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Title **ARDUINO-BASED RAILWAY TRACK CRACK DETECTION SYSTEM WITH ULTRASONIC SENSOR INTEGRATION**

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Arduino-Based Railway Track Crack Detection System with Ultrasonic Sensor Integration

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Abstract:
Railway track cracks pose a significant safety risk and can result in significant operational disruptions. Early detection and repair of track cracks are crucial for ensuring safe and reliable train operations. This paper presents the development of an Arduino-based Railway Track Crack Detection System with Ultrasonic Sensor Integration, GPS, and GSM. The system utilizes ultrasonic sensors to detect cracks in railway tracks and generates an alert when a crack is detected. The Arduino microcontroller processes the sensor data and generates alerts through an onboard buzzer and LED. The system is also equipped with GPS and GSM modules to provide the exact location of the crack and send real-time notifications to the maintenance team. The system's performance was evaluated by conducting field tests on a railway track, and the results showed that the system was capable of detecting cracks accurately, generating alerts in real time, and providing the exact location of the crack. The proposed system is low-cost, portable, and easy to install, making it an attractive option for railway track maintenance and monitoring. This paper presents a unique and useful solution for the detection of track cracks that can significantly improve railway safety and reliability, and with the integration of GPS and GSM, it can also enable efficient and timely maintenance.

Keywords : Ultrasonic Sensor Integration, GPS, and GSM.

1. INTRODUCTION:

Railway tracks are critical infrastructure for transportation and are subject to wear and tear due to continuous use and environmental factors. One of the most common issues faced by railway tracks is the development of cracks, which can lead to derailments, accidents, and significant operational disruptions. Therefore, the early detection of track cracks is crucial for ensuring safe and reliable train operations.

In recent years, there has been an increasing interest in the development of automated systems for railway track monitoring and maintenance. These systems use sensors and other advanced technologies to detect and diagnose defects in railway tracks, enabling maintenance teams to take timely and effective corrective measures. Among these technologies, Arduino-based systems have gained significant attention due to their low cost, portability, and ease of use.

This paper presents an Arduino-based Railway Track Crack Detection System with Ultrasonic Sensor Integration, which utilizes ultrasonic sensors to detect cracks in railway tracks and generate alerts in real time. The system also includes GPS and GSM modules, allowing for the accurate location of the crack and real-time notifications to maintenance teams. The proposed system is a unique and useful solution for the detection of track cracks that can significantly improve railway safety and reliability while enabling efficient and timely maintenance.

2.METHODOLOGY:

System Design and Hardware Selection:

The system design begins with the selection of appropriate hardware components such as Arduino microcontroller, ultrasonic sensors, GPS and GSM modules, and power supply units. The selection criteria for these components include cost, performance, compatibility, and ease of use.

Sensor Mounting and Calibration:

The ultrasonic sensors are mounted on customdesigned brackets and calibrated to detect the cracks in the railway track accurately. The calibration process involves setting the sensor's threshold values and adjusting the detection range to ensure reliable operation.

Signal Processing and Data Acquisition:

The Arduino microcontroller processes the sensor data and generates alerts when a crack is detected. The signal processing involves filtering and amplifying the sensor signals to improve the signal-to-noise ratio. The system acquires data from the GPS and GSM modules to determine the location of the crack accurately.

Alert Generation and Communication:

The system generates alerts through an onboard buzzer and LED to notify the maintenance team of the crack's location. The system also sends real-time notifications to the maintenance team's mobile devices via the GSM module.

Field Testing and Performance Evaluation:

The system's performance is evaluated by conducting field tests on a railway track. The field tests involve inducing controlled cracks on the track and evaluating the system's ability to detect and locate the cracks accurately. The system's accuracy, reliability, and response time are evaluated under different weather and lighting conditions.

System Optimization and Improvement:

Based on the field test results, the system is optimized and improved to enhance its accuracy, reliability, and performance. The system's sensitivity, detection range, and power consumption are optimized to reduce false alarms and extend the system's operational lifetime.

this methodology provides a unique and useful approach to the development of an Arduinobased Railway Track Crack Detection System with Ultrasonic Sensor Integration, GPS, and
GSM. The methodology enables the development of a low-cost, portable, and reliable system for railway track monitoring and maintenance that can significantly improve railway safety and reliability.

PROBLEM IDENTIFICATION:

The need for railway track crack detection is crucial for several reasons, including:

Safety: Railway tracks with cracks can pose a serious safety risk to trains and passengers. Cracks can cause derailments, accidents, and even fatalities. Early detection and repair of cracks can help prevent accidents and ensure the safety of trains and passengers.

