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RESEARCH ARTICLE

Design and development of artificial intelligence assisted railway gate controlling system using internet of things

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Abstract

An improvised solution for the Indian Railways' human-level crossing controls and the attendant reliability issues they cause. In our nation, level crossings have been the scene of several train accidents. So far, there have been zero productive actions. Using an infrared (IR) detector and an audible alert, the proposed system automatically opens and closes level crossing gates based on when trains approach or depart from the crossing. However, it's possible that a car may become stuck between the pedestrian crossing barriers if they're automated. Here, an ultrasonic sensor may identify the obstruction between the crossing gates, and an Internet of Things (IoT) module would inform the train of the situation. When a train approaches or departs from a railroad crossing, infrared sensors detect its presence and alert an arduino-UNO, which then commands the gates to open or close using a little servomotor stationed nearby. Using the node MCU and GPS navigational technology, this system also aims to reduce latency in detecting combustion attacks within the compartment. The resulting section of this paper proves the proposed work efficiency by means of graphically illustrating the following metrics such as: human detection accuracy, gate closing efficiency, alerting system efficiency and data storage efficiency.

Keywords: Artificial intelligence, Arduino controller, Global system for mobile and Global positioning system module, Internet of things, Railway gate control.

Introduction

Train travel in India delivers the best value for money when contrasted to other means of public transportation in the country. The existing railway system suffers from a number of different problems. When it comes to closing and opening railway gates, human interaction is notoriously imprecise, which may lead to a number of accidents. This piece of technology presents the concept of automating railway gates in order to lessen the likelihood of errors being made by humans during the process of opening and closing gates. The investigation will also include the detection of fire attacks within individual compartments (P. Ilampiray, *et al*., 2021). It is far more dangerous to have a fire on a train that is moving than it is to have one in a train that is stationary since the fire will quickly spread to all of the other cars. The repercussions of this will be quite severe. By taking this strategy, we can reduce the amount of damage that is caused by fires. In the event that a fire breaks out, each cabin is outfitted with a fire sensor, a buzzer to alert passengers, and an actuator that works as a water sprinkler to put out the blaze. The upgrading of India's railroad system has been an important concern for a very long time in the country's drive to upgrade its basic infrastructure. Because railroads are among the most effective means of public transportation, it would be unreasonable to simply raise fares without limit in order to compensate for the expenses associated with expansion, maintenance, and the employment of a large workforce (P. Nirmala, *et al*., 2022).

As a result, the Railways ought to give some thought to modernizing their technology in order to maximize their productivity and reduce their expenses. The automation

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of railway gate operations is one example of an improvised solution that considerably reduces the requirement for human labor (Erna Kusuma Wati, 2022). In this case, the solution significantly reduces the amount of work that must be done by humans. At level crossings, the gates are normally operated manually by a designated person who has been given that responsibility. The station agent alerts the nearest gatekeeper to the imminent departure of the train so that the gatekeeper may make the necessary preparations. When the train is running behind schedule, the gates remain closed for extended periods of time, which causes a backup of vehicles at the crossings. Since these level crossings have to be completed without previous knowledge of the train timetable, there is a substantial possibility that a person may make a mistake when performing them.

Because to automate the system, these manual actions are no longer necessary and gate crossings have been the scene of about half of all railway accidents that have happened in the United States. There has not been a single action that is productive thus far (Alexei I. Davydov, *et al.*, 2022). As a result of the implementation of the proposed technology, the operation of the railway crossing gates will likely become automated, which raises the risk that a vehicle could become jammed in between the gates. It is possible for the impediment to be recognized and transmitted to the railway car using a sensor that emits sound and a global positioning system (Anitha G., *et al.*, 2023). Because of this, there would be a substantially lower chance that accidents would occur at the level crossings. The findings of a survey that measured the occurrence of accidents on railways are presented in Figure 1.

A controller will be utilized in the proposed system in order to streamline the railway crossovers and reduce the risk of accidents occurring close to the railway gates. With ongoing maintenance, this system has the potential to be built into a system that cannot fail. The railroad crossings may be automated in a manner that is both efficient and cost-effective using this method. Therefore, this innovation has an opportunity to increase pedestrian safety and security at railroad crossings. The execution of this project requires a connection to be made between a mechanical framework and an electric framework.

