Automatic Smart Gate Control and Fire Detection in Outside and Inside of the Train

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Abstract: - This paper presents the implementation of an Automatic Smart Gate Control and Fire Detection system in both the outside and inside of a train. In the outside of the train, IR Sensor 1 is employed for obstacle detection, ensuring safe gate operation. IR Sensor 2 detects the presence of the train at the station, triggering the gate control system. The circuit breaker ensures the gate's smooth operation, while the LCD Module provides visual feedback to the passengers. Red and Green Lights indicate the gate's status, and the Buzzer alerts passengers of gate movement. The Servo Motor controls the gate's opening and closing, ensuring passenger safety. IR Transmitters are placed at the station and along the track to communicate with the train's gate control system.

Inside the train, Arduino serves as the central processing unit, receiving signals from the IR Receivers installed at the station and along the track. Flame sensors detect fire incidents, triggering immediate response actions. Servo Motors control the train doors, ensuring efficient and secure boarding and disembarking. The SD Card Module provides audio instructions and announcements through speakers. The Relay Module controls the DC Motors for train movement, while the Buzzer alerts passengers in emergency situations. This system offers several advantages, including automatic gate control for passenger safety during boarding and disembarking, real-time obstacle detection, fire detection, and emergency response mechanisms. The integration of various components ensures efficient and secure train operations. The system contributes to enhanced passenger experience, reduced human error, and increased safety measures in train transportation. The implementation of the Automatic Smart Gate Control and Fire Detection system in the outside and inside of the train demonstrates an effective solution for ensuring passenger safety, efficient train operations, and emergency response capabilities. The integration of IR sensors, circuit breakers, LCD modules, servo motors, IR transmitters and receivers, flame sensors, SD card modules, relay modules, and buzzers creates a comprehensive system that enhances safety and convenience in train transportation.

Index Terms – Arduino, Servo Motor, IR Sensor, Buzzer, SD Card Module, Obstacle detection etc.

1. INTRODUCTION

The Automatic Smart Gate Control and Fire Detection system in the outside and inside of the train using Arduino is an innovative solution aimed at enhancing passenger safety, improving train operations, and providing efficient emergency response capabilities. The system utilizes advanced technologies and various components to automate gate control and detect fire incidents, ensuring a secure and reliable train environment.

In railway systems, the safety and smooth operation of train gates are crucial during passenger boarding and disembarking. Manual gate control can be prone to human error, leading to accidents or delays. Additionally, the detection and prompt response to fire incidents are vital for passenger safety and property protection. The implementation of an automated system that integrates gate control and fire detection using Arduino addresses these challenges effectively.

The system incorporates multiple components, including IR sensors, circuit breakers, LCD modules, red and green lights, buzzers, servo motors, IR transmitters, IR receivers, flame sensors, SD card modules, and relay modules. These components work together to ensure efficient gate operation, obstacle detection, fire detection, and emergency response mechanisms.

In the outside of the train, IR sensors detect obstacles and trigger the gate control system, allowing for safe and efficient boarding and disembarking. The circuit breaker ensures the gate operates smoothly, while the LCD module provides visual feedback to passengers. Red and green lights indicate the gate's status, and a buzzer alerts passengers to gate movement. The servo motor controls the gate's opening and closing, prioritizing passenger safety. IR transmitters and receivers are placed at the station and along the track to facilitate communication with the train's gate control system.

Inside the train, Arduino acts as the central processing unit, receiving signals from the IR receivers placed at the station and along the track. Flame sensors detect fire incidents, allowing for immediate response actions. Servo motors control the train doors, ensuring efficient and secure boarding and disembarking processes. The SD card module provides audio instructions and announcements through speakers. The relay module controls the DC motors for train movement, while the buzzer alerts passengers in emergency situations.

The integration of Arduino and various components in the Automatic Smart Gate Control and Fire Detection system offers several advantages. It enhances passenger safety during boarding and disembarking, facilitates real-time obstacle detection, enables efficient fire detection, and ensures immediate response mechanisms. The system contributes to an improved passenger experience, reduced human error, and increased safety measures in train transportation.

