Railway Track Crack Detection System Prototype

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Abstract- *This paper presents a Railway Crack Detection Robot using Arduino, designed to detect cracks and defects in railway tracks. The robot is equipped with sensors that detect cracks and transmit data to a central station. The system aims to improve railway safety by identifying potential defects before they cause accidents. The robot's design and functionality are tailored to navigate railway tracks, detect cracks, and provide real-time data to maintenance teams. This project demonstrates the potential of automation and IoT in enhancing railway safety and maintenance.*

In existing method of crack detection, we not get closer location of crack we only get location of that crack in format of latitude and longitude. So, this system is modified, By adding paint drop system which gives exact location of crack in format of longitude and latitude and also drop paint near crack, so we get closer location of crack & for battery charge we add solar panel.

Keywords- Railway Crack Detection, Robot, Arduino, Sensors, Crack Detection, Real-time Data, Railway Safety, Automation, Defect Identification, Maintenance, Paint Drop System.

I. INTRODUCTION

The Indian Railways has one of the largest railway networks in the world, crises crossing over 1,50,000 km in distance, all over India. However, with regard to reliability and passenger safety Indian Railways is not up to global standards. Among other factors, cracks developed on the rails due to absence of timely detection and the associated maintenance pose serious questions on the security of operation of rail transport. A recent study revealed that the track length is in need of replacement due to the development of cracks on it. Manual detection of tracks is cumbersome and not fully effective owing to much time consumption and requirement of skilled technicians. This project work is aimed towards addressing the issue by developing an automatic railway track crack detection system. This work introduces a project that aims in designing robust railway crack detection scheme (RCODS) using IR SENSOR assembly system which avoids the train accidents by detecting the cracks on railway tracks.

This system is mainly concerned in identifying the cracks in railway tracks and helps to prevent the accidents without manual power. It's not only concentrated on finding damaged tracks but also helpful to find out the derailment and the exact place where it is. In these technical solutions offered by many companies in the detection of cracks in rails involve periodic maintenance coupled with occasional monitoring usually once a month or in a similar time frame. But the robotics possesses the inherent advantage of facilitating monitoring of rail tracks on a daily basis during nights, when the usual train traffic is suspended. Further, that the simplicity of this idea and easy availability of the components make for implementation on a large scale with very little initial investment. The simplicity of this work ensures robustness of operation and also the design has been carefully modified to permit rugged operation.

Problem Statement:

Nowadays, inspection on railway track is done manually in order to locate the cracks. Because of huge size of railway network, it is impossible to monitor the whole railway network manually in a timely manner and find the exact location of the crack on the railway track, which in turn may lead to poor maintenance and hence severe accidents. Also, manual inspection is time consuming and needs more labor requirement. Fig. 1.1 shows the photo of railway track damage, that is being monitored and repaired by the railway authority.

Fig.1.1 Crack on Track [Refer from Times of India]

Objectives:

The main aim of this project work is to develop an autonomous vehicle for detecting crack on the railway track and sending a message and alarm to the nearby railway station operator to intimate that there is a breakage of railway line or there is any object a head of the railway track. Arduino is employed for multiple operation send IR sensors are used to detect any obstacle or crack on the railway track. Solar panel is employed to charge the battery, which in turn operates the motor driver circuit.

Following are the objectives of the project work*:*

- To develop an autonomous vehicle for railway track fault detection.
- To identify fault location using IR sensor and give information about latitude and longitude of fault detection through Arduino using GPS and GSM.
- The main objective of the proposed system is to detect the crack on railway tracks and to avoid accidents due to cracks present on railway track.
- The defect in railway track can be found out easily.
- The proposed system not only replaces the human inspection but also is beneficial in terms of time and money and makes the inspection very much easier and accurate.

