Automated Robotic Visual Inspection and Rectification of Railroad Tracks

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***Abstract*— This paper deals with the inspection of the railway track using multiple sensors along with GPS and GSM modules. On detecting flaws in the railway track, it immediately sends the information to the concerned authorities via text messages and rectifies the crack. This prototype can be used to replace manual labor that is generally used for maintenance and detection of flaws in the railway tracks. This robot is also used to check the ballast conditions and also the surface and near surface of the crack position. It discusses the technical aspects as well as the design aspects of the multi-sensor railway track geometry surveying system in details.**

Keywords—information, GPS, GSM, multi-sensor, ballast, crack, surveying, railway, tracks.

I. INTRODUCTION

Initially, the work done in the field of crack detection was accomplished with the help of ultrasonic sensing techniques, which was thought to be the best solution to detect cracks in railway tracks but later it was found to be affected by external disturbances and hence came to be considered inaccurate. Also, it could not inspect the surface and near-surface cracks, where most of the faults were usually located. LDR sensors cannot be operated in slab tracks, thus limiting its usage. Nowadays, there are methods that use Zigbee technology to detect cracks and also inspect the geometry of the tracks. However, the main disadvantage lies in the longevity of the system. Also, the sensor nodes are to be mounted on the same side of the track to avoid blocking of signals due to the geometry of the passing trains [2]. Our proposed system overcomes these difficulties as it does not require placing the sensors on a particular side of the track. All the sensors are mounted on the same device, thus reducing complexity and space requirement.

GPR systems are already installed in certain railway inspection vehicles to determine ballast conditions. But the method deployed to process such huge amount of data on track inspection, collected by the GPR system, is a tedious one and it can only be used a limited number of times [1]. This complex process can be replaced by using vibration sensors, that are integrated on the track inspection robot. This reduces the cost and time to estimate the ballast conditions and increases efficiency, as more than one operation is performed by the robot at the same time.

In our approach, we are using GPS module for sending the GPS locations of track deformities and sensor alerts wirelessly to the railway authorities, hence making it cost effective and less complex. It has been observed in many examples, such as in traffic acquisition that use vehicular ad hoc networks (VANETS), the vehicles need to have a GPS device and preloaded digital maps to collect traffic information and send it to the user. This makes it more complex and costly as it needs more equipment and storage requirement along with complex computation. So Wireless Sensor Networks (WSN) was proposed to provide a reliable, less complex and low cost method for traffic information acquisition in which various sensor data is communicated wirelessly to user according to his/her query. This shows that wireless data transmission makes the system less complex and more reliable than other types of data transmissions [4]. To provide constant power and to make this prototype sustainable, we are using solar panels along with batteries. In cases, such as maritime wireless communication, which is costlier than land-based wireless communications, solar panels have proved to be effective in reducing its cost [3].

The track detection method that is being proposed in this paper, help to monitor the track damage status by using sensors and wireless modules. A trolley like robot travels over the track and identifies and rectifies the cracks present in the track. A PIC microcontroller is used as a backbone to interface various sensor modules, GPS and GSM modules. When the sensors detect abnormalities in the tracks, they notify and alert the next train coming on the track immediately. The same information can be passed to all trains coming on that particular track. In this prototype, the microcontroller operates the robot to provide wax for joining the cracks. For industrial purpose, this wax material can be replaced with suitable materials. Solar panels are used to make the prototype sustainable and energy efficient.

II.SYSTEM MODEL

The track detection robot that is being proposed in this paper uses a multi-sensor assembly with GPS and GSM modules. The PIC microcontroller coordinates the exchange of information among various modules connected to it. The IR sensor helps in the detection of minute cracks in the tracks. On locating cracks, it signals the track repair kit to pour wax or suitable material to provide an immediate solution. The vibration sensor helps to check the ballast conditions. Metal sensor is used to detect obstacles and explosives found on the tracks. All the information, collected from various sensors, is sent to nearby stations and the next train coming on the track using GPS and GSM modules. This information is used by the authorities to take immediate measures. Solar panels are used to provide a constant power supply along with the batteries. Various repair statuses are displayed on the 2-line alphanumeric LCD display, which is interfaced with the microcontroller unit.