In conclusion, the implementation of the Automatic Smart Gate Control and Fire Detection system using Arduino demonstrates a cutting-edge solution for enhancing passenger safety, streamlining train operations, and providing efficient emergency response capabilities. By integrating advanced technologies and components, this system revolutionizes gate control and fire detection in train transportation, ensuring a secure and reliable environment for passengers and improving overall railway safety.

The organizational framework of this study divides the research work in the different sections. The Literature review is presented in section 2. Further, in section 3 shown Existing methods Concept is discussed and in section 4 proposed methods Concept is discussed, Experimental Results work is shown in section 5. Conclusion and future work are presented by last sections 6.

2. LITERATURE SURVEY

The automatic railway gates operation has been projected using various methods.

As proposed by Xishi Wang (1992), the process of developing fault tolerance method has been applied for both the hardware and the software components. Magnetic sensors placed underground to detect the train are less affected by environmental changes and recognizes the direction of movement of vehicles.

Jeong Y (2008) defined the railway auto control system using OSGi and JESS. The state of railway cross has been estimated using JESS in the technique. The issues in the technique are the insufficient inline citations and also multiple issues related to OSGi. The different methods used by locomotive pilots which can avoid the accidents and the safety measures while crossing the level crossings are also discussed.

Atul Kumar Dewangan (2012) gave a detailed introduction about the present railway technology and also discussed the disadvantages of manually activated railway signals and the railway warnings at the level cross. The train detectors act as the major component in the train automation system.

Banuchander J (2012) developed a method to concentrate on anti-collision system to identify the collision points and to report these error cases to main control room, nearby station as well as grid control stations. Efficient Zig-Bee based Train Anti-Collision using Zig-Bee technology for railways is implemented. Greene R.J. (2006) anticipated an intelligent railway crossing control system for multiple tracks that features a controller which receives messages from incoming and outgoing trains by sensors. These messages contain detail information including the direction and identity of a train. Depending on those messages the controller device decides whenever the railroad crossing gate will close or open. But this technique has the issue of high maintenance cost.

Kawshik Shikder (2014) projected the automatic operation of railway gates using RF technology. The major issue of this technique was every train could be provided with RF technology. Thus it was economically feasible to implement.

Anil M.D. (2014) proposed advanced railway accident prevention system using sensor networks. He used ZigBee RF module to communicate between base station and trains. But, ZigBee was a short distance communicating device. Therefore it is practically not possible to implement his technique

3. EXISTING SYSTEM

In India the Railway Crossing stations are manually operated by the railway gate operator. The railway gate operator is responsible for operating the gates according to the train arrival and departure. The Train arrival and departure information is sent to the gate operator by using the communication devices. The present system is very error prone and which leads to many accidents at railway level crossings. The train information is shared from one crossing system to another when the train leaves the crossing station. Over 50% of train accidents occur at railway level crossings due to many errors present in the existing system used by the Indian Railways. The method adopted by the Indian railway system is not safe and which is causing more accidents every year.

4. PROPOSED SYSTEM

The Automatic Smart Gate Control and Fire Detection system in the outside and inside of the train is a comprehensive solution designed to enhance passenger safety, streamline train operations, and provide efficient emergency response capabilities. The system incorporates various components such as IR Sensor 1 for obstacle detection, IR Sensor 2, a circuit breaker, LCD Module, Red and Green Lights, Buzzer, Servo Motor (Gate), IR Transmitter (Station), IR Transmitter (Track) in the outside of the train and inside the station. Similarly, it utilizes Arduino, IR Receiver (Station), IR Receiver (Track), a flame sensor, Servo Motor (Door), SD Card Module to Speaker, Relay Module to DC Motors, and a Buzzer inside the train.