II. IDENTIFY, RESEARCH ANDCOLLECTIDEA

[1]"Crack Detection System for Railway Track by Using Ultrasonic and Pir Sensor", IJAICT Volume:1, Issue: 1, 2014, ISSN2348- 9928 - Prof. P.
Navaraja: In this project introduced the integration of ultrasonic and total station for railway track geometry surveying system. this project consists of GPS module, GSM modem, IR sensor, PIR sensor for application of communication purpose, crack detection and finding of human being present in the railway track. The GPS module and GSM modem help us to find and sending railway geometric

parameter of crack detection to nearest railway station. In the present of days, we are using the measurement of track distance by using high cost LVDT with less accuracy, but we use the less cost ultrasonic sensor for above process with high accuracy. We implement PIR sensor in this project to avoid manual checking of detection of presences of human being in recent trends of application. The importance of this project is applicable both day and night time detection purpose. System Proposed by P. Navaraja: In their proposed system, project is detecting the rail road crack, measuring distance for two rail road and also measure the pursuing human in the railway track.when IR sensoris used for detect the crack in the track and ultrasound sensor measure the distance between the two track and also PIR sensor is used to detect human being pursuing in the track. If any crack is occurred in the track means longitude and latitude of the place are messaged to the nearest station and ultrasonic sensor are measure the distance between the two tracks if any small variance means they detect and message to the nearest station using GPS and GSM modem. when PIR sensor is detecting the human being and animals on the railway track, if any one pursuing on the track means they stop the surveying work after crossing rail road they are detecting the track.

[2]"Railway Track Crack Detection", IJARND Volume:3, Issue:3 – Rijoy Paul, Nima Varghese, UnniMenon, Shyam Krishna K. : Railways provide the cheapest and most convenient mode of passenger transport both for long distance and suburban traffic. Also, most of the transport in India is being carried out by railway network. Still, accidents are the major concern in terms of railway track crossing and unidentified crack in rail tracks in Indian railway. About 60% accidents are occurring at railway track crossing and due to crack in railway tracks resulting in loss of precious life and loss of economy., there Therefore is need to think about new technology which is robust, efficient and stable for both crack detection in railway track and object detection. This paper proposes faulty rail track detection and object detection system. This project discusses a Railway track crack detection using image processing and is a dynamic approach which combines the use of GPS tracking system and WIFI module to send alert messages and the geographical coordinate of location. A Raspberry Pi 3 is used to control and coordinate the activities of these devices. This project prevents train derailment by detecting a crack in railway track using internet ofthings technology.

Used System: This system provides the basic architecture for the crack detection using the image processing technique. The crack detecting system is software that extracts and computes the numerical information of cracks from the image data. The major advantage of the image-based analysis

of the crack detection is that by using the image processing technique it provides accurate result compared to the conventional manual methods. The processing difficulty of the crack detection completely depends on the size of the image. Recent digital cameras have the image resolution beyond 10megapixels. This increase in resolution enables the acquisition of detailed images of concrete surfaces. By using the trendy cameras of commercial purpose, a wide range of a concrete surface can be acquired in a single shot. For inexpensive applications, a wide range image can be used for the practical crack detection

[3]"Crack Detection in Railway Track Using Image Processing", IJARIIT Volume:3, Issue: 4 – AlizaRazaRizvi, ParvezRauf Khan, Dr. Shafeeq Ahmad.:
Computer vision can provide many potential advantages over manual methods of railway track inspection. Great levels of performance can be achieved through the automation of inspection using computer vision systems, as they allow scalable, quick, and cost-effective solutions to tasks otherwise unsuited to humans. At a minimum, railway track components can be objectively and quantitatively inspected, as the system does not suffer from fatigue or the subjectivity inherent with human inspectors. The digital nature of the data collection involved with a computer vision-based method, archiving inspection results and trending of the data becomes feasible, leading to more advanced failure prediction models for maintenance scheduling and a more thorough understanding of railway track structure. In this research paper, a computer vision-based method is presented. A system has been suggested which can periodically take images of the railway tracks and compared with the existing database of non-faulty track images on a continuous basis. If a fault arises in the track section, the system will automatically detect the fault and necessary actions can be taken, to avoid any miss happening

[4]"Review On Railway Track Detection Using IR Transmitter & Receiver", IRJET Volume:4, Issue:1, 2017, ISSN: 2395 -0056 - Rakesh.V. Pise, Parag.D. Nikhar, Prof. Avinash.K. shelkar.:

The IR transmitter and receiver total station for railway track geometry surveying system. Railway Crack Inspection is dedicated as a measure of railway safety. The defect information can be wirelessly transferred to railway safety management centre using a GSM module and it includes defect level and location information which is acquired by embedded GPS receiver. In terms of the reliability and safety parameters, Indian railway has not yet reached the international standards. The main problem about railway analysis detection of cracks in the structure.This work proposes a cost-effective solution to the problem of railway

track crack detection utilizing IR transmitter and receiver which tracks thelocation of faulty track which then mended immediately so that many lives will be saved. 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 has train derailment can be avoided and chance of loss of human life and economy can be minimized.

