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Design and Implementation of Intelligent Railway System

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***Abstract:** Digital model railway control systems provide a new way to regulate a layout while reducing wiring and increasing operational flexibility. A variety of control systems are available for operating locomotives on model railroads. Analog systems, in which a train's speed and direction are controlled by changing the voltage on the track, are still in use, though computer-based control systems have recently taken their place. Our technology is a cutting-edge computer-assisted railway line inspection technique. It will take the tedium out of manually inspecting train tracks. The proposed system will modernize the inspection process with four modules. Two trains on the same track will be detected by the system, preventing a collision. If this is included, it will automatically activate the level crossing system. Apart from that, it will detect major obstructions on the rail track, as well as track damage and missing rails.*

***Keywords:** Sensors, Railway Tracks, Controlling.*

1. INTRODUCTION

Railways are the most cost-effective and practical mode of transportation for both long-distance and suburban travel. The importance of having a modern and enhanced railway system is growing by the day [1], because railways play such an important role in economic growth. On the other hand, the current railway situation is very different. In recent years, railway accidents have become all too common [2]. Train accidents have become commonplace, claiming the lives of many people. With any human technique, railway maintenance is extremely difficult to handle. As a result, an automated system is essential for preventing all types of train accidents [3].
The most common cause of this type of accident is a minor oversight, such as a small crack in the rail track or a missing fishplate from the track, but the consequences are severe [4].

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The emphasis during the development of this system was primarily on a few key elements, including reliability, accuracy, efficiency, and cost-effectiveness.

When two trains collide on the same track, a large number of people are killed every year [5]. There is no technology in our country that can stop a train engine instantly to avoid a collision. Furthermore, there is no reliable technology in place to detect cracks or breaks in the country [6]. In addition, many accidents occur as a result of miscommunication between the rail level crossing and passers-by in the majority of cases.

IR sensors will be used to identify trains, and collisions between trains will be prevented by using the data obtained by these sensors. In the event that there is an accident, notifications will be sent out. As a second step in the process, an organized strategy for automatically controlling the road crossing will be implemented. In order to detect track deterioration and potential threats, sonar sensors, as opposed to radar, will be required to be used. Because of the utilization of low-power electrical components, this undertaking is uncomplicated and inexpensive [7].

The planned project will include these three deliverables at some point. The microcontroller will carry out the instructions in a variety of different ways, depending on the particular job at hand. It is necessary to use two microcontrollers of a high quality for this purpose. In order to detect train line cuttings, you will need RF modules with a hefty price tag and the regulatory approval to send signals over a wide range. In the event of a train derailment, you will need to have an SOS SIM card.

2. LITERATURE REVIEW

The safety of railroad tracks is going to be the primary emphasis of this investigation. If the railroad tracks are properly protected, it will be to the advantage of both the economy and the transportation network of our country [8]. The following types of materials were used in the construction of the project: The vast majority of the components used in this project are of a mechanical or electrical nature. You will receive the following benefits if you choose for this system:

A. An infrared (IR) sensor is installed in the front of train that makes use of this system. The microcontroller is going to be notified as soon as the system is ready to go and functioning normally. The infrared sensor detects both the ball and the moving train as it moves along the track. Both of these objects are detected simultaneously. If it appears like there are two trains sharing the track, you should reduce your speed and use extreme caution. On the collision track, the distance between the two stop points for the IR train is one kilometer in both directions.

B. When an ultrasonic sensor detects a train, the computer automatically closes the line bar, making it impossible for the train to pass. When the train has completed its crossing of the track, the line bar will still be there for cars to use. Because a voice alert does not require a connection to the internet, the system has become more effective as a result of the incorporation of this feature. Because of this strategy, there is no longer a requirement to manually adjust the line bar. A buzzer will sound and the liner bar will drop as soon as the ultrasonic sensor detects the train. This will prevent any cars from

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going over the track. When a train pulls away from the station, the line bar will rise, making it possible for other vehicles to cross the rail track without risk.

C. Accidents involving trains frequently occur as a result of broken and fractured railway rails, as well as missing train lines [9]. The system that has been presented is able to identify rail fractures or missing rails on the railway track, and it is also able to send an alarm to the control center with the position of the broken rail. Microcontrollers and gyro meters will be used to detect GSM solders and difficulties with railways. For gyro meterthe database will store prepared data sets of potential graphs depending on input and train mass and velocity, varying train speed values, and varied mass. These graphs will be based on input data.