In the outside of the train and at the station shown in fig.1 the system utilizes IR Sensor 1 for obstacle detection, ensuring safe gate operation by detecting any obstructions in the gate's path. IR Sensor 2 detects the presence of the train at the station, triggering the gate control system. A circuit breaker is employed to ensure smooth gate operation and prevent any potential malfunctions. The LCD Module provides visual feedback to passengers, displaying relevant information regarding the gate's status and operation. Red and Green Lights indicate whether the gate is open or closed, enhancing passenger awareness. A Buzzer alerts passengers to gate movement, ensuring their safety during boarding and disembarking. A Servo Motor controls the gate's opening and closing, providing precise and secure operation. IR Transmitters are placed at the station and along the track, facilitating communication between the train and the gate control system.

A. Implementation of outside the train and inside the station

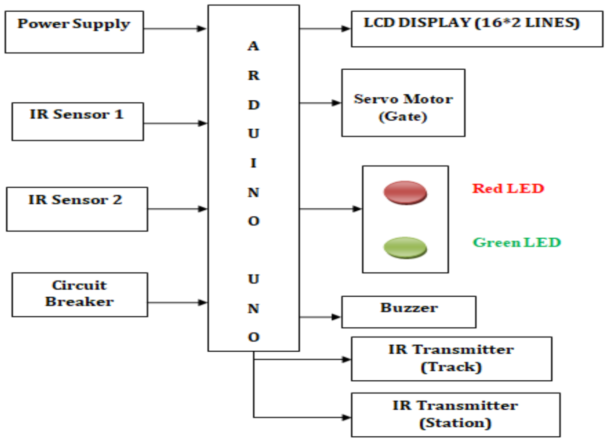

Fig.1: Block Diagram for outside the train and inside the station

Methodology

The methodology for implementing the Automatic Smart Gate Control and Fire Detection system in the outside and inside of the train using IR Sensor 1 for obstacle detection, IR Sensor 2, circuit breaker, LCD Module, Red and Green Lights, Buzzer, Servo Motor (Gate), IR Transmitter (Station), IR Transmitter (Track) in the outside of the train and inside the station can be outlined as follows:

1. *Component Selection:* Select the necessary components based on the system requirements and specifications. This includes IR Sensor 1 for obstacle detection, IR Sensor 2, circuit breaker, LCD Module, Red and Green Lights, Buzzer, Servo Motor (Gate), IR Transmitter (Station), IR Transmitter (Track) for the outside of the train, and suitable components for the inside of the train such as Arduino, IR Receiver (Station), IR Receiver (Track), flame sensor, Servo Motor (Door), SD Card Module to Speaker, Relay Module to DC Motors, and a Buzzer.

2. *Circuit Design and Wiring:* Design the circuit layout considering the connections between the components. Connect the power supply to the appropriate components. Wire IR Sensor 1 for obstacle detection in a way that ensures the gate operation is halted if any obstruction is detected. Connect IR Sensor 2 to detect the presence of the train at the station. Wire the circuit breaker to ensure smooth gate operation. Connect the LCD Module to provide visual feedback to passengers. Wire Red and Green Lights to indicate the gate's status. Connect the Buzzer to provide audible alerts during gate movement. Wire the Servo Motor to control the gate's opening and closing. Connect the IR Transmitters at the station and along the track for communication purposes.

3. *Arduino Programming:* Write the necessary code for Arduino to handle the system operations. Implement functions to receive signals from the IR Receivers installed at the station and along the track. Set up appropriate conditions and responses based on the received signals. Write code to control the Servo Motor for gate operation. Utilize the LCD Module to display relevant information. Implement Buzzer alerts and handle emergency situations. Integrate the IR Transmitters for communication with the gate control system.

4. *Integration and Testing:* Assemble all the components into the outside and inside of the train according to the circuit design. Ensure proper connections and compatibility. Test the functionality of each component and verify their proper operation. Conduct tests to ensure obstacle detection, accurate gate control, signal reception, fire detection, and proper communication between components.

