End semester Core Project report

On

RAILWAY TRACK CRACK DETECTION SYSTEM

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CERTIFICATE

It is certified that the work contained in this final year core project entitled **"Railway track Crack Detection System"** as submitted by **P. Damodhar sai (Registration No. 1700303C204), Garlapati Sai Varun (Registration No. 1700309C204) and D. Surya Praneeth Reddy (Registration No. 1700305C204)** is absolutely based on their own work carried out under my supervision.

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The Final outcome of this project required a lot of guidance and assistance from many people with good expertise we are extremely thankful to have got this all along the completion of our project. All that we have done is only due to such supervision and assistance and we would like to thank the faculty.

We thank **Dr. Meenakshi Agarwal** for providing us an opportunity to do the project and giving us all support and guidance, which made us complete the project duly.

We all truly feel responsible for the work done and this project helped us learn lot of things from various sections of our study and we hope this can help us apply the concepts to other areas of our study.

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Abstract:

An automatic railway track crack detector system for Indian Railway has been proposed here which aims in building a robot that can detect and analyse any kind of crack on the railway line and send the coordinates of that faulty line to the concerned authority. This robot includes an ultrasonic sensor, GPS, GSM modules, and Arduino Mega based crack detection assembly which is cost effective and robust to facilitate better safety standards in railways. As soon as the robot passes through a crack that might cause the derailment of a train, the ultrasonic sensors sense that and generate a signal. Then this signal is fed into the Arduino Mega. At that point, with the assistance of GSM and GPS modules, an alert SMS consisting of the geographic coordinate of that damaged track is sent to the nearby railway authority who can easily take necessary steps to resolve the problem before any major accident occurs. This will save several trains in India from an unwanted discontinuity from the rail track.

Introduction:

Safety and reliability are considered one of the main issues in all transport system, particularly in railways. There is a view from the experts that the present regulatory framework does not clarify effective deal with railway accidents and derailments, approximately 60% of a rail accident is due to the derailment, of which 90% are due to crack problems [1].

India has 164 years of great history of railway network. The first train in India was started on 16th April 1853, Saturday at 3:35 P.M. between Bori bunder to Belgaum. India has world's top largest railway network. Its length is 1, 19, 630 Km of total track and running route is 66,687 km with 7216 stations. In India billions of passengers are traveling in railway. So, it is necessary to provide safety and reliability of railway network. According to newspaper 90% of railway accidents are occur due to railway track fault. Generally, railway track fault occurs due to natural climates or any other mechanical damage. This promotes railway accidents and damage railways and human lives. In recent years developing country like India needs more diversification and innovation in the transportation system. With the increasing number of the population the current safety framework needs to be equipped with safety legislation and more invulnerable. Safe railway track plays a significant role to carry more than sixty thousand people at a time. Therefore, a consistent system is required to detect the cracks in the railway tracks.

So, for reduction of railway accidents we came up with an idea. By using an autonomous railway track crack detection device, we can reduce railway accidents and save people life.

Literature Review:

Existing system:

Over the years many researchers have tried to build up a system for tracking the cracks in rail lines. B. Siva Rama Krishna [2] used IR technology to track the cracks and send it through Bluetooth. Though the Bluetooth system is not effective for long- range communication. Some researchers used IR transmitters and receivers for railway crack inspection and sent the data through GSM module [3-5]. However, sometimes the IR sensor can detect a small crack which might not be that risky for trains and cause an unnecessary concern. Muley, A.S Patil [6] proposed an op-amp based system where the crack has been identified by the change of output voltage in the op-amp. Though a noise in the railway tracks can change the voltage and give a false alarm. Rizvi Aliza Raza [7] and Delforouzi [8] used a computer vision based railway crack detection system.

It's an effective method to inspect the cracks. However, to detect the cracks in the night it needs high functioning cameras, which increase the cost of the system. There are also some other systems that exist to solve the crack problem using different sensors, Zigbee technology and LED-LDR system [8-11]. But most of this system is designed for other countries rather than India.

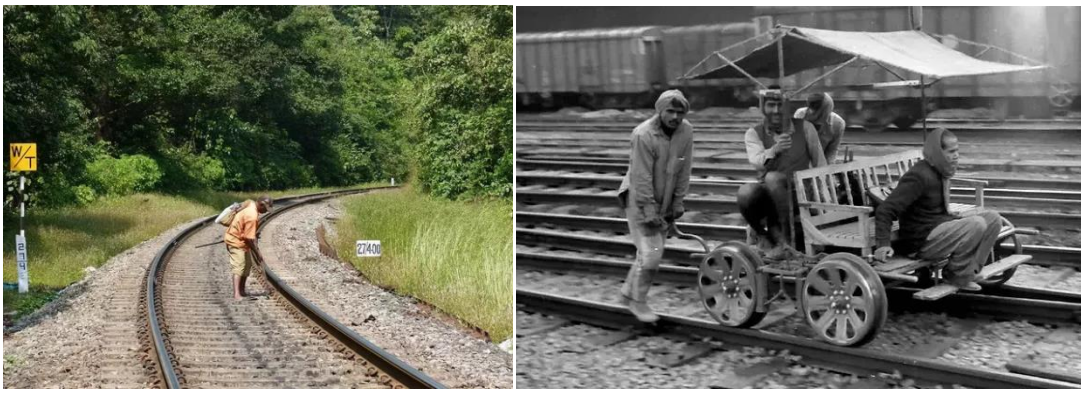


Fig. 1. Some of the early crack detection and Inspection method

Some of the latest crack detection and Inspection method which still require human Intervention