D. The voltage of the negative ground is measured in order to determine whether or not there has been a cut in the railway path. It is possible to communicate with a receiver by delivering a signal while the negative ground voltage is low. This is done so that the receiver can receive the signal. The off-train engine's speed is controlled by the receiver, which makes use of the microcontroller once more.

E. **Schematic Diagram Components**
Arduino Mega (ATMega328P), Arduino Nano (ATMega328P), Servo Motor, MP3 Player, PAM 8304 Amplifier Circuit Memory Card, Ultrasonic/Sonar Sensor (HC-SR004) GSM 800L, 3 axis Gyro meters, Buck Converter, RF Transmitter / Receiver 12V Transformers Speaker, Buzzer LED Matrix Display IR Sensor, 6V / 12V. These are the components that make up the project in the following lines, an in-depth explanation of microcontrollers and the applications for which they are used is presented:

(i) ARDUINO NANO
Arduino Nano is a small, compatible, flexible and breadboard friendly Microcontroller board, developed byArduino.cc in Italy, based on ATmega328p (Arduino Nano V3.x) / Atmega168 (Arduino NanoV3.x).It comes withexactly the same functionality as in Arduino UNO but quite in small size.It comes with an operating voltage of 5V; however, the input voltage can vary from 7 to 12V. Arduino Nano Pinout contains 14 digital pins, 8 analog Pins, 2 Reset Pins & 6 Power Pins. Each of these Digital & Analog Pins are assigned with multiple functions but their main function is to be configured as input or output.

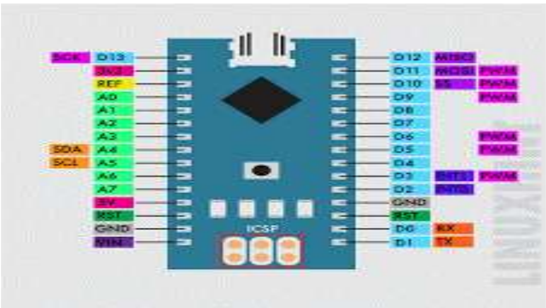

Fig.1 Arduino Nano

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(ii) ULTRASONIC/SONAR SENSOR

Sonar sensing equipment is sometimes known as ultrasonic rangefinders. It consists of a controller, a transmitter, and a receiver all in one package. VCC, GND, Trigger, and Echo are the four pins that may be found on the board. It measures distances between 2 and 400 centimeters by employing sound waves operating at a frequency of 40 kilohertz. This frequency is much outside of the audible range of humans. If there is something in the way of the ultrasonic waves' journey, then the waves will be reflected back to the sensor. It does so by utilizing an IO trigger in order to produce a high-level signal that is maintained for at least 10us. This sensor's pulse input is denoted by the letter "Trigger," and the sensor's pulse output is denoted by the letter "Echo." There is no voltage on the ground. The output voltage is 5 volts. The use of a microcontroller and an Arduino board is quite simple and straightforward.

Fig.2 Ultrasonic sensor

(iii) IR SENSOR/ INFRARED SENSOR

Electronic IR sensors are those that produce their own infrared radiation in order to detect different aspects of their surrounding environment. An infrared (IR) sensor can be used to measure the temperature of an object, and it can also be used to detect motion in the surrounding environment. An IR Sensor, also known as an Infrared Sensor, can be broken down into its two primary components, the IR Transmitter and the IR Receiver. The infrared (IR) transmitter is responsible for broadcasting infrared waves, whilst the infrared (IR) receiver is responsible for picking up on those broadcasted infrared waves. The sensor's V_{out} pin is where the digital data in the form of 0s and 1s that are transmitted by the IR receiver are received. If there is an object in front of the infrared sensor, that object will reflect the infrared rays that are being emitted and will be detected by the infrared receiver. In this scenario, the IR sensor gives a reading of 0, often known as LOW. If there is nothing in front of the infrared receiver, it will not be able to pick up any of the infrared rays that are being sent out by the infrared transmitter. As a result of this circumstance, the IR sensor will produce 1, also known as HIGH.

