DESIGN PROJECT PROPOSAL

Design Lab
Department of Computer Science and Engineering
SCT College of Engineering

RAILWAY CRACK DETECTION SYSTEM

Submitted by

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CHAPTERS

CHAPTER 1
INTRODUCTION

1.1 Background

Indian Railways is India's national railway system operated by the Ministry of Railways. It manages the fourth largest railway network in the world by size, with a route length of 67,368-kilometre and total track length of 121,407-kilometre. Indian Railway runs more than 20,000 passenger trains daily, on both long-distance and suburban routes, from 7,349 stations across India. Mail or Express trains, the most common types, run at an average speed of 50.6 kilometres per hour. Most premium passenger trains like Rajdhani, Shatabdi Exp run at peak speed of 140–150 km/h with Gatiman Express between New Delhi and Jhansi touching peak speed of 160 km/h. In the freight segment, IR runs more than 9,200 trains daily. The average speed of freight trains is around 24 kilometres per hour.

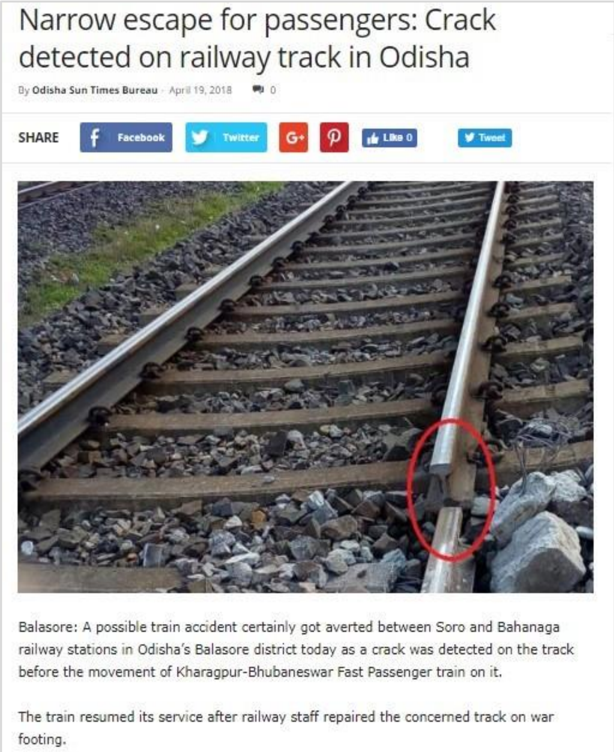
As of March 2017, Indian Railway's rolling stock consisted of 277,987 freight wagons, 70,937 passenger coaches and 11,452 locomotives. IR owns locomotive and coach-production facilities at several locations in India. The world's eighth-largest employer having 1.30 million employees.

1.2 From the News

Derailment due to rail fracture or cracks is a common problem faced by Indian Railways. One such incident that occurred in Bihar in February 2019 is cited below:

At least seven passengers have been killed and several others injured when a New Delhi-bound train derailed in India's eastern state of Bihar. Eleven coaches of the Seemanchal Express derailed near Sahadai Buzurg railway station, about 50km from the state capital Patna, early on Sunday morning.

*According to a statement released by Indian Railways, a "**rail fracture**" caused the accident.*



Narrow escape for passengers: Crack detected on railway track in Odisha

By Odisha Sun Times Bureau - April 19, 2018 0

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Balasore: A possible train accident certainly got averted between Soro and Bahanaga railway stations in Odisha's Balasore district today as a crack was detected on the track before the movement of Kharagpur-Bhubaneswar Fast Passenger train on it.

The train resumed its service after railway staff repaired the concerned track on war footing.

hindustantimes

Wednesday, Sep 04, 2019

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239 train accidents in last 12 years: Why is derailment happening so often?

Derailments are mostly caused by "rail fractures" during extreme summer and foggy winter conditions on account of the expansion or contraction of tracks.

A month and a half after more than 140 passengers died in a train mishap near Kanpur, the Ajmer-Sealdah Express derailed in the same district on Wednesday morning, causing injuries to over 60 passengers.

Minister of Railways of India Piyush Goyal recently claimed to have improved rail safety after a series of deadly accidents in the country.

A 2012 government report said 15,000 people are killed in rail-related accidents every year.

In November 2016, the Patna-Indore express derailed in Uttar Pradesh state, killing 139 people.

