DESIGN AND DEVELOPMENT OF AUTOMATIC RAILWAY LEVEL CROSSING SYSTEM

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SONARGAON UNIVERSITY (SU)

147/I, GREEN ROAD, PANTHAPATH, TEJGAON, DHAKA

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"A Graduation Exercise Submitted to the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Mechanical Engineering"

DEPARTMENT OF MECHANICAL ENGINEERING

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September 2023

STUDENT DECLARATION

This is to certify that the thesis entitled, "**Design and Development of Automatic Railway level crossing system**" is an outcome of the investigation carried out by the author under the supervision of **M. I. Washif Rahman** Lecturer, Dept. of Mechanical Engineering, Sonargaon University (SU). This thesis or any part of it has not been submitted elsewhere for the award of any other degree or diploma or other similar title or prize.

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CERTIFICATION

This is to certify that this project entitled "**Design and Development of Automatic Railway level crossing system**" is done by the following students under my direct supervision. They have carried out this project work in the laboratories of the Department of Mechanical Engineering under the Faculty of Engineering, Sonargaon University (SU), in partial fulfillment of the requirements for the degree of Bachelor of Science in Mechanical Engineering.

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Finally, we would want to express our gratitude to everyone who helped us in any way to finish the thesis.

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DEDICATION

This thesis is dedicated to our Parents and Teachers.

.

ABSTRACT

This paper proposes an affordable, Arduino-based automated level crossing system to enhance safety at train crossings in Bangladesh. Ultrasonic sensors accurately detect approaching trains up to 4m and trigger sequential road gates closure via microcontroller-controlled actuators. Warning lights are activated prior to gate closure to alert vehicles. The system timing is designed for 60km/h train speeds using entry and exit sensors to track the full-length train through the crossing. The microcontroller code filters sensor data to avoid false triggers. Solar power and load sensors are suggested to refine the system. With strategic sensor placement and precise timing, this automated system can operate crossing gates without human intervention. The estimated 2950 Taka cost makes it viable for high-risk intersections in Bangladesh. Further testing and calibration are recommended before full-scale deployment for significant public safety benefits. This low-cost automated solution has the potential to reduce accidents at level crossings.

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CHAPTER 1
Introduction

1.1 Description

This paper describes how an intelligent railway gate system with two ultrasonic sensors is used to create the railway system. This system's primary purpose is to use these sensors to automate unmanned railway gates. We have used essential electrical components to automate the control of the railway gate system. The railroad is a temporary method crucial for conveying people and goods. Therefore, further efforts are required to increase its safety. Today, Bangladesh has the most extensive railway network in the world. Every day, there are hundreds of railroads operating on the tracks. Since we know that a train in motion cannot be stopped, an emergency or hazardous scenario may happen at any time. A prominent consequence of train accidents is the loss of human life and the significant destruction of railway infrastructure. Despite being a developed nation, ours still has many unresolved economic issues. Establishing automated and autonomous mechanisms is necessary to prevent all of these problems. There are two kinds of level crossings: staffed level crossings and unmanned level crossings. Many railroad-related incidents are reported in the daily media, primarily because of negligence in physical labor or a staff shortage at the railway gate. This Smart Railway Gate system is what we are suggesting as a result. The system's primary goal is to create the railroad gate system in a novel and organized manner. Automation is carried out using essential electrical components. In a country like Bangladesh, where railways play a pivotal role in transportation, ensuring the safety of both passengers and the railway infrastructure is of utmost importance. The existing railway gate systems, including staffed and unmanned level crossings, have faced various challenges over the years. This has led to numerous railway-related incidents, often attributed to human error, staff shortages, or negligence. The Smart Railway Gate system represents a significant step forward in addressing these challenges. This innovative system relies on the use of two ultrasonic sensors and essential electrical components to automate the operation of railway gates. Its primary objective is to enhance safety and efficiency in railway operations.

1.2 Objective

This project aims to create an "Automatic Railway Gate Control System" to replace the system now in use in the railroad sector. The method comprises sensors readily incorporated into existing infrastructure, particularly at level crossings. It is now more difficult and time-consuming to manually open the gate at level crossings due to the daily rise in traffic. As a result, accidents happen often, causing many individuals to suffer severe injuries. In some cases, fatal incidents also result in highly significant consequences. By implementing automated railway level crossings, this project may assist us in reducing accidents in society.

The primary goals of this thesis are to expand infrastructure capacity, reduce commute time, and enhance safety. The environment, economics, and health all benefit from these advances. Therefore, the primary goal of Intelligent Transportation Systems (ITS) is to decrease level crossing delays while also reducing trip time. The primary contributors to traffic load include day, time, weather, season, and other uncontrollable events like accidents, special occasions, road maintenance, and construction. Additionally, using guards (people) to handle (open/close) the gate requires a significant amount of labor, which directly adds to inefficiency since it sometimes takes a long time. Road users often experience traffic jams, particularly during peak hours, and many are late for work. Additionally, to enforce the present admission method, the guards must work in harsh weather conditions, including high heat and drizzle.

1. To improve safety at railway level crossings in Bangladesh through automation and technology.
2. To reduce deadly train accidents caused by aging infrastructure and lack of maintenance.
3. To eliminate human errors and delays in manual gate operation that contribute to accidents.
4. To enable faster gate closure times through automation for increased road user safety.
5. To modernize Bangladesh's outdated railway infrastructure through automation and updated technology

1.3 Existing System

The train detection system is the most crucial component of the autonomous level-crossing system. The system must accurately identify a train's arrival and departure from the track to carry out its purpose effectively. Crossings across the globe employ a variety of various parts, including track circuits, axle counters, wheel sensors, and optical position sensors. Wheel and optical position sensors are more recent technologies based on the magnetic inductive principle and visual theories. At the same time, track circuits and axle counters need to be integrated and need reconstruction of the track. These systems require a significant investment to set up and are very complex.

1.4 System Overview

Our System is an operational system. Our plan is straightforward and efficient. The concept is to automatically shut the level crossing gates at railroad crossings and automatically open them accordingly at train arrival and departure times. The automated idea aims to prevent accidents while requiring fewer staff. We are putting ultrasonic sensors close to the railroad lines as part of our System. This System uses ultrasonic sensors because of its superior 4-meter range compared to other types of sensors. These ultrasonic sensors are positioned at a certain distance before and after the level crossing. The location of the sensors is necessary to accurately and efficiently detect both the arrival and departure of the train. The buzzer and LED will turn on automatically to let other road users know that the train is getting close to the level crossing so they can wait until it passes. When the train approaches the first sensor, installed before the level crossing, it senses or detects the train and sends a message to the Arduino connected. The level crossing gates' servo motor will automatically shut them when the buzzer sound begins. The level crossing gates will automatically open, and a buzzer will ring as soon as the train passes the second sensor, which is positioned a predetermined distance behind the gates. Automatically allowing users of the route to utilize the level crossing road safely. Another ultrasonic sensor is situated somewhat farther, at a greater distance than the gap between the first ultrasonic sensor and the Level crossing barriers (because of the size of the train). The Arduino Uno, which is used in this whole design, includes code that was uploaded before the process began. The primary key to work is code. The whole apparatus. Although our System's concept and operation are straightforward, its application will be more efficient. It will undoubtedly reduce accidents at railroad level crossings and guarantee public safety.

1.5 Motivation

Working on this research and development program was motivated by the observation that there are a lot more accidents occurring at railroad crossings in Bangladesh daily. Although the current railway gate control system meets our demands, we wanted to develop a creative concept and create a more workable and dependable solution. As a result, accidents will be less frequent than previously, and this initiative will assist Bangladesh's decision-makers in raising the degree of safety at critical level crossings.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature

The management of railway level crossings is crucial to ensure the safety of both road and rail users. Automatic railway gate-level crossing systems have been developed to mitigate accidents and improve traffic flow at these critical junctures. This literature review discusses these systems' evolution and current state, highlighting key technologies and challenges.

2.2 Importance of Automated Railway gate Control system

An Automated Railway Gate Control System is paramount in ensuring railway operations' safety and efficiency. It is crucial in preventing accidents and collisions by automatically closing and opening railway gates at designated times, synchronized with train schedules. This technology reduces human error and minimizes the risk of accidents at railway crossings, safeguarding both passengers and motorists. Additionally, it improves the overall punctuality and reliability of the railway system, enhancing the transportation experience for all stakeholders while contributing to a safer and more streamlined rail network.

2.3 Bangladesh Railway level crossing system

With more than two-thirds of the 3,111 level crossings in the country considered unsafe, a government survey has recommended improving safety features of around 2,000 rail crossings. It also recommended building overpasses or underpasses at 47 level crossings and introducing an automated system at 194 unmanned crossings so that a warning bell goes off when a train approaches. Other recommendations include setting up gate barriers, putting in place electricity and telephone lines and other basic facilities at 1,436 more crossings. The survey, jointly conducted by Bangladesh Railway (BR) and Local Government Engineering Department (LGED) last year, also suggested shutting down 62 crossings located close to one another. They surveyed 2,083 level crossings, of which 1,080 were unauthorized BR sources said. It recommended recruiting 5,772 people to ensure safety at level crossings, where many accidents occur. After receiving the survey results, BR sent it to the railways ministry recently to take the necessary steps.

