Automated Railway Gate Controlling System

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Abstract*—This paper aims to provide an automatic railway gate at the level crossing replacing the gates operated by the gate keeper by detecting train and stuck on the level crossing, generating corresponding alert signal and controlling the gate. The solution is provided by developing a train detection module, stuck detection module, signal light module, alarm module, railway gate controller and a controller module. There are only four ultrasonic sensors in the train detection module and one ultrasonic sensor in stuck detection module. Both, train detection and stuck detection module generate high frequency signal through the ultrasonic sensors and detect the presence of object if the echo is received back by the sensors. Then the controller unit determines whether the obstacle is train or stuck and takes necessary steps by controlling the gate, alarm generator and signal lights. Experimental studies show that the proposed methodology provides a more cost effective, reliable and simpler railway gate controller than existing dominant work.*

Keywords— *Ultrasonic Sensor, Train Detection, Stuck Detection, Alarm generator, Level Crossing*

I. INTRODUCTION

Railways being one of the safest and cheapest modes of transportation are preferred over all the other means of transport. So, it is essential to maintain and improve the current level of safety. A safe railway is more efficient and also a more attractive transport choice, enabling society to address the environmental and economic challenges of the 21st century. Railway safety is a crucial aspect of rail operation over the world. When we go through newspapers, we come across many railway accidents occurring at different railway level crossings and many people are dying. The place where rail track and highway/road intersects each other at the same level is known as "level crossing". Bangladesh Railway said at least 201 people were killed and 349 others injured in 264 accidents at different level crossings in last seven years till 2013[1]. This is mainly due to the carelessness in manual operations or lack of workers at level crossing. There is an inherent unreliability in the present manual system.

Automatic railway gate control system is an arrangement of physical components which sense the arrival of the train and make the gate pull up and pull down automatically. As a train approaches at the railway crossing from either side, the sensors placed at a certain distance from the gate detect the approaching train and accordingly controls the operation of the gate. To avoid the accidents, sensors placed at some distance from the gate detect the departure of the train. The signal about the departure is sent to the microcontroller, which in turn operates the motor and opens the gate. Thus, the time for which the gate is closed is less compared to the manually operated gates since the gate is closed depending upon the telephone call from the previous station. Also reliability is high, as it is not subjected to manual errors.For the railway, research on automatic gate controller systems has traditionally focused on two main areas: information transmission and gate controlling. Problems related to information transmission concern train detection and fast transmission of this information to the control unit. Problems those are related to the gate controlling very sophisticated and challenging. They comprise presence of train, immediate closing and opening of gates. The existing solutions have many complexities and require research for supporting railway.

This paper proposes the design and implementation issues of an automated railway gate controlling system. The system detects the train and stuck by analyzing the reflected waves, produces alarm, controls light signal and gate. When the whole train passes the level crossing then the gate is opened, alarm generator stopped and indicator light switched on green signal. If there is a stuck on the level crossing the stuck signal is switched on The lesser equipment, reduced cost, simpler design and high efficiency of the proposed system prove the effectiveness over existing work.

The organization of this paper is as follows: Section 2 describes the related work of the proposed system. Section 3explains the construction and operation of the proposed system. The experimental analysis and comparison of specification and accuracy are shown in Section 4. Finally, concluding remarks are drawn in Section 5.

II. RELATEDWORK

Recently, many automatic railway gate controllers with advanced technology are introduced to make the level crossing risk free. Al-Zuhairi et.al concentrated on unmanned level crossing which caused frequent accident[2]. For this, they proposed a Microcontroller based Railway Gate and Crossing Control system. In their system they used IR sensor and Microcontroller. In their system IR sensor sense the presence of train

