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Crack Sensing Scheme in Rail Tracking System

Ch. Muneendra Rao, B. R. Bala Jaswanth
M. Tech Student Gudlavalleru Engineering College
Assistant Professor Gudlavalleru Engineering College

ABSTRACT
A major share to the Indian economy is contributed by the commercial transport railway network. So, any problems of crack detection in railway network when encountered, may be dealt with a robust and cost effective solution, else, there may be a proportionate decrease in the nations economy. This paper attempts to provide a viable solution by discussing the technical details and design aspects. The discussion continues with the explanation of different criteria involved in choosing simple components like GPS module,PC,IR-photo diode based crack detector module, modeled for effective implementation in India.
Keywords:- Railway cracks, Robot, PC, LPC 2148,IR-Photo diode assembly.

I. INTRODUCTION

After US,RUSSIA and CHINA ranking four in its place. The Indian railway network stretches across the globe with a length of 113,617 kilometers (70,598 mi).over a route of 63,974 kilometers (39,752 mi) covering 7,083 stations. The network traverses every nook and cranny of the nation carries over 30 million passengers and 2.8 million tons of freight daily. It is a growing network with a rapid pace catering the economic needs of our nation with impressive statistics, yet, the associated infrastructural facilities of safety have not been with the prior mention proliferation. Relevant to the international standards, the facilities are inadequate. Because of derailment problem often resulting in damage to human lives and property. The survey in 2011 until the month of July comments that the frequency of accidents is going and in that year itself 11 accidents occurred. To explain the crux of the problem, the accidents in railways are due to 60% derailments and 90% crack problems. Irrespective of natural or anti social reasons.

Hence, this problem of cracks on railways became a crucial problem. Which has to be dealt with paramount importance and attention, as the frequency of usage of Indian railways is high. This problem of cracks which is in major proportion, contributes for major train accidents will go unnoticed. Because of irregularity in manual track line monitoring and maintenance. So, to avoid this drastic condition of Indian railway networks from stopping down still more, an automated system which do not rely upon the manual labour is brought into light.

Owing to the crucial repercussions of this problem, this paper presents an implementation of an efficient and cost effective solution suitable for large scale application. With the advent of powerful digital signal processors, 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. The usage of microwave antennas in crack detection [2] in investigated in research. Another important technique for crack detection is infrared sensing ([3],[4]) which seemed to more suitable but later it became inaccurate.

Other techniques based on ultra sonics [5] also contributed to the detection scheme but they can investigate the crux of the track rather than checking for surface cracks and the surfaces where faults are located. Several other methodologies ([6],[7],[8]) and techniques like observation and analysis of the wave. Propagation involving model impacts and piezo actuation came into light but the approaches are expensive. The problem inherent in all these techniques is that the cost incurred is high. Hence this paper proposes a cheap, novel yet simple scheme with sufficient ruggedness suitable to the Indian scenario that uses an IR-Photo diode arrangement to detect the crack in railway lines, which proves to be cost effective as compared to the existing methods.

The important role played by transport in the development of an economy has been studied. In addition, statistics of the number of rail accidents and their corresponding causes have also been studied. This paper is organized as follows: Section II discusses the design issues; Section III discusses the Existing system, Section IV discusses Proposed Scheme using an IR-Photo diode arrangement. Section V elaborates on the electrical design and Section VI explains the mechanical design. Section VII explains implementation of algorithm, Section VIII provides the results of implementation and Section IX provides the conclusion.

II. DESIGN ISSUES INHERENT TO INDIAN SCENARIO

Typically, the Indian railways have small gaps in them for thermal expansion in summer. The designing of the tracks is in such a way that there will not be any twists or cracks due to heat. When the techniques developed before the proposed technique came into light, it was found that the existing technique took wrong signals by counting the thermal gaps as cracks. There will be another problem regarding the presence of railway bifurcations. If the physical or mechanical design of the robot is unsuitable, then it will be strucked in the bifurcations or it may fall out of the tracks.

Actual design implementation of the proto-type model in the field, faced a problem of presence of debris on the outside of the railway tracks. The effects of dirt on the robot wheels would also contributes to the scenario making the circumstances more complex.

A literature survey on the existing techniques for crack detection reveal a number of sophisticated and accurate crack detection technologies.First, in the Indian rails, typically there are small gaps in the rail tracks to provide for thermal expansion during the summer. This design is provided so as to ensure that the track does not twist or crack due to the heat.