Proposed System:

In this project, a cost- effective autonomous railway crack detector robot is proposed for Indian railway. This device can generate a complete solution for the railway track that starts with crack detection, fault analysis using ultrasonic sensor and that end up with an SMS alert to the concerned authority which consists of the location of the crack. Therefore, making it easier to prevent accidents.

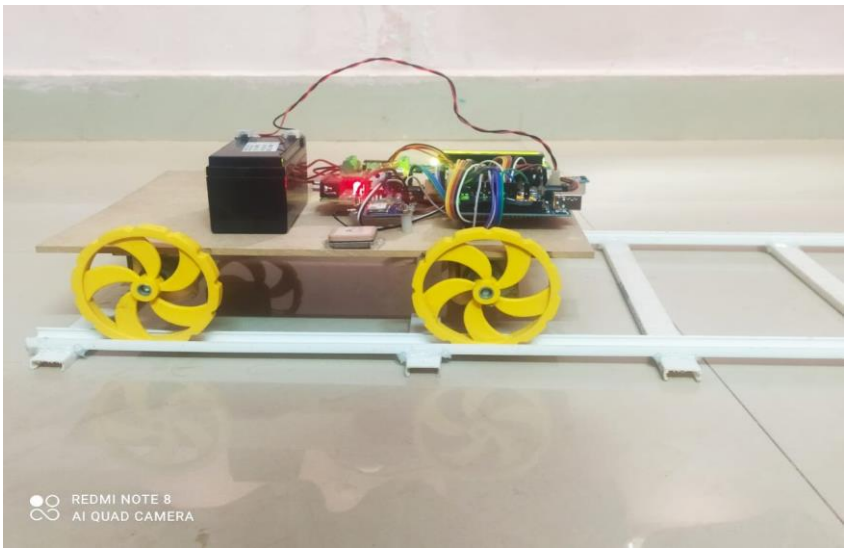


Fig.2. Autonomous Robot which needs no human Intervention

Architecture of the System:

The proposed crack detector robot is a microcontroller based low-cost intelligent device. The cracks in the railway track can be sensed by using ultrasonic sonic waves. This sensor is connected to Arduino Mega which is the central control unit of this project. A DC geared motor is used to move the wheels on the track. A motor driver circuit that passes commands to the dc gear motor and two wheels run the robot. The chassis of this prototype robot is made with the cardboard material. This device also has a feature of sending the location information using GPS and about the fault via SMS alert using a GSM module. An LCD display is connected with Arduino Mega to print the real-time crack status. In fig.3 the block diagram of this robot is given. The complete schematic diagram and Breadboard view is provided in fig.4 and fig.5. Afterwards, a complete description of the system components is provided.