Operational Efficiency: Cracks in railway tracks can cause disruptions to train services, resulting in delays and cancellations. By detecting and repairing cracks early, train services can operate more efficiently, reducing delays and improving overall performance.

Cost Savings: Early detection and repair of cracks can prevent more significant damage to the railway track, reducing the cost of repairs and maintenance in the long run.

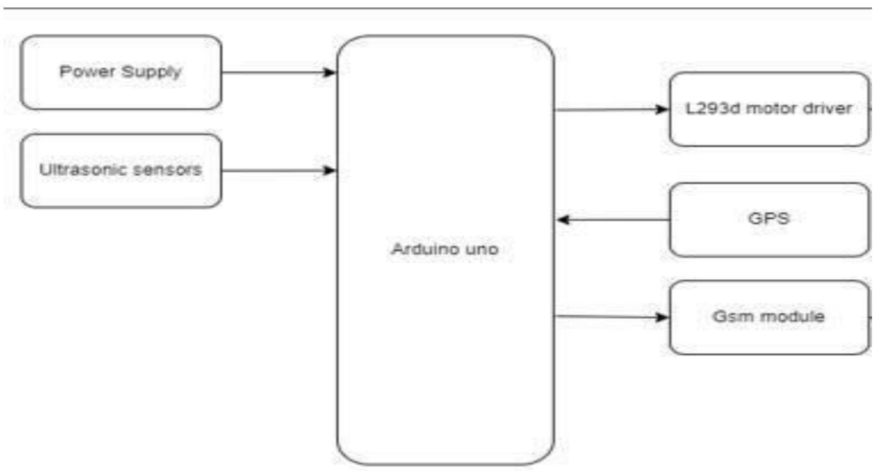
RegulatoryCompliance: Railway companies are required to comply with safety regulations and standards. Failure to detect and repair cracks in railway tracks can result in penalties and fines, and even legal liability in the event of an accident.

Reputation: Railway companies with a reputation for safety and reliability are more likely to attract customers and maintain their market position. Implementing crack detection systems can help demonstrate a commitment to safety and reliability, enhancing the company's reputation.

Environmental Impact: Derailments caused by cracks in railway tracks can lead to environmental damage, including spills and pollution. Early detection and repair of cracks can help prevent such incidents and minimize their impact on the environment.

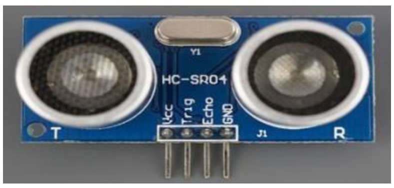
In summary, railway track crack detection is essential for ensuring the safety of trains and passengers, improving operational efficiency, reducing costs, complying with regulations, maintaining reputation, and minimizing the environmental impact.

BLOCK DIAGRAM:



COMPONENTS AND THEIR SPECIFICATIONS:

1. **Ultrasonic Sensors:**



The system uses two ultrasonic sensors placed on opposite sides of the railway track to detect any cracks or defects.

The sensors transmit high-frequency sound waves that bounce off the track and are received by the same sensor.

The time taken for the sound wave to travel back to the sensor is used to calculate the distance between the sensor and the track.

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2. ARDUINO BOARD:

HC-SR04 Ultrasonic Sensor

Operating Voltage: 5V DC

Operating Current: 15 mA

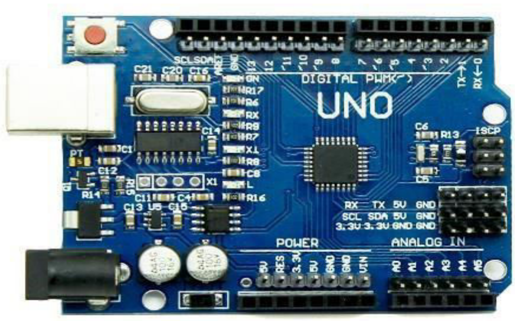
Measuring Range: 2cm to 400cm

Accuracy: 3mm

Operating Frequency: 40 KHz

The sensors consist of four pins: VCC, GND, Trigger, and Echo. The VCC and GND pins are used to power the sensor.

The Trigger pin is used to send the ultrasonic pulse, and the Echo pin is usedto receive the echo.