At least 59 people were killed in October 2018 when a commuter train travelling at a high speed travelled through a crowd of people on the rail tracks in northern India while they were attending Dussehra festival. It was the deadliest accident of the year, bringing the number of victims of train accidents to 72 in 2018.

1.3 Objective

To design an efficient and fool proof system to detect fractures on railway tracks, overcoming the problems of existing technologies.

CHAPTER 2
PROBLEM DEFINITION

2.1 Problem Statement

Cracks in rails have been recognized to be the main factor of derailments in the past, yet there have been no cheap self-acting solutions available. Hence, owing to the crucial repercussions of this problem, focus was on implementing a better performance and cost-effective solution suitable for large scale application. Since the railway was created, rail maintenance had always been a problem.

A crack or damage rail could lead the train to derail from track. The problem has been the lack of cheap and efficient technology to detect defects in the rail tracks and of course, the insufficiency of maintenance of rails which have resulted in the formation of cracks in the rails and other similar problems. In the past, this problem has influence to a number of derailments resulting in a heavy loss of life and property. High safety standards are needed in the management of railroad lines. A system is needed to detect the presence of surface cracks and bolt loosening that could seriously affect the condition of the railway, and therefore passenger's safety.

2.2 Cause of fracture

- In developed countries, there is separate tracks for each type of train (goods/passenger). But in India, we do not have specific tracks and all trains run on the same track. Usually, goods trains are heavier and passenger trains are comparatively lighter. Since in India we use both types of trains in the same track, due to the weight and load difference, the track is more prone to fracture.

- Indian Railways moves a staggering 25 million passengers and 3 million tonnes of freight every day. Since the number of trains do not match the requirement, passenger overcrowding more than the coach capacity of the coach occurs. So, the trains will have more weight than the weight sustainability of the track.

- In northern India, there is a high temperature difference between daytime and night. This leads to an unequal expansion and contraction of tracks which then leads to track weakening and increases chance of fracture.

CHAPTER 3
CURRENT STATUS

3.1 Existing technologies

In general, there exist three main categories of techniques used for damage identification and condition monitoring of Railway tracks.

These include:

- Visual inspections
- Shuddering-based methods
- Non-destructive testing technologies such as acoustic emissions, magnetic field methods and eddy current technique

Visual inspection is the primary technique used for defect identification in tracks in India.

3.2 Disadvantages of Visual inspection

India have about 121,407km of railway tracks. So, regular checking of tracks manually is an impossible task. Moreover, this would require a large number of people to be employed. Even if manual checking is done, it labor-intensive and time consuming. Thousands of miles of railroad track must be inspected twice weekly by a human inspector to maintain safety standards.

Since there are 25 million passengers, in case of an accident, fatality will be high. Hence this method is not preferred.

3.3 Why Ultrasonic based detection

The system we proposed is based on ultrasonic sensor. It provides a more efficient method to detect cracks compared to the alternatives. The ultrasonic sensor itself is cheap and accurate. It can also work in sunlight as compared to sensors like IR.

CHAPTER 4
ENGINEERING APPROACH

4.1 Proposed System

We propose a system of detecting and reporting of rail cracks by non-destructive technique using ultrasonic sensor. The aim is to design a vehicle that can travel in the existing railway tracks and detect cracks which will be reported to the nearest station along with the exact location coordinates with the help of GPS system.

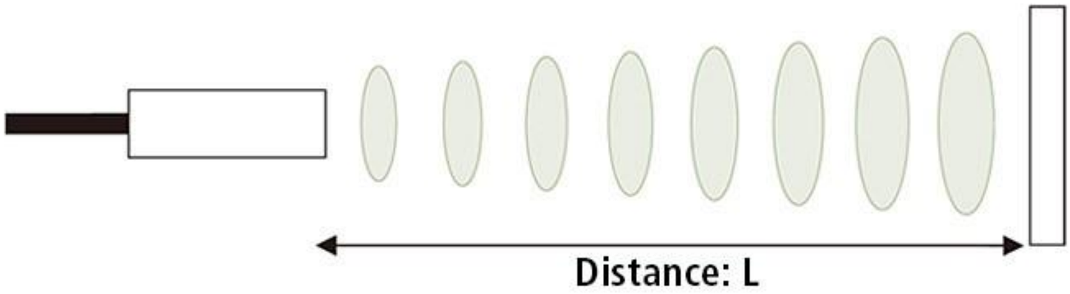
By using ultrasonic rail crack detector system, railway operators will have the benefit of monitoring rails continuously for broken rails without human intervention. This will contribute to ensuring safety of railway tracks and prevent derailments due to crack in railways.