and send the signal to Microcontroller. Based on the signal Microcontroller controls the gate of the crossing. The main limitation of this system is low accuracy. The performance of IR sensor is not adequate at open place and light. Subrata Biswas et.al proposed pressure sensor based swift response anti-collision system for an automatic railway gate control system[3]. The pressure switches which have been integrated in this system detect the condition whether any vehicle gets stuck at the level crossing or not. IR sensors have been used to detect the arrival and departure of the train.. The system is little bit complex and due to use of IR sensors performance is not satisfactory. Sandya Goutam et.al concentrated on predicting the major cause of railway accidents that is collision on the same track[4]. For this purpose a technology used to identify train positions, collision detection as well as the points at where collisions may occur has been used. The primary goal of this paper is anti-collision system to identify such collision points and to report the error cases to main control room, nearby station as well as grid control stations. To build this system, advanced sensing technology, long distance communication system (RS 485protocol), microcontroller (8051) and wireless Communication protocol has been used. But this system is not concerned with the collision between the train and vehicles on the road. J. Banuchandar et.al proposed and an automated unmanned railway level crossing system[5]. In this system when the train arrives in a particular direction the transmitter IR senses and generates appropriate signal, then at the same time the receiver IR receives the signal and generates an interrupt. The main problem of this model is low accuracy because the interrupt signal can be generated even if a small object crosses the IR Sensor. Krishna et.al proposed a model to control the railway tracks by using anti-collision techniques[6]. The model of railway track controller is designed by using 8952 microcontroller to avoid railway accidents. When we go through the daily newspapers we come across many railway accidents occurring at unmanned railway crossings. This model is implemented using sensor technique. They placed the sensors at a certain distance from the gate detects the approaching train and accordingly controls the operation of the gate. Also an indicator light has been provided to alert the motorists about the approaching train. In their system they have used anti-collision device which uses GPS for preventing collision between two train and IR sensor for gate controlling at level crossing. Sheikh Shanawaz Mostafa et.al proposed "A Radio Based Intelligent Railway Grade Crossing System to Avoid Collision"[7]. Their system offers 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. This system is also complex and costly. Upon realizing the importance of automatic railway gate controller in India Acy M. Kottalil el.al proposed Automatic Railway Gate Control System gate[8]. The objective of their system is to provide an automatic railway gate at a level crossing replacing the gates operated by the gatekeeper. The system reduces the time for which the gate remains closed. The system works on a microcontroller based control. Their proposed system uses ATmega 16A microcontroller. With the help of IR sensors the arrival and leaving of the system is monitored and the gate is operated accordingly. Anti Collision and Secured Level Crossing System was proposed by K. Vidyasagar et.al[9]. Their proposed model presents an automatic rail gate control system at level crossing positions and accident prevention mechanism. Two vibration sensors are used to control the open and close state of the gate at level crossing position. An ultrasonic sensor is positioned to detect an unauthorized object on the track. Open and Close status of the gate and unauthorized object on the track will be communicated with the central control room using wireless communication protocol. This system is complex, costly and requires a lot of equipments to implement. The complex design, low performance and cost has raised a question on the effectiveness of the approaches.

III. PROPOSED RAILWAY GATE CONTROLLING SYSTEM

The proposed system uses ultrasonic sensors which have very high efficiency. These ultrasonic sensors are placed near the rail line at the both side of the level crossing. These sensors which are placed at certain distance from the level crossing detect the train coming from either direction to the level crossing. Then the information of the train is transferred to the control unit and the control unit switches on the red light, generates alarm and pull down the gate immediately. The sensors of the either side determines whether the train passes a certain distance or not from the level crossing. If passes the controller switches on the green light, stops generation of alarm and pull the gate up. If any vehicle gets stuck at the level crossing of the rail-line is detected by the sensor placed at the level crossing. Our proposed system is very simple and inexpensive with respect to other system but its performance is very laudable and excellent.

The design methodology of the proposed system is shown as follows.

A. The Design Methodology of the Proposed System

The proposed system consists of three main components. These are: i) Ultrasonic sensor ii) Arduino Uno
iii) Alarm Generator iv) Light indicator. The block diagram of the proposed system is shown in Fig. 1.