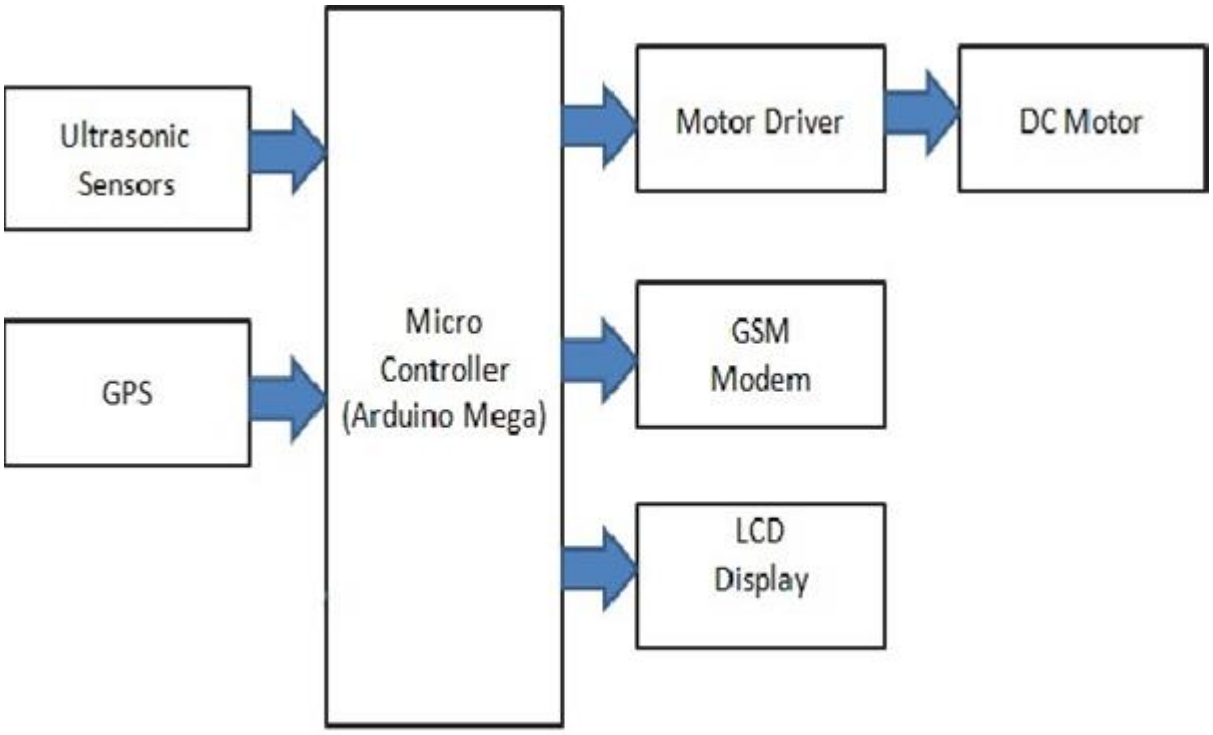


Fig. 3. Block diagram of the robot.

Software Requirements: Embedded C, Arduino IDE, Fritzing

Hardware Components:

- Arduino Mega
- LCD Screen
- L298 Motor Driver module
- HC-SR04 Ultrasonic sensor
- GSM module
- GPS module
- Power supply-12V
- DC Motors
- Antenna

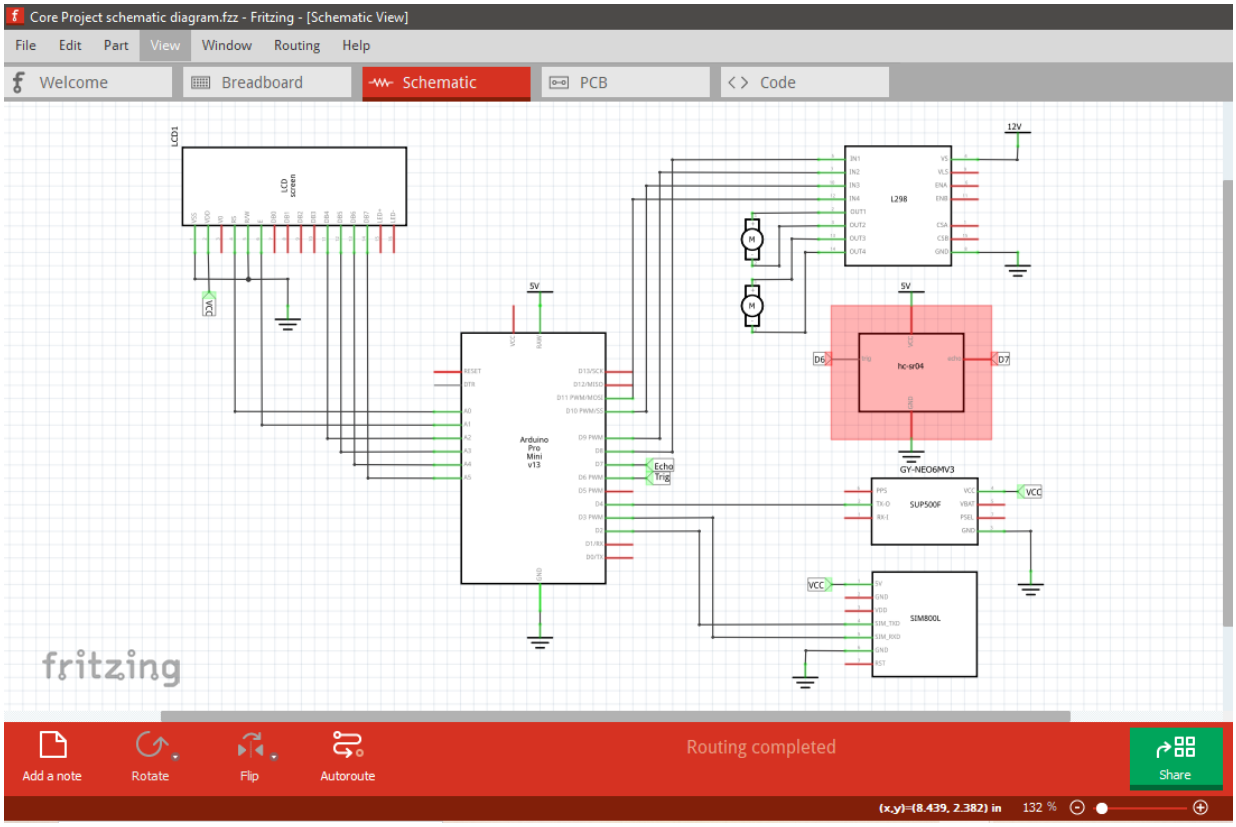


Fig. 4. Schematic diagram of the robot.