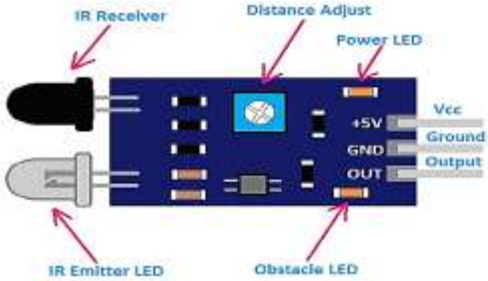

Fig.3 Infrared sensor

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(iv) 3 AXIS GYRO METERS

The MPU-6050 is a very effective motion processor that comes in an extremely compact size. The MPU-6050 incorporates a 3-axis MEMS gyroscope and a 3-axis accelerometer on the same silicon die as well as a DMPTM (Digital Motion Processor) on board in order to avoid cross-axis alignment issues that can occur with discrete parts. These issues can occur when discrete parts are used to measure motion. The intrinsic 9-axis Motion Fusion algorithms of the components can even access external magnetometers or other sensors through an extra master I2C channel. This allows the devices to gather a full complement of sensor data without interference from the system processor.

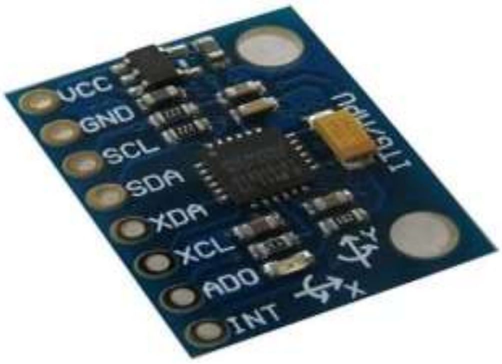

Fig.4 3-axis Gyro meters

(v) SERVO MOTOR

Servo motors can take the form of linear actuators and rotational actuators, among other forms. If you want to rotate an object at a particular angle or distance, then you will need to use a servo motor. At Robotics Bangladesh, we have a comprehensive selection of servo motors from which customers may make their selections. On the website of the firm, you will see that servo motors are available for purchase

Fig.5 Servo Moto

(vi) RF TRANSMITTER/RECEIVER

An RF module is composed of an RF Transmitter as well as an RF receiver. The Tx/Rx pair is responsible for both transmission and reception, and it does so using a frequency of 433 MHz. The antenna that is connected to pin4 of an RF transmitter is used for the wireless transmission of serial data that has been received. The data is sent at a pace that might range anywhere from 1 kbps to 10 kbps. The data that is being sent is picked up by a radio frequency (RF) receiver that works at the same frequency as the transmitter. This inexpensive radio frequency (RF) transmitter has the ability to send signals up to a distance of one

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hundred meters (the antenna design, working environment, and supply voltage will seriously impact the effective distance). One of this strategy's strong points is that it can facilitate the creation of battery-powered gadgets for use on shorter journeys. Both the transmitter and receiver in this system use a frequency of 433 MHz to communicate with one another.

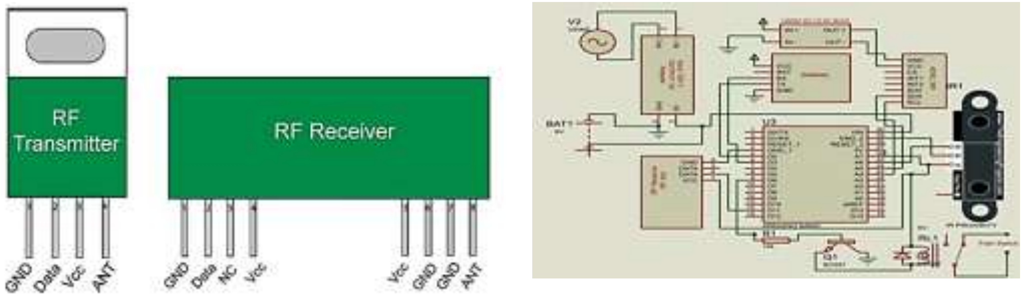

Fig.6 RF Transmitter and Receiver

F. It is essential to one's capacity to stay on target that they have the skill to keep a system under control. Station control is one of the features of this project that is considered to be of the utmost importance. The schematic for station controlling and the circuit arrangements are shown below:

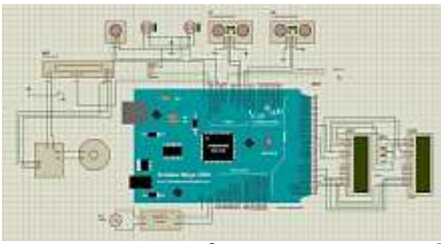

Fig.7 Circuit Diagram for Station Controlling

In order for the Arduino Mega to comprehend where the train is located, the input and output pins for the Digital Write (2) and Digital Write (3) have been attached to the Digital Write (4) and Digital Write (50) ports. The following connections have been made between ATMega and the Pinto LED display input: (rs = 31, en = 35, d4 = 45, d5 = 47, d6 = 49, d7 = 51). Both of the servo motor's Digital Write (10) and Digital Write (11) pins are considered inputs for voice commands that operate the amplifiers. When figuring out where the train faceplate is located, pin 14 was used to supply negative ground voltage, and pin D12 was used to connect the RF transmitter. Both of these pins are located on the same board. The train engine may be turned on and off by using a relay that is attached to the Analogue Read (A4 and A5) pins. This is accomplished by utilizing the Digital Write command (D6). Connecting an infrared (IR) sensor to an Arduinonano requires using the digital read (D5) pin. A train control circuit diagram can show how the train maintains the system that is required for operation and signaling. Below is a diagram of the train control system.

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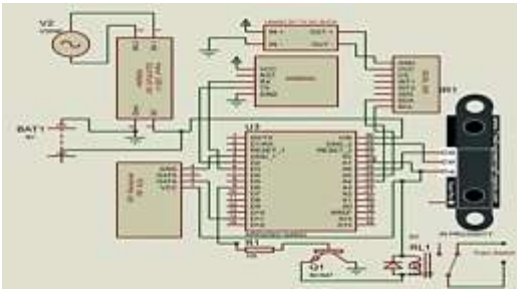

Fig.8 Circuit Diagram for Train Controlling

G. It is necessary to have a block diagram in order to correctly grasp and assess the project. A block diagram that combines all of the different blocks into one cohesive whole may be able to provide some light on how the train and the station are to be controlled, which is necessary for gaining a deeper understanding of how the project is intended to function.

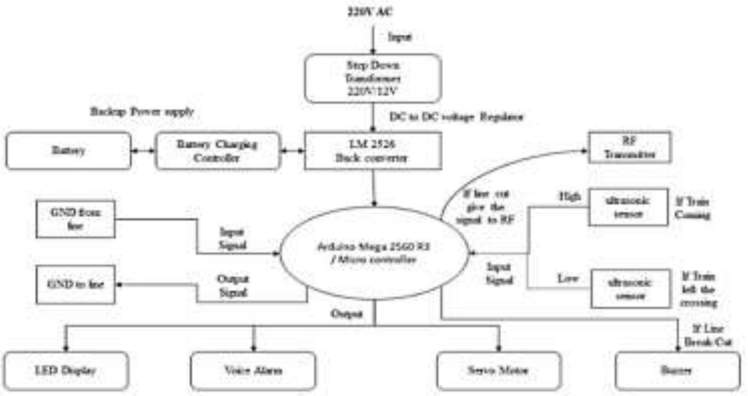

Fig.9 Block Diagram for Station Controlling

A train control circuit block diagram can describe how the train maintains the system that is essential for operation and signaling if it is shown correctly. The following illustration provides a diagrammatic representation of the control system.

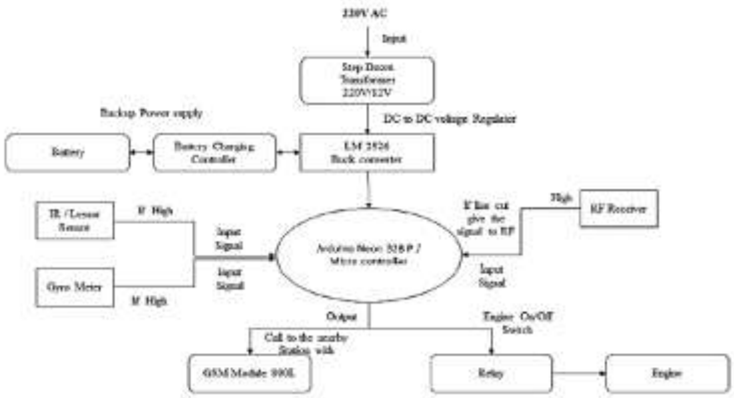

Fig.10 Block Diagram for Train Controlling

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The graphic that is given above is all you need to look at in order to have a better understanding of the Intelligent Railway Controlling System. In this particular system, the power supply inputs include servo motors for the level crossing bar, LED displays for message display, amplifiers for warning audio, ultrasonic sensors for train location and IR sensors for collision, and gyro meters for train collision detection. The processing system was powered by an Arduino Mega and Nano (ATMega328P), which made use of a converter to convert the 220 AC supply to 12 DC voltage. Negative earth voltage is applied to the rail path in order to cut or remove it. An RF module is employed in order to communicate the signal, and a relay is utilized in order to turn the train on or off.

