

A Wireless Approach with Sensor Network for Real Time Railway Track Surveillance System

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Abstract— This paper report discusses the safeness analysis of a railway track. A sensor network has been used to detect the cracks in the railway track. This sensor network incorporates an IR sensor and a photodiode. An Arduino Uno based robot with navigation system and GSM module has been used to make this system automatic. A camera module is also attached with it for capturing image of the faulted track and transmits this image via GPRS service. This system furnishes a cheap, reliable, flexible and intellectual alternative for the existing systems.

Keywords— Arduino, Railway Track Surveillance System, Navigation, GSM module, Sensor Network.

I. INTRODUCTION

Railway being the most convenient and low cost mode of transportation in juxtaposition to other modes and also plays a prominent role in economic blooming of the country. Relying upon recent advancements high speed rails is dominantly used. In the field of transportation railway plays a vital role. The rail carries both freight and passengers. The length of railway track spread over a route of 64,460 km. Railways carry over 30 million passenger and 2.8 million tons of freight daily [1]. Railway accidents can have worse impact in comparison to any other type of transport accidents, while the most of the goods and passenger travel by the railways.

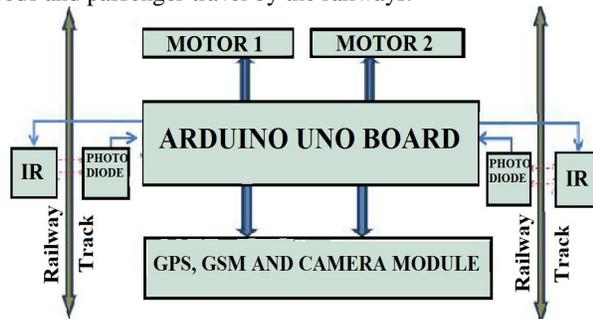


Fig. 1 Wireless approach to support Railway Track

One major cause of the railway accidents is track failure. Railroad cracks have been found out to be prominent genesis of derailments and can introduce a major vandalism to the economy. Railroad safety is of paramount concern and hence the crack detection process is required for its safety. In order to have an effective means of transport, proper surveillance system is necessary for railroad crack analysis. The crux of the issue is that 60% of total railway accidents occur due to

derailments, out of which 90% of them happened due to crack. The most awaited problem in railroad maintenance is the shortage of cheap and efficient technology to detect track flaws. An effective track surveying system is the need of the day for regularity in monitoring the predefined issue. The approach which is in vogue today is manually i.e. by human beings to detect the cracks. This manually approach is lengthy, subjective and cumbersome and lacks objectivity. To overcome the problem regarding manually approach an automatic system has been needed which is capable of scrutinizing cracks on a continuous basis without human intervention, for getting regularity in monitoring procedure. Proper maintenance of tracks leads avoidance of destructive flaws that can results in major accidents.



Fig. 2 Heavy rail passenger injuries from derailments [2]

The proposed system is accurate, intellectual, reliable and effective means for analysis of the cracks present on a railway track without human efforts. The proposed system has assembled automatic robot with arrangement of IR and photo diode for crack detection in a precise way. The control unit consist of an Arduino Uno board, which is helpful to interface the GSM modem with GPS module for transmitting the position of the faulted crack to the concerned authority. To get exact location of the place rather than having a mere glimpse of the location, a camera has been attached with it for capturing the image of the defected crack so that the location and image of the defect gets readily available to the concerned authority station. For the whole process to occur robot should have to be granted with a certain delay after which robot starts its motion again.

II. RELATED WORK

Railway track crack detection system is a grooming area in the field of research. Many systems have been implemented to find the fault on the railway track. An ultrasonic sensor based approach has been studied by Stuart B Palmer et.al for detecting track related problems [3] but later it was examined that it fails to detect surface or near surface cracks which is sometime responsible for major damages. K. Vijayakumar et.al introduced an alternative, which was very accurate while testing in labs is based on microwave horn antenna for crack detection [4]. Successful implementation of this system requires a spectrum analyser which is a costly alternative. One major drawback of this system is that it is very difficult to implement it on a moving robot.



