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ADVANCED SECURITY SYSTEM FOR RAILWAY TRACKS

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Abstract— *This paper describes an advanced security system that can help us detect the exact location of the crack formed accidentally or due to terrorist activities. In India, railways have large infrastructures and prime modes of the transportation system. Railways have become the most popular transportation system due to their capacity, speed, cost and reliability. Thus, a proper maintenance strategy is required to optimise inspection frequency and improve skill and efficiency. Accidents due to track breaking have been a big problem for railways for life security and timely management of services. This breakage needs to be identified in real-time before a train comes near the broken track and gets subjected to an accident. In this paper, different kinds of rail defects inspection and maintenance methods are described.*

Keyword — Crack Detection, ultrasonic sensor, IoT system.

I. Introduction

In general, rail transport in India is growing rapidly, and the associated safety infrastructure facilities have not kept up with the proliferation mentioned above. Our facilities are poor compared to the international standards, and as a result, we have been having frequent derailments that have resulted in severe loss of valuable human lives and property[1]. The poor maintenance of the railways can lead to accidents. New technologies for railways and better safety measures are introduced, but accidents still occur. Thus, a proper strategy is required for the maintenance and inspection of tracks. Detection and maintenance of rail defects are major issues for the rail community all around the world. The defects mainly include weld problems, internal defects worn-out rails, head checks, squats, spalling and shelling, corrugations, and rolling contact fatigue (RCF) initiated problems such as surface cracks. If these defects are not handled and corrected, they can lead to rail breaks and accidents [2]. Cracks in rails have been identified as the main cause of derailments in the past, yet there have been no cheap automated solutions available for testing purposes. Hence, owing to the crucial repercussions of this problem, we have worked on implementing an efficient and cost-effective solution suitable for large scale applications. We hope that our idea can be implemented in the long run to facilitate better safety standards and provide effective testing infrastructure for achieving better results in the future[3].

- Train Derailment in curves and bends,
- Running Train collisions with the Standing Train
- Train Accidents in Slopes,4. Mis- signalling due to fog or Mist.

II. Techniques For Inspecting Cracks In Railway Tracks

2.1 Long Range Ultrasonic Testing (LRUT)

Long Range Ultrasonic Testing (LRUT) technique is proposed as a complimentary inspection technique to examine the foot of rails, especially in track regions where corrosion and associated fatigue cracking is likely, such as at level crossings. LRUT technique is suitable for examining inaccessible areas of railway tracks, such as areas where corrosion occurs and susceptible areas of fatigue cracking. In different parts of the rail section (such as head, web and foot), the properties of guided waves are used and are examined for their capability to detect defects in each part. A suitable array of transducers is developed to generate selected guided wave modes in rails that allow a reliable long-range inspection. The characteristics of ultrasonic guided waves in the rail complex geometrical profile have been identified.

2.2 Vision-Based System

A rail track inspection technique using automated video analysis is proposed [5]. The system aims to replace manual visual checks performed by railway engineers for track inspection. A combination of image processing and analysis methods is used in the paper to achieve high performance automated rail track inspection. This paper focuses on finding missing and blue clips that have been recently replaced in place of damaged clips. The algorithm's objective is to automatically find clips in video sequences and recognise whether they are broken and new or old as indicated by their colour. Metal clips hold the rail track to the sleepers on the ground. Clips are searched to locate their position. Some clips on the track may be broken or missing due to excessive strain on them as the train moves on the track, which may lead to the tracking failure, and these missing clips are identified. The clips used may be of different colours depending on whether it is new (blue colour) or old (grey). So a video colour analysis is done on the clips, and the results are given to track maintenance engineers.

The main image pre-processing steps in recognition of clips include smoothing, edge detection, and short line removal.1The irregularities in the Railway track gauge reduces the service life of rail and vehicles and even result in vehicles falling off rail or wheel trapping, which causes driving accidents. A dynamic inspection method of track gauge based on computer vision is developed in [6]. The inspection system is constructed by using four CCD (Charge-coupled Device) cameras and two red laser sector lights. The inspection principle and corresponding calibration method of the inspection system are analysed. Image processing technologies such as image component extraction, differential, adaptive iteration threshold, dilation, and thinning

extract gauge points are used. Experiment results have proved that the proposed inspection method can fast obtain track gauge value with high accuracy and repeatability and meets the requirement of dynamic inspection for track gauge. The method proposed in the paper [6] confirms the calibration method for track gauge inspection. The method strictly controls the change of railway gauge and provides an effective inspection method with high precision to railway engineers.