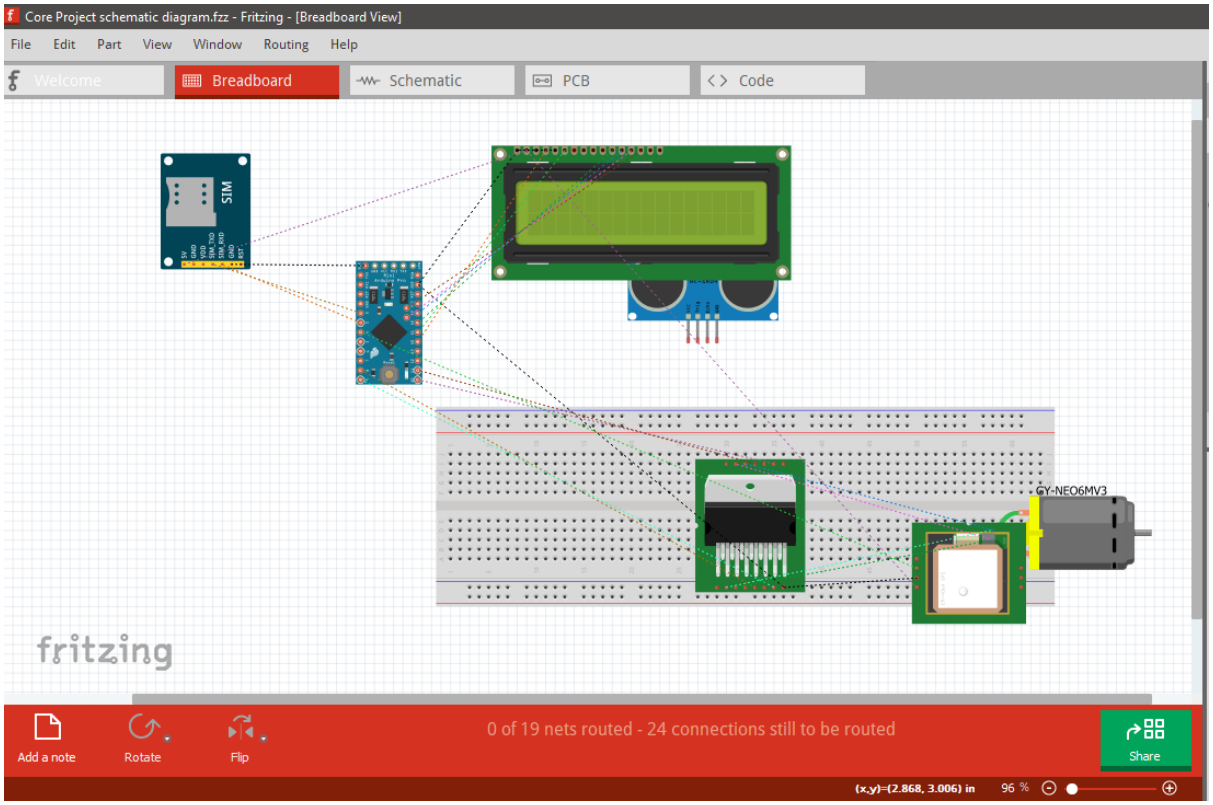


Fig. 5. Breadboard view of the robot.

Ultrasonic sensor:

The ultrasonic sensor is also known as a transducer that uses sound waves rather than light, making them ideal for stable detection of the uneven surface. The working principle is similar compared to radar/sonar which evaluates attributes of target by interpreting the echoes from radio or sound waves respectively [13]. These sensors work well for the application that requires precise measurement. Sensors calculate the time interval between sending the signal and receiving the echo to determine the evaluation of the surface to an object. In this project, the object is a railway track. The ultrasonic sensors are used because these sensors result more accurately than any other sensors that are available in the market. On the other hand, it also reduces the cost.

Arduino Mega:

After getting the signal from the ultrasonic sensor it is fed into the Arduino Mega. A GPS, GSM modem, and an LCD display are connected with Arduino also.

LCD Display:

A 16 x2 display shows real-time crack status after getting a signal from Arduino Mega.

Motor and driver circuit:

A DC geared motor is used to run the robot. An optical encoder is included with Arduino Mega to measure the RPM so that the authority can know the exact location of the robot and

there is a command given in Arduino Mega to skip the regular frame gap of the railway track which is default feature created its implementation period. A motor driver circuit is made to run the motor by using motor driver IC L293D. It basically works on the concept of H-bridge.

Global Positioning system:

A Global Positioning System (GPS) device is used to find out the longitude and latitude data. When a crack is noticed by sensor the Arduino Mega collects the location data from this sensing Device

GSM Modem:

A GSM module is a specialized type of modem which enables a Subscriber Identity Module (SIM) card and operates over a subscription to a mobile operator seems like a mobile phone. The module exposes an architecture that allows applications to send and receive messages over the modem interface [14]. The Arduino Mega sends the crack detection notification with location data to the authority through this GSM modem. In the circuit, the GSM modem is represented through the Virtual Terminal.

