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AUTOMATIC RAILWAY GATE CONTROL USING NODEMCU

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ABSTRACT

This project aims to develop an automatic railway gate control system that integrates infrared and ultrasonic sensors using an Android app and a Node MCU. The system employs ultrasonic sensors to measure the train's distance and infrared sensors to identify the presence of an approaching train. The Node MCU processes the sensor data and then sends commands to a servo motor, which manages the gate mechanism. An Android app pairs with the Node MCU via Bluetooth to enable manual gate control and real-time status updates. This system increases railroad crossing safety by automating gate operations and reducing human error.

Keywords: Node MCU,16 × 2 lcd display, L293 driver, Servo motor, IR sensor, Ultrasonic sensor.

1. INTRODUCTION

Introducing the Automatic Railway Gate Control using Node MCU and Android App integrated with IR Sensor, Ultrasonic Sensor, and LCD Display. The railway network is the foundation of the country's economy, transportation, and communication. It links cities, towns, and villages, makes it easier for people and goods to move across the country, supports millions of jobs, and significantly contributes to the expansion and development of the country. However, manually operating railway gates at level crossings poses a significant safety risk, resulting in accidents and fatalities, irreversible damage to families and communities, and a significant financial burden on the country. This project provides an innovative solution to this urgent issue: an Automatic Railway Gate Control system that combines a Node MCU, Android app, and an infrared sensor.

Accidents at railway crossings, which are important sites, often happen because of human error or delays in manual gate operation. Traditional railway gate control systems require human intervention, which can lead to safety risks and inefficiencies. By using NodeMCU to implement an automatic railway control system that uses sensor-based train detection, automated gate operation, and remote monitoring, these challenges can be mitigated. The NodeMCU ESP8266, a Wi-Fi-enabled microcontroller, is the brain of the system. It recognizes approaching trains by processing signals from magnetic, ultrasonic, or infrared sensors. When the system detects a train, it activates servo or DC motors to automatically close the gate.

2. LITERATURE SURVEY

This literature review looks at significant studies and methods that have helped develop and enhance these prediction models. The automation of railway gate control systems has received a lot of attention lately due to the increase in accidents at level crossings. This literature review aims to give an overview of current research and technological developments in automatic railway gate control systems, with a focus on the integration of LCD displays, NodeMCU, Android apps, and infrared and ultrasonic sensors.

A. **Modern Systems and Technologies**

- Several studies have proposed the use of microcontrollers for automatic railway gate control.
- To detect trains and obstructions, these microcontrollers employ sensors such as infrared and ultrasonic sensors (Kumar et a1).

B. NodeMCU and Android App Integration

- NodeMCU-based IoT Applications: NodeMCU has been widely used in IoT applications due to its Wi-Fi capabilities and ease of programming (Kumar et al., 2018; Singh et al., 2019).
- Android App Development for IoT: Android apps have been developed for various IoT applications, including home automation, healthcare monitoring, and industrial control (Sharma et al., 2019; Rao et al., 2020).

C. LCD Display and Sensor Integration

- Railway Gate Control LCD Display: Railway gate control systems now include LCD displays to visually show the gate's condition (Kumar et al., 2017; Patel et al., 2018).
- Researchers have looked into using a range of sensors, including lidar, ultrasonic, and infrared sensors, to detect trains and obstacles at level crossings (Jain et al., 2018; Sharma et al., 2020).

- This literature survey highlights the existing research and technologies related to automatic railway gate control systems. The integration of NodeMCU, Android app, IR sensor, ultrasonic sensor, and LCD display offers a promising solution for enhancing railway safety and efficiency. Further research is needed to develop a robust and reliable system that can be implemented in real-world scenarios.
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PROBLEM STATEMENT

Manually operated gates at railroad crossings often result in delays, accidents, and human error because of negligence or miscommunication. A NodeMCU-based automatic railway gate control system can significantly improve efficiency and safety by automating the gate operation based on real-time train detection. This system will use Internet of Things components, such as sensors and wireless communication, to detect approaching trains, control the gate mechanism, and send out alerts to cars and pedestrians in order to improve railway crossing management and reduce the risk of accidents.