2.3 Train-Mounted GPR

A technique based on Ground-penetrating radar (GPR) [7] is used to obtain quantitative information about the track's depth and degree of deterioration. This paper aims at automating the processing and interpretation of data to the extent whereby on-site interpretations may be achieved with minimal intervention of the expert. It is done by developing new image and signal processing tools specifically for GPR data and the range of anomalies found on the trackbed. The most efficient way to monitor track conditions and other infrastructure assets is using a train, which can collect data for many parameters simultaneously, where possible at normal line speed. A multi-channel ground-penetrating radar system is presented in the paper, which can operate at speeds of up to 200 km/h. A road-rail variant of the system is also presented, which can collect up to 6 simultaneous continuous channels across the track and deliver an on-site interpretation of ballast thickness and quality, irregularities, weak spots, and utilities. Novel multivariate signal and image processing techniques are used that can automatically detect, quantify and map variations in ballast depth and condition. Multi-resolution texture analysis techniques are applied to enable automatic characterisation and classification of regions of interest within the radargrams. The proposed system can probe the ballast underneath and between the sleepers; thus, individual sleepers can identify potential problems.

2.4 LED-LDR Assembly

An algorithm for crack detection in rail tracks is used in the article [9] for Light Emitting Diode and Light Emitting Resistor (LED-LDR) assembly, which tracks the exact location of the faulty track. The proposed design includes LEDs attached to one side of the rails and the LDR to the opposite side. When there are no cracks, i.e. during normal operation, the LED light does not fall on the LDR, so the LDR resistance is high. Subsequently, when the LED light falls on the LDR, the LDR resistance gets reduced, and the reduction is approximately proportional to the incident light's intensity. Consequently, the presence of a crack or a break in the LED light causes the LED light to deviate from its path, causing a sudden decrease in the resistance value of the LDR. This change in resistance indicates a crack or some other similar structural defect in the rails. To detect the device's current location in case of crack detection, a GPS receiver whose function is to receive the current latitude and longitude data is used to the received information for this GSM modem has been utilised. The GSM module's function is to send the current latitude and longitude data to the relevant authority as an SMS. Four DC motors drive the robot. If this system is employed, only latitudes and longitudes of the broken track only are received so that the exact location cannot be known. GPRS module is used to get the exact location of the broken rail track. ARM7 controller is also used owning to is low cost and less power consumption it also decreases the time used in detecting cracks.

III. Iot Based Crack Detection System Using Ultrasonic Sensor

Figure 1 shows the block diagram of the desired system. There are two modules

1) Monitoring System
2) Train System

1) Monitoring System

This system is in a moving position, so we pass this system before the train is passed. We have to use three sensors. One IR sensor is used for line follow and to detect the obstacle on the track, and two ultrasonic sensors are used to measure the perpendicular distance and convey a message to Raspberry Pi whether the crack or any obstacle is detected [10, 21]. First, we set some threshold range of distance. When the distance is increased or decreased, then definitely there is no obstacle or crack. There is synchronisation between the monitoring system and the train system. The crack detection information is sent to the train system implemented on the railway and all the stations between the source and destination stations. GPS module can update the location of the monitoring system continually. There is also WiFi connectivity for internet access.

2) Train System

Train System is placed on the train, consisting of Raspberry pi module B, GPS module and WiFi connectivity. It is in synchronisation with a monitoring system. When it gets a signal that is track is detected, then it will be stopped.

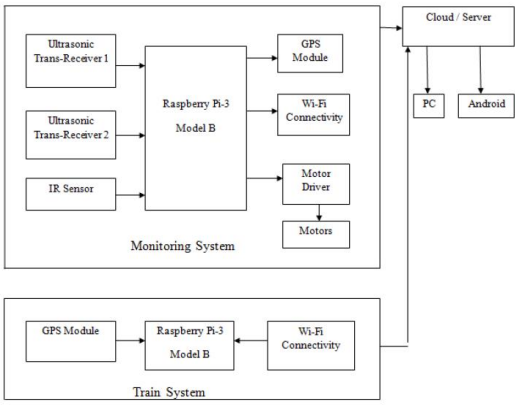

Figure 1 Block diagram of the system

Ultrasonic Sensor(HC-SR04)

Ultrasound sensor methods of detecting defects in the rail-foot have some limitations, particularly in the far

edge of the web from the area under the web, and how the LRUT method provides a significant improvement [11]. Long Range Ultrasonic Testing (LRUT) technique is proposed as a complimentary inspection technique to examine the foot of rails, especially in track regions where corrosion and associated fatigue cracking is likely, such as at level crossings. LRUT technique is suitable for examining inaccessible areas of railway tracks, such as areas where corrosion occurs and susceptible areas of fatigue cracking. In different parts of the rail section (such as head, web and foot), the properties of guided waves are used and are examined for their capability to detect defects in each part [12]. A suitable array of transducers is developed to generate selected guided wave modes in rails that allow a reliable long-range inspection. The characteristics of ultrasonic guided waves in the rail complex geometrical profile have been identified [13, 19, 20].