Arduino Programming:

```
#include <SoftwareSerial.h>
#include <TinyGPS++.h>
#include <LiquidCrystal.h>

#define RMP 9
#define RMN 8
#define LMP 10
#define LMN 11
#define trig 6
#define echo 7

SoftwareSerial gsm(2, 3);
TinyGPSPlus gps;
SoftwareSerial ss(4, 5);
LiquidCrystal lcd(A0, A1, A2, A3, A4, A5);

int flag = 1;
String mob;
String latt,lon;
int get_no = 1;
int gps_got=1;
```

Here we have included required libraries for our project and used Software Serial for serial communications and declared global variables for later uses

```
void setup() {
  Serial.begin(9600);
  pinMode(trig,OUTPUT);
  pinMode(echo,INPUT);
  pinMode(RMP,OUTPUT);
  pinMode(RMN,OUTPUT);
  pinMode(LMP,OUTPUT);
  pinMode(LMN,OUTPUT);
  lcd.begin(16,2);
  lcd.print("Railway Track");
  lcd.setCursor(0,1);
  lcd.print("Detection Robot");
  delay(2000);
  gsm.begin(9600);
  Serial.println(F("Initializing All Modules"));
  Serial.println(F("Checking for GSM Module"));
  gsm_init();
  get_num();
  lcd.clear();
  lcd.home();
  lcd.print("GPS Initializing");
  ss.begin(9600);
  while(gps_got)get_gps();
  ss.end();
  delay(1000);
  Serial.println(F("Setup Completed"));
}
```

Here we have declared our sensors pins as Outputs/Inputs and declared functions for checking whether all modules are connected ,for storing mobile no and for receiving GPS coordinates.

```
void loop() {
  lcd.clear();
  lcd.home();
  lcd.print("Robot Started");
  while(level()<5){
    analogWrite(RMP,200);
    digitalWrite(RMN,LOW);
    analogWrite(LMP,200);
    digitalWrite(LMN,LOW);
    delay(500);
  }
  analogWrite(RMP,0);
    digitalWrite(RMN,LOW);
    analogWrite(LMP,0);
    digitalWrite(LMN,LOW);
  lcd.clear();
  lcd.home();
  lcd.print("Fault Detected");
  sendmsg();
  lcd.clear();
  lcd.home();
  lcd.print("Robot stopped");
  lcd.setCursor(0,1);
  lcd.print("Reset Arduino");
  while(1);
}
```

Here in void loop it should detect distance between ultrasonic sensor and train track and send message if there is any difference between distances and displaying on LCD

```
int level()
{
  int duration, distance;
  digitalWrite (trig, HIGH);
  delay(50);
  digitalWrite (trig, LOW);
  duration=pulseIn(echo,HIGH);
  distance=(duration*0.034)/2;
  Serial.println(distance);
  return distance;
}
```

In this “level” function we are detecting distance between ultrasonic sensor and train track by calculating duration b/w echo and trigger pins

```
void sendmsg()
{
  String cmd, getstr,loct;
  getstr = "Alert: Fault Detected at ";
  loct = "https://www.google.co.in/maps/place/";
  loct += latt+","+lon;
  cmd =  "AT+CMGS=\"";
  cmd += String(mob);
  cmd +="\"";
  cmd +="\r";
  gsm.println("AT+CMGF=1");
  delay(1000);
  gsm.println(cmd);
  delay(1000);
  gsm.println(getstr);
  gsm.println(loct);
  delay(100);
  gsm.println((char)26);
  delay(1000);
  Serial.println(F("sending msg..."));
  lcd.clear();
  lcd.home();
  lcd.print("Sending msg..");
  delay(3000);
}
```

In this “sendmsg” function we are receiving GPS coordinates and sending message to mobile no stored in “mob” using AT commands and displaying on LCD

```
void gsm_init()
{
  Serial.println(F("Finding Module.."));
  lcd.clear();
  lcd.home();
  lcd.print("Finding GSM");
  int at_flag=1;
  while(at_flag)
  {
    gsm.println("AT");
    while(gsm.available()>0)
    {
      if(gsm.find("OK"))
      at_flag=0;
      lcd.setCursor(0,1);
      lcd.print("Module Connected");
      response();
      delay(1000);
    }
    delay(1000);
  }
```

```
  Serial.println(F("Module Connected.."));
  delay(1000);
  Serial.println(F("Finding Network.."));
  lcd.clear();
  lcd.home();
  lcd.print("Finding Network");
  int net_flag=1;
  while(net_flag)
  {
    gsm.println("AT+CPIN?");
    while(gsm.available()>0)
    {
      if(gsm.find("+CPIN: READY"))
      net_flag=0;
      lcd.setCursor(0,1);
      lcd.print("Network found");
      response();
    }
    delay(1000);
  }
  Serial.println(F("Network Found.."));
  delay(1000);
}
```