Solution:An innovative approach to enhancing the effectiveness and security of railroad crossings is provided by an automatic railway gate control system that makes use of NodeMCU and Internet of Things technologies. The system's primary purpose is to detect incoming trains using sensors, such as RFID modules, ultrasonic sensors, or infrared sensors. These sensors are placed at a predetermined distance from the railroad crossing and communicate with the NodeMCU microcontroller to identify the presence and movement of the train. After analyzing the information it gets from the sensors, the NodeMCU starts the required procedures. Operated by servo or stepper motors, the railway gate automatically closes when a train is detected approaching the crossing. To avoid collisions brought on by surrounding cars and pedestrians, warning. To increase the system's dependability even more, emergency override features that permit manual intervention in the case of an emergency or system failure can be added. Additional safety features, such as obstacle detection with LiDAR sensors, can protect cars and pedestrians by preventing inadvertent closures on blocked tracks.

PROPOSED SYSTEM

The proposed system of railway gate control using NodeMCU aims to automate the operation of railway crossing gates to enhance safety and reduce human error. The system utilizes the NodeMCU (ESP8266) microcontroller, which is Wi-Fi enabled and cost-effective, to control gate movements based on real-time data from sensors placed near the railway track. Ultrasonic or infrared sensors are used to detect the arrival and departure of trains. When the system detects an approaching train, it activates warning signals like buzzers and LED indicators and uses a motor to automatically close the gate. Once the train has passed, the gate reopens and the signals are cut off. This automated approach ensures efficient gate control, lowers the chance of accidents, and can be enhanced with remote monitoring via Wi-Fi or cloud integration.

3. METHODOLOGY

A. Hardware configuration

- Connect the infrared sensor to the Node MCU board's D2 pin.
- Connect the ultrasonic sensor to the Node MCU board (D3).
- Connect the LCD display to the Node MCU board (D4-D7).
- Connect the relay module to the Node MCU board's D8 pin.
- Connect the relay module to the resistor and diode.

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B. Programming Node MCU

- Install the Arduino IDE and the necessary libraries (Blynk).
- Write the Node MCU code to read data from ultrasonic and infrared sensors and control the relay module.
- Use the Blynk library to establish communication between the Android app and the Node MCU.

C. Android App Development

- Set up Android Studio and any necessary libraries.

D. Execution and Maintenance

i. Set up the system in a real-world setting, like a railway.

- Monitor the system's performance and accuracy.
- Perform regular maintenance and updates to ensure the system remains dependable and efficient.

E. Algorithm

- Read the data from an infrared sensor to determine when a train is arriving.
- Use ultrasonic sensor data to identify obstacles. If a train is detected, close the gate (relay module).
- Report any obstructions to the authorities. If the train has passed, open the gate (relay module).
- To display sensor data and gate status, use the Android app and LCD display.

Flowchart

A flowchart can be created to visualize the algorithm and system workflow.

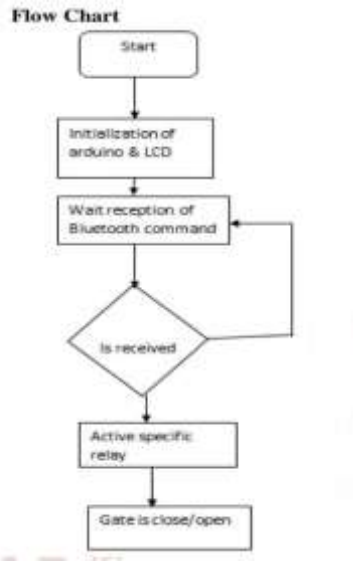

Fig 1. Flowchart of Proposed Model

This flowchart shows a system where an Arduino microcontroller, an LCD screen, and a Bluetooth module control a gate. The system responds to commands via Bluetooth by activating a relay and opening or closing the gate. Let's examine each step in the flowchart to better understand how the system functions.

1. Start

The system begins its operation when it is powered on.

2. Initialization of Arduino & LCD

When the device is turned on, the LCD display and Node mcu are initialized. This ensures that all components, including the WIFI module and relay, are ready for use. When initialization is successful, the LCD display may show a message like "System Ready."

3. Wait for Reception of Bluetooth Command

- The system enters a waiting state after initialization, during which it continues to listen for a Bluetooth command from a smartphone or other connected device.
- The Bluetooth module (HC-05 or HC-06, for example) enables wireless communication.
- A user can send an open or close command from a smartphone app.

4. Decision – Is a Bluetooth Command Received?

- Now, the system checks to see if a Bluetooth command was received.
- In the event that no command is received, the system loops back and continues to wait.
- If a command is received, it moves on to the next step.
- 5. Activate a Specific Relay
- In response to a command, the system turns on a relay module that controls the gate mechanism.
- The relay serves as an electronic switch that allows the Arduino to control the gate motor.
- In reaction to the command, the relay will either turn ON (to open the gate) or OFF (to close it).

5.The gate is either open or closed.

