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Automatic Broken Rail Crack Detection Scheme

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ABSTRACT
In India, as the fuel cost continues to rise, railway transport plays an important role. Although there are, so many options of transportation are available like flights, trains, buses etc but most of the people prefer trains only as it is cost effective and comfortable way of travelling and hence in today's world railway becomes the lifeline of India. When anybody goes through the daily news, they come across many accidents which are related to railroad. So there must be good railway safety for the people as the rail accidents are often dangerous in terms of the severity and death etc, when compared with the other transportation. There are several reasons present for railroad related accidents but the major reason is cracks in rails. It is the main cause of railway derailments and has the capacity to induce major damage to economy of the world. Therefore more efforts are necessary for achieving the good rail safety. This system introduced a method for rail crack detection. The proposed system is LED-LDR and Arduino based rail track detection scheme. It is cost effective and simple way of monitoring the condition of the rails on a continual basis for the improving the railway safety which consists of GSM module and Encoder.

Keywords - **Arduino Uno, Railway Cracks, LED-LDR assembly, GSM, Encoder, Robot.**

I. INTRODUCTION

In today's world transport is an important factor because in its absence it would be impossible for people to reach from one place to another. As there are so many transportation options are available with all people but, majority of people gives priority to trains only for long time journey. The Indian Railway network is the largest rail-passenger transport and it is now the backbone of the country's transport infrastructure. In India, most of the commercial transport is being carried out by the railway network because it is being cheapest mode of transportation preferred over all other means of transportation such as buses, flights etc. The rapidly improving economy of India has resulted in an exponentially increasing demand for transportation in recent years, and this has resulted into a very huge rise in the volume of traffic in the Indian Railway network. Transport is a key necessity for specialization that allows production and consumption of products to occur at different locations [1]. Economic prosperity has always been dependent on increasing the capacity and rationality of transport [1]. But the infrastructure and operation of transport has a great impact on the land and is the largest resource of energy, making transport sustainability and safety a major issue [1].

The Indian railway is an enterprise under the Indian nation which is owned and handled by the Government of India. It's the one of the world largest railway network comprising 115,000km of track over a route of 65,000km and 7,500 stations [2]. Today, India possesses the fourth largest railway network in the world exceeded only by those of the United States, Russia and China. The railways traverse the length and breadth of the country and carry over 30 million passengers and 2.8 million tons of freight daily [1]. In spite of, making proud of such great information, the Indian rail network is still on the developed trajectory trying to fuel the economic needs of Indian nation. However, in terms of reliability and protective parameters, India has not yet reached truly global standards. Though rail transport in India growing at a fast rate, the associated railway safety infrastructure facilities have not kept up with the aforementioned proliferation.

When anybody goes through the daily news of the newspaper they come to know that there are many accidents in railroad railing. Railroad related accidents are occurred mostly due to the major cracks in rails. Therefore railroad related accidents are quite dangerous than other transportation accidents in terms of severity and death etc. Facilities are not sufficient 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 [3]. The principal problem has been the lack of cheap and efficient technology to detect problems in the rail tracks and definitely, the lack of regular maintenance of rails which have resulted in the formation of cracks in the rail track and other

