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Rail Track Crack Detection System Using IR Sensor Assembly

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ABSTRACT: In India, most of the commercial transport is being carried out by the railway network and therefore, any problems in the same has the capacity to induce major damage to the economy-not with standing the social impact of loss of life or limb. This paper proposes a cost effective yet technical solution to the problem of rail track crack detection utilizing a method that is unique, accurate and effective. The paper discusses the technical aspects in detail and also provides the proposed block diagram, algorithm and model of robust crack detection system. The paper also presents the details of the implementation results of the Microcontroller kit(ATMega328) with arduino UNO board utilizing simple components inclusive of a GPS module, GSM Modem and IR transmitter n receiver based crack detector assembly. The proposed scheme has been modeled for robust implementation in the Indian scenario.
The railway track crack detecting system using IR sensor is used to detect both the minor and major cracks. The circuit design for such a system is built with IR sensor assembly, Microcontroller ATMEGA 328, GPS and GSM module. The system is supported by battery and 4 DC motors. The main part comprising of the IR sensor. In this our target is to detect the crack and send SMS to the registered mobile number of respective authority by using GSM module.

KEYWORDS: Railway Cracks, Arduino, IR transmitter and receiver sensor assembly, GSM, GPS, Robot.

I. INTRODUCTION

In today's world, transport is a key necessity because in its absence it would be impossible for products to be consumed in areas which are not in the immediate vicinity of the production centers. Throughout history, transport has been a necessity for the expansion of trade. Economic prosperity can be achieved by increasing the rationality and capacity of transport systems. The proper operation and maintenance of transport infrastructure has a great impact on the economy. Transport, being one of the biggest drainers of energy, its sustainability and safety are issues of paramount importance. In India, rail transport occupies a prominent position in quenching the ever burgeoning needs of a rapidly growing economy. However, in terms of the reliability and safety parameters, global standards have not yet been truly reached.

The Indian railway network today has a track length of 123,000 kilometres (76,428 mi).over a route of 63,974 kilometres (39,752 mi) and 7349 stations(as per 2019). It is the fourth largest railway network in the world exceeded only by those of the United States, Russia and China. The rail network traverses every length and breadth of India and is known carry over 30 million passengers and 2.8 million tons of freight daily. Despite boasting of such impressive statistics, the Indian rail network is still on the growth trajectory trying to fuel the economic needs of our nation. Though rail transport in India growing at a rapid pace, the associated safety infrastructure facilities have not kept up with the aforementioned proliferation. Our facilities are inadequate compared to the international standards and as a result, there have been frequent derailments that have resulted in severe loss of valuable human lives and property as well. To demonstrate the gravity of the problem, official statistics say that there have been 11 accidents in 2011 till the month of July alone, which leaves much to be desired. On further analysis of the factors that cause these rail accidents,

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Vol. 7, Issue 7 , July 2020

recent statistics reveal that approximately 60% of all the rail accidents have derailments as their cause, of which about 90% are due to cracks on the rails either due to natural causes (like excessive expansion due to heat) or due to antisocial elements. Hence these cracks in railway lines have been a perennial problem, which has to be addressed with utmost attention due to the frequency of rail usage in India. These cracks and other problems with the rails generally go unnoticed due to improper maintenance and the currently irregular and manual track line monitoring that is being carried out. The high frequency of trains and the unreliability of manual labour have put forth a need for an automated system to monitor the presence of crack on the railway lines.

Owing to the crucial repercussions of this problem, this paper presents an implementation of an efficient and cost effective system suitable for large scale application.

With the advent of powerful digital IR , Image Processing techniques [1] have been explored to formulate solutions to the problem of railway crack detection. Though it provides good accuracy, this method uses techniques like image segmentation, morphology and edge detection all of which take a lot of processing power and an extreme amount of time rendering the robot slow and thereby unsuitable. Recent research has investigated the use of microwave horn antennas for crack detection [2]. This technique was found to produce very accurate results in lab based testing. But, unfortunately it requires spectrum analyzers which are both costly and also can't be placed onboard a moving robot because of their delicacy. Ultrasonic sensor based approach [3]. It fails to detect surface cracks which are sometimes responsible for major damages. Eddy Current method [4] uses two detection coils which can balance out the large base line signals. corresponding to normal rail. this method finds out rail defects by demodulating differential signals of two coils but due to the non availability of completely cleaned tracks the results were failed to reach the expected.Visual inspection method[5] the present method used by the Indian railways to detect the cracks by a person named as keyman. This was time consuming and human resource dependent. LED-LDR method[6] in which rail tracks are fitted with LED and LDR on either sides of the track and until there is no fault LDR does not receive light emitted by LED hence resistance will be high.when there is crack LDR receives light through the gap and resistance of LDR reduces. In this way fault is detected.