Finally, considering the relay's actions:

- If the command was "Open," the gate motor starts up and the gate opens.
- If the command was "Close," the gate motor stops and the gate closes.
- The LCD display is updated with messages like "Gate Opened" or "Gate Closed."

How the System Works

The process follows a logical sequence:

- The system waits for a command after initializing.
- A user sends a Bluetooth signal using a smartphone.
- The Arduino activates the relay after processing the command.
- The relay turns on the gate motor to open or close the gate.

4. WORKING PRINCIPLE

A NodeMCU-based automatic railway gate system is a creative method to increase efficiency and safety at railroad crossings by automating gate operations. The system primarily uses sensors, microcontrollers, and actuators to detect approaching trains and modify the gate accordingly.

The system detects an approaching train using magnetic, infrared, or ultrasonic sensors placed at a certain distance from the railroad crossing. These sensors send signals to the NodeMCU ESP8266, which interprets the data and determines whether the train is approaching or departing. When the servo motor or DC motor detects the train, it automatically closes the gate to keep cars and pedestrians from crossing.

Additionally, there are LED indicators and a buzzer to alert people to the closing gate. When the train has passed and another set of sensors detects its departure, the system reopens the gate to maintain smooth traffic flow. The system can integrate IoT technology to improve functionality and allow railway authorities to remotely monitor gate status using Wi-Fi or GSM modules. This ensures better coordination and enhances safety measures. Solar-powered systems can also be added to improve energy efficiency and reduce dependency on external electricity sources. Some advanced models even use machine learning algorithms to increase train detection accuracy, decrease false triggers, and speed up response times. Track crack detection is used to identify structural issues with railroad tracks and prevent accidents.

PROPOSED FRAMEWORK

The proposed framework for railway gate control using NodeMCU presents a modern, automated approach to railway level crossing control with a focus on enhancing safety, reducing human intervention, and ensuring operational efficiency. At the core of the system is the NodeMCU (ESP8266), a low-cost, Wi-Fi-enabled microcontroller that offers connectivity and programmability, making it ideal for control systems based on the Internet of Things. The framework uses infrared or ultrasonic sensors that are positioned strategically before and after the railway crossing to detect train movement in real time. When a train approaches, the NodeMCU decodes the sensor data and starts an automatic gate closure mechanism, which is often driven by a DC motor or servo.

LED indicators turn red and a buzzer is activated simultaneously to alert nearby vehicles and pedestrians to the approaching train and closing gate. When the train has completely crossed the crossing, as confirmed by the sensor placed beyond the gate, the system reopens the gate and returns the signal to green, allowing road traffic to resume safe passage. Wireless communication capabilities enable optional integration with cloud servers, control centers, or mobile applications, enabling remote monitoring, real-time alerts, and data logging.

In large-scale implementations, this adds an additional layer of intelligence and traceability to the system, which is especially useful for railway authorities. Because of its modular design, the framework can easily be adapted to a variety of crossing types and geographical locations, from remote rural areas with a staffing shortage to urban areas.

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Furthermore, because of the NodeMCU's small size and low power requirements, the system is suitable for solar-powered operation and is energy-efficient. All things considered, this intelligent railway gate control system combines connectivity, automation, and affordability to create a safer and more efficient alternative to manually operated railway gates. Reliability is further increased by an emergency override mechanism that guarantees manual control when required. By continuously monitoring system performance and warning authorities of possible gate mechanism or sensor failures, predictive maintenance can also be put into practice. With the help of IoT-driven automation for upcoming smart transportation systems, this framework optimizes railway crossing management, lowers human error, and greatly increases railway safety overall.

5. RESULTS

Automatic Gate Operation Based on Train Detection

IR sensors are placed at predetermined intervals before and after the railroad crossing. When a train is detected by the IR sensor, the Arduino automatically closes the gate. When the train departs, the second infrared sensor signals the Arduino to open the gate.

Ultrasonic Sensor for Additional Safety

The ultrasonic sensor detects nearby obstacles (cars, people, etc.) before the gate closes. If an obstruction is detected, the gate remains open until the area is clear to avoid mishaps.

Remote Control via Android App

Users can manually monitor and control the gate using an Android app via Bluetooth. The app can display the gate's current status (open or closed) and allow an operator to override automatic control in an emergency.

Real-Time Status on LCD Display

The **LCD display** provides live updates, such as:

"Train Approaching - Gate Closing" or "Train Passed - Gate Opening" or "Awaiting Train"

Fig 2. Output image of the Proposed Model

CONFLICT OF INTEREST STATEMENT

- The results and conclusions of this study are unbiased and solely based on the data and analysis that were conducted.

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