An Enhanced Crack Detection and Alerting System for Railway Tracks

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Abstract
This paper proposes an advanced approach for the detection of cracks in the railway tracks. The principal problem with the present day system has been the lack of cheap and efficient technology to detect cracks on the railway tracks. If these deficiencies are not controlled at early stages they might lead to a number of derailments resulting in a heavy loss of life and property. The proposed rail crack detection system automatically detects the faulty rail track without any human intervention. This system comprises of GPS module, GSM module, IR sensors, Ultrasonic sensor to bring into operation the crack and object detection. There are many advantages with the proposed system when compared with the traditional detection techniques. The advantages include less cost, low power consumption and less analysis time. By this proposed system the exact location of the faulty rail track can easily be located which will be mended immediately so that many lives can be saved. 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 near future.

Keywords
GPS Module; GSM Module; Derailments; IR Sensors; Ultrasonic Sensors

I. Introduction

Transport is a key necessity for specialization that allows production and consumption of products to occur at different locations. Economic prosperity has always been dependent on increasing the capacity and rationality of transport. But the infrastructure and operation of transport has a great impact on the land and is the largest drainer of energy, making transport sustainability and safety a major issue [3]. In India, it is found that rail transport occupies a prominent position in providing the necessary transport infrastructure to sustain and quench the ever-burgeoning needs of a rapidly growing economy.

Today, India possesses the fourth largest railway network in the world. However, in terms of the reliability and safety parameters, they have not yet reached truly global standards. The principal problem has been the lack of cheap and efficient technology to detect problems in the rail tracks and of course [2], the lack of proper maintenance of rails which have resulted in the formation of cracks in the rails and other similar problems caused by anti-social elements which jeopardize the security of operation of rail transport.

This problem has led to a number of derailments resulting in a heavy loss of life and property. Cracks in rails have been identified to be the main cause of derailments, yet there have been no cheap automated solutions available for testing purposes [9]. Hence, owing to the crucial repercussions of this problem, the proposed system is on implementing an efficient and cost effective solution suitable for large scale application. This 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. Statistics to justify the problem: The Indian Railways, today has 114,617 kilometers (70,598 mi).of total track over a route of 64,974 kilometers (49,752 mi) and 7,084 stations.

II. Literature Survey

The existing conventional signallingsystem depends on the oral communication through telephonic and telegraphic conversations as input for the decision making in track allocation for trains. There is large scope for miscommunication of the information or communication gap due to the higher human interference in the system. This miscommunication may lead to wrong allocation of the track for trains, which ultimately leads to the train derailments. The statistics in the developing countries showing that 80% of worst collisions occurred so far is due to either human error or incorrect decision making through miscommunication in signalling and its implementation. The Anti-collision device system [4] also is found to be ineffective as it is not considering any active inputs from existing Railway signalling system, and also lacks two ways communication capability between the trains and the control centres or stations.

Another approach uses the concept of LDR (Light Dependent Resistor) to detect the cracks [1]. The LED is mounted on one side of the rails and the LDR to the opposite side. During normal operation, the light of LED does not fall on LDR, hence LDR resistance is high. When LED light falls on the LDR, LDR resistance is reduced and the reduction of the amount of light intensity will be nearly proportional. As a consequence, when light from the LED deviates from its path due to the presence of a crack or a break, a sudden decrease in the resistance value of the LDR ensues. This change in resistance indicates the presence of a crack or some other similar structural defect in the rails. In order to detect the Existing location of the device in case of detection of a crack [5], a GPS receiver whose function is to receive the existing latitude and longitude data is used. To communicate the received information, a GSM modem has beenutilized. The function of the GSM module being used is to send the existing latitude and longitude data to the relevant authority as an SMS .The robot is driven by four DC motors. With this existing system only latitudes and longitudes of the broken track will be received so that the exact location cannot be known.

III. Proposed System

Block diagram of the proposed system as shown in fig. 1 contains ARM7 microcontroller, UART, GSM, GPS, UV Sensor, Power Supply, LCD display and Motor driver.

In the proposed project, the robot section we are using ARM based microcontroller LPC2148 which is a 32 bit microcontroller, which oscillates at 60MHZ frequency. All the sensorial units are connected to this microcontroller. A 12v power supply is given to this microcontroller. Robot is driven by 2 DC motors which are connected to microcontroller through relay.

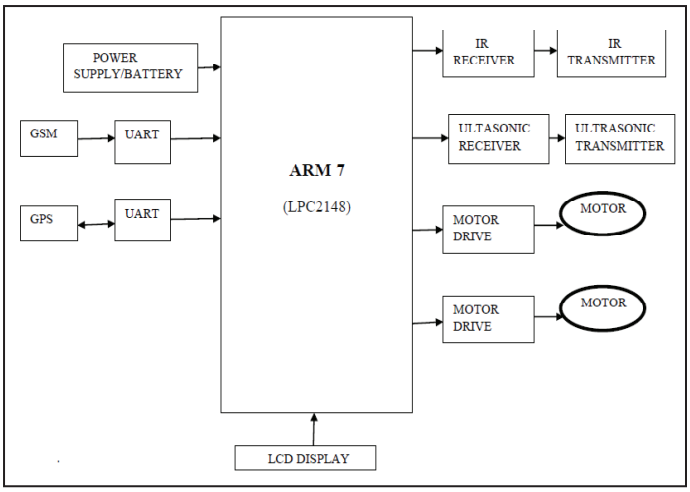

Fig. 1: Block Diagram of the Proposed System

Ultrasonic sensor is connected for detection of obstacle over the track. IR sensor is used to detect the cracks. The accurate position is provided by GPS, and then the warning sent to prescribed mobile number through GSM module. GSM_GPS module is connected to microcontroller through 2 UARTs which are on-board of microcontroller.