The Transformer coil gets excited due to the oscillating magnetic field produced by the RF amplifier, which gives power to the drive loop. The transformer coil is a multi-turn spiral coil next to the single turn drive loop. This system acts as a step-up transformer. A similar arrangement now acts as a step-down transformer on the receiving side due to the single turn load loop connected to the device. The Tx coil and the Rx coil share mutual inductance, which is a function of the distance between them and their geometry. Power can be transmitted through large air gaps when the transmitting and the receiving coil is in resonance and have the same resonant frequency[6-7]. The further approach and description through which transmissions can take place are

IR Sensor HDLC-4260

An infrared sensor is an electronic device that emits to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as to detect the motion. In the infrared spectrum, all the objects radiate some form of thermal radiation. These radiations are invisible to the eyes, which can be detected by an infrared sensor [11].

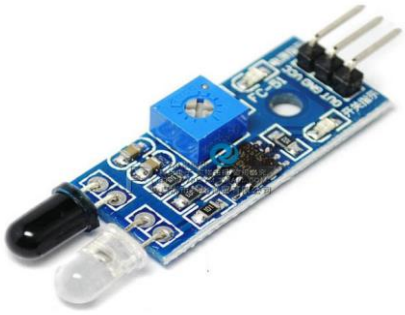

Figure 2: IR Sensor HDLC-4260

GPS Module

This project consists of a GPS module, IoT, IR sensor for communication purposes, crack detection and MONITORING in the railway track. The GPS module and IoT help us find and send railway geometric parameters of crack detection to the nearest railway station. In the presence of days, we measure track distance using high-cost LVDT with less accuracy, but we use the less cost IR sensor for the above process with high accuracy[3]. The importance of this project applies to both day and night time detection purposes. In this project, IR sensors will sense the crack that the signal sent to the microcontroller. The microcontroller will send a signal to the GPS. Again the information that is collected by the GPS modem is passed to the microcontroller. The information is provided by the GPS module of ARSMS[14].

Raspberry pi

The Raspberry Pi is a series of credit card-sized single-board computers developed in the United Kingdom by the Raspberry Pi Foundation. Several generations of Raspberry Pis have been released. The first generation (Pi, 1) was released in February 2012 in basic model A and a higher specification model B. A+ and B+ models were released a year later. Raspberry Pi 2 Model B was released in February 2015, and Raspberry Pi 3 Model B in February 2016. These boards are priced between US$20 and 35. The Foundation provides Raspbian, a Debian-based Linux distribution for download, third-party Ubuntu, Windows 10 IOT Core, RISC OS, and specialised media centre distributions. It promotes Python and Scratch as the main programming language, supporting many other languages[15-16]. The raspberry pi board comprises a program memory (RAM), processor and graphics chip, CPU, GPU, Ethernet port, GPIO pins, Xbee socket, UART, power source connector. SD flash memory card used for mass storage. So that raspberry pi board boot from this SD card is similar to a PC boots up into windows from its hard disk. Essential hardware specifications of raspberry pi board mainly include SD card containing Linux OS, US keyboard, monitor, power supply and video cable. Optional hardware specifications include a USB mouse, powered USB hub, case, internet connection, the Model A or B: USB WiFi adaptor is used, and an internet connection to Model B is LAN cable.

Motor Driver(L293D)

L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal.

Figure 3: Motor driver

This higher current signal is used to drive the motors. L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, forward and reverse direction. The motor operations of two motors can be controlled

by input logic at pins 2 & 7 and 10 & 15. Input logic 00 or 11 stop the corresponding motor. Logic 01 and 10 rotate it in clockwise and anticlockwise directions, respectively. Enable pins 1 and 9 (corresponding to the two motors) must be high for motors to start operating[17]. When an enable input is high, the associated driver gets enabled. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state.

IV. Conclusion

This paper represents implementing the railway crack detection circuit and security system using IOT based ultrasonic sensor. The main component of the system is the crack detection circuit. The GSM Modem helps to alert the railway authorities about the crack in the tracks. Thus, automated crack detection and security systems are proposed in this paper, making the system more reliable, less time-consuming, and reducing human resources requirements.

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