Fig. 3 Ultrasonic based Rail Detection System

Another system has been proposed by Andrew D. Koffman et.al, this alternative approach utilizes eddy current method for crack detection [5]. This system is to be implemented in a perfect track i.e. the track should be cleaned and rust on tracks should be removed which is not always permissible. As it employ a tedious task to be performed before implementation of the proposed system. Prof. P. De Ruvo et.al inspected a system, which uses visual inspection in a fault prone area. It is also pricey and consume more time [6]. The analysis of tracks through Google map presented by Ali Javed et.al., but the problem arises by using Google map services is that it gives obscure images in developing countries[7]. The concept of wireless sensor networks has been examined by S. Gobinathan et.al. It detects the crack using IR sensor and CAN controller but this system is inefficient for locating small cracks as well as not suitable in terms of economic considerations [8]. Although a much efficient system using LED and LDR arrangement has been developed by S. Somalraju et.al. Due to its inefficiency of calculating exact location of the fault it has been considered to be inappropriate [9]. Since the most of the systems deals with certain limitations, to overcome those flaws an automated surveillance system has been proposed.

III. HARDWARE SPECIFICATIONS

The surveillance system is the connection of each module incorporated with the central control unit. A battery has been used to provide necessary power supply for the circuitry as

well as for camera. Camera module needs a separate storage card so that to store images that can be transmitted.

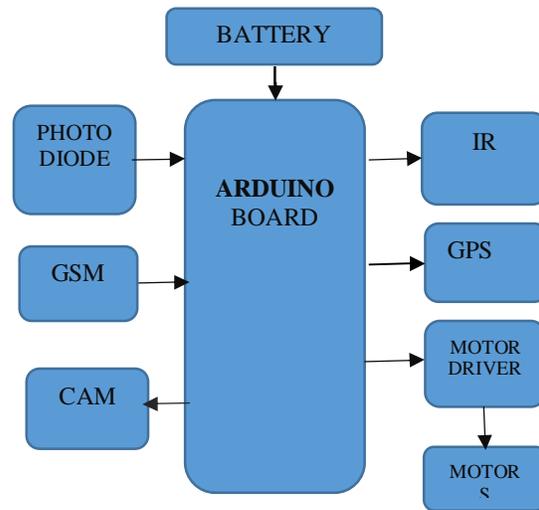


Fig. 4 Block Diagram for Real Time Railway track Surveillance System (Transmitter)

For navigation a GPS module has been used and for the purpose of sending image as well as for transmitting the coordinate of the location a GSM module has been attached. To drive the robot set of DC motors are used. Controlling of motor is performed by a relay driver circuit.

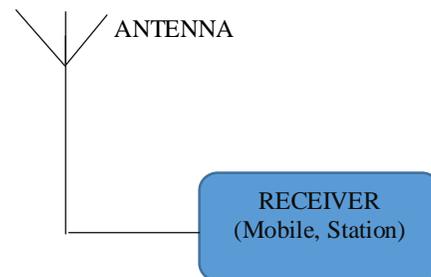


Fig. 5 Receiver for Real Time Railway track Surveillance System

At the receiver end there is a cell phone or a personal computer of the concerned authority station for detecting the latitude and longitude of the faulty track with its real time image.

A. NAVIGATION AND RANGING

For detecting the location of the faulted track, a navigation system has been used. GPS module is a tool which navigates the position by the 24 satellites that are far above the ground level of earth. The global position system works on the principle in which each satellite incorporated transmits messages consisting the parameters.

- The time instant (when the message was transmitted).

- The position of satellite at the instant when transmission of message.

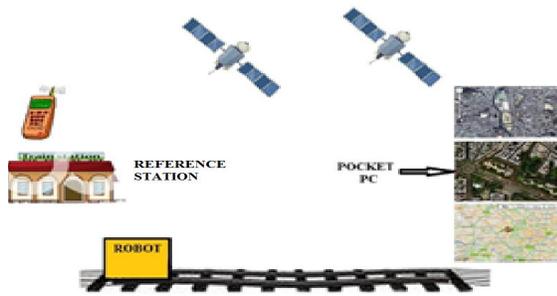


Fig. 6 Navigation approach for Railway Track Surveillance

The location is computed by analysing the transit time taken by the message and speed of light hence the computation of distance of each satellite from the location is computed. Satellite positions and distances calculations define a sphere which is used to describe receiver's location by solving necessary navigation equations. 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.

B. EMERGENCY CALLING SYSTEM

Global System for Mobile communication that is GSM is capable of operating at numerous frequency ranges separated in GSM frequency ranges for 2G and 3G bands. Regardless of whatever frequency selected by the operator it automatically gets divided into time slots to be used by each cell phone.