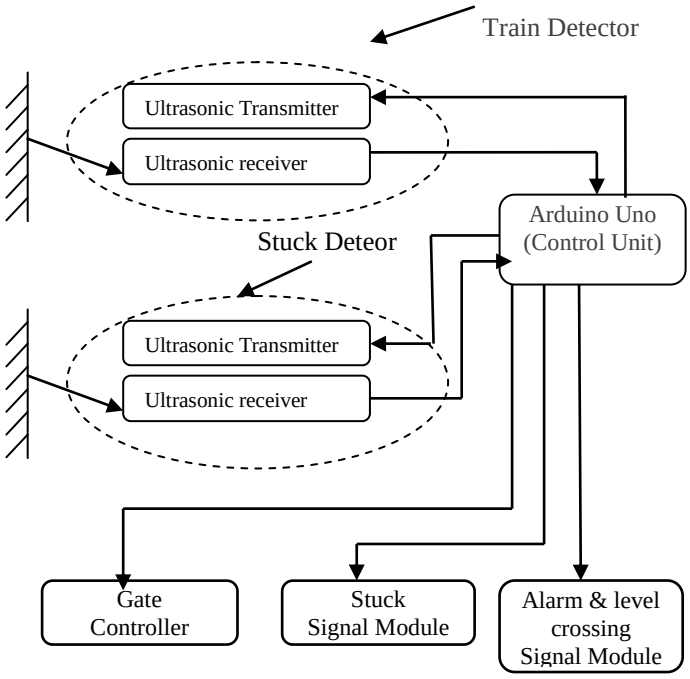

Fig.1. The block diagram of the proposed system

The ultrasonic sensors which are placed at both sides of the level crossing detect the train and another ultrasonic sensor which is placed at the level crossing detects the stuck of vehicle at level crossing. Once the ultrasonic sensors are triggered, the sensors will generate and transmit ultrasound in the forward direction. This ultrasound will be reflected back to the sensor if any object is present within 3 meter range. The ultrasonic sensors are triggered at a regular time interval. If the both ultrasonic sensors of the any side of level crossing receive the reflected sound then the controller unit decides that a train is coming. If the ultrasonic sensor place at the middle of the level crossing receives the reflected sound continuously for a certain period then stuck is detected. If the train is detected, the controller measures the direction of the train, switches on the red lights, and generates alarm through alarm generator and pull down the gate immediately. This situation remains unchanged until the train passes the both sensors of the other either side. After that the controller pulls up the gate, stops sound generation and switches on the green light immediately. When the stuck is detected, the controller switches on the stuck signal light of the both side of line crossing so that the train operator can take necessary steps to avoid devastating accident.

The flow chart of the proposed system is presented by following figure.