When the existing technique of crack detection was implemented, it was found that the system was giving false positive signals; that is, it was counting the thermal gaps as cracks. Another issue faced during practical implementation is the presence of railway bifurcations. If the mechanical design of the robot is unsuitable, then it will have a tendency to either get stuck in these bifurcations or in worst case even fall out of the tracks. During the designing of prototype for actual on-field implementation, the problem of presence of debris on the outsides of the tracks was encountered. Though this problem seemed trivial, the effects of dirt on our robot wheels could have been substantial. In addition, as the proposed design utilized a IR-Photo diode based design, the ambient light intensity variations imposed extreme challenges to our design concept.

III. EXISTING SYSTEM

The finding of cracks in railways tracks takes time consumption due to manual checking. It reduces the accuracy too. This method of design is having limited intelligence and time consuming.

IV. PROPOSED SYSTEM

The core of the proposed crack detection scheme consists of a IR-Photo diode assembly that functions as the rail crack detector. The principle involved in crack detection is the concept of photo diode. In the proposed design, the IR will be attached to one side of the rails and the photo diode to the opposite side. During normal operation, when there are no cracks, the IR light does not fall on the photo diode and hence the photo diode resistance is high. Subsequently, when the IR light falls on the photo diode, the resistance of the photo diode gets reduced and the amount of reduction will be approximately proportional to the intensity of the incident light. Therefore, when light from the IR deviates from its path due to the presence of a crack or a break, a sudden decrease in the resistance value of the photo diode 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 current location of the device in case of detection of a crack, a GPS receiver whose function is to receive the current latitude and longitude data is used. To communicate the received information, a PC has been utilized. The function of the PC being used is to upload the current latitude and longitude data to the relevant authority. The aforementioned functionality has been achieved by interfacing the PC, GPS module and IR-Photo diode arrangement with a microcontroller. DC motors drive the robot and relays were used to control the motors.

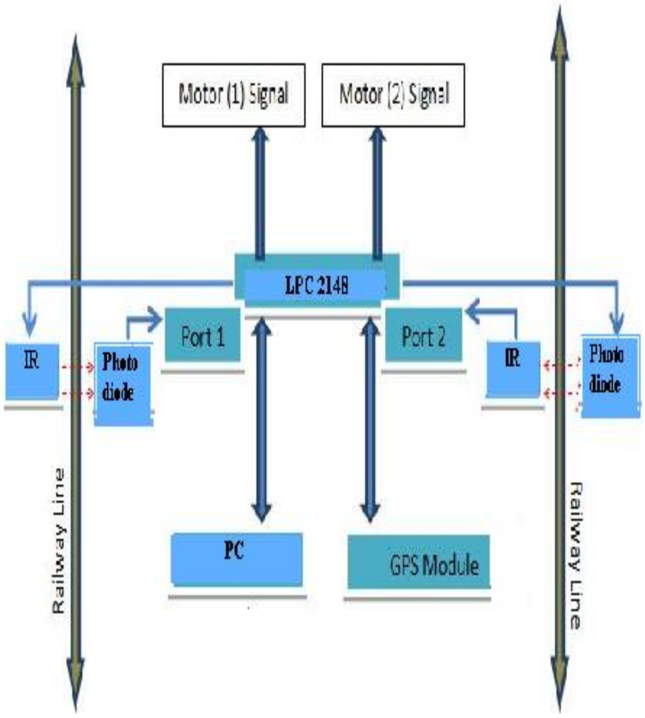

Fig.1: Block Diagram

The various components in the block diagram are mentioned below:

1. LPC2148 Microcontroller
2. Power Supply
3. Crystal Oscillator
4. Reset
5. 16x2 Liquid Crystal Display(LCD)
6. MAX 232

7. Multiplexer
8. PC
9. GPS Module

V. ELECTRICAL DESIGN

A. *Microcontroller Unit*

The LPC2119/2129/2194/2292/2294 are based on a 16/32 bit ARM7TDMI-STM CPU with real-time emulation and embedded trace support, together with 128/256 kilobytes (kB) of embedded high speed flash memory. A 128-bit wide internal memory interface and a unique accelerator architecture enable 32-bit code execution at maximum clock rate. For critical code size applications, the alternative 16-bit Thumb Mode reduces code by more than 30% with minimal performance penalty.

Features of the microcontroller:

1. It is a 32-bit microcontroller.
2. 256K Bytes of In-System Programmable (ISP) Flash Memory.
3. 4Kx 32-bit Internal RAM.
4. 46 Programmable I/O Lines.
5. Two 32-bit Timer/Counters.
6. On chip ADC and DAC.
7. 2 UART Serial Channels.

B. *Power Supply*

The input to the circuit is applied from the regulated power supply. The microcontroller voltage is of 5V. The A.C. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating D.C voltage. So in order to get a pure D.C voltage, the output voltage from the rectifier is fed to a filter to remove any A.C components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage. We are using an IC 7805 as voltage regulator to get a 5V output Voltage.

