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Article Title: **Automatic Railway Gate Crossing Control and Track Crack Detection System Using IoT**

Automatic Railway Gate Crossing Control and Track Crack Detection System Using IoT

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ABSTRACT

This paper involves in an innovative system for automatic railway gate closure and crack detection using infrared (IR) sensors, resistance circuits, Arduino microcontroller, buzzer, servo motor, and LEDs. The primary objective is to enhance railway safety by automating the process of gate opening and closing while also detecting potential cracks on railway tracks. The system employs two IR sensors strategically positioned at the entry and exit points of the railway track. The IR sensor at the entry detects the approaching train, triggering the gate closure mechanism through Arduino control. Meanwhile, the IR sensor at the exit determines when the train has safely passed, prompting the gate to reopen. In addition to gate automation, the system incorporates a crack detection feature for track maintenance. A resistance circuit, integrated with the track, detects any abnormalities indicative of cracks. When a crack is detected, the Arduino system activates a buzzer alert and illuminates an orange LED, signaling the need for immediate inspection and repair. Furthermore, the system utilizes a servo motor to control the gate's movement, ensuring swift and precise opening and closing actions. Visual indicators in the form of LEDs, including a red LED for gate closure and an orange LED for crack detection, provide clear status indications to railway personnel and nearby commuters. Overall, the proposed system offers a comprehensive solution to enhance railway safety by automating gate operations and detecting track cracks in real-time. By leveraging advanced sensor technology and Arduino-based control, this system aims to mitigate potential risks and improve the overall reliability of railway transportation.

Keywords: Arduino UNO, IR Sensors, Servo Meter, Buzzer.

1 Introduction

Wireless Railway transportation plays a crucial role in modern society, facilitating the movement of goods and people over vast distances. Ensuring the safety and efficiency of railway operations is paramount to prevent accidents and disruptions. One critical aspect of railway safety is the timely closure and opening of railway gates at crossings to prevent collisions between trains and vehicles or pedestrians. Traditional methods of manually operating railway gates are not only labor-intensive but also prone to human error, leading to

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potential safety hazards. Moreover, the detection of track defects, such as cracks, is often reliant on visual inspections, which can be challenging to conduct regularly and accurately. To address these challenges, this paper presents an automated railway gate closure and crack detection system using advanced sensor technology and Arduino-based control. The system integrates infrared (IR) sensors, resistance circuits, Arduino microcontroller, buzzer, servo motor, and LEDs to automate gate operations and detect track defects in real-time. The primary objective of this system is to enhance railway safety by automating the process of gate closure and opening, thereby reducing the risk of accidents at railway crossings. Additionally, the system aims to improve track maintenance by detecting potential cracks promptly, enabling timely repairs to prevent derailments and other safety incidents. By leveraging the capabilities of IR sensors for train detection and resistance circuits for crack detection, coupled with Arduino-based control, the proposed system offers a reliable and efficient solution for railway safety enhancement. The integration of visual and auditory indicators, such as LEDs and a buzzer, provides clear alerts to railway personnel and nearby commuters, further enhancing safety awareness.

Overall, this system represents a significant advancement in railway safety technology, offering automated gate operations and real-time crack detection capabilities to mitigate risks and ensure the smooth and secure operation of railway transportation network. Indian railways have been in operation for 160 years and more. India is having the world's biggest railway network. The whole of nation is connected by railways. Over 100 of railway trains are running every day all over the country. Railways are one of the most consistent modes of transportation which has a very important role in day today life. Hence safety and reliability are very critical parameters of the Indian railways.

However, railway related accidents are very dangerous compared with other accidents in terms of death rate, severity etc. We know that it is not possible for a running train to stop at an instant in some critical condition or when any condition arises. Train accidents are having a serious impact on loss of human life, damage to railway property, injury, and etc. Considerable factors which lead to railway accidents are collision derailments, fire in trains, and Collision of trains at the level crossing. When vehicles or pedestrians are passing the level crossing there are chances for an accident to happen. The reasons for accidents are not easy to predict given all possibilities.