IV. Methodology

Proposed approach is useful for railway department to reduce the effort for taking care of track and also the railway crossing management. Basically it consists of modules which are respect to the crack detection, obstacle detection, and railway crossing management. LPC2148 micro-controller is the heart of the system which is based on the arm7 microcontroller architecture. It will interface with all other modules. Microcontroller receives the information from all the modules and processes the data for further uses. Whenever any problem occurs it will give the alerts to the railway department control station. LCD use is to display the robot status.

A. Crack Detection

IR sensor is used to detect the crack and send the information to the microcontroller. It analyses the input and makes robot to stop automatically my providing 0 volts to DC motor. The "crack detected" message is displayed on LCD display of robot section. The position of robot is detected by GPS and information of latitude and longitude is sent to subscribe mobile station through GSM module.

B. Obstacle Detection

Ultrasonic sensor is used to detect the obstacle and sends the information to the microcontroller. It analyses the input, makes robot to stop automatically by providing 0 volt to DC motor. The "obstacle detected" displayed on LCD display of robot section. The position of robot is detected by GPS and information of latitude and longitude is sent to subscribe mobile station through GSM module.

C. Position Detection

When the robot section detect any crack or obstacle GPS module get activated, then it find the latitude and longitude of the position where the crack or obstacle are found. Then through GSM module the location is sent to respected subscriber.

V. Components

A. ARM 7 Microcontroller

LPC2148 is the widely used IC from ARM-7 family. It is manufactured by Philips and it is pre-loaded with many inbuilt peripherals making it more efficient and a reliable option for high end application developer. It has a total of 64 general purpose I/O pins. CPU operating voltage range is of 3.0 V to 3.6 V. It has 8 to 40 kB of on-chip static RAM and 32 to 512 kB of on-chip flash program memory.

B. GSM

SIM300 is a Tri-band GSM/GPRS engine that works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS1900 MHz. This is a plug and play GSM Modem with a simple serial interface. Used to send SMS, make and receive calls and do other GSM operations by controlling it through simple AT commands from micro controllers.

C. IR Sensor

An infrared sensor is an electronic instrument which is used to sense certain characteristics of its surroundings by emittingand detecting the received signal. If a crack is found no reflections from other side is received

D. LCD

A 16*2 LCD display is used to showcase process related information such as "CRACK DETECTED" etc. The supply voltage is 5V and a total of 8 bit data lines are present. RS (Register Select) selects command register if low else data register.

E. GPS

Global Positioning System is a radio navigation system that allows land, sea, and airborne users to determine their exact location, velocity, and time 24 hours a day, in all weather conditions, anywhere in the world. This is used in project to determine coordinates of place where crack and object was detected.

F. Relay

A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a low-power signal or where several circuits must be controlled by one signal. It is used as a motor driver. Here the relay switches from high to low and vice versa based on the signal received from the controller.

VI. Working of the System

The system works in following manner as shown in the fig. 2:

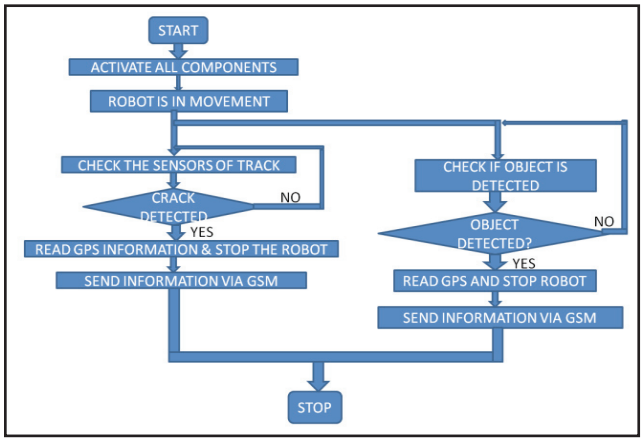

Fig. 2: Flow Chart of the Proposed System

The microcontroller is reset and devices like IR sensor, GPS module, GSM module, LCD display and Ultrasonic sensor are powered up.The system mounted on vehicle is moved through motor controlled as relay by microcontroller.If ultrasonic sensor detects an obstacle while movement, then vehicle is stopped and can be only moved after reset of microprocessor. LCD module displays "OBJECT DETECTED".If track is clear but a crack is detected by IR sensor then vehicle is stopped and moves only after reset of microprocessor. Now the LCD module displays "CRACK DETECTED". The location of crack is monitored by GPS module which sends information (latitude and longitude) to microprocessor through serial transmission. The microprocessor sends the information to GSM module that has SIM inserted in it. The GSM module forwards this location information to registered mobile number. The registered mobile receives location of crack occurrence in track. Corrective action may be taken after by authorized personnel.