The development came as accidents at unmanned level crossings continue to claim lives, with around 70 percent of the crossings under the country's 3,093km railway network being either unauthorized or without dedicated manpower. According to BR data from August 2022, there are 3,111 level crossings in the country. Of those, 1,886 are authorized, but 948 are unmanned. A total of 1,225 level crossings are both unauthorized and unmanned. With the unmanned authorized crossings, there are 2,173 level crossings without dedicated manpower in the country. Different government agencies have been involved in constructing unauthorized level crossings, with LGED having constructed 510, the highest, show BR documents. According to the Road Safety Foundation, at least 37 people were killed in 36 rail-related accidents in the first two months of this year. Last year, at least 326 people were killed and 113 were injured in 354 such accidents, the foundation said, adding that most of them had taken places at level crossings. Safety issues at level crossings took center stage after 11 people died as a train hit a microbus at a level crossing in Chattogram's Mirsharai upozila on July 29 last year. Two more succumbed to their injuries later. After the incident, the railways ministry held an inter-ministerial meeting and asked both the BR and LGED to complete the survey as soon as possible. The survey was completed last year but the report was given to BR headquarters last month, BR sources said. Another recommendation made in the survey was to upgrade classes of 108 level crossings. There are several grades of level crossings -- Special, A, B, C and D -- based on train movement frequency and locations; and staffers are deployed based on the grade. Contacted, BR Director General Quamrul Ahsan said they have sent the survey result to the railways ministry, which will send it to the LGRD ministry. As per the previous decision, LGED will take up projects to ensure safety at level crossings with the help of BR in terms of implementation. He said BR will have to talk to the Roads and Highways Department about constructing the overpasses and underpasses at level crossings, because they will have to be made on roads built by RHD. Replying to a question, Ahsan on March 16 told The Daily Star, "We have taken initiative to establish automated level crossings. We are going to close some level crossings on insignificant roads."[1]

2.4 Related works

Lots of work has been done before with the rail-gate automation system. They use a variety of sensors and controllers to operate the system. Some of these are briefly described below.

Using an Automated Railway Gate Controlling System as a paradigm, (Saifuddin Mahmud et al., 2015)[2] have suggested. Their primary functions were to use ultrasonic sensors to detect trains, shut the automated crossing gates, and give illumination warnings in the event that a vehicle become stopped at the crossing.

A model titled Design and Development of an Automatic Unmanned Railway Level Crossing Gate was created by (T. A. Selvan et al., 2021)[3]. a vibration sensor communicates a train arrival or departure signal to the Arduino. The Arduino sends this signal to the servo motor, which operates the railway crossing gate. The vibration sensor is the primary aspect of their work.

A system of Automatic Railway Gate Controllers was created by (Chandrappa et al.). to run the railway gates without a gatekeeper. Two Infrared obstacle detection sensors detect train arrival and departure, and a stepper motor operates the gate. Here, it is difficult to determine the precise position of the train using merely an IR sensor, and IR sensors are also less effective in low light. But our ultrasonic sensor operates in both light and darkness.[4]

2.5 Our Proposed System

It is a functional system, our Proposed System. Our plan is straightforward and efficient. The concept is to automatically shut the level crossing gates at railroad crossings and automatically open them accordingly at train arrival and departure times. The automated idea aims to prevent accidents while requiring fewer staff. We are putting ultrasonic sensors close to the railroad lines as part of our system. This system uses ultrasonic sensors because of its superior 4-meter range compared to other types of sensors. These ultrasonic sensors are positioned at a certain distance before and after the level crossing. The location of the sensors is necessary to accurately and efficiently detect both the arrival and departure of the train. The buzzer and red LED will turn on automatically to let other road users know that the train is getting close to the level crossing so they can wait until it passes. When the train approaches the first sensor, installed before the level crossing, it senses or detects the train and sends a message to the Arduino connected. The level crossing gates' servo motor will automatically shut them when the buzzer sound begins. The servo motor was chosen for our system because it operates on the principle of angular rotation, which means that the gates will initially be open at 90 degrees, then close at 0 degrees when the train arrives, and then return to their initial position of 90 degrees after the train has passed. The associated servo motor (with angular rotation) is responsible for correctly operating the level-crossing gates. Because they lack angular rotation, if we had utilized other engines, there would have been a problem with the opening and shutting of gates. This servo motor enables the entrances to return to their usual position (90°) after being closed (0°) as opposed to plunging into the earth (270°). The level crossing gates will open automatically when the train passes the second sensor, positioned a certain distance behind them. At that point, drivers may safely utilize the level crossing road. Due to the length of the train, the second ultrasonic sensor is located a bit further away from the level crossing gates than the first ultrasonic sensor. The Arduino Uno, which is used in this whole design, includes code that was uploaded before the process began. The essential key to operating the entire system is code. Although our system's concept and operation are straightforward, its application will be more efficient.

CHAPTER 3

EXECUTION OF HARDWARE COMPONENTS

3.1 Hardware Used in this Circuit.

1. Arduino Uno
2. HC-SR04 Ultrasonic Sensor
3. Servo Motor
4. Power Supply
5. Buzzer
6. Red & Green LED
7. Breadboard
8. Jumper Wires
9. Toy Train
10. PVC Board

3.1.1 Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. You can tinker with your Uno without worrying too much about doing something wrong, worst-case scenario you can replace the chip for a few dollars and start over again. “Uno” means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

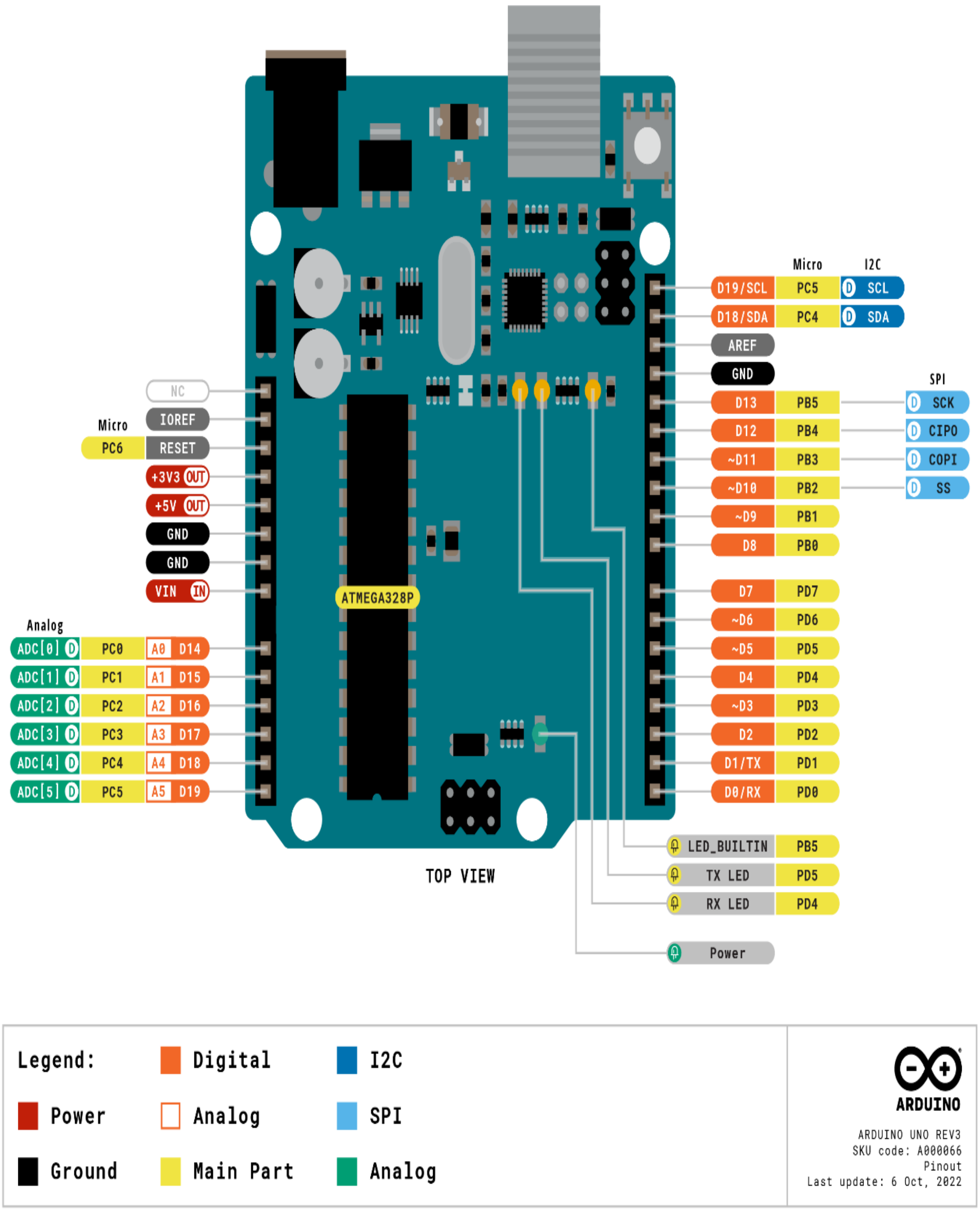

Figure 3.1: Arduino Uno[5]