If the train drivers solely depend on their ow on some kind of warning signals which are given by the detecting drivers, then they usually don't have much time to react to any such massacre happening. Also train drivers don't have enough time to take necessary measures or precautions, thereby accidents at the level crossing. So in order to avoid all harsh things there arises a need for some independent system to overcome the problems faced at the level crossing. There are two types of level crossing namely manned and unmanned the entire railway route includes nearly 14896 unmanned and 17839 manned level crossings. Railways

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being the cheapest and easy affordable modes of transportation for long travelling are mostly preferred all over the country over other means. When we take a glance over our daily newspaper we come to know across many types of accidents occurring at the railway level crossing.

The reason is mostly because of lack of genuine workers, or may be due to carelessness nature in manual operations. Hence in order to make this accident undone at the railway crossing we are making use of simple electronic system and introducing android platform along with electronic components in order to control the operation performed at the railway gate crossing. The project is designed to achieve control on the railway level crossing gate through Android Application by the gate keeper. Opening and closing of railway level crossing gate involves manpower, which could be often incorrect leading to the accidents. The proposed system prevent any human involvement at the railway level crossing

1.1 Embedded System

An Embedded System can be portrayed as dealing with contraption that makes a particular centered showing up concerning. Gadgets, for example, the ventilation system, VCD player, DVD player, printer, fax machine, cell phone and whatnot are occurrences of installed structures. Each of these machines will have a processor and remarkable equipment to meet the particular fundamental of the application near to the installed programming that is executed by the processor for meeting that particular need. The presented composing PC programs are in like way called "firm thing". The desktop/flexible workstation phone a widely profitable PC. Embedded Systems do a particular errand; they can't be acclimated to do grouped things. Preoccupations, word managing, bookkeeping, programming movement et cetera. In contains Embedded systems have unfathomably kept assets, especially you can utilize it for an assortment of vocations, for example, playing structures need to strife with two or three due dates. A particular occupation must be done inside a particular time. In some installed systems, called relentless structures, the due dates are stringent. Missing a due date may understand a calamity death toll or harm to property. Implanted frameworks are obliged for control. A comparative number of introduced systems work through a battery, the power utilize must be astoundingly low. Some implanted frameworks need to work in outstanding organic conditions, for example, high temperatures and Humidity.

1.2 Application Areas

Around 99 for each penny of the processors made breeze up in presented frameworks. The presented framework publicize is a champion among the most amazing progression zones as these structures are utilized as a bit of particularly grandstand parcel purchaser hardware, office mechanization, current computerization, biomedical building, remote correspondence, information correspondence, media trades, transportation, military et cetera.

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1.3 Overview of Embedded System Architecture

Every embedded system consists of custom-built hardware built around a Central Processing Unit (CPU). This hardware also contains memory chips onto which the software is loaded. The software residing on the memory chip is also called the 'firmware'. The embedded system architecture can be represented as a layered architecture as shown in Figure.

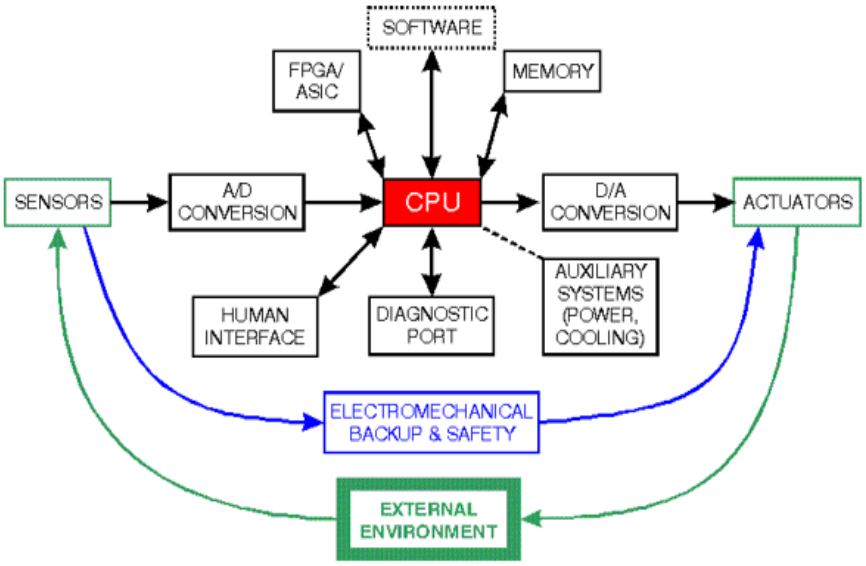

Figure 1.1: *Overview diagram of Embedded system*

1.4 Applications of Embedded Systems

Embedded systems have vast applications in number of fields. The embedded system market is one of the highest growth areas as these systems are used in