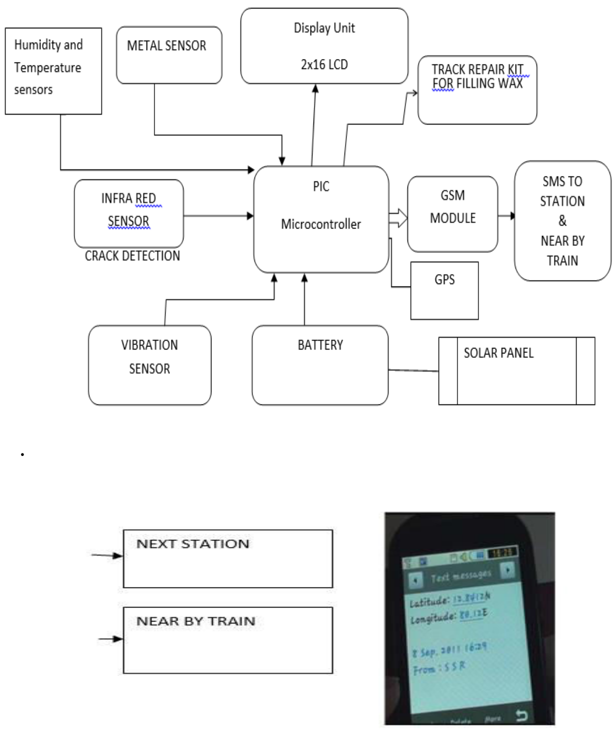


Fig. 1. System Architecture

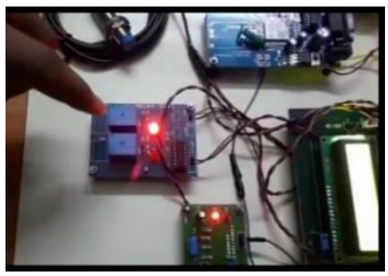
III.METHODOLOGY

The PIC microcontroller acts like the brain of our system which acquires data from various sensors. There are DC motors that are connected to the motor driver unit. The motor driver unit is connected to PIC and this unit propels the robot at a constant speed. When the IR sensor detects any crack present in the railway tracks, the robot stops immediately and the location information is procured using GPS and the SMS alert is sent to the next train and nearby stations respectively using GSM module. Then the track repair kit pours the wax into these cracks and provides an immediate solution. When metal sensor detects any obstacle or an explosive on the surface of the railway tracks, the robot stops immediately and the location information is sent to the railway authorities with the help of onboard GPS and GSM unit. The ballast conditions are checked by vibration sensor and the location information is sent to the railway authority using GSM unit and GPS unit. The prototype has solar panels attached to it that helps in powering up the prototype, making it sustainable.

IV.RESULTS

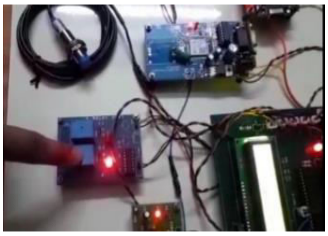
A. *Crack Detection Procedure:*

Two relays are used for controlling the prototype. When a crack is detected by the IR sensor, the left relay switches on as shown in Fig.2(a). The left relay stops the motors and melting of the wax is started by the track repair kit. The LCD displays the message “CRACK DETECTED” followed by the message “REPAIR STARTED” as shown in Fig.2(b). After the repair is completed, the right relay starts working, as shown in Fig.2(c), signaling the end of track repair. The LCD displays the message “REPAIR FINISHED” as shown in Fig.2(d). The location of the cracked region on the track is found out using the GPS module and is sent to the control room using GSM module as shown in Fig.2(e).



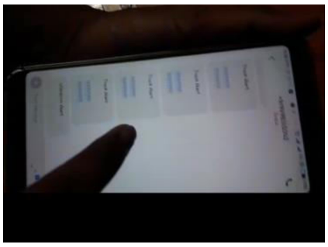
(a)

(b)



(c)

(d)



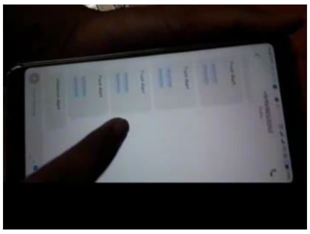
(e)

Fig. 2. Sequential operations performed during crack detection and repair and the corresponding messages displayed by the LCD.

B. Determination of Ballast Conditions:

When the vibration sensor detects any vibration in the railway tracks,the LCD displays "VIBRATION DETECTED" as shown in Fig.3(a) and the location of the defective region on the track is found out using the GPS module and is sent to the railway authorities using GSM module as shown in Fig.3(b).

(a)

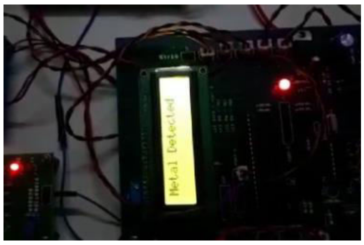


(b)

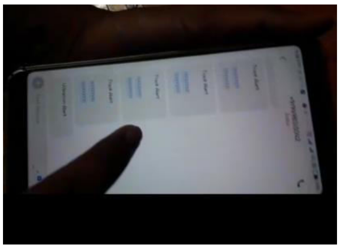
Fig. 3. The message displayed by the LCD after the detection of vibrations in the track and the text message sent to the concerned authorities.

C. Detection of Metal Particles:

When the metal sensor detects any obstacle or any explosives on the tracks,the LCD displays "METAL DETECTED" as shown in Fig.4(a) and the location of this obstacle on the track is found out using the GPS module and is sent to the railway authorities using GSM module,as shown in Fig.4(b).



(a)



(b)

Fig.4. The message displayed by the LCD after the detection of metal in the track and the text message sent to the concerned authorities.

V.CONCLUSION

The prototype discussed in this paper, tries to establish a feasible approach to determine the deformities in the railway tracks. It uses a multi-sensor assembly along with GPS and GSM modules. As sensor values are sent wirelessly to the concerned authorities,this makes the prototype less complex, more compact and cost effective. It also uses solar panels to provide power to the robot, making it sustainable in nature.

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