Features

- Microcontroller : ATmega328P
- Operating Voltage : 5V
- Input Voltage (recommended) : 7-12V.
- Input Voltage (limit) : 6-20V
- Digital I/O Pins : 14 (of which 6 provide PWM output)
- PWM Digital I/O Pins : 6
- Analog Input Pins : 6
- DC Current per I/O Pin : 20 mA
- DC Current for 3.3V Pin : 50 mA
- Flash Memory : 32 KB (ATmega328P)
- SRAM : 2 KB (ATmega328P)
- EEPROM : 1 KB (ATmega328P)
- Clock Speed : 16 MHz
- LED_BUILTIN : 13
- Length : 68.6 mm
- Width : 53.4 mm
- Weight : 25 g[5]

3.1.1.1 Microcontroller ATmega328P

The ATmega328 is a single-chip microcontroller created by Atmel in the megaAVR family (later Microchip Technology acquired Atmel in 2016). It has a modified Harvard architecture 8-bit RISC processor core.

Figure 3.1: ATmega328P[6]

Specifications

The Atmel 8-bit AVR RISC-based microcontroller combines 32 KB ISP flash memory with read-while-write capabilities, 1 KB EEPROM, 2 KB SRAM, 23 general-purpose I/O lines, 32 general-purpose working registers, 3 flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8 channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and 5 software-selectable power-saving modes. The device operates between 1.8 and 5.5 volts. The device achieves throughput approaching 1 MIPS/MHz.[1]

Features

Parameter	**Value**
• CPU type	: 8-bit AVR
• Maximum CPU speed	: 20 MHz
• Performance	: 20 MIPS at 20 MHz
• Flash memory	: 32 KB
• SRAM	: 2 KB
• EEPROM	: 1 KB
• Package pin count	: 28 or 32
• Capacitive touch sensing channels	:16
• Maximum I/O pins	: 23
• External interrupts	: 3
• USB interface	: No[6]

3.1.2 Ultrasonic Sensor

The ultrasonic sensor (or transducer) works on the same principles as a radar system. An ultrasonic sensor can convert electrical energy into acoustic waves and vice versa. The acoustic wave signal is an ultrasonic wave traveling at a frequency above 18kHz. The famous HC SR04 ultrasonic sensor generates ultrasonic waves at 40kHz frequency.

Typically, a microcontroller is used for communication with an ultrasonic sensor. To begin measuring the distance, the microcontroller sends a trigger signal to the ultrasonic sensor. The duty cycle of this trigger signal is 10µS for the HC-SR04 ultrasonic sensor. When triggered, the ultrasonic sensor generates eight acoustic (ultrasonic) wave bursts and initiates a time counter. As soon as the reflected (echo) signal is received, the timer stops. The output of the ultrasonic sensor is a high pulse with the same duration as the time difference between transmitted ultrasonic bursts and the received echo signal.

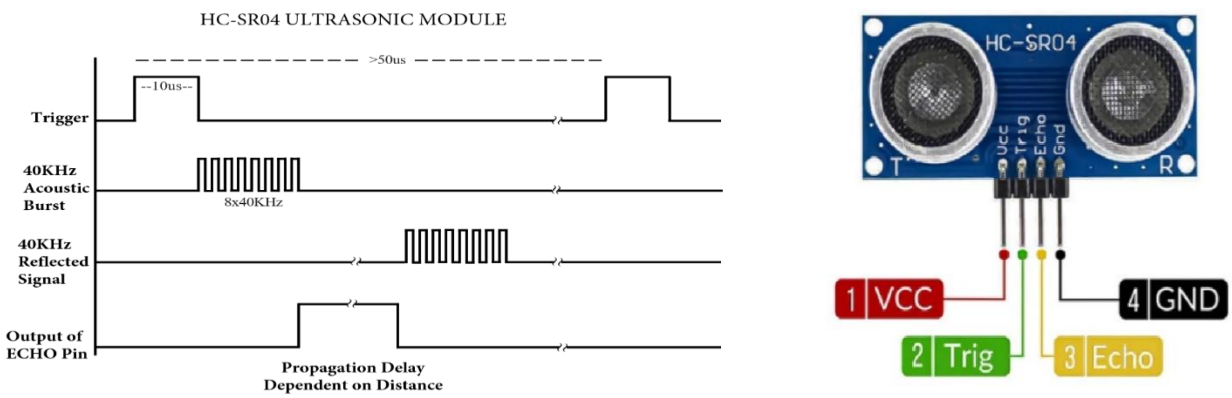

Figure 2.3: Ultrasonic Sensor[7]

The microcontroller interprets the time signal into distance using the following functions:

$$Distance\ (cm) = \frac{echo\ pulse\ width\ (uS)}{58}$$

$$Distance\ (inch) = \frac{echo\ pulse\ width\ (uS)}{148}$$

Theoretically, the distance can be calculated using the TRD (time/rate/distance) measurement formula. Since the calculated distance is the distance traveled from the ultrasonic transducer to the object—and back to the transducer—it is a two-way trip. By dividing this distance by 2, you can determine the actual distance from the transducer to the object. Ultrasonic waves travel at the speed of sound (343 m/s at 20°C). The distance between the object and the sensor is half of the distance traveled by the sound wave. The following equation calculates the distance to an object placed in front of an ultrasonic sensor.[7]

$$distance = \frac{time\ taken\ x\ speed\ of\ sound}{2}$$

Here’s a list of some of the HC-SR04 ultrasonic sensor features and specs:

- Power Supply :+5V DC
- Quiescent Current : <2mA
- Working Current : 15mA
- Effectual Angle : <15°
- Ranging Distance : 2cm – 400 cm/1″ – 13ft
- Resolution : 0.3 cm
- Measuring Angle : 30 degrees
- Trigger Input Pulse width : 10uS TTL pulse
- Dimension : 45mm x 20mm x 15mm

3.1.3 Servo Motor

Servo motors are specially designed motors to be used in control applications and robotics. They are used for precise position and speed control at high torques. It consists of a suitable motor, position sensor and a sophisticated controller. Servo motors can be characterized according the motor controlled by servomechanism, i.e. if DC motor is controlled using servomechanism, it is called as DC Servo motor. Thus, major types of Servo motor may be - (i) DC Servo motor, (ii) AC Servo motor. Servo motors are available in power ratings from fraction of watt upto few 100 watts. They have high torque capabilities. The rotor of servo motor is made smaller in diameter and longer in length, so that it has low inertia.

What is Servomechanism:

servomechanism is a type of control system that uses feedback to control position, velocity, and acceleration. The basic components of a servomechanism are:

- Controlled device - This is the mechanical system that is being controlled, such as an engine, motor, or hydraulic actuator.
- Controller - This device compares the actual state of the system (position, speed, etc) to the desired state and calculates the control signal needed to reduce the error between the two. A common type of controller is a PID controller.
- Output sensor - This device measures the actual state of the controlled system and feeds it back to the controller. Common sensors include encoders, tachometers, accelerometers, and potentiometers.

- Feedback path - This is the route the feedback signal takes from the sensor back to the controller. It may be electrical, mechanical, or a combination.

The controller seeks to reduce error between the commanded input (desired state) and feedback (actual state) by calculating a control signal that will adjust the process accordingly. This creates a continuous closed-loop system that self-corrects to maintain the desired output.