VII. Experimental Results

In this proposed method Ultrasonic sensor is used for the detection of crack location. GPS allocates the crack by considering altitude and longitude of crack location. Then message is sent to control room by using GSM.When the crack is detected on the track the text message is send to the preferred number by using the GSM and GPS service.The text message contains the latitude and longitude value of the place where the crack is detected.

Step 1: When all the components are activated, Robot runs continuously on the track until there is no crack on the railway track as shown in the fig. 3.

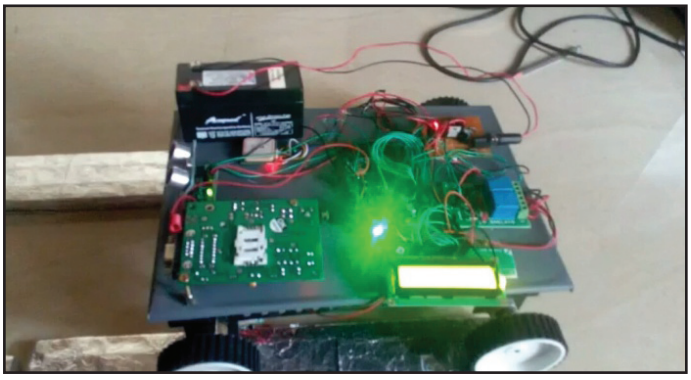

Fig. 3. Crack Detection System

Step 2: When crack is detected by the Infrared sensor on the track then robot stops running. GPS locates the crack and 'CRACK DETECTED' message is displayed and the same is sent to control station through GSM as shown in the fig. 4.

Fig. 4: LCD Displaying Crack Detected Message

Step 3: When any object is detected by Ultrasonic sensor then the robot stops. Location of the object is sent by the GSM to the control station as shown in fig. 5.

Fig 5. LCD Displaying Object Detected Message

Step 4: An alerting message is sent to the concerned authority along with the latitude and longitude values of location where crack or obstacle has been detected as shown in fig. 6.

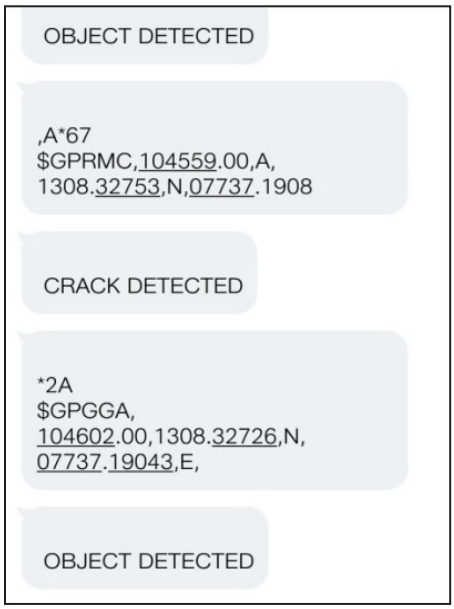

Fig. 6: Messages Received by the Concerned Authority

VIII. Conclusion

The cost of the proposed system is very less.It also checks surface and near surface of the cracking position.Transmitting signals are immediately transferred and accidents are reduced. It can work in any terrain 24*7 and detects cracks accurately. The system is robust and rugged to environmental changes.As more relevant data is acquired it is expected that the present system may assist loco pilot in averting accidents effectively.Since robot is made up of sensor unit it may get damaged anywhere while detecting and power consumption is more.

The project is developed and designed to improve rail track management. The main aim of project is to reduce man power.

By using this project we can detect crack in railway track and obstacle on the track. In the proposed method IR sensor is used to detect the crack and UV sensor is used to detect object on the track. The robotic section continuously checks the crack and obstacle. Location of crack and obstacle is detected by GPS and then send to authority by GSM. The system can be operated in tunnel without any interruptions.

IX. Future Scope

We have developed a prototype of the module. In future this prototype can be taken into production level. Further, most of the modules can be embedded along with the microcontroller in a single board and thereby reduce the size of system. Ultrasonic Sensor and Infrared Sensors are used for detecting cracks and obstacles in the track. This can increase the security for both rails and passengers from crime and terrorism. This system detects single crack after which it must be reset manually. So provisions to control microprocessor remotely that allow reset automatically must be provided. Also drones may be employed that use specialized image processing technique to monitor crack can be employed. DSP processor may be used to analyse severity of crack and report it to maintenance center.

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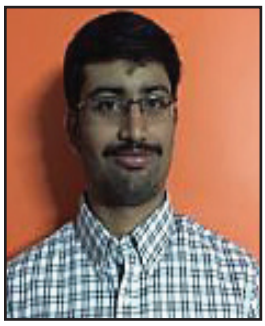

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