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Next-Generation Railway Safety: Designing an Automatic Gate System with Voice-Activated Alarms

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Abstract: ***Railway crossings are high-risk areas that demand constant vigilance and attention to ensure the safety of passengers and other road users. Automatic gate systems have been widely used to mitigate these risks, but their effectiveness is limited by the reliance on visual cues and their inability to alert drivers or pedestrians who are deaf or hard of hearing. To address this limitation, we propose a voice-activated automatic gate railway system that uses voice commands to control the gates and employs an audio alarm to alert road users of the approaching train and will give also alarm who walk on the railway. Our system consists of a voice recognition module, a control unit, and a network of sensors that detect the presence of trains and road users. When a train is detected, the gate closes automatically, and the system generates a voice alarm to alert nearby road users. The voice recognition module ensures that the system can be operated hands-free, making it convenient for drivers and pedestrians. Moreover, the audio alarm feature ensures that people with hearing impairments are alerted to the approaching train. We evaluated the performance of the proposed system using a prototype installed at a railway crossing in a high-traffic area. Our results demonstrate that the system is reliable and effective, with a high degree of accuracy in voice recognition and a low false-positive rate. Our findings suggest that the voice-activated automatic gate railway system with an audio alarm is a promising solution to enhance the safety and security of railway crossings.***

Keywords: Railway Safety, Microcontroller, Ultrasonic, Voice-Activated Alarm.

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1. INTRODUCTION

Railway crossings in Bangladesh are a high-risk area that poses a significant threat to both train passengers and road users. The country's rapidly growing population, increasing traffic volume, and the widespread use of informal transport modes have further exacerbated the risks associated with railway crossings. The studies are based on six years of accident data, from 2005–06 through 2010–11. There were a total of 344 collisions on the Bangladesh Railway throughout the research periods, killing 200 persons and injuring 443 others. The most common form of railway crash in our nation was one at a level crossing [1]. According to analysis, level crossings were the scene of 90% of all fatalities and 73% of all crashes and from the report, we have got that in Bangladesh, out of a total of 1480 permitted level crossings, 80%, or 1184 of them, lack gatekeepers. Bangladesh currently has 0.88 level crossings per kilometer of road which is very strange and unexpected [1]. To mitigate these risks, automatic gate systems have been widely used, but their effectiveness is limited by their reliance on visual cues, which can be problematic for individuals with hearing impairments or for those who are not paying attention [2]. However, the railway network in the country is limited, and railway crossings are a significant concern for both train passengers and road users. Over fifty trains are being run on these tracks every day, and accidents at unmanned railway level crossings are a regular occurrence. Despite this, no fruitful step has been taken so far, and railway gates are operated normally by gatekeepers after receiving information about the train's arrival. Our work is based on 1-2km for detecting trains before arriving at the crossing so that general people simply know when a train is coming or not. It is not last, most people are in our country, there is no awareness train coming or not, they do not see or understand or do not also obey the lamp of the railway and also sometimes face a critical situation when they do not have enough time to see the railway light. So it is a very critical and dangerous situation will be for all people who will cross the railway line. Here, we also see that many types of people walk and spend most of their time on the railway, but it is expected from us. Because it is totally eligible and has given laws from the government. But the maximum number of people who lives village, have no consent or do not know this law. But their safety will be needed by the government from this thinking we are also a system for overcoming this situation [3].

To address these limitations, we propose a voice-activated automatic gate railway system with an audio alarm that is triggered when a train approaches and who have stayed on the railway line they are also understood by making a short-range alarm stand to replace the railway light or adding it in the railway light. The system employs a voice recognition module to recognize user commands, a control unit to operate the gates and a network of sensors to detect the presence of trains and road users. When a train is detected, the gate closes automatically, and an audio alarm is generated to alert nearby road users of the approaching train [4].