How does a servo motor work:

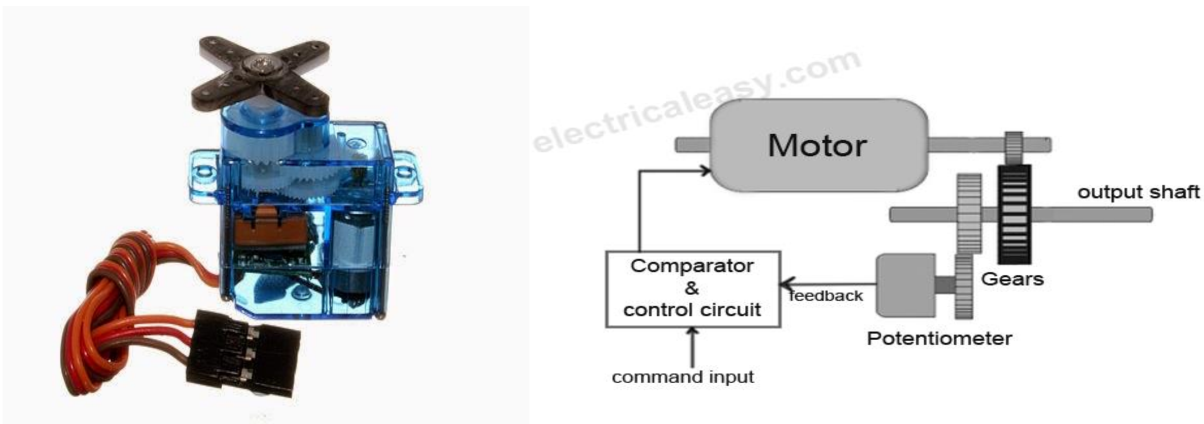

Figure 3.3: Servo Motor[8]

Servo motors are used to control position and speed very precisely, but in a simple case, only position may be controlled. Mechanical position of the shaft can be sensed by using a potentiometer, which is coupled with the motor shaft through gears. The current position of the shaft is converted into electrical signal by the potentiometer, and the compared with the command input signal. In modern servo motors, electronic encoders or sensors are used to sense the position of the shaft. Command input is given according to the required position of the shaft. If the feedback signal differs from the given input, an error signal is generated. This error signal is then amplified and applied as the input to the motor, which causes the motor to rotate. And when the shaft reaches to the required position, error signal becomes zero, and hence the motor stays standstill holding the position. The command input is given in the form of electrical pulses. As the actual input applied to the motor is the difference between feedback signal (current position) and applied signal (required position), speed of the motor is proportional to the difference between the current position and the required position. The amount of power required by the motor is proportional to the distance it needs to travel.

How is the servo motor controlled:

Usually, a servomotor turns 90° in either direction, i.e., maximum movement can be 180°. A normal servo motor cannot rotate any further due to a built-in mechanical stop.

Three wires are taken out of a servo: positive, ground and control wire. A servo motor is controlled by sending a Pulse Width Modulated (PWM) signal through the control wire. A pulse is sent every 20 milliseconds. Width of the pulses determine the position of the shaft. For example, a pulse of 1ms will move the shaft anticlockwise at -90°, a pulse of 1.5ms will move the shaft at the neutral position that 0° and a pulse of 2ms will move the shaft clockwise at +90°.

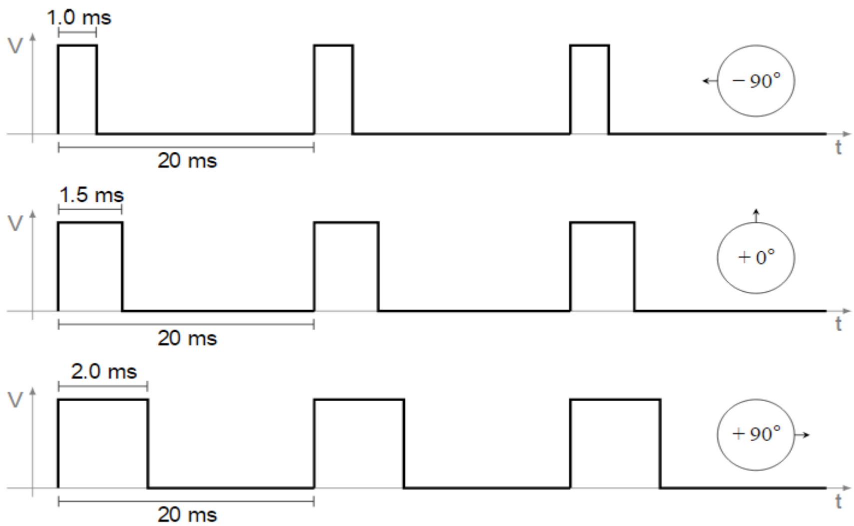

Figure: 3. 4 PWM Module

When the servo motor is commanded to move by applying pulses of appropriate width, the shaft moves to and holds the required position. If an external force is trying to change the position of the shaft, the motor resists to change. Pulses need to be repeated for the motor to hold the position.

Applications of servo motor:

Servo motors are popularly used in robotics, computers, CD/DVD players, toys etc. Servos are extensively used in those application where a specific task is to be done repeatedly in a very precise manner.[8]

3.1.4 Buzzer

A buzzer is a component used to generate audio sound for any warning or signal. Controlling a Buzzer uses two functions in a program. One is the "tone ()," used to make the sound. The other is the "no Tone ()" to turn off the sound and a "delay ()" is used between the two. The "tone ()" function has two components: one is a digital PIN, and the other is a sound signal such as tone (digital PIN, sound signal in kHz).

Figure 3.5: Buzzer

3.1.5 Power Supply

A consistent and reliable DC voltage source is critical when powering electronic devices. Most gadgets, from laptops to household appliances, need a DC supply for stable operation. This DC power supply is usually derived from the single-phase AC mains available in most homes and workplaces. A 12 Volts DC adapter is employed as the external power source in our specific project. The adapter converts the AC voltage from the mains into the required 12V DC, which is then utilized by the electronic components in the project. This ensures that the circuitry operates within the specified power supply limits, guaranteeing safety and functionality. Using an external adapter isolates the device from potential fluctuations in the main AC supply, adding an extra layer of security against electrical inconsistencies. Moreover, the 12V specification suggests that the adapter is compatible with various devices and applications, making it versatile for multiple projects. The DC adapter ensures a steady current flow, vital for sensitive electronic components that might be negatively affected by irregular power supply.

Figure 3.6: Power Supply

3.1.6 Breadboard

A breadboard, solderless breadboard, or protoboard is a construction base used to build semi-permanent prototypes of electronic circuits. Unlike a perf-board or stripboard, breadboards do not require soldering or destruction of tracks and are hence reusable. For this reason, breadboards are also popular with students and in technological education. A variety of electronic systems may be prototyped by using breadboards, from small analog and digital circuits to complete central processing units (CPUs).

Compared to more permanent circuit connection methods, modern breadboards have high parasitic capacitance, relatively high resistance, and less reliable connections, which are subject to jostle and physical degradation. Signaling is limited to about 10 MHz, and not everything works properly even well below that frequency.[9]

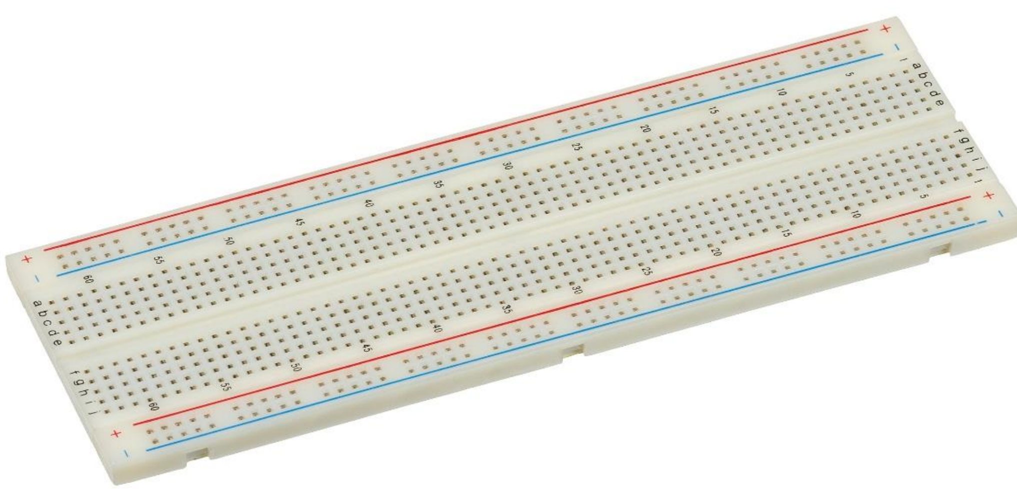

Figure 3.7: Breadboard[9]

3.1.7 Jumper wires

A jump wire (also known as jumper, jumper wire, DuPont wire) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.[10]

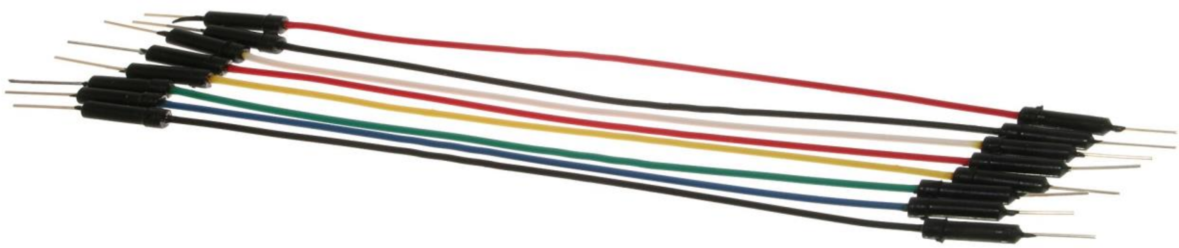

Figure 3.8: Jumper wires[10]

Jump wire is a short, flexible insulated cable used to connect electronic components together without soldering. They get their name from their use of "jumping" connections between points on a circuit.