4.2 Working

The main components used for working of the prototype were:

1. Arduino UNO
2. Ultrasonic Sensor (HC-SR04)
3. Motor Driver (Adafruit 4WD Motor Driver)
4. Motors (x4)
5. Chassis for 4WD vehicle

Ultrasonic refers to sound having frequency greater than 20,000Hz, that is more than the human ear's audibility limit. The principle behind the use of ultrasonic sensor is given below:



The ultrasonic sensor has two parts:

1. Trigger
2. Echo

Trigger emits the ultrasonic wave which then strikes on an obstacle and gets reflected. This reflected wave is received by the echo part. The time taken for the wave to go and return is used to calculate the distance between the sensor and the obstacle.

4.3 Advantages of Proposed System

The detector is automated and requires no driver which can help to cutdown labor costs. The detector uses ultrasonic sensor which is cheap and effective. It is also very reliable and we can use it even at night. Hence, we can say that this system is foolproof and can be used 24/7.

4.4 Alternative Solution

LDR is Light Dependent Resistor. LDR can be used to detect the cracks. The LED will be attached to one side of the rails and the LDR to the opposite side in the existing approach. When cracks during normal operation, and hence the LED does not fall LDR, LDR resistance is high. After falling of the LED light after LDR, LDR resistance is reduced and the reduction of the amount of light intensity will be nearly proportional. As a consequence, when light from the LED deviates from its path due to the presence of a crack or a break, a sudden decrease in the resistance value of the LDR ensues. This change in resistance indicates the presence of a crack or some other similar structural defect in the rails.

4.5 Disadvantages of LDR based crack detection

The disadvantage of this system is that it is not very efficient in summer and also during harsh sunlight. Moreover, LDR needs to be calibrated frequently. It is necessary because the LDR has a natural tendency to show a drifting effect because of which, its resistance under the same lighting condition may vary with time and may cause false alarms.

CHAPTER 5
TASKS AND DELIVARABLES

5.1 Scope and Tasks

I. *Choosing the suitable electronic items for build up the system*

This is because the electronics component has their own characteristics and limitations for designing circuit process to avoid this component is burn out during attach on the circuit.

II. *Understanding all railway crack detection systems, their applications and limitations*

By learning about the different systems, the proposed system could be designed as efficiently as possible. The ultrasonic sensor itself has a limitation that it will only be able to detect the distance in centimetre, but not in millimetre.

III. *Designing the railway crack detection system*

The design of system should be taken in terms of dimension and position of components, it because the sensors, motor driver and motor will be placed on lower base platform. For the upper base platform, the components will be placed are Arduino and the circuit of connection for all the components in breadboard.

5.2 Components

The main components used for working of the prototype were:

1. Arduino UNO
    a. The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller.
    b. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.

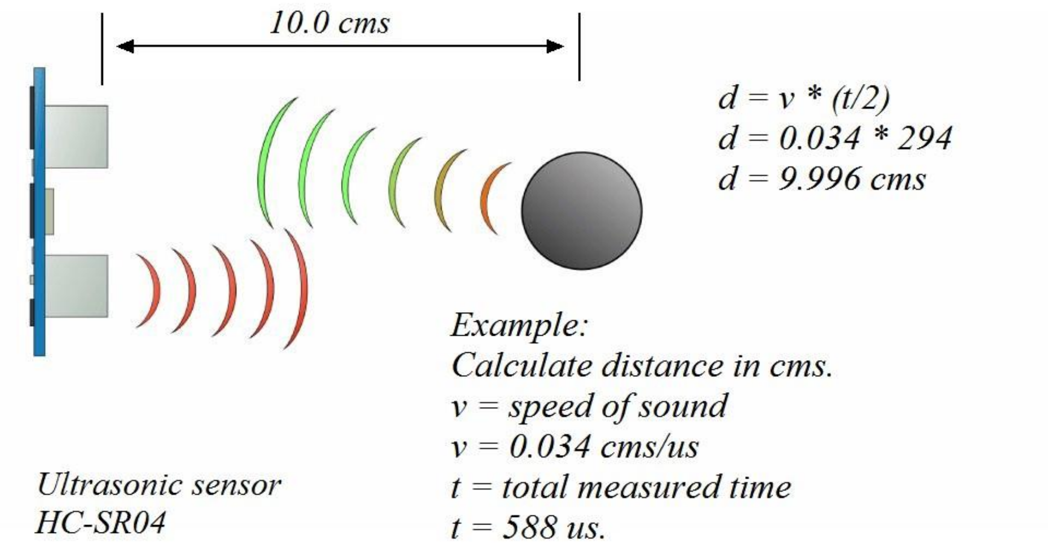
c. The board has 14 digital I/O pins, 6 analog I/O pins and is programmable with the Arduino IDE, via a USB cable.