Related Study

The IoT is a distributed network of computing devices that can collect and exchange data via the use of embedded technologies like RFID tags and sensors (M. Abinaya, *et al.*, 2019). Conventional networking communication protocols including TCP, UDP, and ICMP are used by these gadgets. Each of these devices may be addressed by a unique string of characters. In this setting, machines are conversing with one another independently of human intervention. The creation of an automatic railway gate controller is the purpose of this study. This controller will allow railway

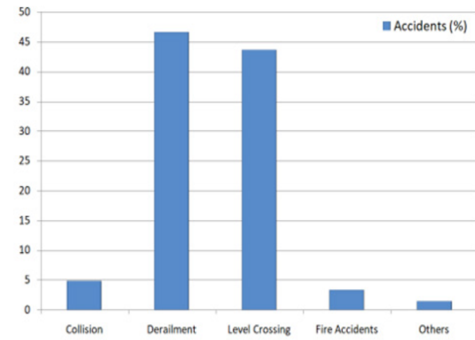

Figure1: Train accident ratio w.r.t several factors

gates to be operated without the need for a gatekeeper, making it suitable for use in operations at level crossings. This controller is responsible for shortening the amount of time that the gate is kept closed. As a result, it increases the level of safety for those driving on the road by lowering the number of accidents that are often brought about by the negligence of both drivers and gatekeepers. An additional passenger-friendly module is installed as a supplement to this. To get destination arrival notifications, passengers in this scenario are required to register their phone numbers on the respective websites. This system is efficient in terms of costs, operates in real-time, and is fully automated.

Transport is of the utmost importance in order to move cargoes and products from one region of the country and even internationally to another, and as a result, the Bangladeshi Railway plays an extraordinarily significant role in this process. The railway network of Bangladesh utilizes, for the most part, either the conventional manual railway crossing approach or boom entryways over the entirety of the country's 2,955.53-kilometer-long rail course. Accidents are frequently caused by the failure to establish a gate structure that is both detectable and capable of working fast. This is compounded by the fact that there are fewer safety precautions used at train crossings. At this time, there are only a small number of automated railroad crossing systems (that do not include an obstruction detector) on the market; nevertheless, every one of these systems does not have a backup plan in case of an unexpected emergency. In recent years, intelligent traffic systems for railway item detection have become a primary focus of study.

If we want to lessen the chances of bad things happening, like accidents (Meheniger Alam and Alimul Rajee, 2023), the author of this paper proposes a method that would lead to the intelligent and autonomous administration of a railway transportation system. Although the system is developed in such a way that it will be most successful in Bangladesh, it is also capable of being simply applied to the railroad infrastructure of any other country. Simple adaptation to the train networks of other countries is also possible. Using infrared sensor coordinates, the system can actively identify trains, and a hydraulic road can detect obstacles at grade crossings. Trains and level crossings may both automatically and manually communicate with one another using the technology. The train system, hydraulic road control system, automated gate control system, and central control system based on arduino UNO are the four separate subsystems that come together in our concept. Infrared (IR) sensors will power the arduino UNO-operated railroad crossing devices. Not only would the implementation of such a system in Bangladesh train give an extensive degree of safety in train transit, but it will also move Bangladesh one step closer to the much-anticipated ambition of the Bangladesh government of developing a "Digital Bangladesh." The suggested technique offers a railway gate controller that is more cost-efficient, dependable, and straightforward than the previous dominating work (Samuthira Pandi, V *et al*l., 2022), according to the results of experimental experiments.

IoT is the interconnected global network of computing devices that can collect and share data over the internet (Md. Ether Deowan, *et al*., 2022) in real-time. Because of this, significant advances have been made in sensor, network, and communication technologies thanks to the Internet of Things. Technologies like long-term evolution (LTE), fifth-generation (5G), and wireless sensor networks (WSN) are just a few examples of these advancements. That's on top of the other technical developments in recent years. This research provides a comprehensive and in-depth analysis of the many IoT technologies that might be used to improve railway management, administration, maintenance, video monitoring, and safety at level crossings.

This research also examines recent developments in IoT technology, green IoT applications, and a wide range of related research initiatives, all of which have practical implications for the railway industry. We also investigate several challenges associated with IoT applications and provide potential strategies for overcoming them. It is hoped that this study's findings will shed light on the viability of Internet of Things (IoT) technologies for environmentally responsible rail transportation, their potential and future benefits to relevant stakeholders and authorities, and the critical future research needs that will need to be addressed.

The points at which a road and a train track meet are referred to as railroad crossings. Automobiles and trains both put themselves at danger when they cross the tracks at the same time. According to the findings of the research, the majority of collisions that occur at railroad crossings are the result of human drivers. This article's goal is to investigate whether or not it is possible to construct a knowledge base for an intelligent system that would be able to evaluate the amount of safety offered by a railroad crossing. In order to accomplish this objective, the necessary conditions for the construction of such a base have been taken into consideration. It has come to light that crossings that have an operator present have a significantly higher rate of safety infractions than those that do not. As of right now, there is no centralized method for assessing and correcting infractions of this nature (Rehman Aniqa, *et al*., 2019).