Instead of soldering components directly together, jump wires allow you to make removable connections. They consist of a copper conductor with connectors or "end pins" on each end. The connectors fit into holes on circuit boards, breadboards, or electronic equipment.

Jump wires come pre-assembled with various connector types on the ends, such as alligator clips, pin headers, banana plugs, etc. This allows them to easily interface with many different electronic components and prototyping platforms. Some are sold as a bundle of assorted colors and lengths.

They are very useful for building and testing circuits before final assembly, since components can be quickly wired together without permanent soldered connections. Jump wires are commonly used with breadboards, Arduinos, and Raspberry Pis for this purpose.

Engineers and hobbyists keep a supply of jump wires on hand to prototype and experiment with new circuit designs. They allow you to safely connect components and modify the circuit as needed without damage. Overall, jump wires offer flexibility and convenience for electronics prototyping and testing.

3.1.8 Toy Train

A toy train is a toy that represents a train. It is distinguished from a model train by an emphasis on low cost. And durability, rather than scale modeling. A toy train can be as simple as a pull toy that does not even run on the track or might be operated by clockwork or a battery. By the way, many of today's model trains might also be signed as toy ones, providing they are not strictly scale ones in favor of robustness appropriate for children or reasonable manufacturing.

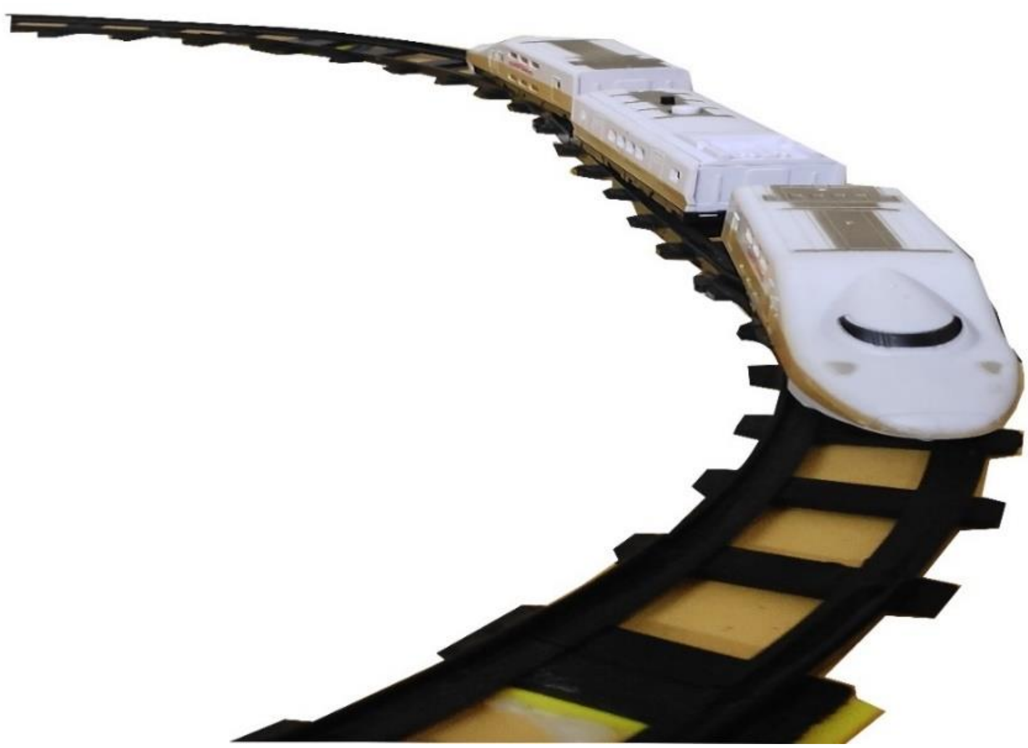

Figure 3.9: Toy Train

3.1.9 Red & Green LED lights

DC LED lights with colored lenses and a diffused round shape are versatile lighting solutions that can add vibrant and eye-catching illumination to various applications. Operating at a low voltage of DC 3V, these LEDs are energy-efficient and suitable for multiple projects. Our projects use red and green LED lights for traffic signal indicators.

Figure 3.10: LED Lights

3.1.10 PVC board

PVC board, also known as PVC foam board or PVC sheet, is a versatile and durable material made from polyvinyl chloride (PVC). This plastic sheet type is commonly used in a wide range of applications due to its excellent properties. In this project, we used PVC board as a structure.