- Consumer electronics
- Bio-Medical engineering
- Wireless communication
- Data communication
- Military
- Automobiles
- Aerospace

1.5 Characteristics

All Embedded Systems are task specific. They do the same task repeatedly/continuously over their lifetime. An mp3 player will function only as an mp3 player. Embedded systems are created to perform the task within a certain time frame. It must therefore perform fast enough. A car's brake system, if exceeds the time limit, may cause accidents. They have minimal or no user interface (UI). A fully automatic washing machine works on its own after the program is

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set and stops once the task is over. Some embedded systems are designed to react to external stimuli and react accordingly. A thermometer, a GPS tracking device. Embedded systems are built to achieve certain efficiency levels. They are small sized, can work with less power and are not too expensive. Embedded systems cannot be changed or upgraded by the users. Hence, they must rank high on reliability and stability. They are expected to function for long durations without the user experiencing any difficulties.

2 Literature Survey

2.1 The author namely Krishnapriya K B1 , Sreelakshmi K U 2 , Vivek John(International Journal of Innovative Research in Science, Engineering and Technology (An International Organization for Standardization 3297: 2007 Certified Organization) Vol. 5, Issue 9, September 2016) describes the paper "Railway Level Crossing Gate Control & Measurement System for Railway Track Condition Monitoring" At present people choose various modes of transportation such as by buses, flights, motor cycles, cycle, car, train etc.

Out of this majority depend upon railway; people use this because they always seek for the service with more comfort with cheaper rates. As a demand for travel by trains increases, railway sector has followed a lot of safety standards in order to ensure life's of travellers any problems in the same have the capacity to induce major damage to the economy factor. In spite of this safety measures followed by people, everyone could see a lot of accidents took happened in this sector; knowingly or unknowingly it may take away lives of many ones. The occurrences of these accidents are mainly because of defects of rails. Now railways are performing various fault detection by means of manual inspection by human beings, so it will be better if go for an advanced system where Railway track damage status is monitored transfer related information through wireless modules. Because majority of railway accident prime reason is fault within the track such as occurrence of crack etc. As there need to ensure safety at all related aspects, unmanned railway crossing also need to be taken to account. This problem can be solved by introducing a fully automated system controlling railway level crossing gate more effectively.

2.2 The author namely Pranav Sharma, Rajesh Kumar, Sarika (Journal of Network Communi and Emerging Technologies (JNCET) Volume 5, Special Issue 2, December (2015))

2.3 The author namely Rohini Jadhav, Harshal Patil, Prof. M. S. Wagh (International Research Journal of Engineering and Technology (IRJET) e 0056 Volume: 04 Issue: 04 | Apr p-ISSN: 2395-0072).

3 Existing Project

In previous work is designed using 8051 microcontroller to avoid railway accidents happening at unattended railway gates, if implemented in spirit. This paper utilizes two powerful IR transmitters and two receivers; one pair of transmitter and receiver is fixed at upside (from where the train comes) at a level higher than a human being in exact alignment and similarly the other pair is fixed at down side of the train direction. Sensor activation time is so adjusted

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by calculating the time taken at a certain speed to cross at least one compartment of standard minimum size of the Indian railway. We have Automatic Railway Gate Control System considered five seconds for this paper. Sensors are fixed at 1km on both sides of the gate.
We call the sensor along the train direction as 'foreside sensor' and the other as 'after side sensor's. When foreside receiver gets activated, the gate motor is turned on in one direction and the gate is closed and stays closed until the train crosses the gate and reaches aft side sensors. When aft side receiver gets activated motor turns in opposite direction and gate opens and motor stops. Buzzer will immediately sound at the fore side receiver activation and gate will close after 5 seconds, so giving time to drivers to clear gate area in order to avoid trapping between the gates and stop sound after the train has crossed.