2. Ultrasonic Sensor (HC-SR04)
    a. As the name indicates, ultrasonic sensors measure distance by using ultrasonic waves.
    b. The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic Sensors measure the distance to the target by measuring the time between the emission and reception.
    c. An optical sensor has a transmitter and receiver, whereas an ultrasonic sensor uses a single ultrasonic element for both emission and reception.
    d. In a reflective model ultrasonic sensor, a single oscillator emits and receives ultrasonic waves alternately. This enables miniaturization of the sensor head.

3. Motor Driver (Adafruit 4WD Motor Driver)
    a. Motor drives are circuits used to run a motor. In other words, they are commonly used for motor interfacing.
    b. These drive circuits can be easily interfaced with the motor and their selection depends upon the type of motor being used and their ratings (current, voltage).
    c. They are basically current amplifiers which accept the low current signal from the controller and convert it into a high current signal which helps to drive the motor.

4. Motors (x4)
    a. A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy.
    b. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

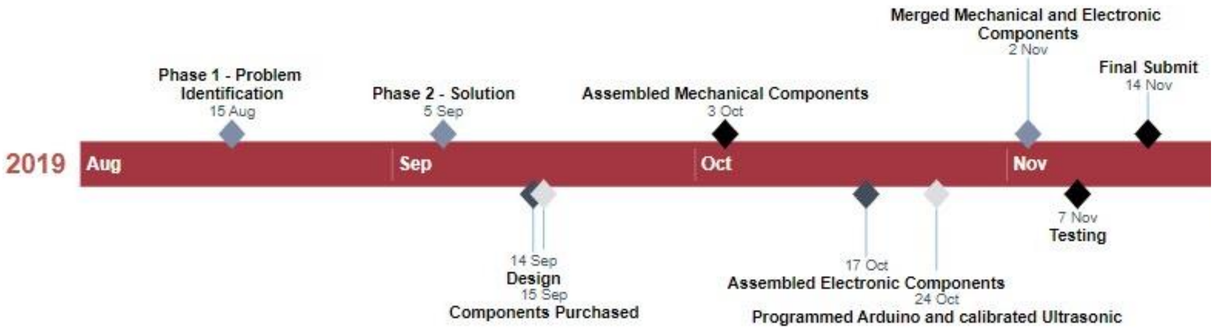
5. Chassis for 4WD vehicle
    a. Since the vehicle had to mimic the motion of a vehicle running on railway track, we had to use a 4 wheel drive vehicle.
    b. A chassis is used to hold the motors, wheels and all the components.
    c. It is the foundation of the vehicle.



Distance Measurement Formula

CHAPTER 6
PROJECT MANAGEMENT

6.1 Timeline



6.2 Tasks Assigned

Designing was done combinedly by both group members. Research was done on different systems available already. This information was used in designing more efficient prototype for our system.

Tasks were categorized into three:

1. Mechanical
2. Electronic
3. Build and Code

6.2.1 Mechanical

Mechanical included all mechanical work including building of chassis, prototype track, motor assembly and wheel placements. This task was handled by Vasudev.

The chassis had to be assembled in levels. The lower level had the motors, wheels and wires soldered to the terminals of the motors. The upper level is to hold the Arduino, motor shield, batteries and other components. There is a protruding arm, which is used to hold the sensor. Since the sensor had to be placed exactly above the tracks, this arm had to be placed perfectly in line.

6.2.2 Electronic

This task included wiring up of the various electronic components such as Arduino, ultrasonic sensor, motor driver, buzzer and LED. This task was handled by Aiswarya. The motor driver is mounted on top of the Arduino. All connections to the Arduino had to be connected through the shield. This shield provides safety to the board as there is a high chance that the Arduino and connected components may burnout due to back emf if the shield was not connected.

6.2.3 Build and Code

Build and code is the phase where the mechanical and electronic components were merged and the project started to take shape. After building, coding was started. Coding consisted of testing and calibration of motors and sensors. This task was handled by Vasudev.