Figure 3.11: PVC Board

3.2 Circuit diagram and physical aspect of this project

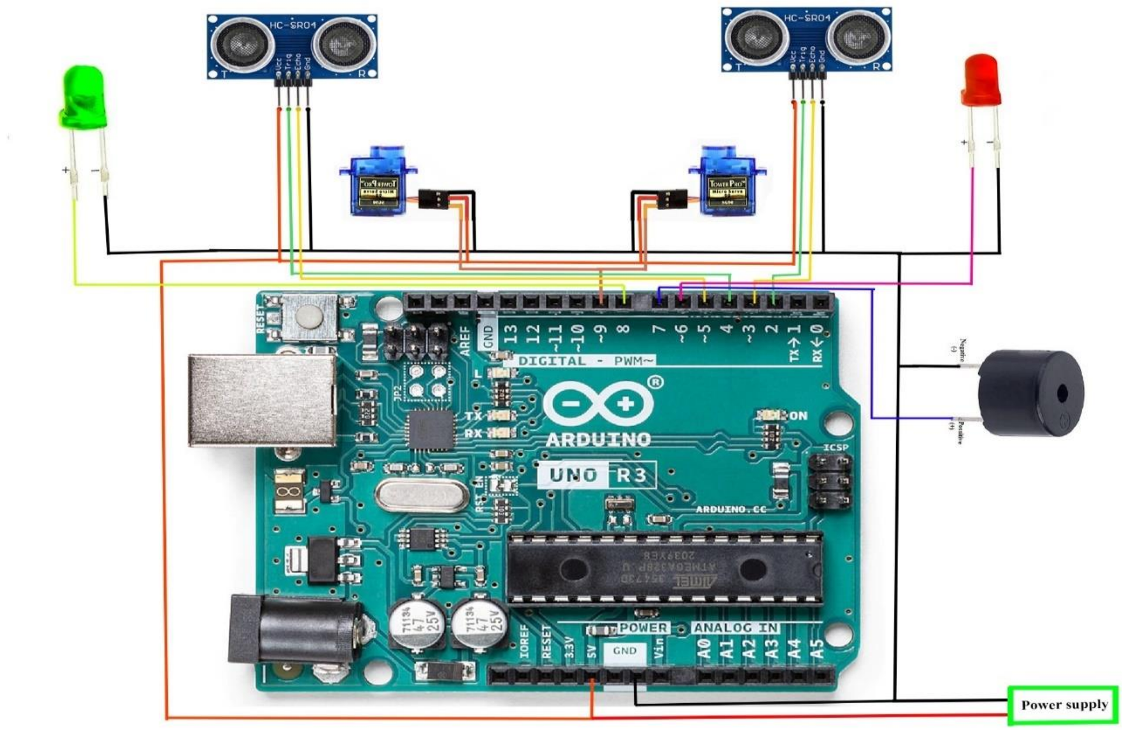

Figure 3.12:Circuit Connection

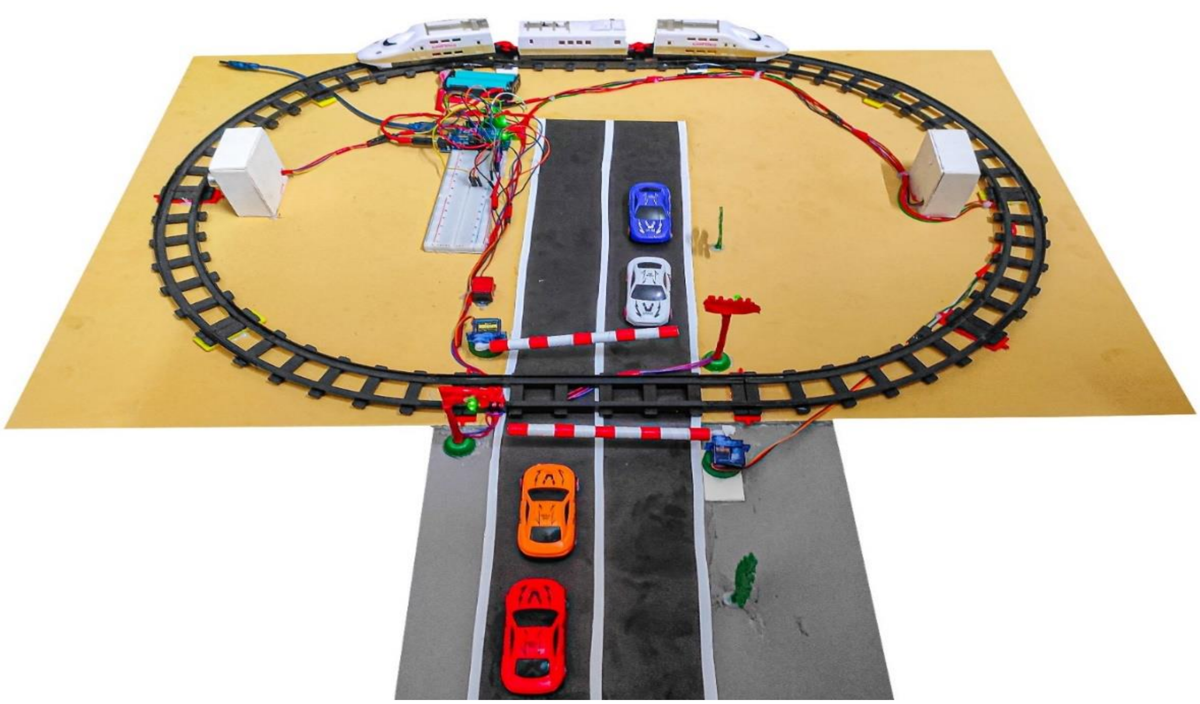

Figure 3.13: physical aspect of this project

CHAPTER 4

IMPLEMENTATION AND RESULTS

4.1 Working Procedure

Our concept has been adopted and evolved into a practical design. A crucial component of the level crossing arrangement is that the tracks must be between the two gates facing each other and separated by a gap. The gates are fastened with LED lights, and servo motors have been installed. Additionally, ultrasonic sensors have been installed at around 45.4 cm before and after the level crossing gates. Further, sensors are positioned on either side of the track at about 7 Inch. The Arduino Uno R3 has been used to link the whole system. The Arduino is put close to the buzzer. The external power source has been connected to the Arduino. A toy train is then fastened to the track after everything is complete. The toy train then begins to move with the aid of batteries. A power supply is turned on to form the operation. The toy train then starts moving when we switch it on, and the crossing gates will shut when it approaches the first ultrasonic sensor and open when it reaches the second. The servo motor coupled to the system is assisted in opening and closing the gates and has Angular Rotation. Like the gates, the buzzer and red LED will likewise come on automatically when the train approaches the first sensor and switch off when it approaches the second. The power supply should be on during the procedure. Before doing any of these processes, the Arduino must have the necessary process code uploaded. The transmission connection, which enables the Arduino to be readily connected to a PC or laptop, may be used to send code to the Arduino. It is simple to upload and reset the code. The code on the PC is uploaded to the Arduino using the Arduino IDE program.

4.2 Research Flowchart of this project

STEP 1: Check ultrasonic 1 for detecting train arrival.

STEP 2: If the train arrives, go to STEP 3,

STEP 3: Turn on the red LED, turn off the green LED, and blow the buzzer. Go to STEP 4,

STEP 4: Close the crossing gate using a servo motor from both sides.

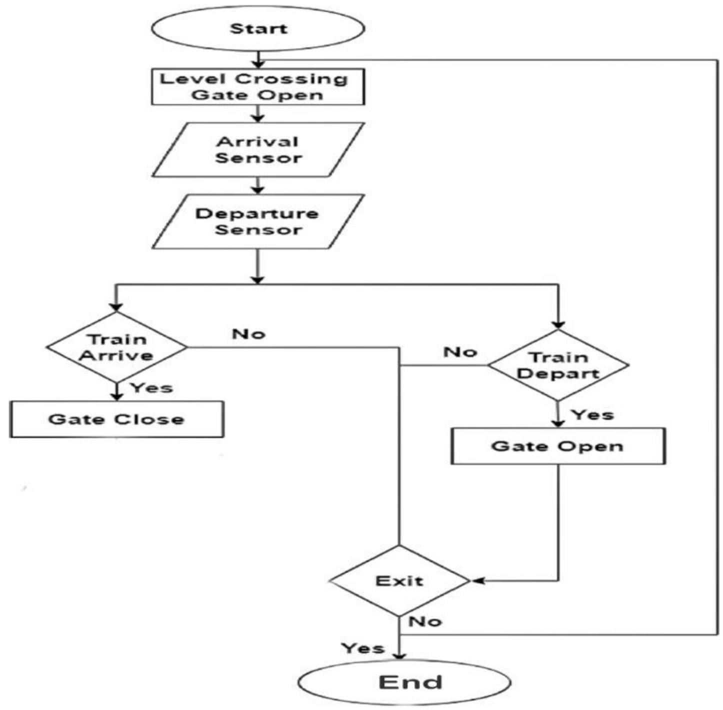

Figure 4.1: Flowchart of the proposed system[11]

STEP 5: Check ultrasonic sensor 2 for detecting train departure.

STEP 6: If the train departs, go to step 7,

STEP 7: Turn off the red LED & buzzer and turn on the green LED. Open the level crossing gate from both sides. [11]

4.3 Block diagram of this system:

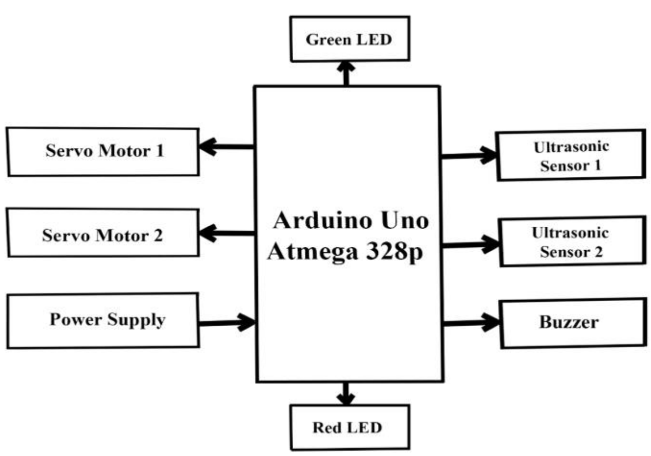

Figure 4.2: Block diagram

4.4 Table: The properties are used for several conditions depending on the train's presence.

Rail Presence	Sensor(1st) State	Sensor(2nd) State	Motor Angle	Buzzer State	Traffic light Signal State	Rail gate State
No Presence	Low	Low	No motor rotation	Low	Green	Open
Rail on 1st sensor	High	Low	Motor rotates in CW 0^o to 90^o	High	Red	Close
Sensor on 2nd sensor	Low	High	Motor rotates in CCW 90^o to 0^o	Low	Green	Open

4.5 Data and Calculation

In this section, we will calculate the average speed of a toy train moving on a rail line. We will also determine the time needed for gate opening and closing based on the train's speed.

Calculating the Average Speed of Toy Train:

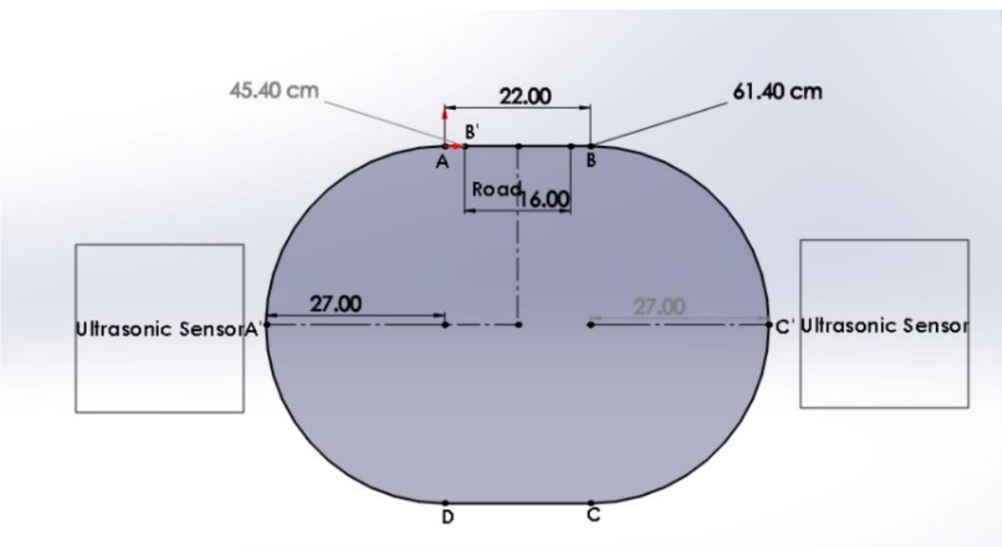

Figure 4.3: Top Rail Truck view

Parameters

- S_{AB} = 22cm
- $S_{BC} = \pi*DBC/2$
- S_{CD} = 22cm
- $S_{DA} = \pi*DAD/2$
- DBC = 27cm
- DAD = 27cm

The formula for Total Distance:

$S = S_{AB} + S_{BC} + S_{CD} + S_{DA}$

$= 22 + (\pi*27/2) + 22 + (\pi*27/2)$

$= 22 + 42.41 + 22 + 42.41$

= 213.64 or 214cm

Total Time Duration:

$T = T_{AB} + T_{BC} + T_{CD} + T_{DA}$

$= 1.3 + 2.7 + 1.3 + 2.7$

= 8 sec

Formula for Average Speed:

$\overrightarrow{V} = S/T$

$= 214/8$

= 26.75cn/s

Calculating Gate Timing:

Time for Gate Closing:

Distance from 1st sensor to the road A`B`(D_1) = 45.4cm

$T_1 = D_1/\vec{V}$

$= 45.4/26.75$

$= 1.7$ sec

Time for Gate Opening:

Distance from B` to the 2nd sensor C`(D_2) = 61.4cm

$T_2 = D_2/\vec{V}$

$= 61.4/26.75$

$= 2.3$ sec

Total Time for Gate Operation:

Total time taken = $T_1 + T_2$

$= 1.7 + 2.3$

$= 4$ sec

It will take the toy train 4 seconds to cover a total distance of 106.8 cm from the 1st sensor to the 2nd sensor. Therefore, the gate will be closed for 4 seconds for this average speed.