Fixing infractions at the crossings while there is not currently an operator on duty is quite impossible to do. It has been determined which elements played a role in causing the infractions. The criteria below were considered while designing the method of creating a repository of information for a system with intelligence. This foundation may be used to analyze the level of reliability at railway crossovers by bringing together the fragmented data we have on the factors that affect this safety. When such a database is applied, in conjunction with the information that is obtained from the authorities, it will be possible to forecast how the situation will progress at each institution (Singh P., *et al*., 2022).

In this environment, there is no need for human interaction because the devices can communicate with one another. The goal of this project is to create a controller for automatic railway gates. Level-crossing operations may benefit from this controller since the railway gate can be operated without a guard being present. The amount of months the gate is closed is regulated by this controller, which also raises the bar on security for those who use the road by lowering the number of accidents that are often the result of carelessness on the part of both the customers and the watchmen (Senthilkumar, S. *et al*l., 2023). In addition to that, an additional module is carried out specifically for the traveler's lodging. In this location, visitors are required to enroll their telephone number through the site in order to receive an objective appearance warning. This structure is efficient in terms of cost, it is ongoing, and it can be programmed.

Methodology

Usually, the gatekeeper at a level crossing will manually control the gates. The nearest gatekeeper is alerted by the station agent before to the train's departure. If the train is running late, the gates will remain closed for extended periods of time, causing traffic jams at the crossings. Due to the lack of previous information of the train timetable, these level crossings carry a high risk of human error. By switching to an automated system, these tedious manual procedures may be eliminated without compromising on security. The block design of the suggested technique is shown in Figure 2, together with the appropriate specifications, and the flow diagram is shown in Figure 3.

The Role of Automatic Gates in Railways

There is a maximum speed limit of 91.82 km/h for passenger and cargo trains in India, with a minimum speed limit of 59 km/h. In light of this, the maximum time the gate can be closed is 5 minutes, and sensors monitoring the arrival and departure of trains should be placed 3 kilometers (km) from the level crossings. The proposed approach employs two

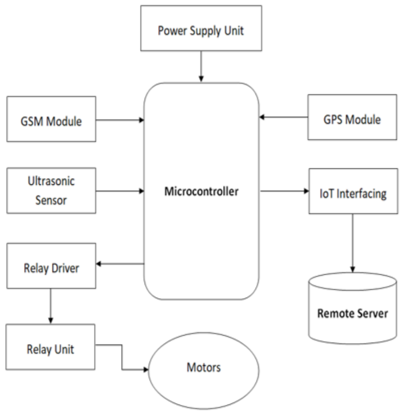

Figure 2: Block diagram

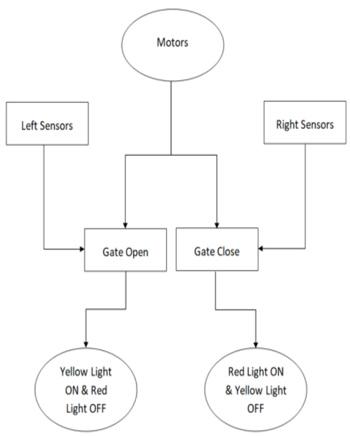

Figure 3: System flow diagram

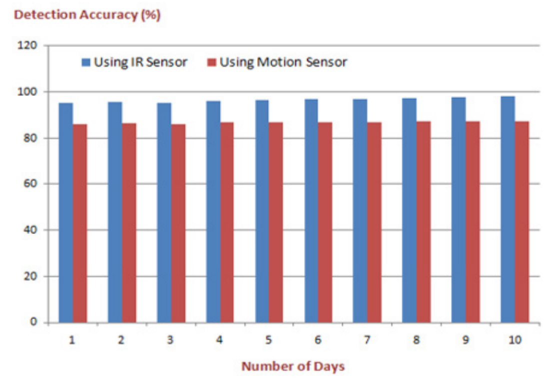

Figure 3: Human detection accuracy

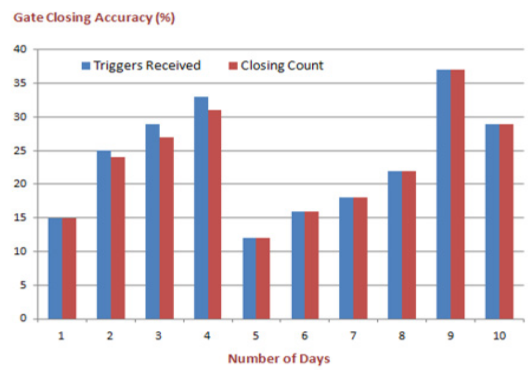

Figure 4: Gate closing efficiency

infrared sensors, a liquid-crystal display (LCD) display, relay-unit, a motor and a buzzer unit to automate the opening and shutting of railway gates.