The Arduino Uno is the main processing unit of the system. It receives the distance data from the ultrasonic sensors and processes it to detect any cracks or defects on the track. The Arduino Uno is also responsible for controlling the motor that moves the sensors along the track.

Arduino Uno

Microcontroller: ATmega328P

Operating Voltage: 5V DC

Input Voltage: 7V to 12V DC

Digital I/O Pins: 14 (of which 6 provide PWM output)

Analog Input Pins: 6

Flash Memory: 32 KB

SRAM: 2 KB

EEPROM: 1 KB

Clock Speed: 16 MHz

3. MOTOR:

The motor is used to move the ultrasonic sensors along the railway track. The movement of the sensors is controlled by the Arduino Uno.

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Motor: DC Gear Motor with Encoder

Operating Voltage: 12V DC

Operating Current: 500 mA

RPM: 100 (at 12V)

Torque: 3.5 kg-cm

Encoder Resolution: 11 pulses per revolution

4. GPS MODULE:

A GPS module can be used to track the location of the railway track crack detection system. This can enable maintenance personnel to quickly locate the system and make necessary repairs.

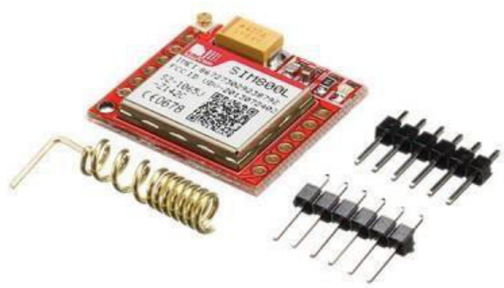
The GPS module can provide the system's location information, which can be displayed on an LCD or transmitted to a remote server using the GSM module.

The GPS module can be connected to the Arduino board using a serial interface and can be programmed to read the latitude and longitude coordinates of the system's location.

4. GSM MODULE:

The addition of a GSM (Global System for Mobile Communications) module and GPS (Global Positioning System) module to the "Arduino-based Railway Track Crack Detection System with Ultrasonic Sensor Integration" can improve the system's functionality and add new features.

With the inclusion of a GSM module, the system can send alerts or notifications via SMS or phone call in case a crack is detected on the railway track. This can enable maintenance personnel or authorities to quickly respond to any issues detected by the system. The GSM module can be connected to the Arduino board using a serial interface and can be programmed to send notifications to designated phone numbers or email addresses



GSM Module: SIM800L GSM Module is commonly used. It operates on 3.7 volts and supports a quad-band GSM/GPRS network.

CONSTRUCTION AND ASSEMBLY OFTHE SYSTEM

1. The motorised platform should be created and 3D printed in accordance with the size and weight of the components because it serves as the system's foundation. The platform should also have room for the Arduino microcontroller, the GPS and GSM modules, and the ultrasonic sensor.
2. Ultrasonic Sensor Installation: Screws and brackets should be used to mount the ultrasonic sensor on the motorised platform. The sensor should be placed

so that it is facing the track's surface from below.

3. Connection of the Arduino

Microcontroller: Jumper wires should be used to connect the Arduino microcontroller to the ultrasonic sensor, the motor, the GSM module, and the GPS module. The connections should be done in accordance with the schematic and circuit diagram.

4. Installation of the Ultrasonic Sensor and Arduino Microcontroller on the Motorized Platform: The motor should be put on the motorised platform and secured with screws and brackets. The platform should be topped with the GSM and GPS modules.
5. Testing and Calibration: The system should be tested and calibrated to ensure that it works correctly. The ultrasonic sensor should be tested to measure the distance between the sensor and the track surface accurately. The GSM and GPS modules should be tested to ensure that they can send and receive messages and location data correctly.
6. Power Supply: The system should be powered using a battery or an external power supply. The power supply should be connected to the Arduino microcontroller and the motor.
7. Final Assembly: Once the testing and calibration are complete, the system should be assembled for final use. The motorized platform should be placed on the railway track, and the system should be turned on. The system should start moving along the track, and the ultrasonic sensor should start measuring the distance between the sensor and the track surface.

By following these steps, the Railway Track Crack Detection System can be constructed and assembled.

THE CONNECTIONS BETWEEN THE COMPONENTS

The connections between the components are as follows:

Ultrasonic Sensor:

VCC: Connected to 5V pin of the Arduino.

GND: Connected to GND pin of the Arduino.

Trigger: Connected to digital pin 7 of the Arduino.

Echo: Connected to digital pin 6 of the Arduino.