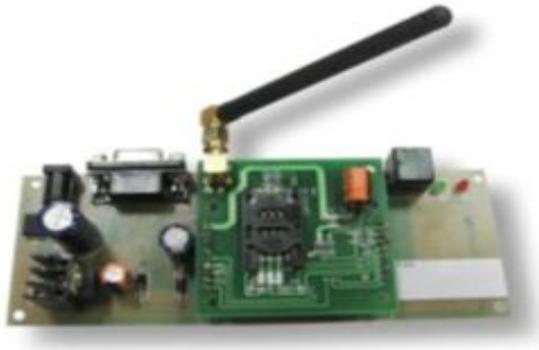


Fig. 7 Snapshot of GSM Module

The band described for 2G frequency range 900 MHz to 1800 MHz bands. But in rare cases for some countries 400 MHz and 450 MHz bands are used because of their use in first generation computers [10]. To provide the exact location of the receiver and for sending the images of the cracks GPRS has been used.

C. SENSOR NETWORK ARRANGEMENT

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

1) IR Sensor Network:

An infrared sensor is an electronic device that is used to sense certain characteristics of its surrounding by either emitting or detecting infrared radiation. In electromagnetic spectrum, its wave length is higher than the wave length of visible light. The wavelength region is from (0.75-3) micrometre is termed as near infrared, the region from (3 - 6) micrometres is termed as mid infrared region after that it is far infrared region. One can use 5V IR for this arrangement which is powered by one of the digital pins on the Arduino board.

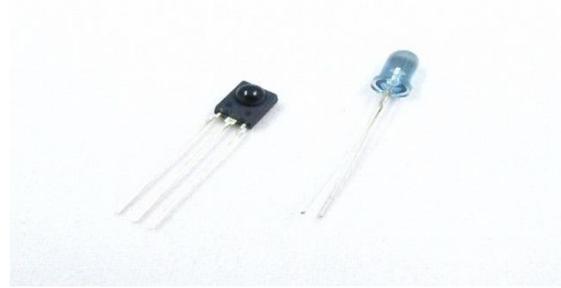


Fig. 8 Snapshot of Sensor Element

2) Photodiode:

Photodiode is a semiconductor device whose resistance varies inversely with the intensity of light falling on it. The photodiode has a resistance of 45 kilo ohms and arranged in the form of a potential divider circuit the output of this potential divider arrangement is given to one of the analog pins on the board.

D. CONTROL CIRCUIT

The control unit consists of an Arduino Uno board, motor driver circuit and a camera module. Arduino is an open source hardware technology that consists of Atmega series microcontroller. Arduino Uno module is used along with Arducam shield camera module that have standard SPI slave interface it is capable of capturing 1080p standard jpeg still image cam has low power consumption and able to use battery for a long time. For driving the dc motor ULN 2003 relay motor driver circuit has been used. A discrete motor control is opted for proper operations of the system requires constant velocity. 12V cannot be provided by the microcontroller so the relay driver ULN2003 uses a Darlington pair which can supply 500mA current induced in each channel.

IV. MECHANICAL DESIGN

Since the need is that the robot should run on both the railway tracks. It is necessary for increasing its stability which prevents it from falling on encountering track defects. Robot should have to be well aligned or rather symmetrical. The Robot constitutes two frame works each supporting two

motors. The components are assembled in such a way so that stability is ensured the frameworks are connected via use of aluminium rods. The length of aluminium rod such that the wheels rest precisely on the broad gauge railway. In India the distance between two rails in a broad gauge railway track is 1.676m [11]. The wheels arrangement of robot considered similar to wheels of a train.

V. PROPOSED METHODOLOGY

The system uses the concept of sensor network with GSM and GPS module to determine the cracks on the railroad. The system inherits IR sensor on one side of the track and a photodiode on the other side of the track. When the robot starts its motion IR sensor gets activated, the resistance of the photodiode remains high until no cracks are there on the railway track. Whenever a crack gets detected, IR rays directly fall on the photodiode and decreases its resistance value. The resistance of the photodiode is inversely proportional to the intensity of incident light falling on it. Hence the soul concept lies on the fact that a change in resistance determines whether a crack is there or not.