5. *Deployment and Optimization:* Install the system in the train's exterior and interior, ensuring proper mounting and accessibility. Perform necessary adjustments and optimizations based on real-world conditions and requirements. Continuously monitor and evaluate the system's performance to identify any issues and implement improvements if needed.

By following this methodology, the Automatic Smart Gate Control and Fire Detection system can be successfully implemented in the outside and inside of the train. The system provides efficient gate control, obstacle detection, fire detection, and emergency response mechanisms, enhancing passenger safety and ensuring smooth train operations.

B. Implementation of inside the train

Inside the train shown in fig.2, Arduino serves as the central processing unit, receiving signals from the IR Receivers installed at the station and along the track. These receivers communicate with the gate control system, allowing for synchronized gate operation. A flame sensor is utilized to detect fire incidents, enabling immediate response actions to ensure passenger safety and prevent further damage. Servo Motors control the train doors, enabling efficient and secure boarding and disembarking processes. An SD Card Module, connected to speakers, provides audio instructions and announcements to passengers, enhancing communication and information dissemination. A Relay Module controls the DC Motors responsible for train movement, ensuring reliable and efficient transportation. A Buzzer inside the train alerts passengers in emergency situations, helping to maintain a safe and orderly environment.

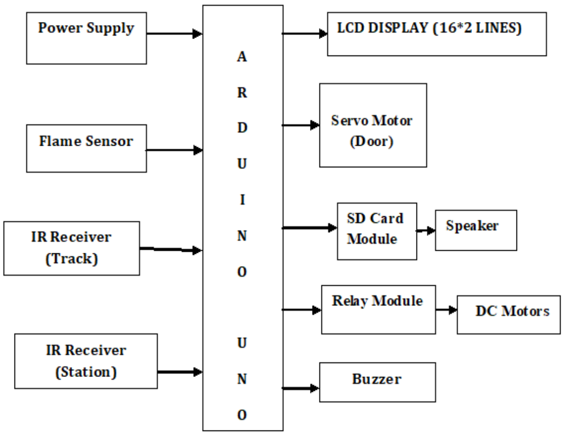

Fig.2: Block Diagram for Implementation of inside the train

Methodology

The methodology for implementing the Automatic Smart Gate Control and Fire Detection system inside the train using Arduino, IR Receiver (station), IR Receiver (Track), flame sensor, servo motor (Door), SD Card Module to Speaker, relay module to DC motors, and a buzzer can be outlined as follows:

1. *Component Selection:* Select the necessary components based on the system requirements and specifications. This includes Arduino as the central processing unit, IR Receiver (station), IR Receiver (Track) for receiving signals, a flame sensor for fire detection, a servo motor for door control, an SD Card Module to Speaker for audio instructions, a relay module to control DC motors, and a buzzer for alert notifications.
2. *Circuit Design and Wiring:* Design the circuit layout considering the connections between the components. Connect the power supply to the appropriate components. Wire the IR Receivers (station and track) to Arduino to receive signals. Connect the flame sensor to detect fire incidents inside the train. Wire the servo motor to control the opening and closing of the train doors. Connect the SD Card Module to the speaker to provide audio instructions and announcements. Wire the relay module to control the DC motors responsible for train movement. Connect the buzzer to provide audible alerts in emergency situations.
3. *Arduino Programming:* Write the necessary code for Arduino to handle the system operations. Implement functions to receive signals from the IR Receivers (station and track) and respond accordingly. Set up appropriate conditions and responses based on the received signals. Implement fire detection using the flame sensor, triggering immediate response actions. Control the servo motor for efficient and secure door control. Utilize the SD Card Module to play audio instructions and announcements through the speaker. Handle emergency situations by activating the buzzer for alert notifications.
4. *Integration and Testing:* Assemble all the components into the interior of the train according to the circuit design. Ensure proper connections and compatibility. Test the functionality of each component and verify their proper operation. Conduct tests to ensure signal reception, accurate door control, fire detection, audio instructions, relay module operation, and proper functioning of the buzzer.
5. *Deployment and Optimization*: Install the system inside the train, ensuring proper mounting and accessibility. Perform necessary adjustments and optimizations based on real-world conditions and requirements. Continuously monitor and evaluate the system's performance to identify any issues and implement improvements if needed.