Proposed System: In this proposed system we use PIC16F877A microcontroller. It is a low power, high speed CMOS FLASH/EEPROM technology. It is also a low cost easy to program microcontroller which have only 35 instructions set. Before the start of the rail- way line scan the robot has been programmed to self-calibrate the IR Transmitter and Receiver. After calibration, the robot waits for a predetermined period of time so that the onboard GPS module starts reading the correct geographic coordinate. The principle involved in this crack detection is that light reaching the IR receiver is proportional to the intensity of crack i.e. when maximum light transmitted by transmitter reaches the receiver the crack intensity is more. The IR transmitter will be attached to one side of the rails and the IR receiver to the opposite side. During normal operation, when there are no cracks, the light from transmitter does not fall on the receiver and hence the set value is low. When the light from transmitter falls on the receiver, the value gets increased and the amount by which it is incremented will be proportional to the intensity of the incident light. As a consequence, when light from the transmitter deviates from its path due to the presence of a crack or a break, a sudden increase in the value can be observed. This change in value 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, we make use of a GPS receiver whose function is to receive the current latitude and longitude data. To communicate the received information, we make use of a GSM modem. The GSM module is being used to send the current latitude and longitude data to the relevant authority as an SMS.

The aforementioned functionality has been achieved by interfacing the GSM and GPS modules with the PIC16F877A microcontroller. The robot has four wheels which are powered by two 12V batteries. The design is simple and sensible enabling the device to be easily portable.
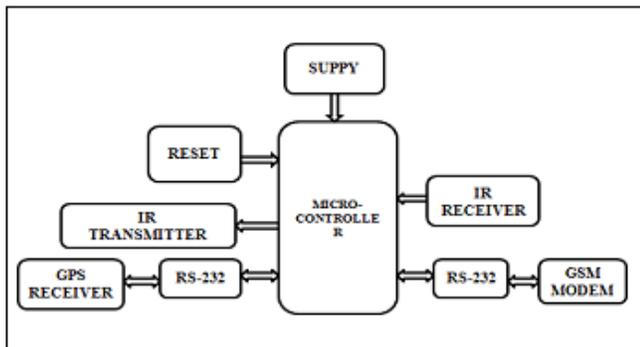
Fig.2.3FunctionalDiagram

[5] "Review Paper on Railway Track Crack Detection Robot Using IOT", Volume:8, Issue:3, 2022, IJARIIE-ISSN-2395- 4396 – Avini Nandkumar, Shreedarshan Nanotkar, Sakshi Bhure, Satish Kathane.: In terms of network size, Indian Railways is the fourth largest in the world. Most of Indians depends on railway to travel and transportation of goods to one place to another. Indian Railways contributes significantly to the country's GDP. But railway department is facing many train accidents by crack, discontinuity on railway track, and train crash. The accidents of trains harm the lives of people and property of train hence it is necessity to maintain the good track without any defaults. So Indian railway department appoints many labours to find and repair the cracks and discontinuity through manually. Here the labours cost is more, it may take more time and also, it's not accurate. To overcome this problem the automatic crack detection robot model is made by using Node MCU development board along with Wi-Fi module. The distance sensors will collect the signals whether the condition of track is good or not and send to the Node MCU and robot will stop immediately. Simultaneously the information is sent to operator through IoT by showing the red alert in the blank application. So, it is possible to take immediate action to repair the track. So, it helps the railway department to maintain the good condition of track with low cost.

Proposed System: To overcome the above disadvantages, here sensers are used, which will detect the crack accurately. This system has GPS module which will give the real time location to the nearest railway station. The prototype of testing tracks and this prototype takes the power supply from a 12v battery. Cloud computing and http protocol for the data transmission.

III. SCOPE OF THE PROJECT or OVERVIEW

Nowadays, inspection on railway track is done manually in order to locate the cracks. Because of huge size of railway network, it is impossible to monitor the whole railway network manually in a timely manner and find the exact location of the crack on the railway track, which in turn may lead to poor maintenance and hence severe accidents. Also, manual inspection is time consuming and needs more labour requirement.