II. FIELD ANALYSIS

❖ Reasons for crack

- Manufacturing defects
- Environmental factors

❖ Types of cracks

- Minor crack-cracks within 32mm
- Major crack-cracks above 32mm

Fig 2.1: crack above 32mm

ISSN: 2350-0328
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Vol. 7, Issue 7 , July 2020

- **Track manufacturing materials**
  - Iron Rails
  - Pre stressed concrete(PSC) sleepers
  - Steel sleepers for traction bridges
  - Guard rail for derailment
- **Methods to repair the crack**
  - **Temporary method:** If the crack is below 32mm this method is used

a. **Free rail clamper** : When the track is straight two ends of the crack is inserted between free rail clamper which is suitable and efficient method.

b. **Fish plate clamper**: When the track is curvy two ends of the crack is inserted between the fish plate and the rail is joined.

- **Permanent method:** If the crack is above 32mm this method is used

TYPES OF TRACK STRUCTURES IN INDIA:

- Free rail track(13mtr)
- Short welded(26mtr)
- Long welded(65mtr)

TRACK MEASUREMENTS (between two rails)

- Broad gauge -1676mm
- Meter guage–1000mm
- Narrow gauge– 650-762mm

Distance between two sleepers is 65 cm. During crossing it decreases to 60 cm.

Special features of bridge tracks

- These tracks are employed with steel sleepers.
- Guard rail: To avoid derailment.
- Apron: for mechanical support instead of ballast.
- Switch expansion joint.

III. MATERIALS REQUIRED

A. Hardware requirements

1 Microcontroller ATMega328

An AT Mega328 in DIP package, pre-loaded with the Arduino UNO and Arduino Duemilanove Boot loader. This will allow using Arduino code in custom embedded project without having touse an actual Arduino board. To get this chip working with Arduino IDE, you will need an external 6MHz crystal or resonator, a 5V supply, and a serial connection.

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Vol. 7, Issue 7 , July 2020

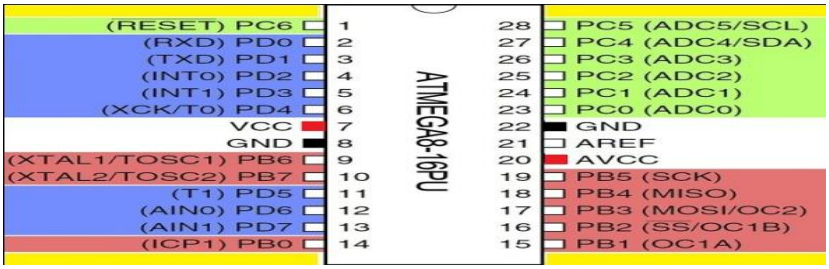

Fig 3.1: Pin diagram of ATMega328

Atmel's AT Mega328 8-Bit Processor in 28 pin DIP package. It's like the AT Mega168, with double the flash space 32K of program space, 23 I/O lines, 6 of which are channels for the10-bit ADC and runs up to 20MHz with external crystal.

2 Navigation and ranging

For detecting the location of the faulted track, a navigation system has been used. The global position system works on the principle in which each satellite incorporated transmits messages consisting the parameters. The location is computed by analysing the transit time taken by the message and speed of light. This GPS module is used to provide the coordinate of faulty track in terms of longitude and latitude parameters to a predefined number or concerned authority.

