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An Inspection System for Detection of Cracks on the Railway Track using a Mobile Robot

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***Abstract*— In India rail transport occupies a prominent position in providing the necessary transport infrastructure to sustain 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, we have not yet reached truly global standards. The main problem about a railway analysis is detection of cracks in the structure. 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. This paper proposes a cost effective solution to the problem of railway track crack detection utilizing IR sensor array assembly which tracks the exact location of faulty track, then inform to nearby railway station through short messaging application, so that many lives will be saved.**

Keywords*— Arduino microcontroller, IR sensor array, Ultrasonic sensor, GSM (Global System for Mobile communication)

I. INTRODUCTION

The Indian railways are the largest railway passenger transport in today's world and it is the backbone of 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. The rapidly developing economy of India has resulted in an exponentially increasing demand for transportation in recent years and this has resulted into an enormous 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. Transport has throughout history been a spur to expansion as better transport leads to more trade. 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 drainer of energy, making transport sustainability and safety a major issue. In India, we find 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 [4]. The Indian railway network today has a track length of 113,617 kilometers (70,598 mi).over a route of 63,974 kilometers (39,752 mi) and 7,083 stations [11]. 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. In terms of the reliability and safety parameters, we have not yet reached truly global standards. Though rail transport in India growing at a rapid pace, the associated safety infrastructure facilities have not kept up with the aforementioned proliferation.

When we go through the daily newspaper we come across many accidents in rail-road railing. Rail-road related accidents are more dangerous than other transportation accidents in terms of severity and death etc. 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 [6]**.** The principal problem has been the lack of cheap and efficient technology to detect problems in the rail tracks and of course, 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.[4]

Analysis of the factors which causes these rail accidents recent statistics shows that approximately 60% of all the rail accidents have their cause as derailments out of which 90% is due to cracks or breaks in rails either due to natural causes like excessive expansion due to heat or due to anti-social elements. These problems with the rails generally go unobserved due to lack of proper maintenance and the currently irregular and manual track line monitoring that is being carried out in the current situation. Therefore more efforts are necessary for improving safety. Railway safety is the crucial aspect of rail operation the world over. Malfunction resulting in accidents usually get to wide media coverage even when the railway is not at fault and give to rail transport among uniformed public, and undeserved image of inefficiency often calls for immediate reforms.

II. RELATED WORK

The prompt detection of the conditions in rails that may lead to crack or rather a break now plays a critical role in the maintenance of rails worldwide. With the arrival of powerful digital signal processors, image processing techniques have been searched to formulate solutions to the problem of

railway crack detection. In spite of the fact that these methods provides good accuracy, it uses techniques like image segmentation, morphology and edge detection all of which take a lot of processing power and an extreme amount of time causing the robot speed slow and thereby inconvenient. The understanding of these mechanisms is constantly improving and to guarantee the safe operation of rail traffic non-destructive inspection techniques are used to detect damages on rails. Now-a-days rails are exposed to a constant increasing very dense overall traffic with heavy loads and high speed trains.

Non-destructive testing is one part of the function of quality control and is complementary to other long established methods. By definition non-destructive testing is the testing of materials, surface or internal flaws or metallurgical condition without interfering in any way with the integrity of the material or its suitability for service. In other words non-destructive testing is not just method for rejecting substandard material. It is also an assurance that the supposedly good is good. The evolution of a range of complementary NDT (Non-Destructive Testing) techniques has resulted in a number of tools for us to choose from such as acoustic, emissions or ultrasonic methods, magnetic field methods, radiography, eddy current techniques, thermal field methods, fiber optic sensors of various kinds.

Among the inspection methods used to ensure rail integrity, the common ones are visual inspection, ultrasonic inspection and eddy current inspection. Visual inspection is the oldest of all the methods. Components are scanned visually, sometimes with an aid of low or high power lenses, fiber scopes, cameras and video equipment, to determine surface condition. However, in the Indian scenario we find that the visual form of inspection is widely used though it produces the poorest results of all the methods. It is now becoming widely accepted that even surface cracking often cannot be seen with the naked eyes. As a result this method can be costly, time consuming and ineffective for large and complex structural systems such as the rail track. Ultrasonic inspection [4, 5 and 6] is common place in rail industry in many foreign countries. It is relatively well understood technique and was thought to be the best solution to crack detection. However ultrasonic can only inspect the core of material that is, the method cannot check for surface and near surface cracking where many of the faults are located [3]. Microwave horn antenna [4] technique for crack detection was found to produce very accurate results in lab based testing. But it requires spectrum analyzers which are both costly and also cannot be placed on board a moving robot. Eddy current [7, 8 and 9] method is used to overcome this limitation associated with ultrasonic and microwave horn antenna techniques. They are effectively used to check for cracks located at the surface of the metals such as rails. Further MPI (Magnetic Particle Inspection) is also used in rail industry but there are number of problems inherent with this technique some of which are mentioned below:

