since it is a battery-operated system, hardware involvement needs to be less.
2. STM32 offers high performance, real-time capabilities, digital signal processing, low-power and low-voltage operation while maintaining full integration and ease of development.
3. If the IR sensor due to its shortcomings fails to uncover a crack, it is backed up by the ultrasonic sensor, which remains unaffected by environmental factors, and vice-versa. It also reduces the possibility of false crack detection and thereby increases the veracity of results.
4. GSM is a low power and cost-effective alternative to other wireless modules and provides extensive coverage making it more reliable than internet dependent modules.
5. GPS provides an ‘anywhere’, ‘anytime’ access feature, ensuring accurate location information gathering technique.

IV. CONCLUSION AND FUTURE SCOPE

The proposed system aims at solving the critical problem of railway track crack detection. If these cracks are not detected in time, it can lead to devastating outcomes such as derailment and train accidents. This paper was designed to improve rail track management and reduce the dependency on man power. In this system, a dual approach in order to increase the accuracy of crack recognition was studied. It was designed such that it is economical and robust enough to handle environmental conditions. The use of a fast microcontroller, enables fast processing of the data recorded. The system can work in any terrain and detects cracks while maintaining accuracy.

While the system right now focuses on collection of data and plans on avoiding future accidents by diverting attention to the problem area as soon as possible, the future of this system can also include implementation of immediate action. By interfacing the brake system as well, a quick detection before the train passes the crack can also help stop the train from advancing, thereby, reducing the possibility of an accident, Another future advancement can include the use of PIR sensors, which can help stop the train in a dangerous scene of sudden appearance of humans or animals on the tracks. Therefore, the future of this project can provide a high level of safety on this widely used mode of commute.

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