3 Emergency calling system

Global System for Mobile communication that is GSM(SIM900) is capable of operating at Regardless of whatever frequency selected by the operator it automatically gets divided into time slots to be used by each cell phone. The band described for 2G frequency range 900 MHz to1800 MHz bands.GSM Modem from rhydo LABZ is built with SIMCOM Make SIM900 Quad-band GSM engine, works on frequencies 850 MHz, 900 MHz, 1800 MHz and 1900 MHz It is very compact in size and easy to use as plug in GSM Modem. The baud rate can be configurable from 9600-115200 through AT command. Initially Modem is in Auto baud mode. It is suitable for SMS as well as DATA transfer application in M2M interface. The modem needed only 3 wires (Tx, Rx, GND) except Power supply to interface with Arduino microcontroller.

4 Sensor network arrangement

The proposed system uses two entities to form a complete sensor network described as:

- IR Transmitter

An IR LED, also known as IR transmitter, is a special purpose LED that transmits infrared rays in the range of 760 nm wavelength. Such LEDs are usually made of gallium arsenide or aluminium gallium arsenide. They, along with IR receivers, are commonly used as sensors. The appearance is same as a common LED.

- OPT101 (IR Receiver)

The OPT101 is a mono11lithic photodiode with on-chip transimpedance amplifier. Output voltage increases linearly with light intensity. The 0.09 x 0.09 inch photodiode is operated in the photoconductive mode for excellent linearity and low dark current. The OPT101 operates from +2.7V to +36V and quiescent current is only 120μA. It is available in clear plastic 8-pin DIP, and J-formed DIP for surface mounting. Temperature range is 0°C to +70°C.

5 Battery (12V)

An electric battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell contains a positive terminal, or cathode, and a negative terminal, or anode. Electrolytes allow ions to move between the electrodes and terminals, which allows current to flow out of the battery to perform work.Batteries operate by converting chemical energy into electrical energy through electrochemical discharge reactions. Batteries are composed of one or more cells, each containing a positive electrode, negative electrode, separator, and electrolyte. Cells can be divided into two major classes: primary and secondary. Primary cells are not rechargeable and must be replaced once the reactants are depleted. Secondary cells are rechargeable and require a DC charging source to restore reactants to their fully charged state.

ISSN: 2350-0328
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Vol. 7, Issue 7 , July 2020

6 DC MOTOR

The DC Motor is a machine that transforms electrical energy into mechanical energy in the form of rotation. Its movement is produced by the physical behaviour of electromagnetism. DC Motors have inductors inside, which produce the magnetic field used to generate movement. The basic working principle of DC Motor is whenever a current carrying conductor is placed in a magnetic field it experiences a mechanical force. The direction force is given by the Fleming's left hand rule and its magnitude is given by

F=BIL where

F = force experienced by conductor in Newton
B= magnetic field in tesla
I= current through conductor in Amperes
L=length of conductor in metres

B. Software Requirements

- Tool : Arduino Beta and Arduino Alpha
- Program language : Arduino C/C++.

Arduino programs are written in C or C++. The Arduino IDE comes with a software library called "Wiring" from the original Wiring project, which makes many common input/output operations much easier. The users need only to define two functions to make an executable executive program.

- Setup (): a function run once at the start of a program that can initialize settings.
- Loop (): a function called repeatedly until the board powers off.