Our proposed system offers several advantages over conventional automatic gate systems in the context of Bangladesh. Firstly, it allows the system to be operated hands-free, making it more convenient for drivers and pedestrians. Secondly, it offers a more inclusive solution for individuals

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with hearing impairments, who may otherwise be unable to perceive visual cues. Finally, the voice-activated feature reduces the risk of human error, ensuring that the system is operated accurately and reliably.

The objective of this paper is to describe the design, implementation, and evaluation of the proposed voice-activated automatic gate railway system in the context of Bangladesh. In the following sections, we will describe the hardware and software components of the system, the methodology used for testing, and the results of our evaluation. Our findings suggest that the voice-activated automatic gate railway system with an audio alarm is a promising solution for enhancing the safety and security of railway crossings in Bangladesh.

2. METHODOLOGY

The system of automatic gate system for railways is made by using a different type of sensor and component to combine with a microcontroller and has made an easy and needy project for Bangladesh. In the world, the train is one of the fastest vehicles after the airplane and it cannot stop at any place without a railway station. But railway to road crossing is a very common situation in our country. And there are maximum crossing levels that have no gateman and give to a gate man it is also very cost-effective. But our project will be effective in removing this limitation without any suffering. We have used Ultrasonic sensors so that they can detect trains properly which is shown in Figure 1. When the train will detect the gate will close and the voice alarm will activate and inform the people who will cross the road and who also stay on the railway [5]. This simple method can be a game-changing system that will decrease railway crossing accidents.

Description of different components used in the developed system

1. Micro-controller

A microcontroller is a small computer that serves as a control center, managing a range of devices and processes. Thanks to its small size and programmable design, it's highly adaptable and features advanced logic circuits on a single chip made possible by VLSI technology. This single integrated circuit (IC) houses all the key components of a traditional desktop computer in a compact package. A microcontroller contains many important components that enable it to carry out complex tasks with ease. Arduino is an open-source microcontroller board that simplifies the creation of complex electronic projects even for individuals with limited hardware knowledge and skills[6].

2. Ultrasonic Sensor

The ultrasonic sensor is a technology used to measure the distance of specific points on a vehicle from the ground. It operates by measuring the time it takes for an ultrasonic pulse to travel to the ground and be reflected back. A constrained optimization approach is utilized to obtain reflected pulses that can be easily detected by a threshold comparator [7]. This approach considers the frequency response of the ultrasonic transducers and enables sub-wavelength detection.

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Ultimately, the technology allows for precise and accurate measurements of the distance between the vehicle and the ground.

3. Servo Motor

A servo motor is an electromechanical device that transforms electrical signals into rotational motion. It is composed of four primary components: a DC motor, a gear reduction unit, a position-sensing device, and a control circuit. The control circuit sends electrical signals to the motor, which causes the shaft to rotate. The position-sensing device provides feedback to the control circuit, which enables it to adjust the motor's position and velocity to match the desired output [8]. Modern systems use different types of servo motors, including AC and DC motors based on induction and synchronous motor designs, as well as DC brushless motors. Servo motors are extensively utilized in robotics, manufacturing, and other industries where precision motion control is critical [9]. They are also popular in hobbyist applications such as radio-controlled cars and drones. In closed-loop control systems, servo motors are used to monitor and adjust the programmed position and velocity based on feedback from the position-sensing device, ensuring precise and accurate control of the motor's output.

4. Speaker

A speaker converts electrical signals into sound waves using a diaphragm, voice coil, magnet, and suspension system. They come in various shapes and sizes and are used in audio systems, public address systems, and entertainment systems. Frequency response and impedance are critical factors in speaker performance. A well-designed speaker should have a flat frequency response for equal levels of sound across all frequencies. The speaker's impedance should match the amplifier's output impedance for efficient power transfer and optimal sound quality. Advancements in speaker technology have resulted in improved sound quality, increased power handling capabilities, and enhanced durability. Speakers have become an essential component of the audio industry, delivering high-quality sound and immersive listening experiences.