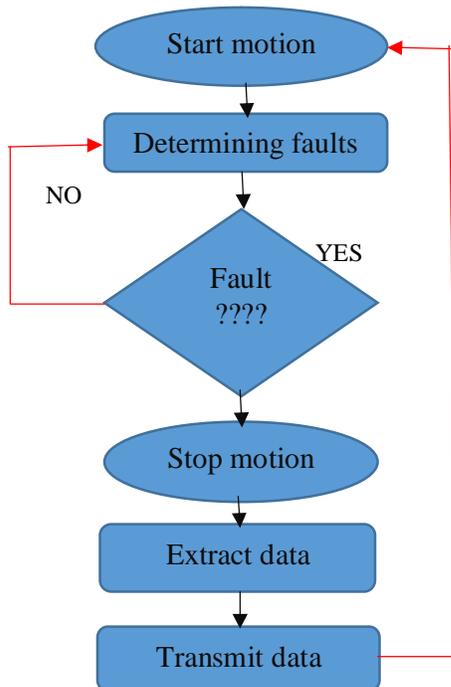


Fig. 9 Working Procedure of real time surveillance system

After a crack gets detected in the first step, robot stops its motion and starts extracting data such as position coordinates by GPS module and image of the crack by camera module simultaneously. The second step is to send extracted data via GSM modem. On completion of the task robot resumes its motion after a certain delay. A huge rail path can be surveyed with a single automated robot in a lucid way.

VI. FUTURE WORK

Although work can be done in order to provide a better speed to the automated vehicle robot. Also enhancement can be done to get better accuracy about the location of the place where the fault had occurred. Also the robot can be made large so that by using its weight track shiftiness i.e. stress and strain parameters of the track can be determined so as to make this system more effective. A zigbee module can also be incorporated for low cost short distance scrutinizing mechanism in order to provide good connectivity at a low input cost.

VII. CONCLUSIONS

The proposed system possess an intellectual approach which is capable of surveying cracks on rail tracks quite efficiently. It is evident that the system can detect major as well as near surface cracks in the best suitable way.

REFERENCES

- [1] Indian Railways Facts and Figures (2011-2012) by *Ministry of Railways*, Government of India, 2012.
- [2] Rail Safety Statistics Report by the Office of Safety and Security, An analysis of safety data reported by state safety oversight agencies and rail transit agencies for the years 2003-2008, Prepared by the *Office of Safety and Security*, Department of Transportation USA, 2009.
- [3] Stuart B Palmer, Steve Dixon, Rachel S Edwards and Xiaoming Jian, "Transverse and longitudinal crack detection in the head of rail tracks using Rayleigh wave-like wideband guided ultrasonic waves," *Nondestructive Evaluation and Health Monitoring of Aerospace Materials*, Composites, and Civil Infrastructure IV, edited by Shull, Gyekenyesi, Mufti, Proc. of SPIE Vol. 5767 (SPIE, Bellingham, WA, 2005) · 0277-786X/05/\$15 · doi: 10.1117/12.598142.
- [4] K. Vijayakumar, S.R. Wylie, J. D. Cullen, C.C. Wright, A.I. Al-Shamma'a, "Noninvasive rail track detection system using Microwave sensor," *Sensors & their Applications XV, Journal of Physics: Conference Series 178* (2009) 012033, doi:10.1088/1742-6596/178/1/012033, 2009.
- [5] Ze Liu, Andrew D. Koffman, Bryan C. Waltrip, and Yicheng Wang, "Eddy Current Rail Inspection Using AC Bridge Techniques," *Journal of Research of the National Institute of Standards and Technology*, Volume 118, 2013.
- [6] P. De Ruvo, G. De Ruvo, A. Distanto, M. Nitti, E. Stella and F. Marino, "A Visual Inspection System for Rail Detection & Tracking in Real Time Railway Maintenance," *The Open Cybernetics and Systemics Journal*, 2008, 2, 57-67.
- [7] Ali Javed, Khuram Ashfaq Qazi, Muazzam Maqsood and Khuram Ali Shah, "Efficient Algorithm for Railway Tracks Detection Using Satellite Imagery," *International Journal of Image, Graphics and Signal Processing (IJIGSP)*, ISSN: 2074-9074/11, 34-40, 2012.
- [8] S. Ramesh, S. Gobinathan, "Railway Faults Tolerance Techniques using Wireless Sensor Networks," *International Journal of Electronics & Communication Technology (IJETT)*, ISSN: 2230-7109, Vol. 3, Issue 1, Jan. - March 2012.
- [9] S. Somalraju, V. Murali, G. Saha, V. Vaidehi, "Robust railway crack detection scheme (RRCDS) using LED-LDR assembly," in *IEEE conference Recent Trends in Information Technology (ICRTIT 2012)*, pp- 477-482, 19-21 April 2012.
- [10] Rappaport, Theodore S., *Wireless Communications: Principles and Practices*, 2nd Ed. Upper Saddle River, NJ: Prentice Hall, 2002. p. 554.
- [11] INDIAN RAILWAYS SCHEDULE OF DIMENSIONS by *government of India, Ministry of Railways*, Railway Board, Rail Bhawan, New Delhi-110 001, REVISED, 2004.