A system is a technique for working, orchestrating, or doing at least one undertaking as per a bunch of rules, a timetable, or a methodology. Itis an arrangement where the entirety of the units cooperate to finish an undertaking progressively by adhering to a bunch of laws. It can likewise be depicted as a strategy for working, masterminding, or finishing at least one errands as per a foreordained timetable. An Embedded System is a PC equipment framework that has programming implanted in it, permitting it to be utilized for an assortment of utilizations or a specific piece of an application or item, or as a feature of a bigger framework. An Embedded System is a computer-hardware system that has software embedded in it, allowing it to be used for a variety of applications or a particular part of an application or product, or as part of a larger system.

- An embedded system is a computer system with software embedded in it that can be used for a number of purposes.
- Embedded systems are typically used to perform particular tasks and provide real-time output based on the embedded system's various characteristics.
- A smaller component of a larger device may be used for serving a more specific application to perform a variety of tasks using a hardware-software intermixing configuration in an embedded system.
- It has a high level of reliability and can perform calculations in real time.
- To detect crack in railway track and avoid railway accidents caused due to crack.
- Detect crack in track easily and give location automatically to maintenance team without involving any person.

EXISTING SYSTEM:

Inexistingmethodcrackintrackisdetectedmanually.Labourisrequiredfor detect crack in manual method.

Drawbacks of existing system:

- Increase in cost required for inspection.
- Required more time for detect crack.

PROPOSED SYSTEM:

In the proposed system, we can monitor as well as control safety status of the crack. The system which

implements detection of crack on railway track and also human efforts are reduced. When crack is detected, crack location is marking by dropping paint at that point where crack is present.

Advantages of proposed system:

- Crack detect automatically.
- Consumeless time than manual inspection.
- Give location of crack through message and dropping paint.
- Dropping paint system gives exact location of crack.
- Reduce human efforts & labour cost required in manual inspection.

IV. DETAILS OF DESIGN, WORKING AND PROCESSES

The main aim of project is to design the railway crack detection using IR sensors. The project block diagram is shown in Figure4,1, which contains microcontroller (Arduino), IR sensor, - motor driver, motor, GPS module when the crack is detected, relevant geographical location coordinates will send to the nearest station. This recording and sending of coordinates are done by GPS module. GPS network used by cell phones provides a low cost, long range wireless communicationchannelforapplicationsthatrequireconnectivityr atherthanhigherdata rates. Infrared transmitter is one type of the LED which emits infrared rays generally called IR transmitter.
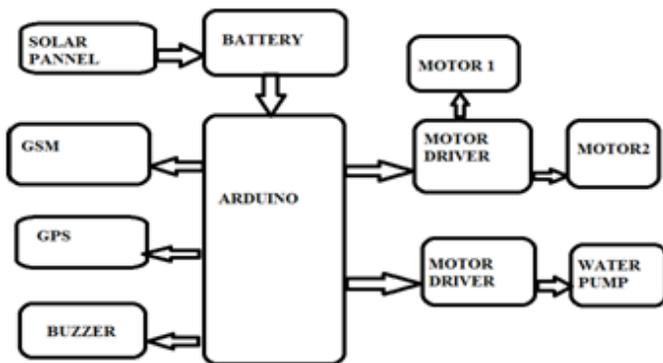

Fig. 4.1 Block diagram of proposed system

Component description:-

1) Arduinouno:

The Arduino Unoisa microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs),

6analoginputs,16MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC to DC adapter or battery to get started. The Uno differs formal l preceding boards in that it does not use the FTDIUSB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB.

Features:

1) Microcontroller-ATmega328
2) OperatingVoltage-5V
3) Input Voltage(recommended)-7-12V
4) Input Voltage(limits)-6-20V
5) Digital I/OPins-14 (of which 6 provide PWM output)
6) Analog Input Pins-6
7) DC Current per I/OPin-40mA
8) DC Current for 3.3V Pin-50mA
9) Flash Memory -32KB (ATmega328) of which 0.5KB used by boot loader
10) SRAM-2KB (ATmega328)
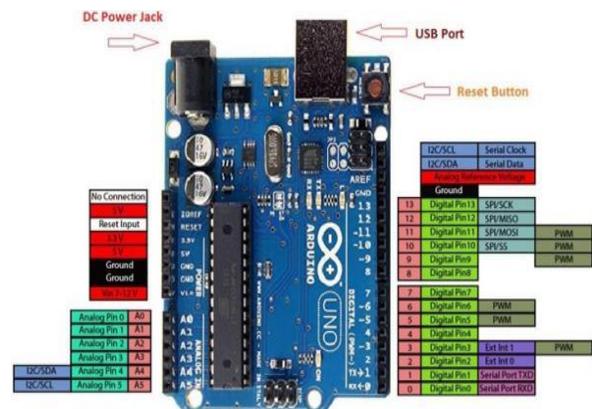11) EEPROM -1KB (ATmega328)
12) ClockSpeed-16MHz