4.6 Graph Analysis

Velocity Vs Time

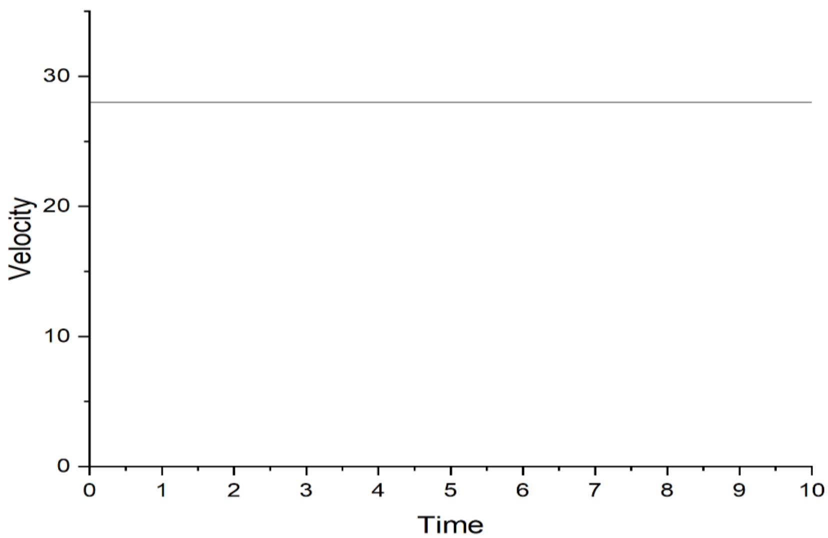

Figure 4.4: Velocity vs Time Graph

Since the velocity of the toy train is constant at 26.75 units per unit time, its motion can be represented on a position vs time graph as a straight line with a constant positive slope.

As time increases, the position of the train increases linearly. At time = 0, the train is at position 0. As time increases in uniform increments (let's say in 1 second intervals), the position of the train increases by 26.75 units each second.

Distance Vs Time

Figure 4.5: Distance vs Time Graph

On the graph, the x-axis is time in seconds from 0 to 10. The y-axis is distance traveled in units from 0 to 500.

At time = 0 seconds, the distance traveled is 0 units. As time increases linearly from 1 to 10 seconds, the distance traveled increases linearly as well, at a constant rate of 50 units per second. At 1 second, the distance is 50 units (1 * 50) At 2 seconds, the distance is 100 units (2 * 50) At 3 seconds, the distance is 150 units (3 * 50) And so on until: At 10 seconds, the distance traveled is 500 units (10 * 50)

Plotting these points on a graph result in a straight line with a constant positive slope of 50 units/second. This slope represents the unchanging speed or velocity of the motion. The linear shape shows the direct proportional relationship between elapsed time and distance traveled at this constant speed.

4.7 Proposed model by our calculation

Proposed Model:

- Use HC-SR04 ultrasonic sensors with a 4m sensing range. These will be placed 3m perpendicular from the outer edge of the train track and at a height of 2.75m above ground using mounting poles. This height is above the average train height of 3.65m to avoid obstruction.
- The ultrasonic sensors will be interfaced with Arduino microcontroller using trigger and echo pins. The Arduino code will be programmed to detect objects between 2.8m to 3.1m from sensor as confirmation of a train's presence. Any object outside this range will be ignored.
- The train speed limit within cities in Bangladesh is 60km/h. So, we will design the system timing sequence based on this maximum expected speed.
- The first entry sensor will be placed 1.1km away from the level crossing on the track.
- When a train is detected, we will have a 2 second delay before initiating the next sequence to avoid false triggers.
- Next, 5 seconds of flashing warning lights will be activated at the level crossing to alert vehicles and pedestrians.
- Simultaneously, the 10 second gate closure sequence will start. This will close the gates one at a time on each side for over 10 seconds - 5 seconds for each gate.
- By the time the gates are fully closed, the train will have reached 282m from the entry sensor at 60km/h speed.
- At 300m from the entry sensor, a green confirmation light will be placed to signal the train driver that gates have fully closed.
- The exit sensors will be located 50m away from the level crossing on both sides down the track.
- When the 500m long train passes the exit sensors at 60km/h, it will take approximately 33.96 seconds to fully clear the 16m wide level crossing road.
- After the train has passed, a 2 second sensor delay will prevent false triggers before opening.
- Finally, the 10 second gate opening sequence will be initiated, taking 5 seconds for each gate.

By providing more specifics on sensor types, mounting, wiring, detection ranges, Arduino programming, and exact sequence timings, this expanded model provides comprehensive details while aligning with the real-world data.

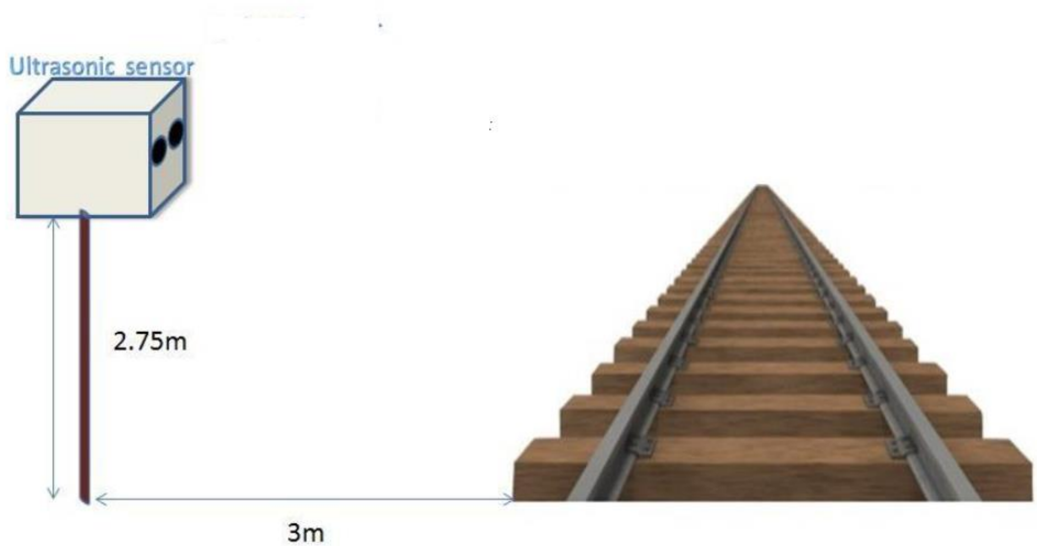

Figure 4.6: Proposed Model from our data.

4.8 Programming Software for Arduino Uno

Arduino IDE is used to develop the prototype of the software. Arduino IDE is available on the official website of Arduino.