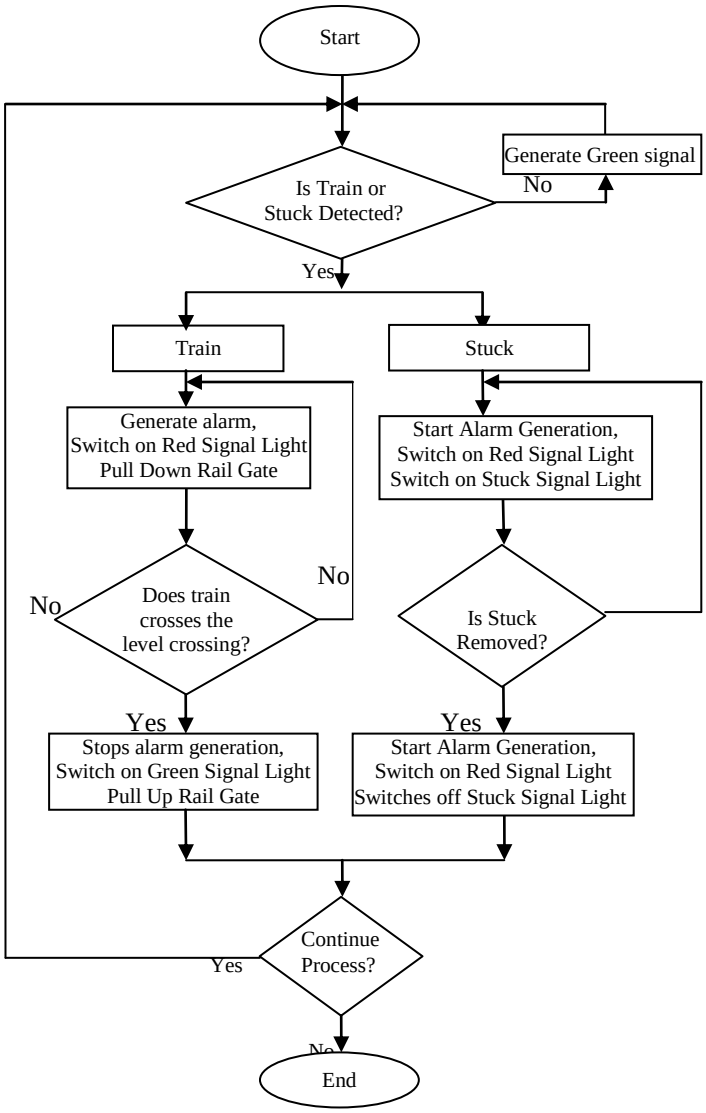

Fig.2. The flowchart of the proposed system

B. The Train and Stuck detection

The scan angle of the proposed system is set to 0˚ because the sensors are placed parallel to the train. Ultrasonic signal transmitter and receiver are used for detecting the train and stuck on the level crossing in this system. Two ultrasonic sensors are located at the left and another two sensors are located at right side of the level crossing. The pair of sensors are placed one Km apart from the level crossing and distance between two sensors of a pair is 10m. The transmitter emits the ultrasonic wave simultaneously and the receivers get the reflected wave. By analyzing the reflected wave the object can be detected. In the proposed system if two sensors of either side of the level crossing detects object at a time then it is

assumed that a train is coming because 10m long object running through the rail line is generally the train. Obstacle is calculated using TOF (time of flight). In the proposed system The Ultra sonic sensors are place 1.5m apart from the rail line and it is considered that The maximum operating speed of train of Bangladesh is 100 km/h. The time taken to travel 1km, the distance between the sensor meter is 36 seconds. If no obstacle is found then the sensors are triggered at the time interval of 1s seconds. If any obstacle is found by any sensor the system triggers the sensor repeatedly at 0.5s second interval.

C. *Detection of Stuck on the level crossing*

When there is a stuck on the level crossing the ultrasonic sensor which is place at the middle of the level crossing can detect the stuck. The scan angle of the sensor is set to 60˚. The sensor is triggered in every second. The received signal of the receiver is analyzed in every 10 seconds. If all transmitted signals are reflected and received by the receiver then the controller decides that there is a stuck on the level crossing.

D. *Warning and light signal generation*

When a train is found, the controller starts generating alarm sound, switches off the green signal and switches on the red signal at both side of the road. Drivers stop their vehicles as soon as possible whenever they notice the red signal and alarm sound. When a stuck is detected on the level crossing the controller switches on the stuck signal lights so that the train operators can take decision to avoid collision.

E. *Rail gate controlling*

The rail gate at the level crossing is operated according to the train coming towards the level crossing. The gate is always up position and when a train comes towards the level crossing the rail gate is pulled down. When the train passes the train a certain distance from the level crossing then the gate is pulled up. In our proposed model we have used two servo motors. The motor is operated from 0^o to 90^o. Initially the gate is perpendicular to the ground and when the gate is pulled down then it becomes parallel to the ground. In our proposed system the gate is placed two meters apart from the both side of the level crossing. Gates, signal lights and alarm are synchronised by the control unit. When the train comes towards the level crossing the controller switches on red signal lights, starts alarm generation and pull down the gate at a time. When the controller observes the train passed then the level crossing it immediately switches off the red signal, switches on green signal, stops alarm generation and pull up the gate at a time.

The properties used for the several conditions depending on the presence of train are shown in Table I.

TABLE I.THE PROPERTIES USED FOR THE SEVERAL CONDITIONS DEPENDING ON THE PRESENCE OF TRAIN.