C. *Crystal Oscillator*

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time (as in quartz wrist watches), to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, so oscillator circuits designed around them became known as “crystal oscillators”. This block provides necessary frequency sine wave to the micro controller. This frequency is converted to square wave within the micro controller.

D. *Reset*

Control reset is to execute the entire program cycle from beginning.

F. *MAX232*

The microcontroller can communicate with the serial devices using its single serial port. The logic levels at which this serial port operates is TTL logics. But some of the serial devices operate at RS 232 logic levels. So in order to communicate the microcontroller with modem, a mismatch between the logic levels occurs. In order to avoid this mismatch, in other words to match the Logic levels, a serial driver is used.

A MAX232 is a serial line driver used to establish communication between modem and microcontroller. The interfacing of GSM modem with microcontroller using MAX 232 as a serial line driver is shown in Fig.3. The voltage levels of Max 232 are given in Table 2.

RS232 Line Type & Logic Level	**RS232 Voltage**	**TTL Voltage to/from MAX232**
Data Transmission (Rx/Tx) Logic 0	+3 V to +15 V	0V
Data Transmission (Rx/Tx) Logic 1	-3 V to -15 V	5V
Control Signals (RTS/CTS/DTR/ DSR) Logic 0	-3 V to -15 V	5V
Control Signals (RTS/CTS/DTR/ DSR) Logic 1	+3 V to +15 V	0V

Table 2: Voltage levels of Max 232

G. *Global Positioning System (GPS)*

The Global Positioning System(GPS) is a satellite based navigation system that sends and receives radio signals. A GPS receiver acquires these signals and provides the user with information. Using GPS technology one can determine location, velocity and time, 24 hours a day, in any weather conditions anywhere in the world for free. GPS was formally known as the NAVSTAR (Navigation Satellite Timing and Ranging). The basis of the GPS technology is a set of 24 satellites that are continuously orbiting the earth. These satellites are equipped with atomic clocks and sent out radio signals as to the exact time and location. These radio signals from the satellites are picked up by the GPS receiver. Once the GPS receiver locks on to four or more of these satellites, it can triangulate its location from the known positions of the satellites. It is a higher performance, low power satellite based model. It is a cost effective and portable system which accurately detects the location. The GPS receiver used here is Sky Traq Venus 6 GPS module ST22 which is having TTL logics and also RS232 as option. The GPS receiver is shown in Fig.5. This GPS is used to track the position of the train after the emergency brake is applied in order to avoid the accidents.

GPS Receiver Specifications:

1. 65 channels-1Hz Update rate
2. Hot Start- 1sec
3. Baud rate- 9600bits/s
4. Operating Voltage-5Volts dc
5. O/P Format-NMEA 0183-RS232
6. Operating Temperature: -40 to +85 ^{o}C
7. Sensitivity- Tracking: -160 dBm

Reacquisition: -158 dBm
Cold Start (Autonomous): -148 dBm

Fig.3: GPS Receiver

H. DC Motors

To traverse a distance of 22 Km in 4 hrs, an average speed of 1.5 meters/sec is needed. The proposed design uses 4 DC motors (Torque Rating: 10Kg and Speed Rating: 500 rpm) interfaced with the LPC 2148 With a wheel diameter of 5.2 cm and the total mass of around 5 Kg the approximate speed of the robot is around 0.5 metres/sec. Hence it has been calculated that three such robots would be required to scan the whole Railway System.

I. *IR-Photo diode Assembly*

The common 5V IR and Photo diode was found to be sufficient. The IR is powered using one of the digital pin of the LPC 2148. The photo diode and a 45kΩ resistor form a potential divider arrangement. The output of the potential divider is given to one of the analog input channel of the LPC 2148.

VI. MECHANICAL DESIGN

The robot runs on both the railway tracks. This increases its stability preventing it from falling when it moves over a railway bifurcation. In addition, the robot has been designed to be symmetrical. It consists of two wooden frameworks each supporting 2 motors, 1 battery and one IR-Photo diode assembly. Each battery was found to weigh a little over 300 grams giving additional weight on the wheels which also ensured stability of the robot when it moved over railway bifurcations. These two wooden frameworks were connected by two cylindrical aluminum rods (3/4 inch diameter and 0.25 mm thickness). The length of the aluminum is so chosen that the four wheels of the robot rest exactly on a typical broad gauge railway track. In India, the distance between two rails in a broad gauge railway is 1.676 meter. The circuit box containing mainly the LPC 2148 Board, the GPS module and PC is exactly centered on the aluminum rod. Two bunches of 10 wires (2 each for the IR, the Photo diode, the two motor and the battery) each enters the circuit box from its left and right side. The proper packaging of these many wires is a crucial in design of the robot. There are few more design criteria which were taken into account:

1) The wheels of the robot will be similar to the wheels of the a train, i.e. a big wheel welded/joined with a smaller wheel. The smaller wheel runs on the track while the bigger one prevents the robot from falling. It is must that the bigger wheel is on the inner side of the railway track. It is because in the general Indian scenario the stones and other debris are comparatively less on the inner side tracks. If the bigger wheels are placed outside it may brush against the debris causing it to destabilize or in worst case get stuck or even fall.
2) The IR-Photo diode assembly shouldn’t go below the rim of the rail otherwise it may get damaged due to the scattered debris.
3) The distance between the front wheel and the IR-Photo diode assembly is a crucial design aspect. The front wheel of the robot should be kept sufficiently behind the IR-Photo diode assembly so that the robot has sufficient distance to stop after a crack is detected. In our case it is 12 cm.

VII. IMPLEMENTATION OF ALGORITHM

After the robot is powered ON it executes the following

algorithm:
1) Set LowThreshold = 200, HighThreshold = 800.
2) Calibrate Photo diode:
   a) Switch OFF left IR.
   b) Set *LOWleft* = Average of left Photo diode signal
   c) Switch OFF right IR.
   d) Set *LOWright* = Average of right photo diode signal.
   e) Switch ON left IR.
   f) Set *LOWleft* = Average of left photo diode signal.
   g) Switch ON right IR.
   h) Set LOWright = Average of right photo diode signal.
3) Turn ON GPS.
4) REPEAT
   a) Read Latitude from NMEA string
   b) Read Longitude from NMEA string
   UNTIL (Latitude and Longitude not equal Zero)
5) Turn ON motors.
6) Read left photo diode and right photo diode signal.
7) Map left and right photo diode signals between 0 and 1000
   using following formulas.
Analog read (Photo diode left) and analog read (photo diode right)
   Signal from photo diode
   Mapped values
INTENSITY left and INTENSITY right
8) If *INTENSITYleft < LowThreshold* and *INTENSITYright < LowThreshold* then,
   a) Motors are powered ON.
9) *If INTENSITYleft < HighThreshold and INTENSITYright < HighThreshold then,*
   a) Motors are powered OFF.
   b) Read robots coordinate using GPS.
   c) Send robots coordinates to the PC and it will upload the values to predefined website.
11) Jump to step 6.

VIII. RESULTS

Whenever the IR light falls on the photo diode the GPS receiver receives the current latitude and longitude data.

Then the received latitude and longitude data are sent to PC which will upload those values to the predefined website address www.stupros.com/site/live8.php by using a software which is installed in PC as shown in figure 4.

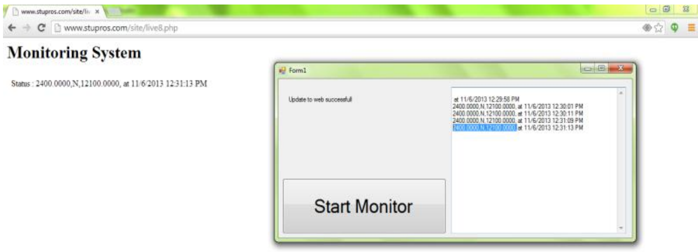

Fig.4: Webpage

The webpage contains the information about the time when it is received and latitude and longitude values as shown in figure 5.

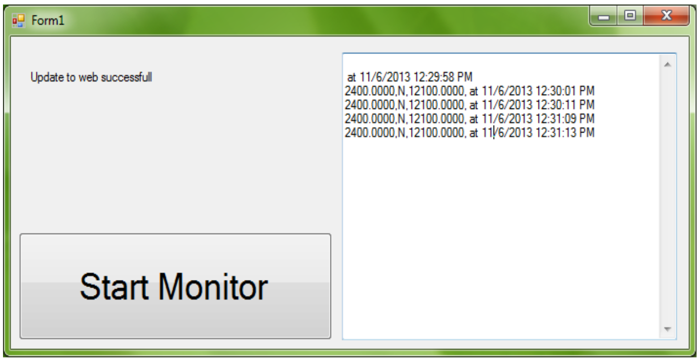

Fig.5: Window displaying the data

IX. CONCLUSION

This paper makes an attempt in providing a viable solution in making the railway tracks crack free with IR-photo diode based railway detection scheme. The main idea of the project can be implemented on a large scale in order to have safe India with sound infrastructural facilities for better results in future.

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AUTHOR’S PROFILE

CH.MUNEENDRA RAO is pursuing M.Tech in Gudlavalleru Engineering College.His areas of interest are embedded systems and Microcontrollers.

B.R.BALA JASWANTH is working as an Assistant Professor in Gudlavalleru Engineering College.