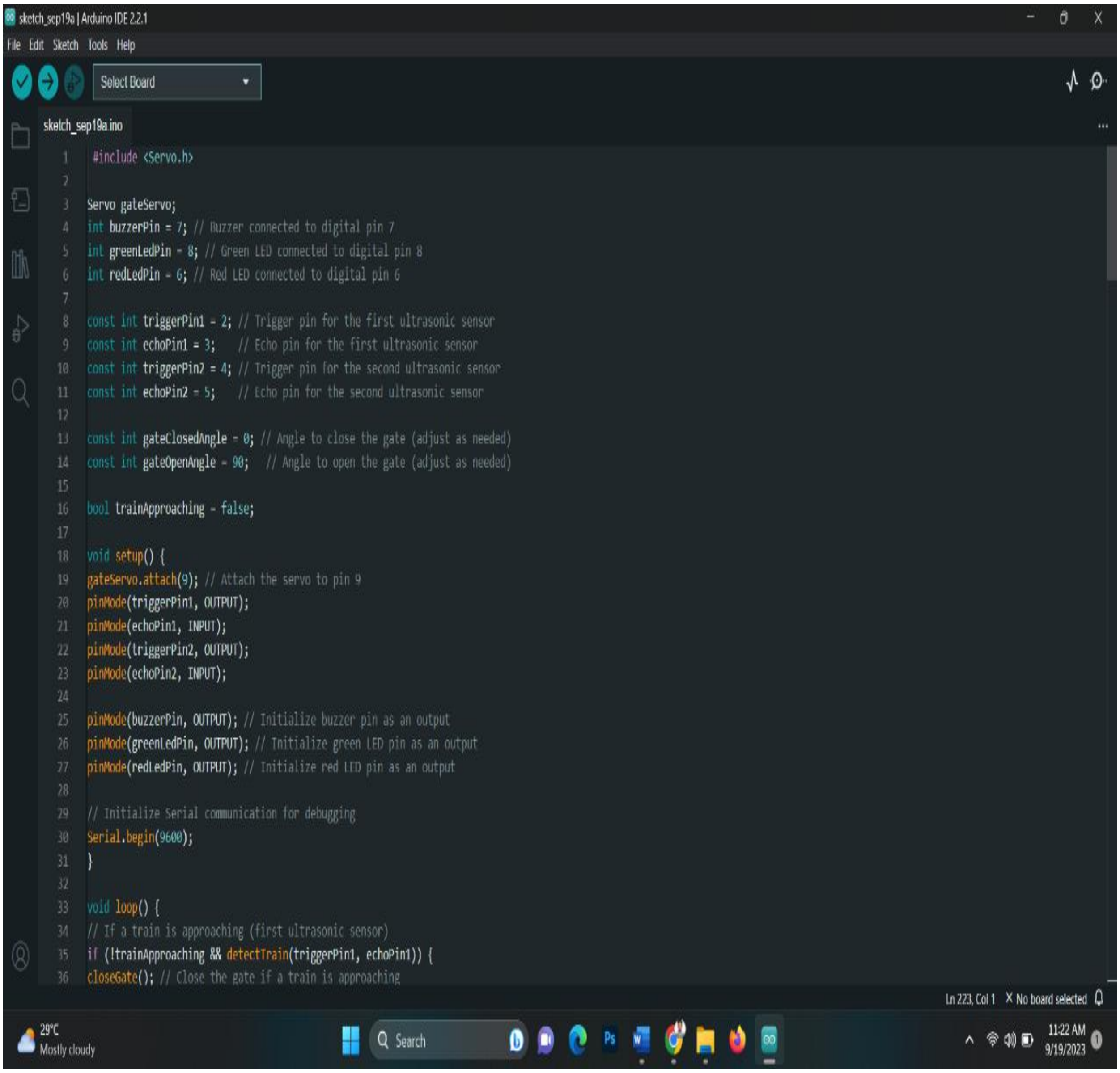

Figure 4.7: Programming Software

4.9 Cost Analysis:

Serial	Components	Price in (BDT)
01	Arduino Uno	1000/-
02	Servo Motor	500/-
03	Connecting wire	200/-
04	Power supply	150/-
05	Ultrasonic Sensor	300/-
06	LED Lights	20/-
07	Toy Train	600/-
08	PVC Board	300/-
09	Glue Gun & Stick	250/-
10	Buzzer	30/-
11	Others	500/-
Total Cost		= 2950/-

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Discussion

This project's use of ultrasonic sensors in combination with the affordable "Arduino UNO" platform is one of its primary features. This method dramatically lowers the project cost compared to the more complex and expensive railway gate control systems. We increase this solution's accessibility while ensuring cost efficiency using a more straightforward equipment configuration. This becomes even more important when considering rural communities and outlying towns without a station master or lineman. Our wholly automated design shows itself to be a workable and dependable solution in such areas. A crucial function is served by placing railway sensors on both sides of the gate. These sensors efficiently detect the arrival and departure of the train, resulting in prompt and accurate gate control operations. This automated solution reduces the need for human involvement and improves the effectiveness and safety of railroad crossings in various contexts.

5.2 Conclusion

The proposed automated level-crossing system utilizes ultrasonic sensors, Arduino microcontrollers, and precise timing sequences to detect approaching trains and control road gate without human intervention.

Key aspects of the design include:

- HC-SR04 ultrasonic sensors for reliable train detection up to 4m range
- Arduino programming to filter sensor data and trigger appropriate outputs.
- Warning lights and sequenced gate closure time of 10+ seconds to safely alert and block road traffic
- strategically placed entry and exit sensors to accurately track the 500m long train through the crossing.
- All timings are calculated based on the maximum expected train speed of 60km/h

By leveraging these technologies and calculations, the system can autonomously operate the level crossing when trains approach, providing enhanced safety compared to manual gatekeepers.

The estimated cost of ৳2950 makes this an affordable solution to reduce accidents between trains and road vehicles. With some calibration and testing, this design can be deployed to high-risk level crossings in Bangladesh for significant public safety benefits.

5.3 Future work

For future system enhancement, load sensors can be installed on the tracks before the road crossing. These will detect the axle weights of the train as it passes over and provide additional verification of a train's presence. The load measurements can also give insights into the train size and weight.

Solar panels and batteries can also be deployed to provide backup power to the level crossing control system. The components used, like Arduino and ultrasonic sensors, consume low energy, so a relatively small solar PV system will suffice. This will maintain uninterrupted operation, improving reliability even if grid power is disrupted.

The load sensors and solar power supply present opportunities to further refine the system for robust real-world implementation. With these augmentations, the automated level-crossing design will be well-poised for providing enhanced safety and traffic control.

CHAPTER 6
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APPENDEX

Here is our code for this project:

```
#include <Servo.h>

Servo gateServo;
int buzzerPin = 7; // Buzzer connected to digital pin 7
int greenLedPin = 8; // Green LED connected to digital pin 8
int redLedPin = 6; // Red LED connected to digital pin 6

const int triggerPin1 = 2; // Trigger pin for the first ultrasonic sensor
const int echoPin1 = 3;    // Echo pin for the first ultrasonic sensor
const int triggerPin2 = 4; // Trigger pin for the second ultrasonic sensor
const int echoPin2 = 5;    // Echo pin for the second ultrasonic sensor

const int gateClosedAngle = 0; // Angle to close the gate (adjust as needed)
const int gateOpenAngle = 90;   // Angle to open the gate (adjust as needed)

bool trainApproaching = false;

void setup() {
gateServo.attach(9); // Attach the servo to pin 9
pinMode(triggerPin1, OUTPUT);
pinMode(echoPin1, INPUT);
pinMode(triggerPin2, OUTPUT);
pinMode(echoPin2, INPUT);

pinMode(buzzerPin, OUTPUT); // Initialize buzzer pin as an output
pinMode(greenLedPin, OUTPUT); // Initialize green LED pin as an output
```

```
pinMode(redLedPin, OUTPUT); // Initialize red LED pin as an output

// Initialize Serial communication for debugging
Serial.begin(9600);
}

void loop() {
// If a train is approaching (first ultrasonic sensor)
if (!trainApproaching && detectTrain(triggerPin1, echoPin1)) {
closeGate(); // Close the gate if a train is approaching
trainApproaching = true;
activateBuzzer(); // Activate the buzzer when the gate closes
deactivateGreenLed(); // Turn off the green LED when the gate closes
activateRedLed(); // Turn on the red LED when the gate closes
}

// If the train has departed (second ultrasonic sensor)
if (trainApproaching && detectTrain(triggerPin2, echoPin2)) {
openGate(); // Open the gate if the train has departed
trainApproaching = false; // Reset the flag
deactivateBuzzer(); // Deactivate the buzzer when the gate opens
activateGreenLed(); // Turn on the green LED when the gate opens
deactivateRedLed(); // Turn off the red LED when the gate opens
}
}

bool detectTrain(int triggerPin, int echoPin) {
digitalWrite(triggerPin, LOW);
delayMicroseconds(2);
digitalWrite(triggerPin, HIGH);
delayMicroseconds(10);
```

```
digitalWrite(triggerPin, LOW);

long duration = pulseIn(echoPin, HIGH);
int distance = duration / 58.2; // Calculate distance in centimeters

Serial.print("Distance: ");
Serial.print(distance);
Serial.println(" cm");

// Adjust the threshold distance as needed (12.7 cm in this case)
if (distance < 12.7) { // If a train is close
return true;
} else {
return false;
}
}

void openGate() {
gateServo.write(gateOpenAngle); // Open the gate
delay(1000); // Delay for gate to open completely
}

void closeGate() {
gateServo.write(gateClosedAngle); // Close the gate
delay(1000); // Delay for gate to close completely
}

void activateBuzzer() {
digitalWrite(buzzerPin, HIGH); // Turn on the buzzer
}
```

```
void deactivateBuzzer() {
digitalWrite(buzzerPin, LOW); // Turn off the buzzer
}

void activateGreenLed() {
digitalWrite(greenLedPin, HIGH); // Turn on the green LED
}

void deactivateGreenLed() {
digitalWrite(greenLedPin, LOW); // Turn off the green LED
}

void activateRedLed() {
digitalWrite(redLedPin, HIGH); // Turn on the red LED
}

void deactivateRedLed() {
digitalWrite(redLedPin, LOW); // Turn off the red LED
}
```