The electronic components were fitted onto the chassis. The components were placed in their prescribed levels. After building, the Arduino was connected to the computer and coding was started. Arduino IDE provides an easy and convenient way to program the microcontroller. Testing had to be done along the way so as to ensure all the components were working and that they were in sync.

6.3 Budget

The project costed around Rs.2000, the costliest component being the chassis and motor set. The system had to be designed as a 4-wheel drive as it had to mimic the movement on railway track.

The total budget split-up is as follows:

1. Arduino UNO – Rs. 450
2. Motor Driver – Rs.400
3. Ultrasonic Sensor – Rs.150
4. Chassis and motors – Rs.800
5. Wires, buzzer, LED, Resistors – Rs.200

6.4 Resources Used

Adafruit libraries were used to code motor. These libraries helped in controlling speed and direction of the motors.

CHAPTER 7
CONCLUSION

From the start of railways, fracture of railway tracks has been a worry for the railway authorities. India have about 121,407km of railway tracks. So, regular checking of tracks manually is an impossible task. Railway is one of the major transportation methods in India. So, derailment due to fracture would cause a huge disaster as many people rely on railways for their commute.

We presented an efficient method for crack detection – automated detection using ultrasonic sensor. An alternative to this system is an LDR based detection. But as shown in Chapter 4, it is not as efficient and foolproof as proposed system.

The system we proposed is based on ultrasonic sensor. It provides a more efficient method to detect cracks compared to the alternatives. The ultrasonic sensor itself is cheap and accurate. It can work in sunlight as compared to sensors like IR. The calibration of ultrasonic sensor is also much easier compared to LDR where frequent calibration maybe required.

The proposed system is cost effective, foolproof and can be used 24/7. This system is automated and doesn't require a driver. The cost is further brought down if we use old engine parts to make these crack detectors and they can run on existing tracks without modification. We first split the mechanical and electronic jobs and completed them individually. It was then assembled together and testing had to be done so as to calibrate the sensors. Speed was adjusted so as to prevent the crash of the detector vehicle itself.

This project helped us to learn more about one of the major transportation methods in India. The prototype designing and testing was completed successfully and we were able to present a fully working prototype.

REFERENCES

- Paper on "Evolution of Railway Track Crack Detection System" by Pranav Lad and Mansi Pawar of Vellore Institute of Technology

  http://ieeexplore.ieee.org/document/7847816/

- Implementation of Railway Track Crack Detection and Protection by N.Karthick, R.Nagarajan, S.Suresh, R.Prabhu - Asst. Professors, Gnanamani College of Technology, Namakkal

  https://www.researchgate.net/publication/317288415_Implementation_of_Railway_Track_Crack_Detection_and_Protection