In this “gsm_init” function we are checking whether GSM module is connected or not using AT commands and displaying on LCD

```
void get_gps()
{
  while (ss.available() > 0)
  if (gps.encode(ss.read()))
  Serial.println(F("getting gps"));
  displayInfo();
}

void displayInfo()
{
  Serial.print(F("Location: "));
  if (gps.location.isValid())
  {
    latt = String(gps.location.lat(),6);
    Serial.print(latt);
    Serial.print(",");
    lon = String(gps.location.lng(),6);
    Serial.println(lon);
    gps_got=0;
  }
  else
  {
    Serial.println(F("INVALID"));
     delay(500);
  }
}
```

In this “get_gps” function we are for checking for any data response from GPS module and In “displayInfo” function we are storing required received data from GPS module into “latt” and “lon” variables

```
void get_num()
{
  String str;
  char ch;
  int i,j;
  gsm.println("AT\r");
  delay(800);
  gsm.println("AT+CMGF=1");
  delay(1000);
  gsm.println("ATA\r");
  delay(800);
  gsm.println("AT+CLIP=1\r");
  delay(800);
  showResponse(2000);
  Serial.println("Waiting for Incoming Call");
  lcd.clear();
  lcd.home();
  lcd.print("Waiting for call");
  while(get_no)
  {
    while(!gsm.available());
    if(gsm.available()>15)
    {
    while(gsm.available()>0)
    {
    str += String(char (gsm.read()));
 }
    Serial.print("content: ");
    Serial.print(str);
 if(j=str.indexOf('"'))
 {
   for(i=j+4,j=0;j<10;i++,j++)
   {
     mob+=str[i];
   }
   mob[j]='\0';
   gsm.println("ATH\r");
   delay(1000);
   get_no=0;
   //Serial.println("got num");
 }
 }
    }
  }
  Serial.print("Mobile No:");
  Serial.println(mob);
  lcd.setCursor(0,1);
  lcd.print(mob);
  delay(2000);
}
```

In this “get_num” function we are storing user mobile number and sending alert signals to mobile no using AT commands and displaying them on LCD.

Result and Discussion:

In Fig. 6 the flow chart of the process is given. As soon as the robot is put on the railway track it starts the inspection. If any crack is found on rail lines the robot stops and sends the location coordinates to the authority so that they can take essential steps. The robot continues its crack detection if no crack is found. A complete hardware is shown in Fig.7.

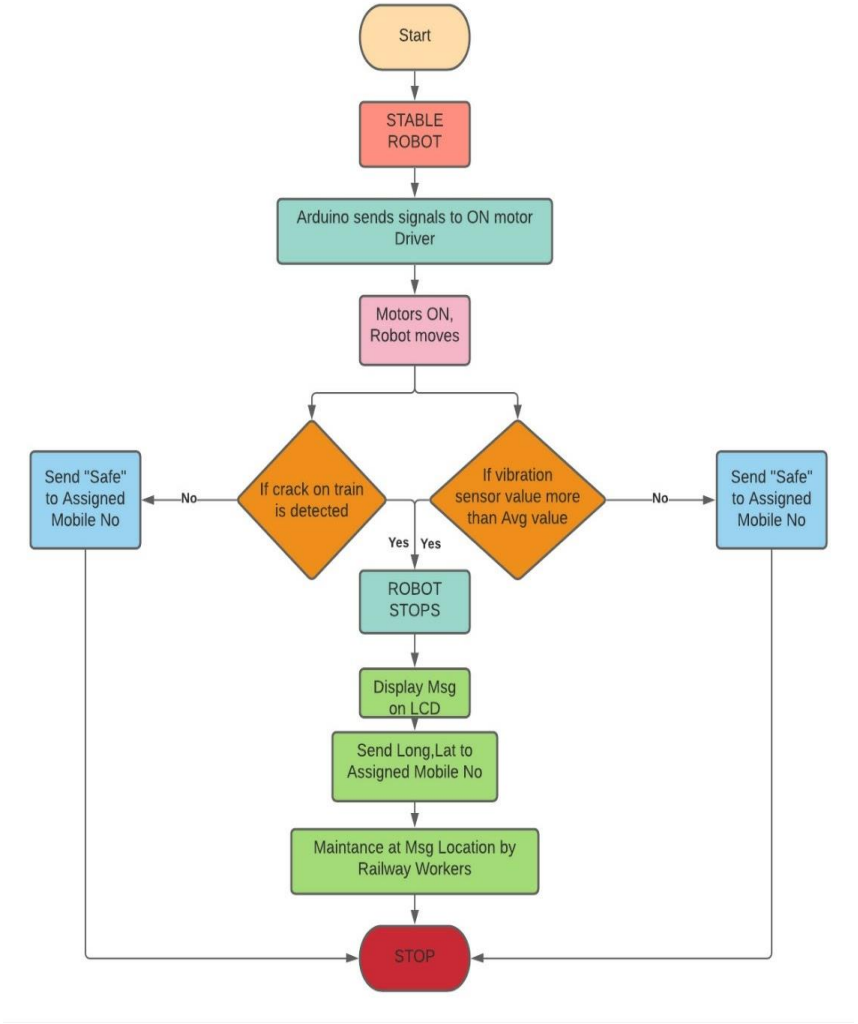


Fig. 6. Flow chart of the process.