5. Buzzer

Experts describe the Buzzer as an electronic element capable of converting electrical signals into sound waves. The component operates by producing sound vibrations through a membrane with a coil. Typically, buzzers are used as audio devices for anti-theft circuits or early warnings. Unlike AC voltage-powered speakers, buzzers work on DC voltage, and the coils attached to the diaphragm move back and forth, resulting in air vibration that produces the sound or buzzing effect [10].

6. LED

LED, or Light Emitting Diode, is a semiconductor device that emits light when an electric current flows through it. LEDs are widely used in various applications due to their efficiency, durability, and low power consumption. They are commonly found in electronic devices, lighting fixtures, automotive lighting, and many more. One of the primary advantages of LEDs is their energy

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efficiency. They consume significantly less power than traditional incandescent bulbs, making them an excellent choice for energy-conscious applications. Moreover, LEDs last longer than incandescent bulbs, reducing the need for frequent replacements[11].
LEDs are also highly durable and resistant to shocks, vibrations, and extreme temperatures, making them an ideal lighting option for outdoor environments. Additionally, they can emit light in a wide range of colors, allowing for creative and decorative applications. In recent years, advancements in LED technology have resulted in higher light output and improved color rendering capabilities, making them an increasingly popular choice for general lighting applications. As a result, LEDs have become an essential component of the lighting industry, revolutionizing the way we illuminate our surroundings.

Block diagram

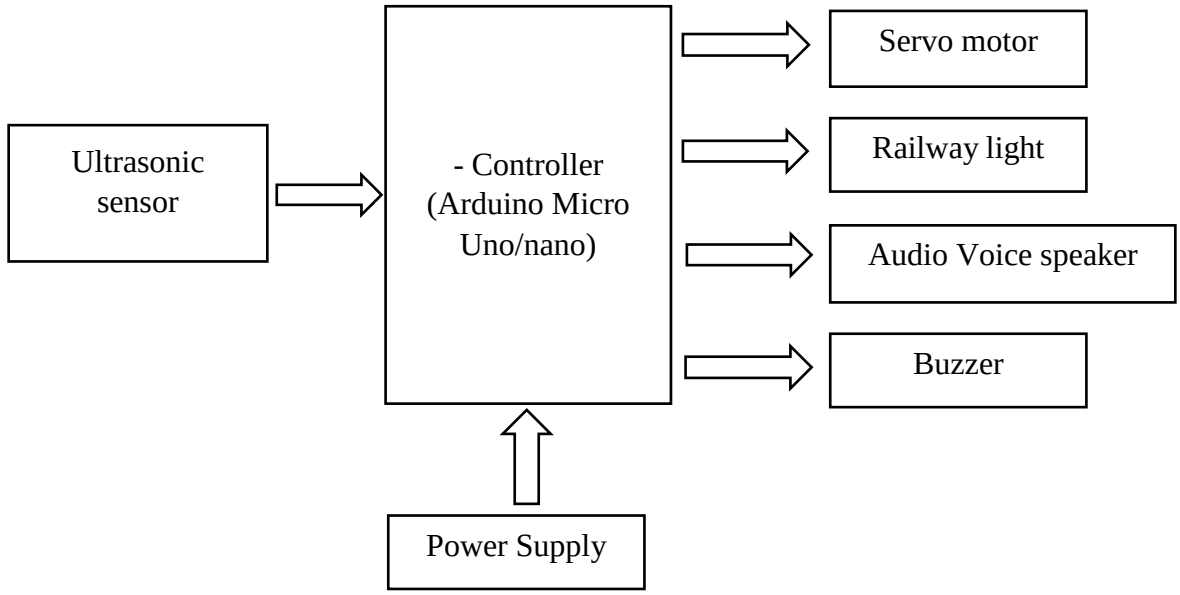

Fig. 1 Block Diagram of Automatic Railway Gate System with Voice alarm

Details of Block Diagram
This system uses an ultrasonic sensor to detect the arrival and departure of a train. However, we will add multiple ultrasonic sensors to detect the train before it arrives at the gate. These sensors will be installed on either side of the lever gate, and a microcontroller will be used, which can be programmed using the Arduino software. To open and close the gate, servo motors will alternate between clockwise and counterclockwise rotations [4].