Fig.4.2 ArduinoBoard

*2)GLOBALSYSTEMFORMOBILECOMMUNICATION(GSM):*The GSM is one among the representative wireless networks that has low power, low value and convenience to use. GSM networks operate at various carrier frequency ranges with most 2G GSM networks in operation within the 900 MHz or 1800 MHz bands. The longest distance the GSM specification supports in sensible use is thirty-five kilometres. One among the key options of GSM is that the Subscriber Identity Module, usually called a SIM card. A GSM electronic equipment is a special kind of electronic equipment that receives a SIM card and operates over a contribution to a conveyable operator like a mobile. This permits the user to

retains his or her information once switching handsets. GSM offers 3 basics steps to services:

• Telephone services or teleservices:

These services include Voice Calls, Video text and Short Text Messages (SMS).

• Data services or bearer services:

This is the essential building block resulting in wide spread mobile net access and mobile knowledge transfer.

• Supplementary services:

These services embody caller identification, telephony, telephone, multi-party conversations.

Fig.4.2 SIM808module

SIM808 is all in one module with GSM, GPRS, GPS andBLUETOOTH.SIM808 has GNSS receiver which enables easy GPS FIX. SIM 808 has 2 antenna sockets one for GSM & other for GPS.

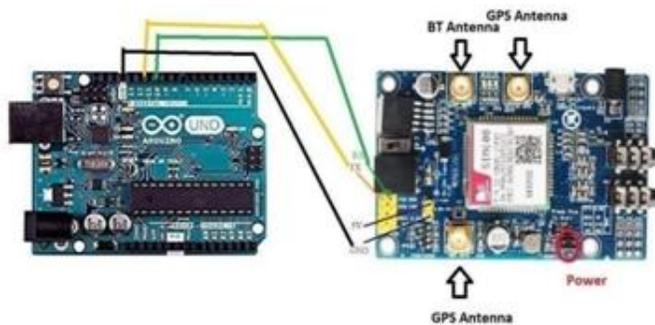A stub antenna is used for GSM & a magnetic external patch antenna is used for GPS.

Fig. 4.3 Interfacing of Arduino with SIM808 Module

To send the GPS coordinates as a text message to the predefined mobile number with aSIM card, the following steps are done:

• Inserting the SIM card into a boards lotthat's mounted on the GSM
• Plugging the module in to the Arduino board.

• USB cable and pressing the facility On/Off switch for some moments thatthe power On/Off indicator crystal rectifier g lows with success the crystal rectifier can blink unceasingly each 3 seconds.
• Notice the blinking rate of network crystal rectifier, it starts to blink in quick for few seconds (Searching for network). Once the association is established with success the crystal rectifier can blink unceasingly each 3 seconds.

3) INFRAREDSENSOR:

The purpose of a sensing element is to respond to some quite of an input physical property to convert it into an electrical signal that is compatible with electronic circuits. The sensor's output signaling could also be within the style of voltage, current, or charge. An Infrared (IR) sensor is used to detect obstacles in front of the robot to differentiate between colours depending on the configuration of the sensor.
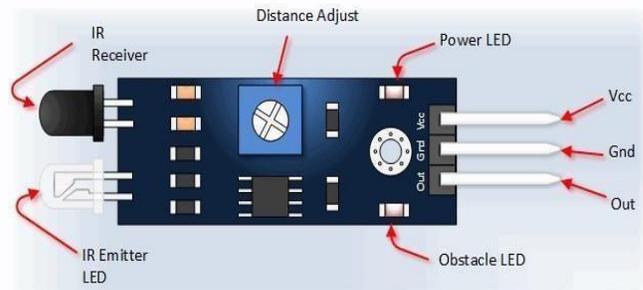