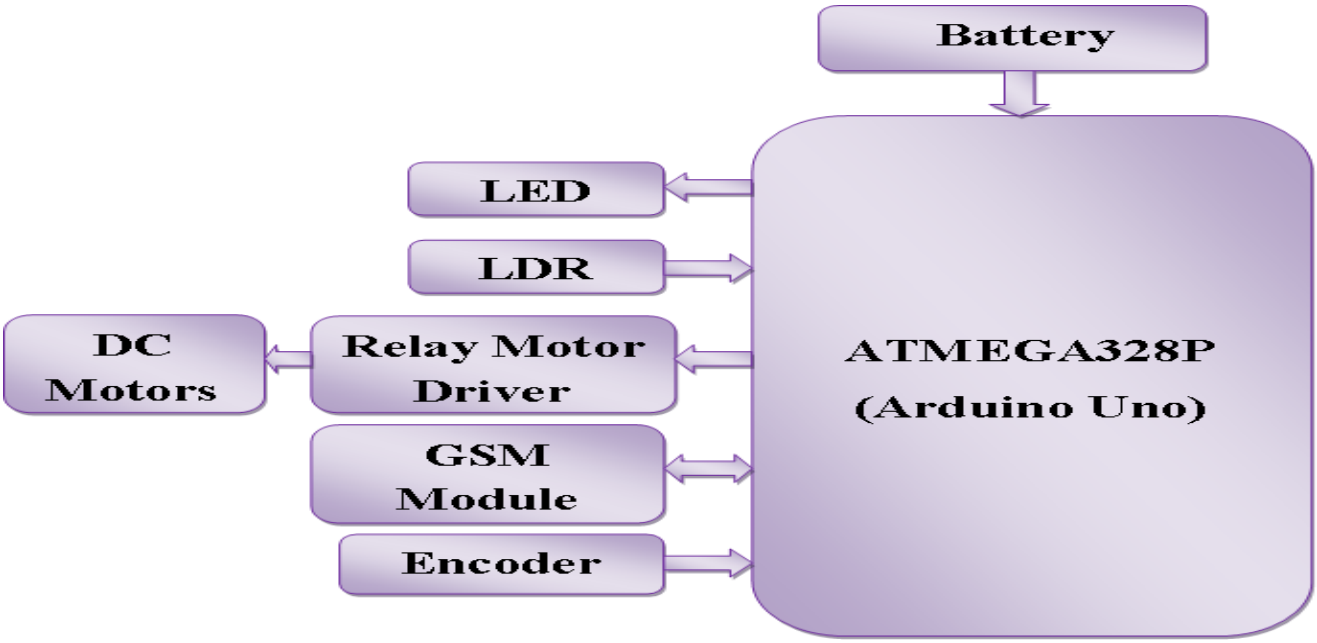

Figure 1: Block Schematic of Rail Crack Detection Scheme

similar problems caused by anti-social elements which jeopardize the security of operation of rail transport [1].

Recent statistics shows that approximately 60% of all the rail accidents have their reason as derailments, out of which about 90% are due to cracks or breaks in rails either due to natural causes (like excessive expansion due to heat) or due to anti- social elements(like due to bomb blast). Out of 100 accidents seven takes place due to the features tracks. According to railway own estimate remaining takes place by combination of problems such as human error, engineering defects, natural climates and storage. Therefore more efforts are necessary for improving the railway safety of the world.

Railway safety is difficult aspect of rail operation the world over. Faulty performance resulting into railroad railing accidents usually get wide media coverage even when the railway is not at fault for railroad railing accidents, among uniformed public, an unsuitable image of inefficiency often fuelling calls for immediate reforms.

II. LITERATURE SURVEY

There are so many methods have been used for prompt detection of the conditions in rails. With the introduction of powerful Digital Signal Processors, Image Processing techniques have been searched to give solutions to the problem of railway crack detection. These methods provides good accuracy but it uses techniques like image segmentation, morphology and edge detection all of which take a lot of processing power and a large amount of time means these methods are costly and time consuming resulting into the robot speed slow and thereby unsuitable [3]. Hence to guarantee the safe operation of rail traffic non-destructive inspection techniques are used to detect defects on rails.

Non-destructive testing method provides different ways for detecting rail defects. From definition non-destructive testing is the testing of materials, without interfering in any way with the integrity of the material or its suitability for service. In other words can be explained as, it is the way for defining that good is good. The method can be applied on a sampling basis for individual examination or may be used for 100% checking of material in a production quality control system. (Non Destructive Testing) NDT techniques give number of tools or ways for people to choose. So various method of NDT are ultrasonic crack detection methods, magnetic particle inspection methods, radiography methods, eddy current techniques, thermal field methods, dye penetrant or liquid penetrant methods, fibre optic sensors of various kinds.

Among all the available detection methods used to make sure rail integrity, the common ones are visual inspection, ultrasonic inspection and eddy current inspection. Among all the available methods Visual Inspection is the oldest and cheapest method. However, in case of Indian scenario, the visual form of inspection method is mostly used, though it produces the poorest results of all the available methods.