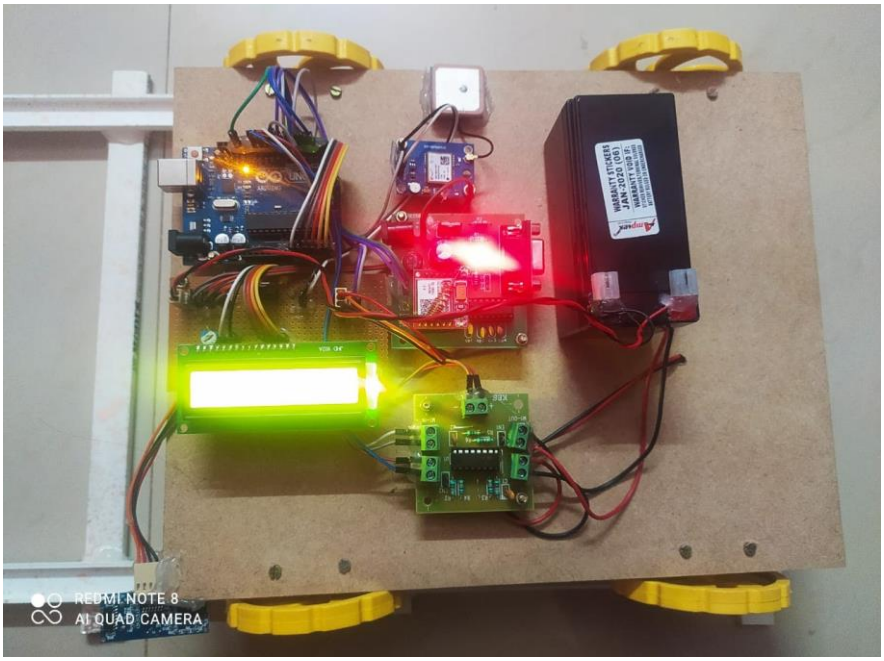


Fig. 7. Complete hardware circuit.

In Fig. 8, the designed robot is kept on a dummy railway track made of plastic. In that track, we have considered the crack as the end point of the track where there is nothing present it is made to clarify the results. In Table 1 real-time status on LCD display and SMS alert on a cell phone are shown. As soon as the crack is detected the GPS location is sent to the cell phone via SMS alert.

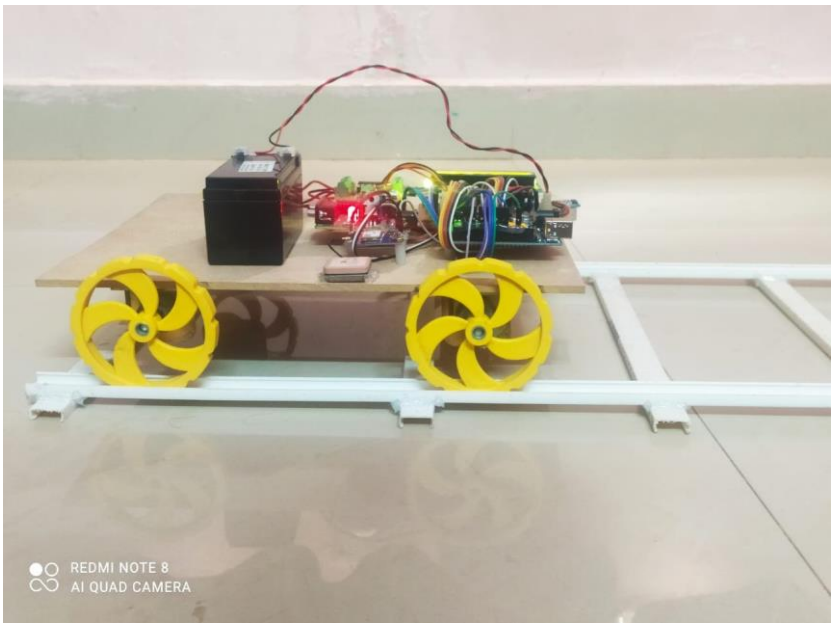
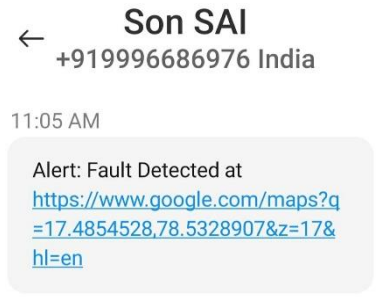


Fig. 8. Crack Detection Robot on a dummy railway track made of plastic.

Table 1 Hardware Result

Description	Hardware Result
Real- time LCD display	
Real-time status of crack on LCD display	
SMS alert on a cell phone	

Advantages:

Some of the advantages of the device are discussed below.