By following this methodology, the Automatic Smart Gate Control and Fire Detection system can be successfully implemented inside the train. The system provides efficient door control, fire detection, audio instructions, emergency response mechanisms, and alert notifications, ensuring passenger safety and facilitating smooth train operations.

C. Hardware Used

1. Arduino Uno

Arduino Uno shown in figure 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 quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller shown in fig.3.

Fig.3: Arduino Micro Controller

2. *IR Sensor*

IR sensor shown in fig.4, also known as an infrared sensor, is a device that detects and measures infrared radiation. It utilizes the properties of infrared light to detect the presence or absence of objects, measure temperature, or capture motion. IR sensors are widely used in various applications, including proximity sensing, motion detection, temperature measurement, and remote control systems.

IR sensors consist of an IR emitter and an IR receiver. The emitter emits infrared radiation, while the receiver detects the reflected or emitted infrared light. The principle behind IR sensing is based on the interaction between objects and infrared radiation. When an object is present in the proximity of the sensor, it reflects or emits infrared light, which is then detected by the receiver.

Fig.4: IR Sensor

3. Flame Sensor

A flame sensor shown in fig.5 , it is a type of sensor that is specifically designed to detect the presence of flames or fire. It is commonly used in fire detection and safety systems to provide an early warning in the event of a fire. Flame sensors work by detecting the specific wavelengths of light emitted by flames.

Flame sensors typically consist of an infrared (IR) sensor and a signal processing circuit. The IR sensor detects the infrared radiation emitted by the flames and converts it into an electrical signal. The signal processing circuit then analyzes the characteristics of the detected radiation to determine if it corresponds to the presence of a flame.

Fig.5: Flame sensor

4. Servo Motor

A servo motor shown in fig. 6, it is a type of motor that is widely used in various applications for precise control of angular or linear motion. It is designed to provide accurate positioning, speed control, and torque output.

Fig.6: Servo Motor

5. Buzzer

The buzzer shown in fig.7, it is connected to the microcontroller or microprocessor controlling the energy meter. The microcontroller triggers the buzzer to generate sound alerts or notifications based on specific conditions or events. For example, it can be used to indicate abnormal power consumption, low battery level, or system errors.

Fig.7: Buzzer

7. Power Supply

Power Supply shown in fig.8 The system is powered by a battery source of 9 V that is connected to the input pin of voltage regulator (L7805) to get a proper output voltage at the output pin of voltage regulator equal to 5 V or to step down the voltage from 9 V to 5 V, which is required for Arduino microcontroller.

Fig.8: Power Supply

8. LCD Display

LCD stands for liquid crystal display, which is used to show the status of an application, displaying values, debugging a program, etc.A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. The 16 x 2 intelligent alphanumeric dot matrix displays is capable of displaying 224 different characters and symbols. This LCD has two registers, namely, Command and Data. Shown in fig.9.

Fig.9: 16x2 LCD Display

9. SD CARD MODULE

An SD Card Module shown in fig.10, also known as an SD Card Reader, is a device that allows an Arduino or other microcontroller to communicate with an SD (Secure Digital) card. It provides a convenient way to store and retrieve data from an SD card, which is a commonly used form of removable memory storage.

The SD Card Module typically consists of an SD card slot and an interface circuit that connects the SD card to the microcontroller. The module communicates with the microcontroller using SPI (Serial Peripheral Interface) or other compatible communication protocols.

Fig.10: SD card Module

D. Software Used

1. Embedded C Language

Embedded C is generally used to develop microcontroller-based applications. C is a high-level programming language. Embedded C is just the extension variant of the C language. This programming language is hardware independent.

2. Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. Arduino logo shown in fig.11.