- Surface of the rail or component must first be cleaned of all coatings, rust and so on.
- To get sensitive readings, contrast paint must first be applied to the rail, followed by the magnetic particle coating.
- The same inspection must then be carried out in two different directions at a very slow overall speed.
- The problem inherent in all these techniques is that the cost incurred is high.

III. CURRENT SYSTEM

In the current system the core of the crack detection method consist of Light Emitting Diode (LED), Light Dependent Resistance (LDR) assembly that functions used to detect the cracks in a railway track. In this assembly, LDR is used to monitor the light intensity following upon it. In the current system the LED is attached to one side of the rail and the LDR to the opposite side. During normal operation, when there are no cracks the LED light does not fall on the LDR and hence the LDR resistance is high. Afterwards 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 consequence when the light from the LED deviates from its path due to the presence of crack or a break, a sudden decrease in the value of LDR ensues. This change in resistance indicates the presence of crack or some other similar structural defect in the rails. In order to detect the current location of device in case of a detection of crack in current system a GPS receiver is used, whose function is to receive the current latitude and longitude data. 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. The robot is driven by four dc motors. With this current system only the latitude and longitude of the broken track will only be received so that the exact location cannot be known.

The problem in current system the cost incurred is high; the robot does not have any provision for off track. Hence this paper proposes a cheap, novel yet simple scheme with sufficient ruggedness suitable to the Indian scenario. This proves to be cost effective as compared to the existing methods.[10 and 11].

IV.PROPOSED SYSTEM

It is not possible to get exact location of the faulty track from the base station in case of current system. Current system only gives latitude and longitude of the rail crack location. The proposed system will overcome the limitations of both the traditional and the current system that are using for detection of faulty tracks. In the proposed system we are using suitable mechanism for on and off tracks. In this proposed system we are using ATMega2560 microcontroller on board UNO board. The Arduino integrated development environment is an open source project which simplified the coding greatly. Proposed system will consist of IR sensor array assembly for crack detection and Ultrasonic sensor for obstacle detection. Then analog readings from IR sensor array and ultrasonic sensor will be converted into the digital reading and set point will be allotted to these sensors. Motor driver will be used to drive dc motors. The microcontroller is used to control the IR sensor array output and ultrasonic sensor output and transmit the information by using the GSM module and the function of GSM module being used is to send the signal whenever it detects the crack to the base

station through an SMS. Hence the proposed system is very efficient as compared to the traditional and current system. As we know there are number of hairline cracks are present which are not visible to the naked eyes. Proposed system is also capable of detecting such type of complete hairline cracks of rail. For the detection of minor crack, the principle of conductivity will be used. Any material which is metallic in nature has property to conduct electrons or current through itself, when a potential difference is applied across its length. If the metal is disconnected in between, cannot conduct and hence current cannot pass through it. By using this principle, the proposed system will detect the minor crack.

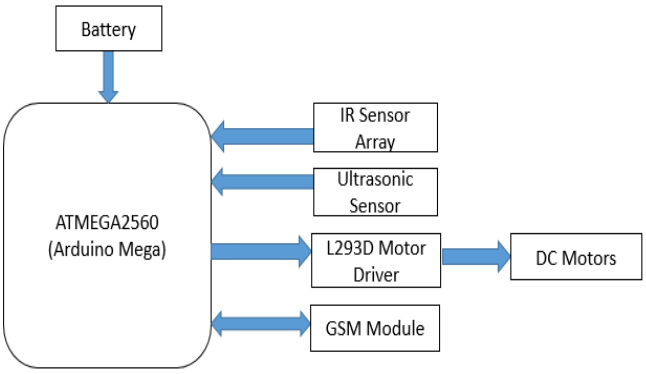

Fig 1: An inspection system for detection of cracks on the railway track using a mobile robot

A. System Architecture

The proposed rail track detection system architecture, shown in figure 1,which consist of ATmega2560 Arduino microcontroller, two IR sensor array, two ultrasonic sensors, GSM module and DC motors.