3.1 Existing Block Diagram

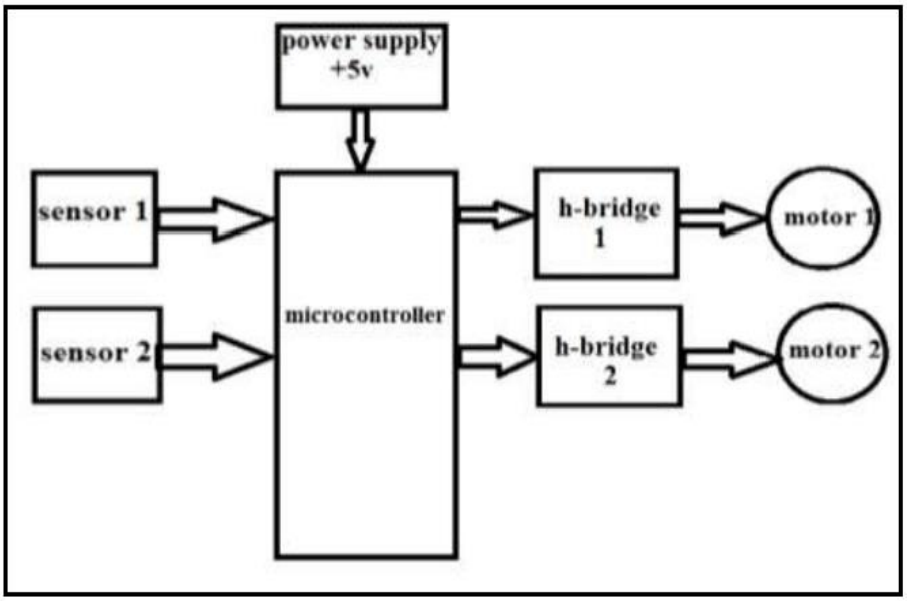

Figure 3.1: *Existing Block Diagram*

4 Proposed Work Explanation

The system's operation begins with the placement of infrared (IR) sensors at the entry and exit points of the railway crossing. When a train approaches the crossing, the IR sensor positioned at the entry point detects its presence and triggers the Arduino control system. In response, the Arduino microcontroller initiates the gate closure sequence, signaling the servo motor to lower the railway gate, thereby preventing vehicles or pedestrians from crossing the tracks.
Simultaneously, the Arduino system activates the resistance circuits embedded within the railway track to monitor for potential cracks or defects. These circuits continuously measure the electrical resistance along the track. If a deviation from the normal resistance levels is detected, indicating a possible crack or anomaly, the Arduino control system is alerted. Upon

detecting a train passing through the crossing, the IR sensor at the exit point sends a signal to the Arduino microcontroller, indicating that it is safe to reopen the railway gate.

In response, the Arduino system instructs the servo motor to raise the gate, allowing traffic to resume its passage across the tracks. Throughout this process, the Arduino microcontroller coordinates the operation of the system, processing input signals from IR sensors and resistance circuits and activating output devices accordingly. Visual indicators such as LEDs provide real-time feedback to railway personnel and nearby commuters, with colors signaling gate status (e.g., red for closure, green for opening) and crack detection alerts (e.g., orange for anomalies). In the event of a crack detection alert, the Arduino system activates the buzzer to emit audible signals, alerting nearby personnel and commuters of the potential hazard.

Additionally, the orange LED illuminates to provide a visual indication of the detected anomaly, prompting timely inspection and maintenance of the track. Overall, the system's working involves the seamless coordination of sensor inputs, microcontroller processing, and output device activation to automate railway gate operations and detect track defects in real-time. By leveraging advanced technology and integrated components, the system enhances railway safety, mitigates risks, and ensures the efficient and secure operation of railway transportation networks.