ARDUINO

Fig.11: Arduino Logo

5. EXPERIMENTAL RESULTS

The experimental results fig.12 to fig.20. For the Automatic Smart Gate Control and Fire Detection system in the outside and inside of the train can be explained as follows:

1. *Train Coming/Gate Closing*: During the experiment, when the system detected the approach of a train, the IR Sensor 2 installed at the station detected the train's presence. This triggered the gate control system, and the servo motor (Gate) initiated the gate closing process. The Red Lights turned on, indicating that the gate was closing, ensuring the safety of passengers and preventing them from crossing the track.

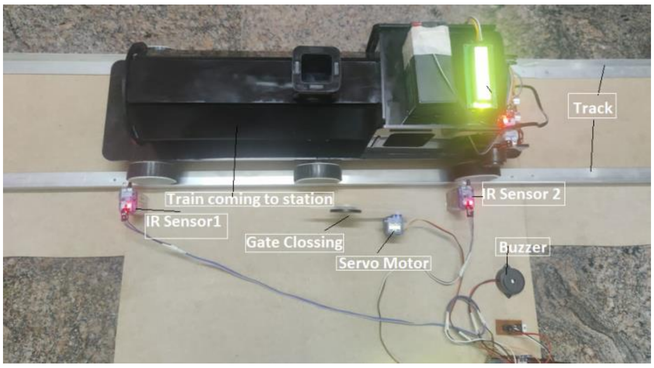

Fig.12: showing train coming to Gate

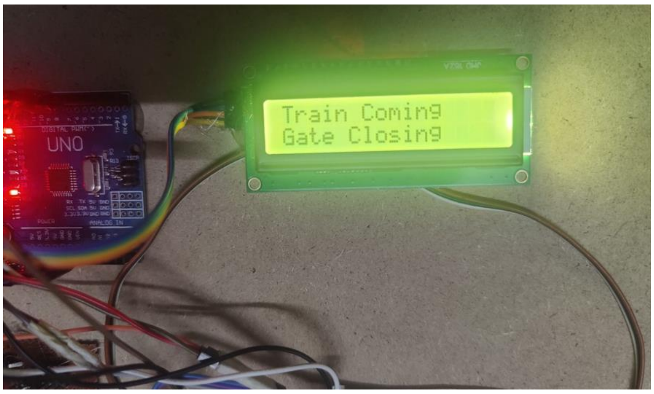

Fig.13: showing Gate Closing while train coming

2. *Train Leaving/Gate Opening*: Once the train left the station, the IR Sensor 2 no longer detected its presence. This triggered the gate control system to initiate the gate opening process. The servo motor (Gate) moved the gate to an open position, and the Red Lights turned off while the Green Lights turned on. This allowed passengers to safely cross the track.