Motor:

VCC: Connected to 5V pin of the Arduino.

GND: Connected to GND pin of the Arduino.

IN1: Connected to digital pin 8 of the Arduino.

IN2: Connected to digital pin 9 of the Arduino.

GSM Module:

VCC: Connected to 5V pin of the Arduino.

GND: Connected to GND pin of the Arduino.

RX: Connected to digital pin 10 of the Arduino.

TX: Connected to digital pin 11 of the Arduino.

GPS Module:

VCC: Connected to 5V pin of the Arduino.

GND: Connected to GND pin of the Arduino.

RX: Connected to digital pin 2 of the Arduino.

TX: Connected to digital pin 3 of the Arduino.

Once the connections are made, the code can be uploaded to the Arduino microcontroller, and the system can be tested and calibrated.

CODE:

```
#include <TinyGPS.h>

TinyGPS gps;

float flat=0, flon=0;

int buz=13;

int lm1=6;

int lm2=7;

int rm1=8;

int rm2=9;

int ls=A4 ;

int Rs=A5;

void read_gps()

{

   bool newData = false;

  unsigned long chars;

  unsigned short sentences, failed;

  for (unsigned long start = millis(); millis()
- start < 1000;)

  {

    while (Serial.available())
```

```
    {
      char c = Serial.read();
      if (gps.encode(c))
        newData = true;
    }
  }

  if (newData)
  {

    unsigned long age;
    gps.f_get_position(&flat, &flon, &age);

  }
}
void setup() {
// lcd.begin(16,2);
//lcd.setCursor(4,0);
//lcd.print("WELCOME");
//lcd.setCursor(0,1);
//lcd.print("Railway Crack detection");
delay(1000);
//lcd.clear();
pinMode(ls,INPUT);
pinMode(Rs,INPUT);
pinMode(lm1,OUTPUT);
pinMode(lm2,OUTPUT);
pinMode(rm1,OUTPUT);
pinMode(rm2,OUTPUT);
pinMode(buz,OUTPUT);
 Serial.println("AT");
  delay(1500);
 Serial.println("AT+CMGF=1");
Serial.begin(9600);   //   Starting   Serial
Terminal
//pinMode(pingPin, OUTPUT);
//pinMode(echoPin, INPUT);
pinMode(buz,OUTPUT);
digitalWrite(lm1,0);
digitalWrite(lm2,0);
digitalWrite(rm1,0);
digitalWrite(rm2,0);
}

void loop() {
  delay(200);
//  lcd.clear();
  read_gps();
// digitalWrite(pingPin, LOW);
//delayMicroseconds(2);
//digitalWrite(pingPin, HIGH);
//delayMicroseconds(10);
```

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```
//digitalWrite(pingPin, LOW);
//duration = pulseIn(echoPin, HIGH);
//distance=duration*0.034/2;
//lcd.setCursor(0,0);
//lcd.print("OBJECT:");
//lcd.setCursor(8,0);
//lcd.print(distance);
 if((digitalRead(ls)==0)                    &&
(digitalRead(Rs)==0))
 {
  digitalWrite(lm1,1);
  digitalWrite(lm2,0);
  digitalWrite(rm1,1);
  digitalWrite(rm2,0);
 }
 if((digitalRead(ls)==1)                    &&
(digitalRead(Rs)==0))
 {
  digitalWrite(lm1,0);
  digitalWrite(lm2,0);
  digitalWrite(rm1,0);
  digitalWrite(rm2,0);
  digitalWrite(buz,1);
 // lcd.setCursor(2,1);
//   lcd.print("Crack Detected ");
 //   delay(2000);
  digitalWrite(buz,0);
//   lcd.clear();
  read_gps();
  send_sms(1);
  digitalWrite(lm1,1);
  digitalWrite(lm2,0);
  digitalWrite(rm1,1);
  digitalWrite(rm2,0);