The sensors will be positioned at a specific distance from the gate to prevent accidents and shorten the wait time for car users. When the train is still far from the gate (within 1 km), a voice-controlled

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alarm will sound, saying "Stop, Stop, the train is coming." When the train arrives within 500m, the gates will automatically close to ensure the safety of road users.
From the block diagram, we can see that a buzzer has been added for people walking on the railway. This buzzer will make a small sound and provide an alarm if the train will come and aware an unknown person who will not know whether the train is coming or not. This system can entirely prevent human mistakes since it doesn't require any human interaction. The information is sent to the controller when the train blocks the ultrasound sensor, which is then reflected back onto the sound receiver. The controller will close the gate by rotating the servo motor in a clockwise manner. Similarly, when the train passes the sensor, the gate will automatically open, and information is sent to the controller at all times, which will then turn the motor counterclockwise and open the gates if the system does not work correctly.

Flow Chart

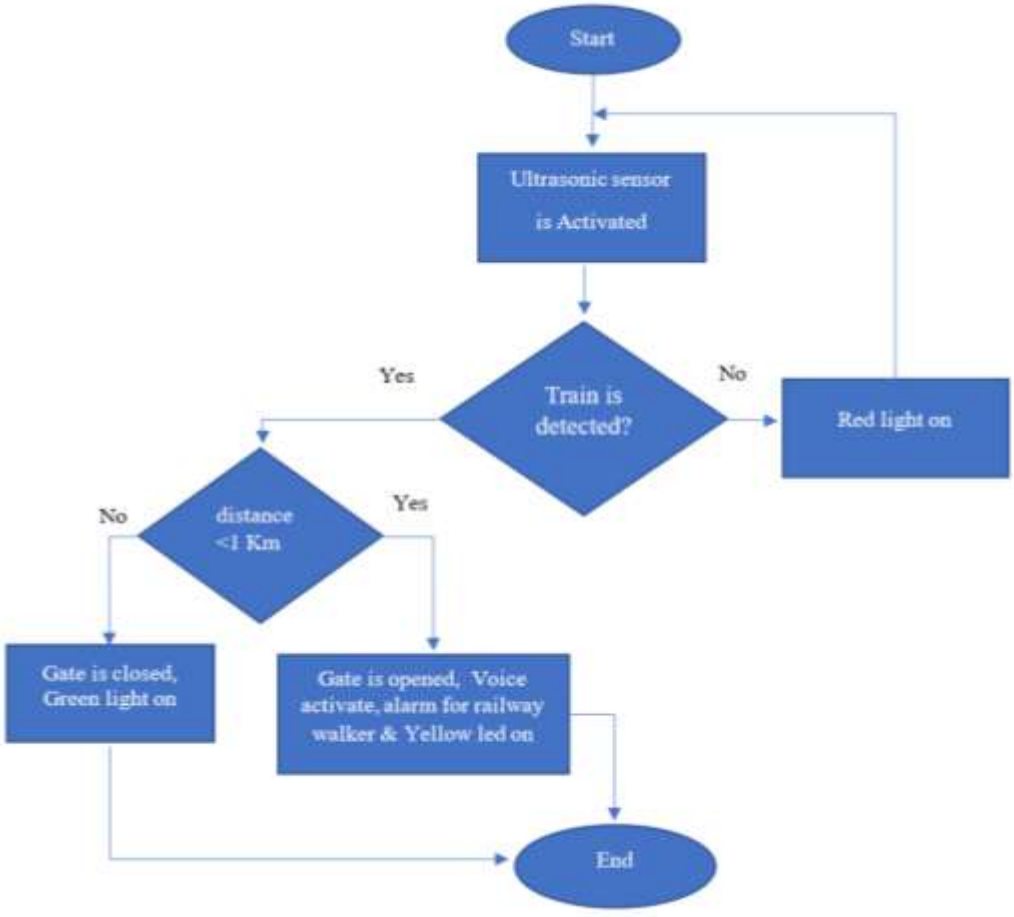

Fig 2: Flow chart of automatic railway gate system with voice alarm

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Circuit Diagram and its Details