Fig. 4.3 Infrared (IR) sensor

Fig.4.3 shows a very simple black box model of the IR Sensor. The sensor emits IR light and gives a signal when it detects there reflected light. An IR sensor consists of an emitter, detector and associated circuitry. The circuit required to make an IR sensor consists of two parts; the emitter circuit and the receiver circuit. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IRLED. When IR light falls on the photo diode,its resistance and correspondingly, its output voltage, change in proportion to the magnitude of the IR light received. This is the underlying principle of working of the IR sensor.
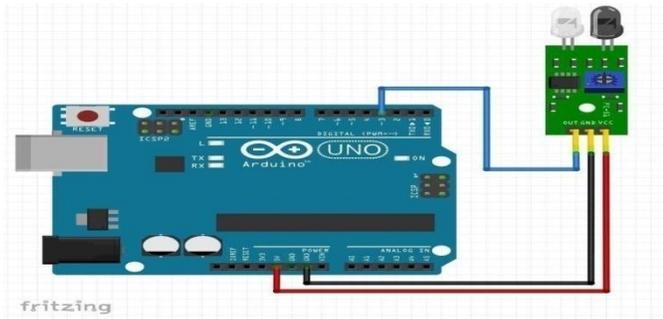
Fig.4.4 Interfacing of IR Sensor with Arduino

4) DCMOTORDRIVER

Almost each mechanical movement is accomplished by an electrical motor. The DC motor includes a lot of applications in today's field of engineering and technology ranging from an electrical shaver to elements of vehicles, altogether tiny or medium sized driving applications DC motors comeback handy. In most cases, electrical motor compass a stator coil (stationary field) and operate through the interaction of magnetic flux and electrical phenomenon to provide force.

Fig.4.5 DC Motor Driver

5) BATTERY:

Solar power can be stored in the rechargeable battery. A rechargeable battery, storage battery, or accumulator is a type of electrical battery. It comprises of one or more electrochemical cells, and is a type of energy accumulator. It is known as a secondary cell because its electrochemical reactions are electrically reversible. Rechargeable batteries come in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network. Photovoltaic is a solar power technology that uses solar cells or solar photovoltaic carries to convert light from the sundirectly into electricity.

Fig.4.6 -Voltbattery

6) BUZZER:

A Buzzer or Beep risasignalling device, usually electronic, typically used in automobiles, house hold appliances such as microwave ovens, or game shows it most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or apreset time has lapsed, andusually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound.

Fig.4.7 Buzzer

7) SOLARPANEL:

A solar cell panel, solar electric panel, photo-voltaic (PV) module or solar panel is an assembly of photo-voltaic cells mounted in a framework for installation. Solar panels use sunlightasasourceofenergytogeneratedirectcurrentelectricity.A collectionofPVmodules is called a PV panel, and a system of PV panels is called an array. Arrays of a photovoltaic system supply solar electricity to electrical equipment.

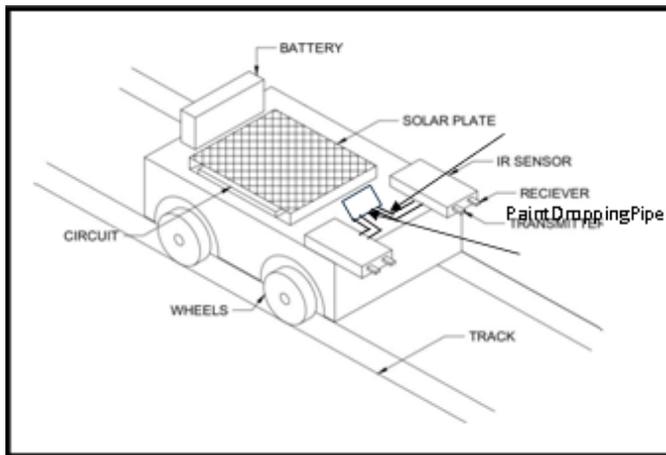
Fig.4.8 Solar Panel

Layout :