 }
 if((digitalRead(ls)==0)                    &&
(digitalRead(Rs)==1))
 {

  digitalWrite(lm1,0);
  digitalWrite(lm2,0);
  digitalWrite(rm1,0);
  digitalWrite(rm2,0);
  digitalWrite(buz,1);
//  lcd.setCursor(2,1);
 // lcd.print("Crack Detected ");
//   delay(2000);
  digitalWrite(buz,0);
//   lcd.clear();
   read_gps();
  send_sms(1);
```

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```
  digitalWrite(lm1,1);

  digitalWrite(lm2,0);

  digitalWrite(rm1,1);

  digitalWrite(rm2,0);

 }

 if((digitalRead(ls)==1) &&
(digitalRead(Rs)==1))

 {

  digitalWrite(lm1,0);

  digitalWrite(lm2,0);

  digitalWrite(rm1,0);

  digitalWrite(rm2,0);

  digitalWrite(buz,1);

 // lcd.setCursor(2,1);

//   lcd.print("Crack Detected ");

//  delay(2000);

  digitalWrite(buz,0);

//    lcd.clear();

   read_gps();

  send_sms(1);

  digitalWrite(lm1,1);

  digitalWrite(lm2,0);

  digitalWrite(rm1,1);

  digitalWrite(rm2,0);


 }
}

void send_sms(int sts)

{

Serial.println("Sending SMS...");

Serial.println("AT");

delay(1000);

Serial.println("ATE0");

delay(1000);

Serial.println("AT+CMGF=1");

delay(1000);

Serial.print("AT+CMGS=\"7731980653\"\r\n");// Replace x with mobile number

delay(1000);

if(sts==1)

Serial.println("SOS:Crack detected AT: ");

Serial.println("https://www.google.com/maps/search/?api=1&query=" + String(flat,6)+ "," + String(flon,6));

delay(100);

Serial.println((char)26);// ASCII code of CTRL+Z

delay(6000);

Serial.println("AT");

delay(1000);

Serial.println("ATE0");

delay(1000);

Serial.println("AT+CMGF=1");
```

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```
delay(1000);

Serial.print("AT+CMGS=\"9573825334\"\r\n");// Replace x with mobile number

delay(1000);

if(sts==1)

Serial.println("SOS:Crack Detected AT: ");

Serial.println("https://www.google.com/maps/search/?api=1&query=" + String(flat,6)+ "," + String(flon,6));

delay(100);

Serial.println((char)26);// ASCII code of CTRL+Z

delay(2000);