B. Operation

This section explains the operation of module, which are present in the faulty rail track detection system architecture. In this architecture, we are using two inputs namely, IR sensor array and ultrasonic sensor. The output in this project is GSM module and motors.

1. Microcontroller

The Arduino Mega2560 is a microcontroller board based on the ATMega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UART's (hardware serial ports), 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller, simply connect it to a computer with the USB cable or power it with the AC to DC adapter or battery to get started. The board can operate with the external supply of 6 to 20 volts.

2. IR sensor array

The IR sensor array is a device with seven mounted infrared sensors. Each IR sensor is capable of detecting black and white colors. The array is capable of emitting sound. The IR array can perform detection at proper distances. The infrared sensor transmitters or receivers have optimal operating range of 0 to 5cm. The 3 pin connector provides power, pressing the right button initializes the array with set threshold values. Press the button one more time, the arrays halts auto calibration and reverts back to set threshold values. Set values=(MAX_VALUE+2*MIN_VALUE)/3, where MAX_VALUE is maximum value of sensors between the first and the second button presses, and MIN_VALUE is the minimum value of sensors between the first and second button presses.

3. Ultrasonic distance sensor

The ping is an ultrasonic range finder from Parallax. It detects the distance of the closest object in front of the sensor (From 2cm up to 3m). It works by sending out a burst of ultrasound and listening for the echo when it bounces off of an object. The Arduino board sends a short pulse to trigger the detection, then listen for a pulse on the same pin using the pulseln () function. The duration of this second pulse is equal to the time taken by the ultrasound to travel to the object and back to the sensor. Using the speed of the sound, this time can be converted to distance.

4. Global System for Mobile communication(GSM)

The SIM900 GSM module has been chosen to achieve the SMS functionality [13]. GSM modem is a specialized type of modem, which accepts SIM card and operates over a subscription to a mobile operator, just like a mobile phone. When a GSM modem is connected to a computer, this allows the computer to use the GSM module to communicate over the mobile network. While these GSM modems are most frequently used to provide mobile internet connectivity, many of them can also be used for sending and receiving SMS and MMS messages.

5. Motor driver

L293D is a typical motor driver or motor driver IC, which allows DC motor to drive on either direction. L293D is 16 pin IC which can control a set of two DC motors simultaneously in any direction. It means that we can control two Dc motor with a single L293D IC. The L293D can drive small and quite big motors as well. It works on the concept of H-Bridge. H- Bridge is circuit, which allows the voltage to be flown in either direction. Vcc is the voltage that it needs for its own internal operation 5V; L293D will not use this voltage for driving the motor. For driving the motor it has separate provision to provide motor supply Vss.

6. DC motor

The proposed design uses seven DC motors, of which 4 motors are of 60rpm, 2 motors of 10rpm and one motor of 200rpm. DC motor works based on the principle that when a current carrying conductor is placed in a magnetic field it experiences a mechanical force, whose direction is given by Flemings' left hand rule. These motors are interfaced with the Arduino with the wheel diameter of 5cm.

V. CONCLUSION

The proposed Arduino based rail crack detection system has the potential for detecting the cracks in the rail track including minor cracks automatically without any human intervention. There are many advantages with the proposed system as compared with traditional detection techniques. The advantages includes fast detect and reporting system, less cost, low power consumption and less analysis time. Also the easy availability of the components and the simplicity of idea make the proposed system ideal for implementation on a large scale with very little initial investment. Therefore it can work efficiently and effectively under working condition. By this proposed model, we will easily avoids the accidents occurs by the track side crack which will help us for saving many lives.

VI. FUTURE SCOPE

By using Wireless sensor network techniques we can develop more and more reliable security system applications in which continuously monitors the railway track through the sensor and detects any abnormality in the track. The sensor nodes are equipped with the sensors that can sense the vibration in the railway track due to coming train. The geographical positioning sensors are placed on the trains. These sensors send the train's geographic location. The complete process is needed to be real time in nature and should meet the deadlines.

The crack detection system can be enhanced using Anti Collision Device (ACD) is a self-acting microprocessor based data communication device designed and developed by Konkan Railway (KR). The network of ACD system prevents high-speed head on collision in mid-sections, station areas and at level-crossing gates, thereby saving the lives of rail passengers and road users. This device can be integrated with the Anti-Collision Device for better sophistication and optimization.

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