3. RESULT ANALYSIS

The objective of the project was to create a "Intelligent Railway Controlling System," and it was accomplished with the help of Arduino mini and Mega microcontrollers. The following is the output produced by the system:
The information that is sent from the infrared sensor is received by the microcontroller (IR). A command is transmitted by the microcontroller using a system that has been predetermined. The GSM module is responsible for sending a message to the specified location when it has been instructed to do so by a command. Because of the low IR values, it was essential to make a change to the weight in order to accomplish the desired end result. The resister was crucial in assisting us in achieving our objective by playing a pivotal role. The range of the FSR's output when there is no resistor present is 01 to 10. The output range of a 100k resistor is between 50 and 1023.
It was necessary to employ an infrared sensor in order to bring the train to a halt, and there was a very specific distance that needed to be maintained between the IR sensor and the locomotive. The microprocessor was providing commands quickly and efficiently in order to avoid a collision, and as a result, the train was able to come to a halt.
A servo motor was used to operate the line-bar at the pedestrian crossing. The Atlantic Sensor was delivering the necessary data, and it was taking appropriate action based on that data.Due to the fact that the sonar sensor was functioning normally and precisely measuring the distance, the servo would not fall even if there was something beneath it. After being removed from the line bar, the object almost immediately made its way to the bottom of the pile. 6.67 cm is the distance that can be measured between the sonar and the ground.

Fig.11 Railway Control Track

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Even though there is insufficient vibration coming from the train, the vibration sensor is unable to determine the appropriate distance, and the demonstration as a whole gives the results that were anticipated. On the other hand, IR servos and Sonar modules worked well with microcontrollers

The GSM module for transferring messages was responsive and worked well with microcontrollers. Due to the miniature nature of the arrangement, the presentation did not include any means by which the various train locations could be distinguished from one another. Because of this, infrared (IR) was used to halt the train rather than GPS, and a single message was transmitted to the control center, which at the time was operating normally.

4. FUTURE SCOPES

The control room will be able to monitor the location of the trains and ensure their safety in real-time using apps similar to this one, and if required, they will be able to warn the drivers using this app [10] in the future [11]. Because it would be simpler and more efficient to inspect train tracks using the proposed technology, railway lines will be improved in terms of their level of safety and security.

In the future, integration will also occur with regard to the remaining two facets of our initiatives. For example, recognizing a broken rail track or recognizing an impediment on a rail track. In the future, we will implement the theoretical specifications and algorithms for these two features on hardware in order to provide a complete system for a brand-new, improved, and secure railway track monitoring system. This system will alleviate the sufferings that are associated with manual railway track monitoring. Both theoretical specifications and algorithmic solutions are in our possession.

5. CONCLUSION

Before making a concluding conclusion, it is necessary to bring attention to the fact that incidents involving rail transportation frequently result in the loss of many lives. Because of this, it is necessary to employ a method that is both intelligent and dependable in order to both stop mishaps of this nature and determine the likelihood that they will occur. The notion that was offered is for an independent inspector of the train network. This is a very reliable and cost-effective method that can be utilized on any route, regardless of whether it is in the middle of the city or in the suburbs. Because of its compact size and low weight, this system offers a straightforward answer to all of the challenges that are associated with an accident involving a train in a single system. This system will run all of the modules at the same time in order to avoid any accidents from occurring. Within the scope of our project, mobile apps and web apps will be utilized to search for cracks. Because boarding the train without a valid ticket will be prohibited, a ticket-punching machine will be put on the platform where passengers wait for the train.

Authors Contributions

M.S.R. developed the core concept and established the theoretical analysis of the article. M.A.K. developed the systematic analysis and conductedmodeling of the concept. K.M.R. contributed to the implementation of the concept into the article. ProfH.A. and R.A. both authors contributed to the final version of the manuscript. F.R. thoroughly supervised and directed the total article.

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