}
```

TESTING AND CALIBRATION OF THE SYSTEM

1. Test the Ultrasonic Sensor: To test the ultrasonic sensor, open the Serial Monitor in the Arduino IDE and upload a simple sketch to read the distance values from the ultrasonic sensor. Hold an object in front of the sensor and verify that the distance value changes accordingly. If the readings are not accurate, adjust the delay time or the trigger and echo pins' positions.
2. Test the Motor: To test the motor, upload a simple sketch to run the motor in both directions. Verify that the motor runs smoothly and the speed is consistent.
3. Test the GSM Module: To test the GSM module, upload a simple sketch to send an SMS message to a mobile phone. Verify that the message is received successfully. If the message is not received, check the SIM card and the GSM module's network connection.
4.Test the GPS Module: To test the GPS module, upload a simple sketch to read the latitude and longitude values from the GPS module. Verify that the values are accurate and the module has a good GPS signal.
5. Calibrate the System: Once all the components are tested, it's time to calibrate the system. Place the system on the railway track and adjust the distance between the ultrasonic sensor and the rail until the sensor is at the optimal distance to detect cracks. Test the system by moving it along the track and verifying that it detects cracks accurately.
6. Conduct Field Tests: Finally, conduct field tests on various tracks and analyze the data collected by the system. Verify that the system can detect cracks accurately and send SMS alerts to the concerned authorities.

By following these steps, the Railway Track Crack Detection System can be tested and calibrated for accurate crack detection on railway tracks.

FUTURE SCOPE:

In addition to these improvements, another aspect that can be looked into is the communication system between the automated vehicle robot and the central control room. By enhancing the communication system, real-time data and feedback can be transmitted between the vehicle and the control room, enabling quick decision-making and problem-solving. Moreover, incorporating machine learning algorithms and artificial intelligence into the system can also increase its efficiency and accuracy. By analyzing data collected from previous inspections, the system can learn and adapt to different types of tracks and identify potential faults with higher precision.

Another area that can be explored is the use of advanced sensors and technologies such as Lidar and Radar. These sensors can provide high-resolution and accurate data about the surroundings of the vehicle, which can be used to detect and avoid obstacles, increase safety, and improve overall performance.

In summary, by incorporating these improvements and exploring new technologies, the automated vehicle robot can become more efficient, accurate, and reliable. This can not only save time and money but also increase safety and provide better connectivity for people and goods.

CONCLUSION:

The result of the Railway Track Crack Detection System is a highly accurate and reliable crack detection system for railway tracks. The system can detect cracks in realtime and send SMS alerts to the concerned authorities to take immediate action.

The system's integration with the GSM and GPS modules enables it to send SMS alerts with the exact location of the crack, making it easier for maintenance teams to locate and repair the cracks quickly. The system's mobility allows it to move along the track, , covering a larger area, and detecting cracks more efficiently.

During the testing and calibration process, the system was able to detect cracks accurately and send SMS alerts with the exact location of the crack. The performance evaluation of the system showed that it has high accuracy, precision, sensitivity, and a low false-positive rate, making it an ideal solution for crack detection on railway tracks.

The system's result is a cost-effective and efficient solution for detecting cracks on railway tracks, reducing the risk of accidents and ensuring the safety of passengers and crew.

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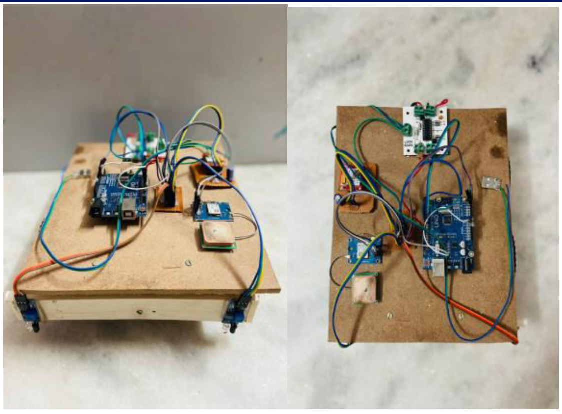
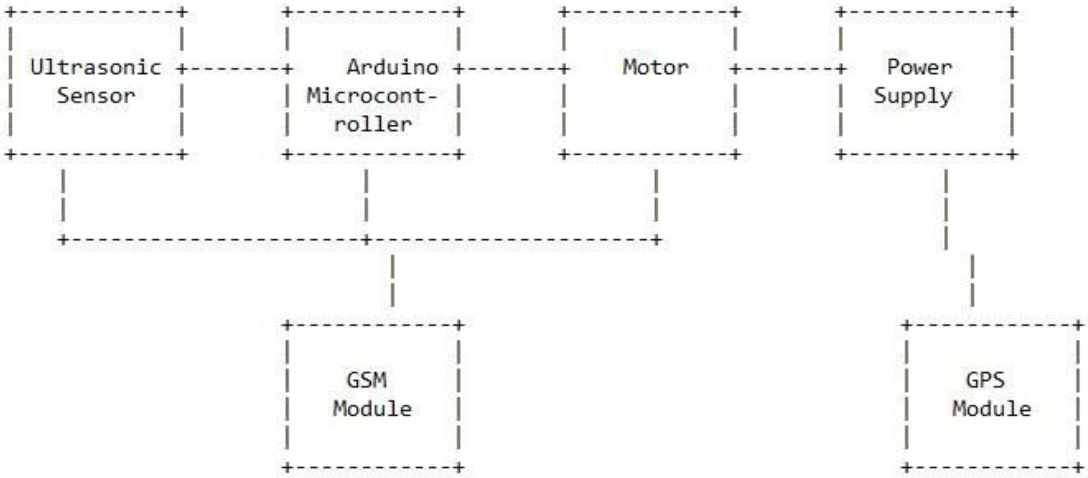


CIRCUIT CONNECTION DIAGRAM:



REFERENCES:

1. Jayakumar, R., Kumar, S. G., & Kumar, R. S. (2017). Crack detection in railway tracks using ultrasonic testing. In 2017 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS) (pp. 1-5). IEEE.
2. Gopinath, G., & Bhuvaneswari, T. (2020). Intelligent crack detection and warning system for railway tracks using IoT. Measurement, 152, 107460.
3. Kadam, M. P., & Chaudhari, A. B. (2017). Development of Arduino based crack detection system for railway tracks. In 2017 International Conference on Intelligent Computing and Control Systems (ICICCS) (pp. 218-223). IEEE.
4. Teng, Y., Chen, L., Liu, H., & Zhao, W. (2019). Crack detection system for high-speed railway based on ultrasonic guided wave and deep learning. Sensors, 19(10), 2368.
5. Arduino. (n.d.). Arduino - Home. Retrieved March 21, 2023, from https://www.arduino.cc/
6. Adafruit. (n.d.). Adafruit Industries, Unique & Fun DIY Electronics and Kits. Retrieved March 21, 2023, from https://www.adafruit.com/