5 System Design

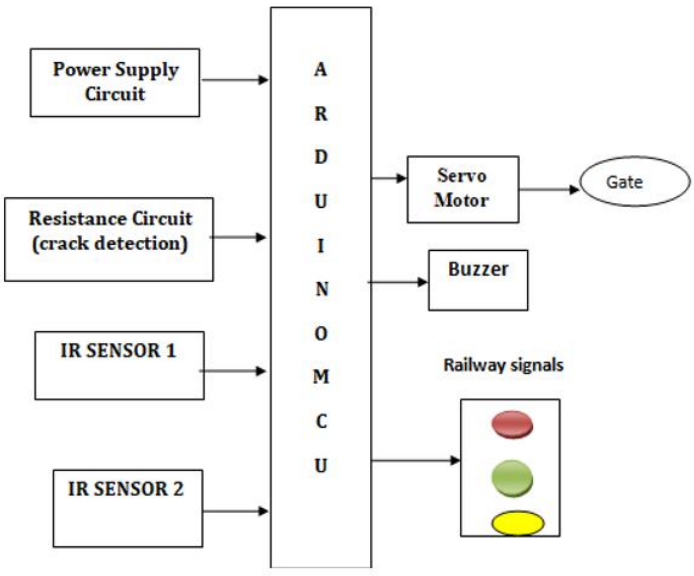

Figure 5: *Proposed Block Diagram*

6 System Description

Proposed system consist of various blocks for different methodologies that is discussed below.

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A. Arduino UNO

Based on the ATmega328P, the Arduino uno is a full microcontroller board that is suitable for use on a bread board. Just use a USB cord to connect it to a PC. Six analog inputs, a reset button, an ICSP Header, a power jacket, a USB Port, and a cearamic resonator operating at 16MHz. Everything required to sustain the microcontroller is contained in it.

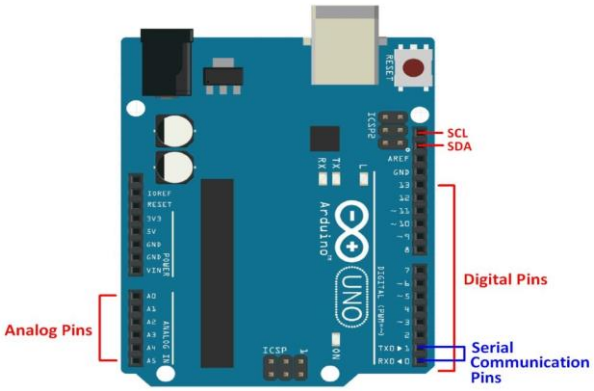

Figure A: Arduino UNO

B. Buzzer

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.
The helmet is also designed with panic button. This button is used to alarm other workers working at various floors of the large building in case of any disaster or emergency situations. It is designed primarily to intimate every other worker involved in the construction process instantly to avoid large disaster. It is an audio signaling device.

Figure B: *Buzzer*

C. LCD Display

LCD is an abbreviation for liquid crystal display.it is one type of electronic display module that is utilized in many different circuits and gadgets, such as TV sets computers, calculators, mobile phones and so on. Seven segments and multi segment, light emitting diodes are the

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major applications for these displays. The primary advantages of utilizing these module are its low cost, ease of programming, animations, and unrestricted character, special, and animation display options.

Figure C: *LCD Display*

D. IR Sensors

IR sensor is an electronic device that emits the light in order to sense some object of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, but infrared sensor can detect these radiations.

Figure D: *IR Sensor*

E. Servo Motor

A servo motor is a part of a closed-loop system consisting of a motor (AC or DC), a gear system, a position sensor (usually a potentiometer), and a control circuit. The motor is connected to the gear system, which reduces the motor speed, increases torque, and provides feedback to the potentiometer. Servo motor applications the servo motors are used in many as robotics , packing industries, automatic doors , automobile industry.

G. LED

G.1. Infrared Transmitter

Infrared Transmitter is a light emitting diode (LED) which emits infrared radiations called as IR LED's. Even though an IR LED looks like a normal LED, the radiation emitted by it is invisible to the human eye.

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Figure G.1: *Infrared Transmitter*

G.2. IR Receiver

Infrared receivers or infrared sensors detect the radiation from an IR transmitter. IR receivers come in the form of photodiodes and phototransistors.
Infrared Photodiodes are different from normal photo diodes as they detect only infrared radiation.

Figure G.2: IR Receiver

Software Requirements

Arduino 1.0.6 software tools used to program microcontroller. The working of software tool is explained below in detail.