IV. METHODOLOGY

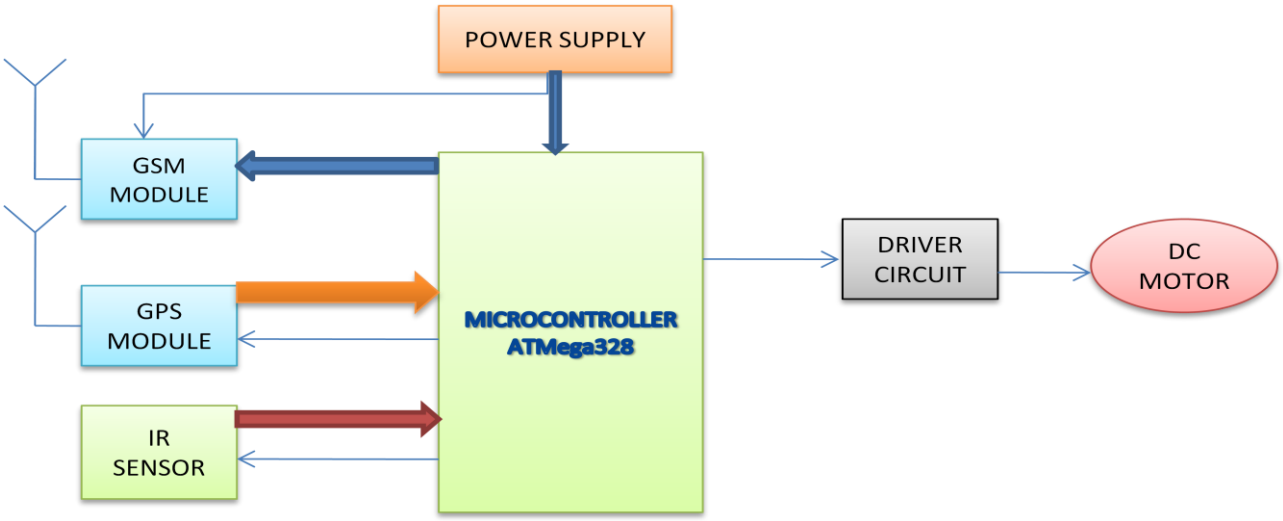

Fig. 4.1. Block diagram of the system

The Robot movement is controlled by RF transmitter, receiver module through the mobility of the wheels powered by DC motors as the system inherits IR transmitter on one side of track and optical sensor on other side of the track. When the system is on, the wheels rotate in forward direction and IR transmitter gets activated, the output value of the optical sensor remains low until no cracks are detected. The system uses the concept of sensor network with GSM and GPS module to determine the cracks on railroad. Whenever a crack is detected, IR rays directly fall on the optical sensor. The output value of the optical sensor is directly proportional to the intensity of light incident on it. Hence the soul concept lies on the fact that, when the received value is greater than the threshold value determines whether a crack is

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there or not. When a crack is detected robot stops its motion and GPS fetches the locations. after a certain time delay this is sent to nearer railway station via GSM module. regulator changes the polarity of the voltage supplied to the motor and motor reverses back to initial position. A huge rail path can be surveyed with a single automated robot in a perfect way.

V. CONCLUSION

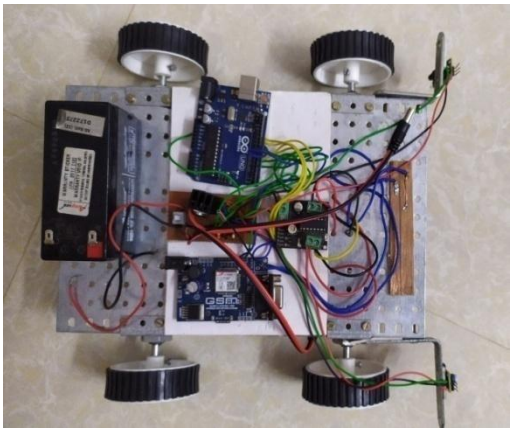

Fig 5.1: Working model

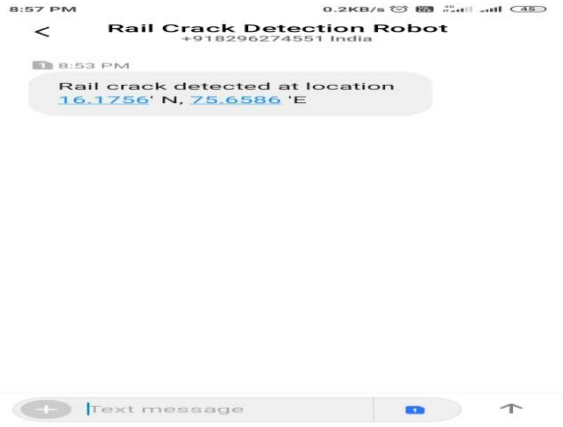

Fig 5.2: Location of crack detected sent through message

It is intellectual and technical based approach which is accurate and advanced. The detection of crack with respective coordinates helps immediate repair of cracks without negligence and saves lives as well as national loss.This method is also implied to the rails on bridges which is impossible by keyman routinely.

VI. THANKS

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