Conditions for signal and alarm generation	Stuck signal	Alarm Genera-tor	Level Crossing signal	Gate Position
Stuck on the level crossing	On	Off	Green	Up
Train coming but distance between level crossing and train>1km, no stuck on level crossing	Off	Off	Green	Up
Train coming but distance between level crossing and train>1km but stuck on level crossing	On	Off	Green	Up
Train coming but distance between level crossing and train<=1km but no stuck on level crossing	Off	On	Red	Down
Train passing level crossing	Off	On	Red	Down
Train passed level crossing	Off	Off	Green	Up

Table I. shows that at first stuck on the level crossing is checked and necessary actions are taken. Secondly the position of the train is considered. If the train is more than one kilometre apart from the level crossing, our proposed system does not change any of its status. But when the distance is less than or equal to one kilometre then the gate is pulled down, alarm is generated and red signal of the level crossing is switched on. When the train crosses the level crossing then red signal is switches off, green signal is switched on, alarm is switched on and get is pull on.

IV. EXPERIMENTALANALYSIS

This section describes the construction, specification and experimental results of the prototype of the system.

A. *The Prototype of the System*

The prototype of the system is according to the figure as shown in Fig. 3. According to the specification there are five ultrasonic sensors. At the center point of the road which is two meters apart from the level crossing there is an ultrasonic sensor. This sensor detects stuck on the road. Among the four sensors two sensors are placed at the left side and

another two sensors on the right side of the level crossing for train detection. There are two stuck signal lamp near the each pair of ultrasonic sensor. There are also two level crossing signal modules and two alarm modules. One level crossing signal module and alarm module is placed each side f road motorists about the approaching train. Each side of the level crossing there is servo motor to control the gate.

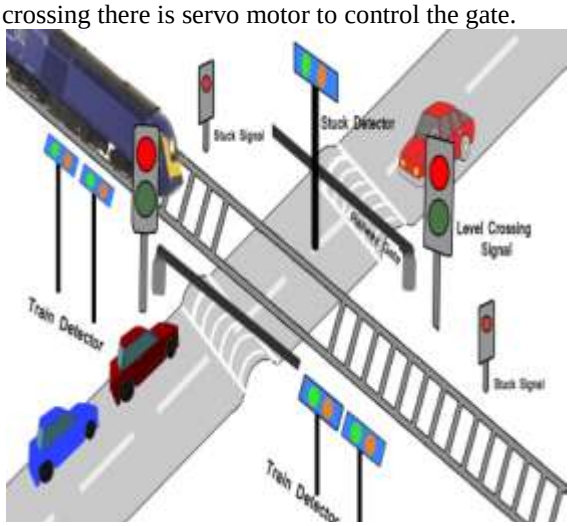

Fig.3. The prototype of the proposed system

TABLE II.THE SPECIFICATION OF THE PROTOTYPE OF THE PROOSED PROPOSED SYSTEM

System	Proposed System		
Detecting Range	Distance / Angle	Train Detector	Stuck Detector
	Distance(cm)	200cm	300cm
	Angle(^{o})	0	60
Power Supply	5v DC		
Total Cost	$50		

B. Experimental Results and Discussion.

To measure the performance of the proposed system we conduct several experiments. We design different cases like stuck on level crossing, train is apart from the train detector sensor with no stuck, train crossing the train detector sensor, train crossing the level crossing, train passed a certain distance from the level crossing. Based on these cases the Almost in every case we get the desired result. The performance of the system does not depend on the speed of the train, temperature and weather. The accuracy of the proposed is very laudable. So our proposed system is very trustworthy.

V. CONCLUSIONS

To save the human life and vehicles from miserable train accidents is a challenge of the era of modern science and technology. The working model was fabricated within the laboratory premises. The results exhibit that it is one of the expedient approach for secure railway system. The ultrasonic sensors detect the train and stuck on the level crossing very quickly and communicate with the control unit. The control unit takes proper steps which lead the train and vehicles movements either to move forward or to stop to avoid collision. Consequently, this is able to play a great contribution to the railway gate automation with reliability and lower cost. In future this developed working model will be equipped with GPS to navigate the position of the train and the track to avoid collision between two trains.

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