- Get the arurdino board and connect to USB cable

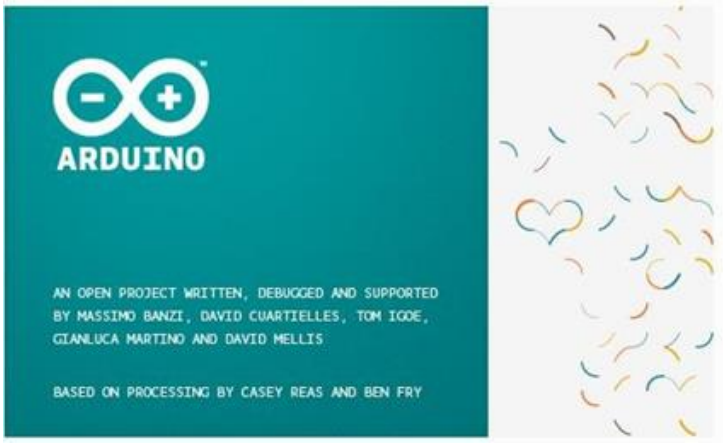

Figure: *Connect the board*

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Open the blink example:

Open the LED blink example sketch: File > Examples >1.Basics> Blink.

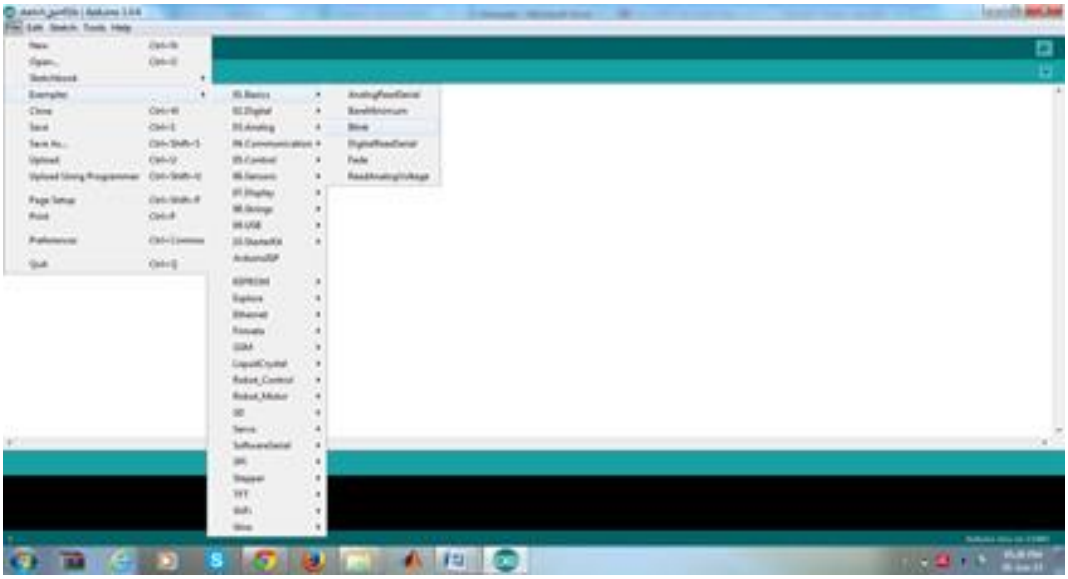

Figure: *Opening Blink Example*

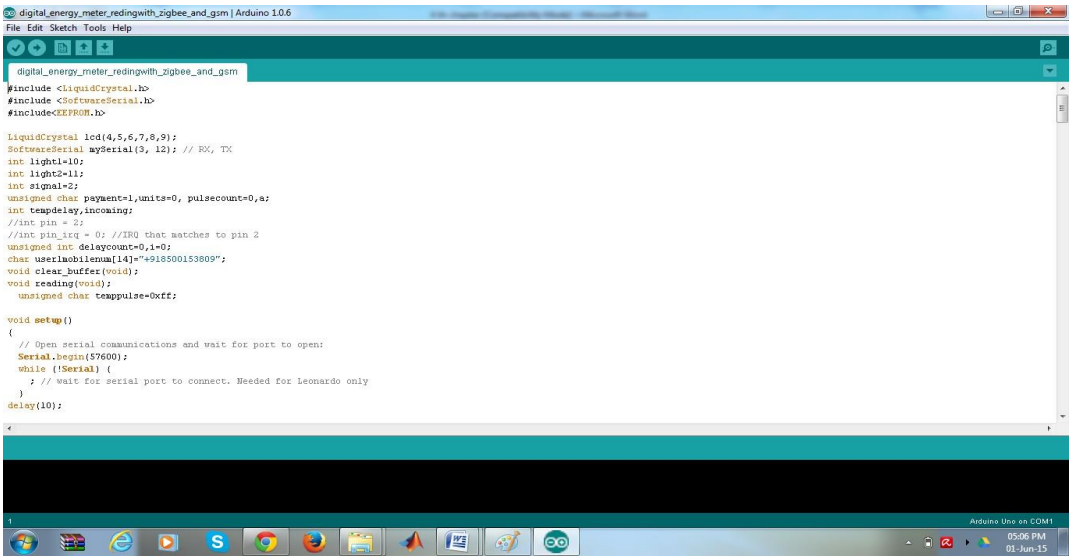

Figure: *Source Code Written in Arduino Compiler*

Select your board

You'll need to select the entry in the Tools > Board menu that corresponds to your Arduino.

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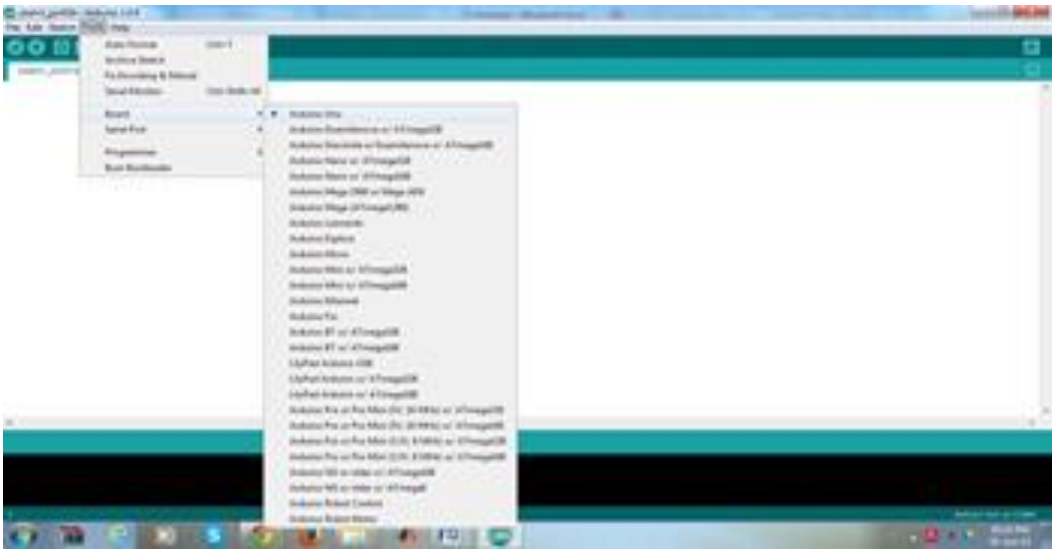

Figure: *Selecting an Arduino Uno*

7 Result And Discussion

Railway system is most commonly used transport system especially in India. But due to miscommunication about the railway schedule and lack of coordination, accidents happen. The primary objective is to enhance railway safety by automating the process of gate opening and closing and also detect the potential cracks on the railway tracks. These means to the title automatic railway crossing control and track crack detection. In these system the output displays about the crossing the railway gate automatically without manually and in the addition it also detects the cracks on the track and intimate the information on the LCD with the LED .

Figure: *Railway gate crossing and crack detection*

Automating the process of gate opening and closing while also detecting potential cracks on railway tracks. The system employs two IR sensors strategically positioned at the entry and

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exit points of the railway track. The IR sensor at the entry detects the approaching train, triggering the gate closure mechanism through Arduino control. Meanwhile, the IR sensor at the exit determines when the train has safely passed, prompting the gate to reopen.