- Adafruit Motor Shield Library

  https://github.com/adafruit/Adafruit-Motor-Shield-library

- Arduino tutorials from Tutorials Point

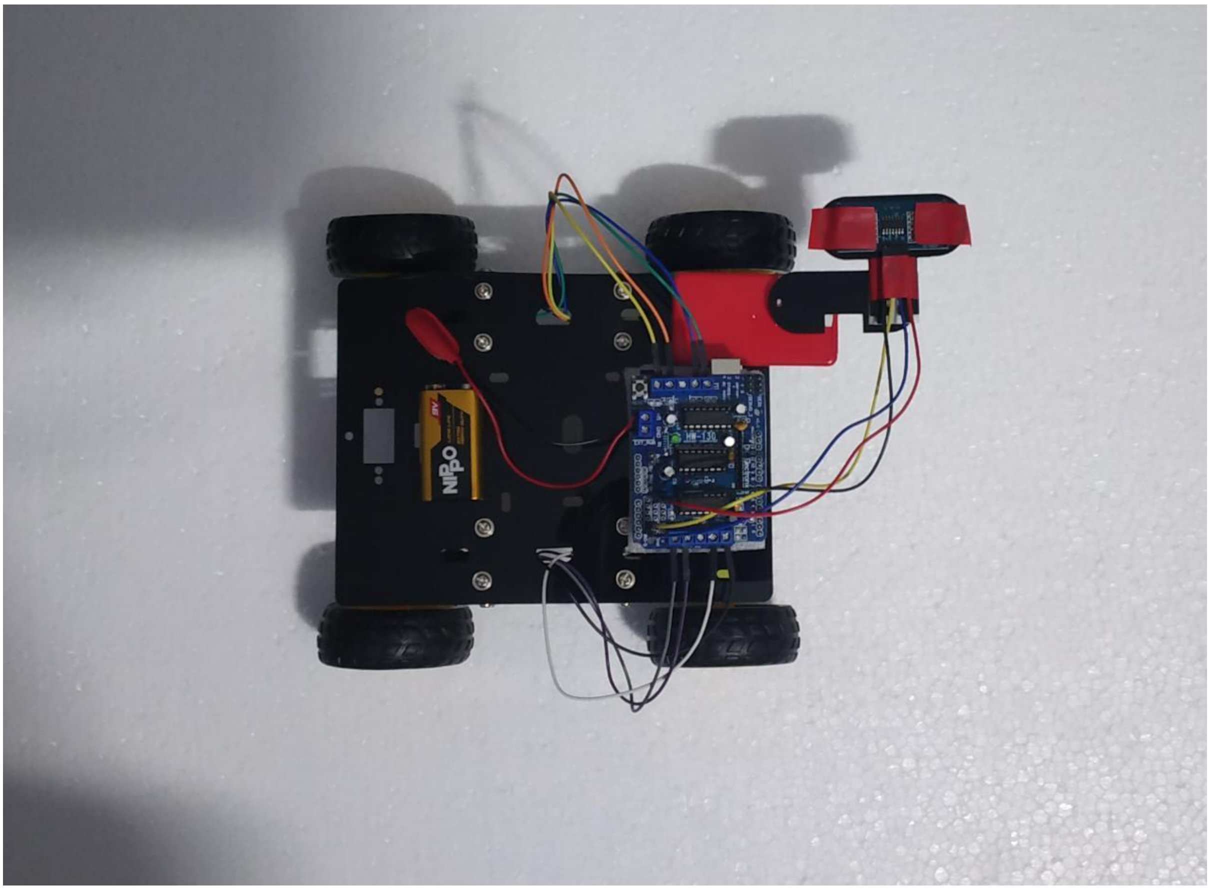
  https://www.tutorialspoint.com/arduino/

- Google Scholar

  https://scholar.google.com/

SUPPORTING DOCUMENTS

Photo of prototype :



Code :

```
//Adafruit Motor Shield Library

#include <AFMotor.h>

//Declaration of sensor and other components

const int trigPin = A5;

const int echoPin = A4;

const int led1 = A3;

const int led2 = A2;
```

```
const int buzz = A1;
//Global variables for storing ultrasonic sensor values
long duration;
int distance;
//Declaration of motors
AF_DCMotor motor1(1);
AF_DCMotor motor2(2);
AF_DCMotor motor3(3);
AF_DCMotor motor4(4);

void setup() {
        pinMode(trigPin, OUTPUT);
        pinMode(echoPin, INPUT);
        pinMode(led1, OUTPUT);
        pinMode(led2, OUTPUT);
        pinMode(buzz, OUTPUT);

        motor1.setSpeed(100);
        motor1.run(RELEASE);
        motor2.setSpeed(100);
        motor2.run(RELEASE);
        motor3.setSpeed(100);
        motor3.run(RELEASE);
        motor4.setSpeed(100);
        motor4.run(RELEASE);
        digitalWrite(led1, LOW);
        digitalWrite(led2, LOW);
}
```

```
void loop() {
	static int flag=0, i, n=500;
	digitalWrite(trigPin, LOW);
	delayMicroseconds(2);
	digitalWrite(trigPin, HIGH);
	delayMicroseconds(10);
	digitalWrite(trigPin, LOW);
	//Distance Calculation
	duration = pulseIn(echoPin, HIGH);
	distance= duration*0.034/2;
	if(distance<11 && distance>5 && flag==0)
	{
		motor1.run(FORWARD);
		motor2.run(FORWARD);
		motor3.run(FORWARD);
		motor4.run(FORWARD);
	}
	else
	{
		motor1.run(RELEASE);
		motor2.run(RELEASE);
		motor3.run(RELEASE);
		motor4.run(RELEASE);
		flag=1;
		for(i=0;i<=n;i++)
		{
		if(i==0 || i==1 || i==2)
```

```
            digitalWrite(buzz, HIGH);
        else
            digitalWrite(buzz, LOW);
        digitalWrite(led1, HIGH);
        delay(500);
        digitalWrite(led1, LOW);
        digitalWrite(led2, HIGH);
        delay(500);
        digitalWrite(led2, LOW);
        }
    }
}
```