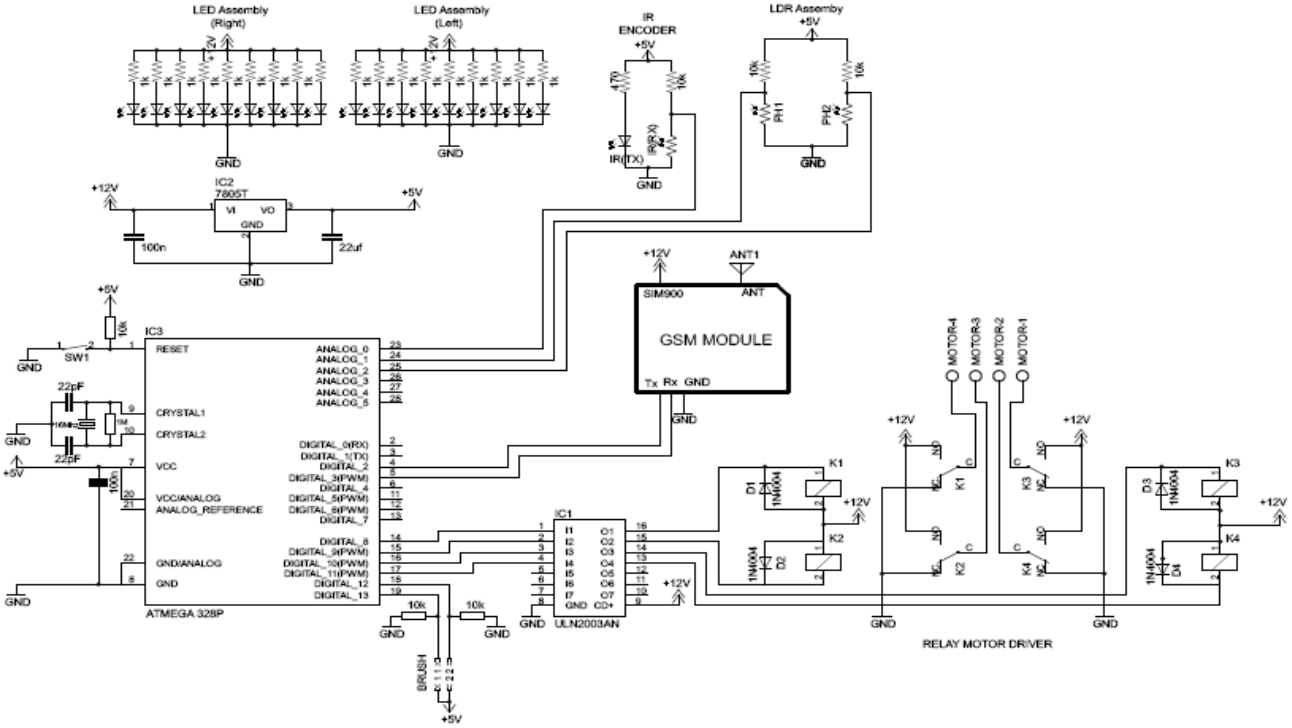

Figure 2: Circuit Diagram of Rail Crack Detection Scheme

Ultrasonic Inspections [4, 5 and 6] are common methods in many foreign countries for rail crack detection. However, Ultrasonic can only inspect the core of materials; that is, the method cannot check for surface and near-surface cracking where many of the faults are located [3]. Eddy current [7 and 8] method is used to overcome this disadvantages associated with ultrasonic and microwave horn antenna techniques. In Dye penetrant method test material is coated with visible dye solution then excess dye is removed from the surface then by using ultrasonic lamp anyone can detect the crack in rail but there are a number of problems inherent with this technique also.

Current system uses the LED-LDR assembly with the GPS and GSM module. In order to detect the current location of the device in case of detection of a GPS receiver whose function is to receive the current latitude and longitude data is used. To communicate the received information, a GSM modem has been utilized. The function of the GSM module being used is to send the current latitude and longitude data to the relevant authority as an SMS. With this current system only latitudes and longitudes of the broken track will only be received so that the exact location cannot be known [3].

The problem inherent in all these techniques are that the cost occurred is high. Hence this paper proposes a cheap, novel, yet simple scheme suitable for the Indian scenario. This proves to be cost effective way as compared to the all available methods [9 and 10].

III. SYSTEM DEVELOPMENT

The main aim of the proposed scheme is to develop the inspection method that will detect the crack of rail and to measure exact distance of crack from starting station.

A. Block Schematic

The proposed rail track detection system block schematic is shown in Figure 1, which consists of Arduino Uno Controller, Encoder, GSM Module, LED-LDR Assembly, DC Motors and Relay Driver. This section explains the module wise operation of the rail crack detection system architecture. This block diagram consists of two inputs namely IR transmitter-receiver encoder and LED-LDR assembly and the output in this proposed system is GSM module and DC motors.