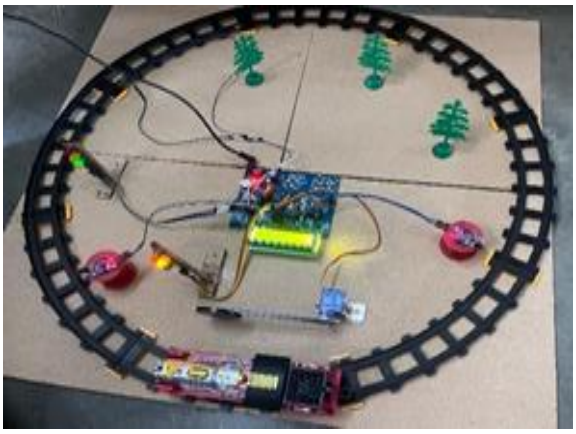

Figure: *Railway gatelevel as closing*

The above figure describes the automatic closing the gatelevel. Whenever the train is arriving it will be sensed by the IR Transmitter it detects and sent the information to Arduino it activates servomotor.

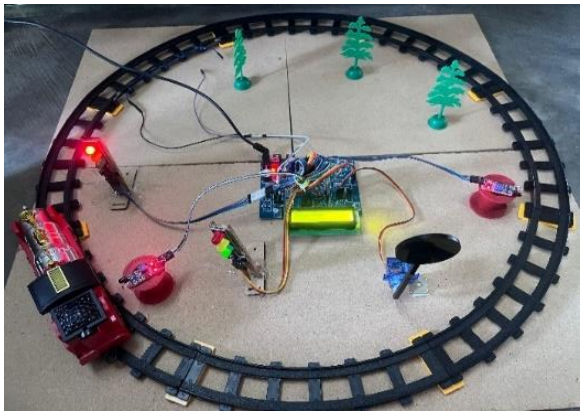

Figure: *Railway gatelevel as reopening*

The above figure describes the automatic gatelevel reopening. In these process the railway gate reopens when the IR receiver senses the rail.

In addition to gate automation, the system incorporates a crack detection feature for track maintenance. A resistance circuit, integrated with the track, detects any abnormalities indicative of cracks.

When a crack is detected, the Arduino system activates a buzzer alert and illuminates an orange LED, signaling the need for immediate inspection and repair. Furthermore, the system utilizes

a servo motor to control the gate's movement, ensuring swift and precise opening and closing actions. Visual indicators in the form of LEDs, including a red LED for gate closure and an orange LED for crack detection, provide clear status indications to railway personnel and nearby commuters.

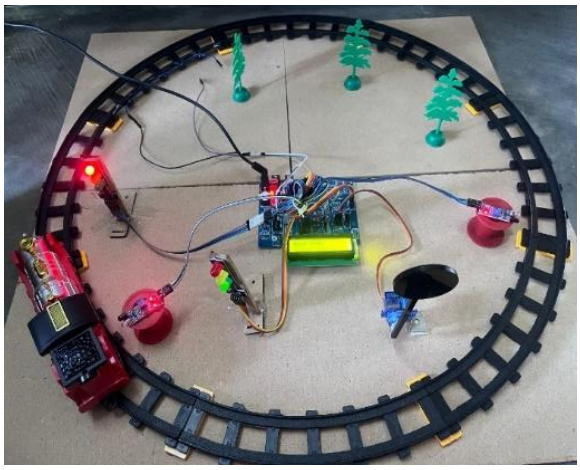

Figure: *Railway track crack detection*

8 Conclusion

The automated railway gate closure and crack detection system presented in this study offer a comprehensive solution to enhance railway safety and efficiency.

By integrating advanced sensor technology, Arduino-based control, and various output devices, the system automates gate operations, detects track defects in real-time, and provides timely alerts to railway personnel and nearby commuters.

Through extensive testing and validation, the system has demonstrated its reliability, accuracy, and effectiveness in mitigating risks and ensuring the smooth and secure operation of railway transportation networks.

9 Future Scope

Explore the integration of additional sensors, such as cameras or radar, to enhance train detection accuracy and reliability, especially in adverse weather conditions or challenging environments. Implement machine learning algorithms to analyze sensor data and predict potential track defects or irregularities, allowing for proactive maintenance and further reducing the risk of accidents

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