Launch of Train Service

Infrared sensors placed three kilometers on either side of the track monitor the level crossing in real-time. IR1 will alert the microcontroller if a train is coming. When a train approaches a level crossing where the gates have not been closed, the microcontroller plays a warning bell. The controller activates the direct current (DC) motors that move the railway gates. The DC motor turns clockwise for 5 seconds to correctly close the railroad gates. The progress being made may be seen on a 16x2 LCD. When the IR1 detects a train, "TRAIN ARRIVED" will appear on the LCD and "GATES CLOSED" will appear when the gates are locked.

Securing the Rails

After the train has over the level crossing, IR2 will send a signal to the controller to let them know the train has left. To remind the driver to close the railroad crossing gates, the microcontroller blasts the buzzer once again. Once the gates are in the open position, the controller will run the pair of DC motors in reverse for 5 seconds. The gates are opened and "GATES OPENED" is shown on the LCD when the IR2 detects the train.

Identifying Dangers in the Space between Train Platforms

Due to the anticipated automation of the railway gates, it is possible for a vehicle to become jammed in between them. So, the system has taken decisive action to save them. On one side, ultrasonic sensors have been installed in the crosswalks. There is a permanent barrier on the over-the-level crossings, or alternatively. The ultrasonic sensor is a two-part device consisting of a transmitter and a receiver. The constant impediment might be a result of the transmitter constantly transmitting the ultrasonic waves. The ultrasonic sensor waits for the train gates to close before activating itself. If something gets stuck between the gates at the train station, an ultrasonic sensor can pinpoint its location. It was possible that the estimated distance might be inaccurate by more than the threshold when impediments were present. After that, the ultrasonic sensor relays the information to the controller.

Safeguards against Collision

Microcontrollers are responsible for initiating GSM service, which stands for "Global System for Mobile." The GSM sends a text message to the train's locomotive pilot if it detects an obstruction. The receiver cell phone numbers were obtained from the most recent version of an Indian Railways

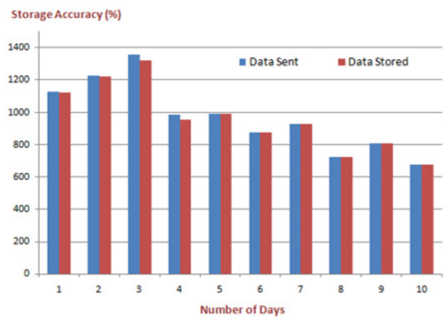

Figure 5: Data storage efficiency

directory. Train times at each crossing may be obtained after the system is in sync with the server database. Locomotive pilots may still keep their trains under control by slowing down or halting at level crossings.

Results and Discussions

The prototype shows the following results:

- It can tell when a train has arrived or left a station.
- Program the DC motor to open and close the railroad gate mechanically.
- An audible and visual indication to inform the public of the approaching and departing train.
- Conducts a visual inspection of the crossing for obstructions before any train proceeds.

The benefits include a reduced risk of accidents, improved service quality and security, less reliance on human labor, and more precise gate opening and closing. The prototype was designed to help minimize accidents at unmanned crossings, and if it proves successful there, it may be proposed at staffed crossings to help reduce accidents there as well. To make it fully automated, we need to install a renewable energy source capable of powering the gates at all times; solar panels provide this answer. After collecting data from the sensors, the microcontroller processes the information and sends out instructions to the appropriate component of the network based on a predefined algorithm.

The background algorithm for the railway gate control system must be established based on the speed and length of the train and this may be done easily using a microcontroller. The microcontroller determines the code of appropriate delay to regulate the DC motor's spins. This system is an effort to recreate, on a smaller scale, the functionality of the actual railway gate control system. Using PLCs and several distributed control systems (DCSs), this is possible in real-time with larger horsepower motors. Several potential benefits to the public might result from installing an automatic railway gate control system at the crossing. Due to the fact that the process is automated, human error is eliminated. The efficiency of the suggested technique is depicted graphically in the following figures: Figure 3 depicts the human detection accuracy, Figure 4 depicts the efficiency of the gate closure, and Figure 5 depicts the efficiency of the data storage.

Conclusion and Future Scope

By implementing this strategy across the country, we can significantly cut down on the amount of accidents that occur near train crossings. It is possible that the rate of operational errors that occur at railway crossings may be minimized, and that this strategy can also prove to be straightforward, cost-effective, and reliable. It is possible that in the not too distant future, this system may be upgraded by having a solar panel installed in lieu of the existing power supply, therefore making it fully automated and able to regulate itself.

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