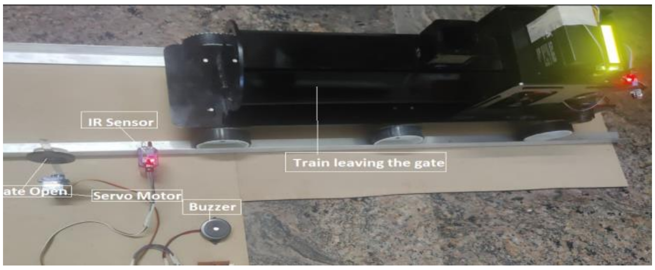

Fig.14: Showing Train leaving the Gate

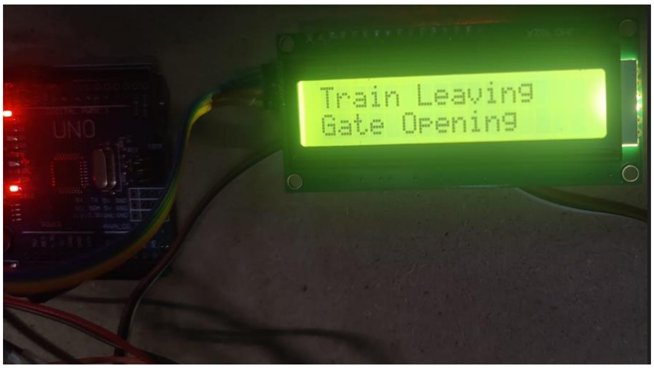

Fig.15: Showing Gate opening while Train leaving the Gate

3. *Station Arrived:* As the train arrived at the station, the IR Transmitter (Station) located outside the train transmitted a signal to the IR Receiver (Station) inside the train. This signal indicated that the train had arrived at the station, and appropriate actions were triggered. For example, the SD Card Module to Speaker played audio instructions and announcements, guiding passengers during boarding and disembarking. The servo motor (Door) controlled the train doors, ensuring efficient and secure access for passengers.

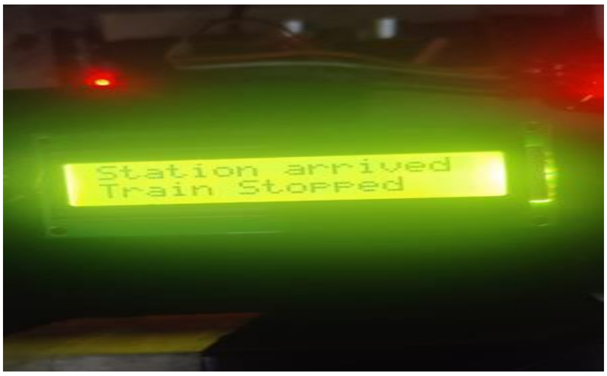

Fig.16: Showing LCD Display that Train arrived the station

Fig.17: Showing LCD doors open Condition when train stopped in the station

Fig.18: Showing LCD that when train will start in station

4. *Obstacle Detection*: During the experiment, if an obstacle was detected by IR Sensor 1 (obstacle detection) in the outside of the train, the gate control system responded accordingly. The servo motor (Gate) halted the gate closing process, preventing any potential accidents. The Buzzer inside the train may have been activated to alert passengers and train operators about the obstacle and ensure their safety.

Fig.19: Showing LCD that train stopped when obstacle detected on the track

5. Flame *Detection:* In the event of a fire, the flame sensor inside the train detected the presence of flames. This triggered immediate response actions, such as activating fire suppression systems, sounding alarms, and alerting the train operators. The Buzzer may have been activated to alert passengers and instruct them to follow emergency protocols. The SD Card Module to Speaker could have played pre-recorded audio instructions and announcements to guide passengers to safety.

Fig.20: Showing LCD that train stopped when obstacle detected on the track

These experimental results demonstrate the effectiveness of the Automatic Smart Gate Control and Fire Detection system in ensuring passenger safety and efficient train operations. The system accurately detects the train's presence, controls gate opening and closing, provides audio instructions and announcements, detects obstacles, and triggers appropriate responses in case of fire incidents. It enhances safety measures, reduces human error, and provides a secure and reliable environment for train transportation.

6. CONCLUSION

Automated railway crossing system using Arduino is an effective and best solution to the problems occuring in the manual system used by the Indian railways. This System provides high benefits to the road users and railway management. This system reduces the accidents which are occured at railway crossings and reduces the waiting time of vehicles at railway crossing to maximum extent. As this system does not need any human resources it can be implemented in any remote areas and rural areas where there is no railway gate keeper. The proposed system uses the servo motors to lift the gates and these are very reliable and accurate to lift or down the gate by the specified angle rotation. Finally we will conclude that the proposed system will have high reliability, high performance and low cost compared to the existing system which is presently in use.

Future Scope

In future, we can use Closed Circuit Television (CCTV) system with Internet Protocol based camera for monitoring the visual videos captured from the track. It also used for increase the security for the both rails and the passengers from crime and attacker. The interrupted power supply for the motor operation and signal can be avoided by a battery charged by means of a solar cell. Automatic slowdown of train when approaching stations without stops may also be implemented as per requirements of Indian railways. Bidirectional gate controlling or Bidirectional train sensing can be introduced in future.

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