1) Microcontroller: The Arduino Uno board consists of the ATmega328P microcontroller which forms the brain of this proposed scheme. Arduino Uno simplifies the coding and debugging process as the Arduino Integrated Development Environment is an open source project. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It has all the required pins to interface peripherals and contains everything on board needed to support the microcontroller; simply we just need to connect it to computer with an USB cable or power it with an AC-to-DC adapter or battery to get started.

The board can operate on an external supply of 6 to 20 volts[11].

2) *Encoder:* Encoder used in the proposed scheme is the new idea because; Encoder is used calculate the exact distance of crack from starting point. Encoder consists of IR transmitter-receiver pair. Encoder generates pulse according to the each rotation of shaft or wheel and analog readings of IR Encoder will be converted into digital reading by inbuilt ADC converter of the microcontroller. Each rotation of wheel gives a definite number of pulses which we can count in the microcontroller. We can calculate the number of pulses for a specific period and can know how much revolution the shaft has taken. By calculating the revolution of the wheel or shaft we can easily find out the distance covered by the wheel by measuring the circumference of the wheel or shaft.

3) *GSM Module:* The SIM 900 GSM module is used to achieve the SMS functionality [12]. GSM module communicates with Arduino Uno using serial communication. Serial communication uses two pins of microcontroller that is the transmitter and receiver. GSM basically used for communication purpose which will transmit a SMS to the relevant authority when proposed system detects the crack in the rail.

4) *LED-LDR Assembly:* LED-LDR assembly basically used for rail crack detection system and this assembly is the core of the proposed scheme. In LED-LDR assembly cadmium sulphide LDR is used to monitor the light intensity falling upon it and this light will be produced by the LED assembly. Crack will be detected by the changes in the resistance of LDR. 12V supply to the LED assembly is given by the battery.

5) Relay Driver: As during working process of the robot it does not require change of speed and for driving DC motors it requires 12V supply hence ULN2003 relay driver will convert the 5V supply of Arduino Uno into 12V power circuit.

6) *DC Motor:* The proposed design uses 4 permanent magnet DC motors interfaced with the Arduino Uno with a wheel diameter of 7 cm. Each of 12V running at speed of 1800 rpm. This 1800 rpm then stepped down to 30 rpm by a gear box of ratio 1:60. Two DC motors are used for left side of rail and other remaining two are used for right side of rail for driving robot.

B. Circuit Diagram

To ensure robustness and easy implementation, the principle idea of the system has been kept very simple. Circuit Diagram of rail crack detection scheme is shown in Figure 2, which consists of Arduino Uno Board, the Encoder, the relay driver, LED-LDR assembly and GSM module.

In LED assembly, we can use 5mm white bright colored LED's which produce high amount of intense light. There is series resistance of value 1KΩ with the LED's. Such 9 LED's are connected parallel for a single side. Voltage provided to them is 12V then by Ohm's law, current flowing through the individual LED would be 12mA which is sufficient enough to glow a LED. In the proposed design, the LED assembly is attached to one side of the rails and the LDR to the opposite side. During normal operation, means whenever there are no cracks, the LED light does not fall on the LDR and hence the LDR resistance increases. Alternatively, when the LED light falls on the LDR, the resistance of the LDR gets reduced and the amount of reduction will be approximately proportional to the intensity of the incident light. As a result, when light from the LED fluctuates from its path due to the presence of a crack or a break in rail track, a sudden decrease in the resistance value of the LDR takes place. This change in resistance of LDR indicates the presence of a crack in rail track. A potential divider circuit is used to convert this change of resistance into voltage.

In proposed system 12V relay driver is used to drive 12V DC motors. The relay driver is more reliable than the H-Bridge MOSFET circuit as some times due to high current surge the H- Bridge motor driver burns out resulting into the failure of budget. The ULN2003 converts the 5 volt supply of the microcontroller into 12V.

In order to detect the current location of the device in case of detection of a crack encoder is used, which consists of IR transmitter-receiver pair. Encoder basically used for measuring the distance of the fault occurring point from the starting point or station. In IR transmitter-receiver again potential divider circuit is used to measure the change in the resistance of the IR receiver. When any obstacle comes in front of the IR transmitter-receiver pair the voltage across the voltage divider circuit reduces. This reduced voltage is sensed by the microcontroller and the event of occurrence of obstacle is considered which comes in front of IR transmitter-receiver pair. This concept can be used to find the distance of the robot travelled and then the GSM module successfully transmits the current coordinates obtained from encoder and microcontroller.