- A fully automated security system ensures a safe railway track to carry out thousands of passengers.
- Less time consuming compared to current manual crack detection system.
- Reduce human effort results a profited output.
- This device is portable so that it can travel to the area where a human cannot easily pass.
- It is cost effective and affordable.
- We can control it manually or automatically by sending SMS.

Conclusion:

The main causes of rail accidents in India are a collision between trains and derailment. Derailment of trains occurs mainly due to cracks in railway tracks. The proposed robust and cost-effective system helps to detect these cracks. In this project, an autonomous system is designed for railway track security by developing a microcontroller-based robot. This device brings a digital solution for the real-time problem that is a huge threat for thousands of people who are using the train as a major transport in their daily life. The crack can be detected without any error. The government of India can take initiative to implement this in large scale. In the long run, it will facilitate better safety standards for rail tracks and provide effective testing infrastructure for achieving better results in the future. This robot will create a revolutionary transformation in the railway security system.

Future Work:

If possible we can modify or redesign the robot for better durability and performance by adding solar cells for battery ,vibration sensor etc for better detection etc

References:

[1] Ch. MuneedraRao and B.R. BalaJaswanth, “Crack sensing scheme in rail tracking system”, Int. Journal of Engineering Research andApplication, Vol. 4, Issue 1, January 2014, pp.13-18.

[2] B.Siva Rama Krishna, D.V.S Seshendra, G.Govinda Raja, T.Sudharshan, and K.Srikanth, "Railway Track Fault Detection System by Using IR Sensors and Bluetooth Technology", Asian Journal of Applied Science and Technology (AJAST), Volume 1, Issue 6, Pages 82-84, July 2017

[3] Rakesh V. Pise, Parag D. Nikhar, Prof. Avinash H. Shelar, "Review on Railway Track Crack Detection Using Ir Transmitter and Receiver"; International Research Journal of Engineering and Technology(IRJET), 4(1), 1723–1726, 2017.

[4] Lad, P., & Pawar, M., "Evolution of railway track crack detection system", 2nd IEEE International Symposium on Robotics and Manufacturing Automation, ROMA 2016.

[5] Er.Nisthul G, Lijo George, Nelson Varghese, Sebin Jose, Nithin John & Nandhumon K R., "Automatic Railway Track Crack Detection System", Imperial Journal of Interdisciplinary Research (IJIR) Vol-3, Issue-4, 2017.

[6] Muley, A. S., Patil, S. B., & Shelar, P. A. H., "Railway track crack detection based on GSM technique", International Research Journal of Engineering and Technology(IRJET), 4(1), 1252–1254, 2017.

[7] Rizvi Aliza Raza, Khan Pervez Rauf, Ahmad Shafeeq., "Crack Detection in Railway Track Using Image Processing", International Journal of Advance Research, Ideas and Innovations in Technology, Volume-3, Issue-4, 489–496, 2017

[8] Delforouzi A., Tabatabaei A.H., Khan M.H., Grzegorzek M. (2018), "A Vision-Based Method for Automatic Crack Detection in Railway Sleepers", Kurzynski M., Wozniak M., Burduk R. (eds) Proceedings of the 10th International Conference on Computer Recognition Systems CORES 2017. CORES 2017. Advances in Intelligent Systems and Computing, vol 578. Springer, Cham.

[9] Stefan Hensel and Carsten Hasberg., “HMM Based Segmentation of continuous Eddy Current Sensor signal”, 11th International IEEE conference on intelligent transportation system, China, vol.13, page 760-765, 2008.

[10] D. Sri Rajitha, L.Chandra Shekar and R.Murali, "An Embedded Based Railway Track fault Detection Using ARM7LPC2148", International Journal& Magazine of Engineering,Technology,Management and Research, Vol. 2, Issue 3, pp. 300-304, March 2015.

[11] Boggula Ramesh Reddy, K. Srinivarsa Reddy,Geetha Reddy Evurl, "Advanced railway security system (ARSS) based on zigbee communication for track fault", International Journal of Engineering Invention & Development; vol.1, Issue 3, September 2014, pp. 100-104.

[12] V.Pedda Obulesu,T.Nagendra Goud,B.V. MadhuSudhan Reddy,P. Uday Kumar, "A microcontroller based scout robot with automatic crack detection in railway tracks using led-ldr assembly" ,International Journal of Science, Engineering and Technology Research (IJSETR), Volume 3, Issue 5, May 2014.

[13] Latifa Oukhellou, Patrice Aknin, Jean-Paul Perrin., "Dedicated Sensor and classifier of Rail Head Defects", Control Engineering Practice, Vol. 7, pp 57-61, 1999, U.S.A.International Journal of Scientific & Engineering Research,Volume 4,Issue 1, January- 2013 ISSN 2229-5518 IJSER 2013.

[14] Rainer Pohl, A Erhard, H.-J Montag, H.-M Thomas, H Wüstenberg., "NDT Techniques for Railroad wheel and Gauge Corner Inspection", NDT International, Elsevier, vol. 37, pp 89-94, 2004, U.S.A.