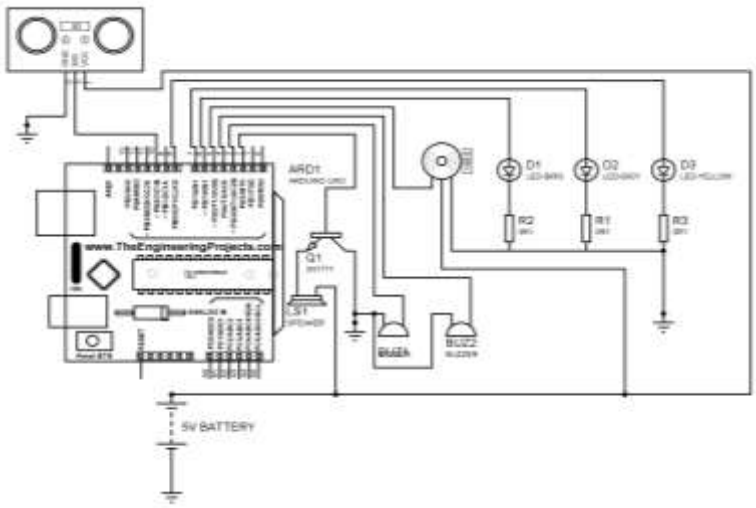

Fig. 3 Circuit diagram of automatic railway gate system with voice alarm

A brief explanation of my automatic railway gate system using an Arduino Uno and components such as an ultrasonic sensor, buzzer, LED, speaker, and servo. The ultrasonic sensor's VCC and GND pins are connected to the 5V and GND pins of the Arduino, respectively, while the SIG pins are connected to the digital pins 10 and the Arduino, respectively. The buzzers are connected to digital pins 3,4 and GND, and the LEDs are connected to digital pins 6,7,8, and GND. The speaker is connected to digital pin 2 and GND, and the servo's VCC and GND pins are connected to the 5V and GND pins of the Arduino, respectively, while the data pin is connected to digital pin 5. Finally, the 5V and GND pins of the Arduino are connected to the 5V and GND rails on the breadboard and this circuit has worked properly.

3. RESULT AND DISCUSSION

To confirm the practical viability of the suggested system as an operational model for a level crossing in real-world scenarios, an experiment was conducted using an ultrasonic sensor placed in front of the train, as shown in Figure 5. The system also includes LED lights, a speaker, a buzzer, an Arduino, an amplifier, and a servo, all connected to each other.

When the train approaches within 70 cm, the buzzers start making a sound to inform the railway walker people that a train is approaching. When the train gets closer, within 30 cm, a voice alarm is activated, and the gate is automatically closed to inform the road users and prevent any potential accidents.

After the train passes, and the sensor no longer detects its presence, the gate will open, allowing pedestrians to cross the road safely. It is agreed that the experimental work and real-life scenarios will be the same.

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Overall, the system serves as an effective warning and safety measure for level crossings, ensuring the safety of both pedestrians and railway passengers.

Fig. 4 Model of Automatic railway gate system with voice alarm

4. CONCLUSION

Our research proposes a voice-activated automatic gate railway system with an audio alarm to improve safety at railway crossings in Bangladesh. The system offers several advantages over conventional systems, including hands-free operation and inclusivity for individuals with hearing impairments. We evaluated the system's performance and found it to be accurate, reliable, and effective in reducing risks. Our proposed solution has the potential to mitigate the risks associated with unmanned railway level crossings and reduce human error. By improving the safety of the transportation network in Bangladesh, our system could enhance the country's overall development. We hope our research will inspire further work in this area and lead to the implementation of effective solutions. Our findings suggest that our proposed system is a promising solution that could also be implemented in other countries. Overall, our research demonstrates the potential for technology to enhance safety and security in the transportation sector, particularly in developing countries like Bangladesh.

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