There are number of hair line cracks are also present on railway track which are not visible to our naked eyes. For the detection of minor crack the principle of conductivity is used. Potential of 5V will be provided to one end of the rail and the output would be taken from the other end and the other end would be pull down to ground with resistor of 10K. The output would be attached to pin no 12 and 13 for detecting the crack on right and left rail respectively.

IV. ALGORITHM

Step 1. Include the GSM library to access the GSM module.

Step 2. Initialize all the variables that we are using in the program
Step 3. Initialize the functions that would be used.
Step 4. Define the INPUT and the OUTPUT pins for the microcontroller.
Step 5. Initialize the GSM module.
Step 6. Check if the GSM module is ready, if not return to Step 5, and print the error message, if GSM module responds then proceed.
Step 7. Get the analog readings from the LDR sensor and the IR Encoder.
Step 8. Convert them into digital values.
Step 9. Set a reference values for the sensors.
Step 10. Check if there is any error in the rail route by comparing the LDR sensor values with the reference value set.
Step 11. Count the number of times the IR Encoder sensor gets obstacle and convert this count into distance.
Step 12. If error is found print the respective error message, and send the respective error message through a SMS. Also include the distance at which the error has occurred.
Step 13. If any of the error is not found than go back to Step 7 and repeat all the above Steps, till any error is detected.
Step 14. STOP.

V. RESULTS AND DISCUSSIONS

The proposed Arduino based rail crack detection system is suitable for detecting cracks in the rail track including minor cracks automatically by simple and cost effective way. IR transmitter-receiver pair is used to measure exact distance of crack from home station. A rotatory disk is placed upon the wheel or shaft which is having slots along its circumference. By placing the IR transmitter-receiver pair in front of this disk anyone can count the number of slots on the rotatory disk when it rotates. Thus, anybody can count the number of slots passing in front of the IR transmitter-receiver pair. When any obstacle comes in front of the IR transmitter-receiver pair the voltage across the voltage divider circuit reduces. This reduced voltage is sensed by the microcontroller and the event of occurrence of obstacle is considered which comes in front of IR transmitter-receiver pair. This concept can be used to find the distance of the robot travelled. Table 1 shows the displayed distance which we can receive through SMS shown in Figure 3 and measured distance (which can measure with the help of scale). Thus taken the different readings of crack from starting point and compared that displayed readings with the measured readings. From this comparison it is observed that the error occurred between these two readings is very low which is tolerable means this proposed system gives the exact distance of crack from home station or the starting station.

Table 1: Observatios of Detected Crack Distance

Sr.No.	Measured Distance	Displayed Distance through SMS	Error
1	0.085m	0.09m	0.005
2	0.14m	0.15m	0.01
3	0.165m	0.17m	0.005
4	0.255m	0.26m	0.005
5	0.285m	0.29m	0.005
6	0.315m	0.32m	0.005
7	0.436m	0.44m	0.004
8	0.455m	0.46m	0.005
9	0.5m	0.52m	0.02
10	0.62m	0.64m	0.02

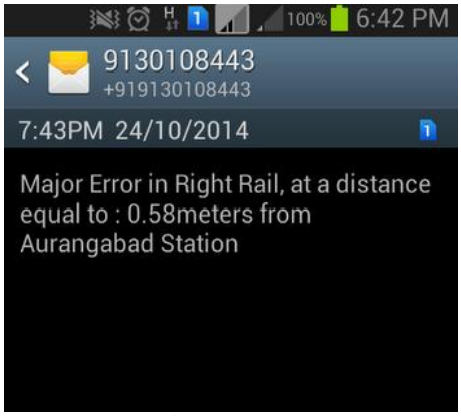

Figure 3: Distance of Detected Crack Received as SMS

VI. CONCLUSIONS

The proposed rail crack detection scheme possesses many advantages such as fast monitoring and reporting system, low cost, low power consumption and less analysis time. Also the easy availability of the components makes an ideal project for industrial use with very little initial investment. So the current location device on rail track can easily be measured from home station. By this proposed model many lives can be saved by avoiding accidents. In future this proposed system can be used with complex system for detecting other rail defects as well and it can be implemented simultaneously on different track for detecting crack in rails.

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