Fig.4.9 CAD Drawing

System Description: The proposed railway track crack detection system consists of an infrared sensor, which acts as the transmitter and receiver assembly that functions as the rail crack detector. In order to detect the current
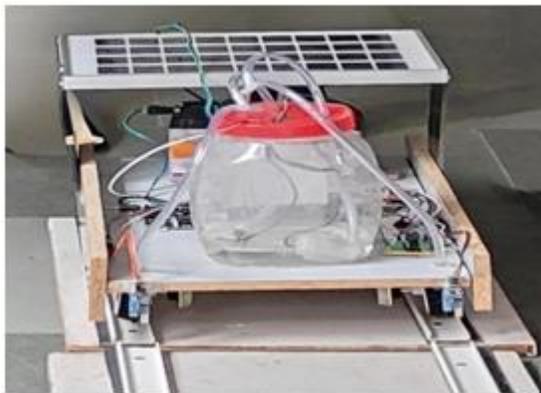

Fig.4.10 Actual Model

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 GSM modem has been utilized. System simulation done in Proteus software is a simple method for identifying the errors in electrical or electronic circuits by using computers. It allows the engineer to test the design before it is built in the real situation. The overall circuit shown in the Fig 12 is designed and tested using an Arduino Uno, GSM module, GPS module and IR sensor libraries.

Working Principle:

- When vehicle travels over the track, IR transmitter transmits the IR signal continuously.
- When crack is detected in the track, the transmitted IR signal is passed through crack and received by the receiver.

- When transmitted IR signal is received by receiver,this signal is feed to the comparator which compares the two signals i.e. transmitted and received signal.
- When the signal is high then comparator pass the signal to the microcontroller which indicates that crack is detected.
- At this instant motor is stopped & paint from paint tank is pumped by pump and drop near the crack.
- Then location of crack is tracked by using GPS (Global Positioning System) and send message on mobile using GSM (Global System for mobile communication) in format of longitude and latitude.
- Afterdroppingpaintinsetquantitythisprocedureisrepeat eduntilnextstation.

V. CONCLUSION

The main aim of this study is to replace the manual method of crack detection of railway using robotic crack tracing system. The hardware was designed and implemented using simple components inclusive of an Arduino board interfaced to IR sensor, motor,SIM808 having GSM and a GPS module. The system is robust and cost effective, it is convenient in regions where manual inspection is hard and requires a lot of effort like in mountain areas, dense forests and far regions. The system with its both software and hardware sides has been tested and results are presented. On considering the results, the system is found to work effectively. If the system is applied in railways, it will save a lot of time compared with the traditional detection techniques, sinceit is completely automated.

Monitoring the condition of tracks is done with fewer chances for error to occurs, hence preventing train accidents to a very large extent.

Advantages:

1) Crack detect automatically.
2) Give location of crack through message and dropping paint.
3) Dropping paint system gives exact location of crack.
4) Reduce human efforts & labor cost required in manual inspection.

VI. RESULT AND APPLICATIONS

Result: As per the study the existing systems are time consuming as well as uneconomical. The proposed system is

not only overcome the problems but also improve accuracy and crack detection in rails. It is the most economical solution provided in order to achieve good results of railways of our country in order to minimize the status of accidents caused. There by possible to save precious lives of passengers and loss of economy. It also saves the time and money for identification of crack.

Applications:

1) Automatic Crack Checking:
The vehicle draws power from the battery. The IR sensor is used to detect the crack in the railway track. Suppose any cracks are in the track the vehicle will automatically stop and detect crack.

2) Wireless Application:
Wireless application protocol (WAP) is the communications protocol that is used for wireless data access through the most mobile wireless network. WAP enhances wireless specification interoperability and facilitates instant connectivity between interactive wireless devices (such as mobile phones) and the Internet. Wireless Application Protocol is a technical standard for the accessing information over a mobile wireless network.AWA Pb row series web browser for mobile devices such as mobile phones that uses the protocols. Though WAP is a new technology, but it reuses the concepts found in the Internet.

3) Railway Track Damage Detection Application:
A railway damage detection and measurement system using neural networks. Railway-defects and damages often cause train accidents. Experimental result shows that this neural network- based measurement system has high precision and is suitable for online railway damage detection and measurement applications. A list of methods used to detect flaws in railways. Ultrasound is the most popular method. Eddy current inspections great for surface flaw & near surface flaws. Magnetic Particle Inspection used for detailed manual inspections. Ultrasonic sensor is used to detect the crack on the railway track by not receiving the echo from the track if the echo sound is received then no crack is detected on the track. The output of ultrasonic sensors is given to the microcontroller, which is connected to the GPS, motor driver IC.

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