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Design and Construction of a micro-controller based automated railway gate control system

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ABSTRACT
This paper reflects on the automation of the control of railway gate using micro-controller. A complete prototype is designed and constructed that contained several sensors on both sides of the railway gate to provide necessary input data related to gate closure into micro-controller, which then sends signal into the gate control system for immediate opening or closing of railway gate. For input sensors Lasers are used on both sides combined with LDR. For all the data processing Arduino (UNO) is used for overall simplicity. This automated system can be used in faraway places where human recruitment for manual gate control is much problematic and unreliable.

Keywords: Automation, gate control, Lasers, LDR, Arduino (UNO).

1. Introduction

Bangladesh is a country which depends significantly on railway transport system. For this reason level crossing at the places of huge traffic density is not rare in our country. Even though the concept of implementing automated railway gate in faraway places is not new in foreign developed countries, it is still not considered as a solution of most of the level crossing related accidents. Railway gates are controlled by human operators depending on the information received from the stations.

This system can causes inevitable human error due to lack of responsibilities, bad weather or lack of good communication system. For these reasons in densely populated areas where drivers and pedestrians are not careful enough, the closure or opening of the gate cannot be done properly at the right moment, depending only on the guessing of the gate operator. This can cause traffic jam or accidents in many cases. Any level crossing accident causes heavy financial burden due to railway and road service obstruction and also for the damage to the railway and road properties. The objective here is to design and construct an automated system for railway gate and developing a program that determines the time of gate opening and closure and send signals accordingly. By using automated railway gate at level crossing the closing and opening of the gate can be determined by placing sensors placed at both sides of the gate, which will results in reduced time for road obstruction and also reduced human labor. This type of railway gate can also be implemented in faraway rather less populated areas where human recruitment and maintenance is difficult. As the whole system is completely automated, therefore any error due to manually operating the gate can be avoided. Using micro-controller also makes it also highly economical.

2. Gate Control System

To construct the controlling system of the railway gate using micro-controller, Arduino board is used for the overall simplicity of the system and its high reliability and effectiveness. Sensors are placed on both sides of the railway gate to provide the information of the arrival and departure of the train. Several pairs of laser light and LDR are used together at both sides of the gate for the high reliability of this sensing system and for the ability of working in any kind of environment. Using more than one sensor at one side makes it more reliable to determine the arrival or departure of the train. Servomotor is used for controlling the movement of the gate in clockwise and anticlockwise direction.

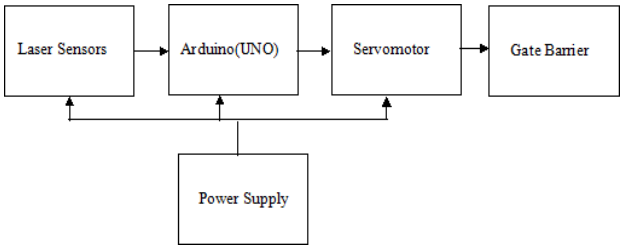

Fig.1 Block diagram for automated railway gate control system.

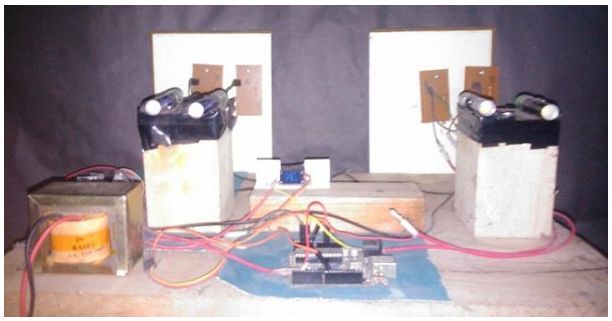

Fig.2 Constructed system with all the necessary equipment.

2.1 Arduino

The Arduino is an Atmel AVR micro-controller based computing platform [1]. The specific board used in this project is the uno board that is based on ATmega328. It has 14 digital input/output pins, thus creating enough options for using several lasers and LDR for input signals. The Arduino is used here as a processing unit.

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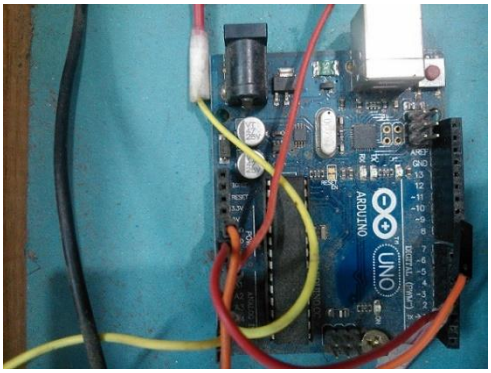

Fig.3 Arduino (UNO) used in the construction

2.2 Servo Motor

A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration [2]. It consists of a suitable motor coupled to a sensor for position feedback. The motor is connected with the Arduino which provide position and speed feedback. At the default position the motor keeps the gate at open position. After receiving signals coming from the Arduino the gate is closed or opened by the motor. This creates a loop for the gate control system. If any error occurs the gate is reset at its default position and kept there until new input signal comes from the sensors.

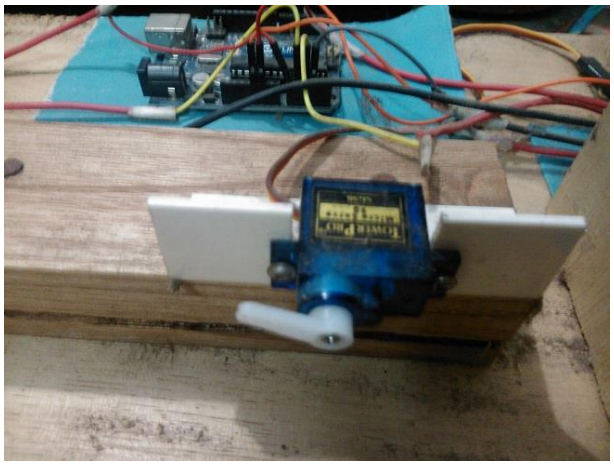

Fig.4 Servomotor connected with Arduino(UNO)

2.3 Light Dependent Resistor (LDR)

LDR or Light Dependent Resistor is a special kind of resistor whose resistance decreases with increasing incident light intensity [3]. The reason of using LDR coupled with Laser is the intensity of light incidence from the laser is quite which enables the LDR to create a quite high voltage resistance when there is any absence of light source. The laser light sources and LDR are placed on both sides of the railway track. Whenever a train crosses the light path of the laser, the resistance of the LDR increases immediately, which provide signals to the Arduino for immediate activation of the control system of the gate. As the laser light is not absorbed by air or water and goes in straight way, this system works in various environments as long as the light is not obstructed by any other unwanted object. If the sensors get activated without any train on the rail due to people or animal on the track the gate will close the road unnecessarily.

3. Avoiding unnecessary activation

One main disadvantage of using LDR and laser as sensor unit is the unnecessary activation of the gate control system without any train obstructing the light source. As the railway tracks are usually unprotected it is possible for the people or animals to obstruct the laser light source easily. This will cause the gate to close or open immediately. To avoid this occurrence several pairs of sensors consisting of a laser light source and a LDR are placed on each side of the gate. The minimum number of sensor should be at least two for each side and for further safety the number can be increased to four or six. The gate will close or open only when all of the sensors at one side of the gate activates at the same time.

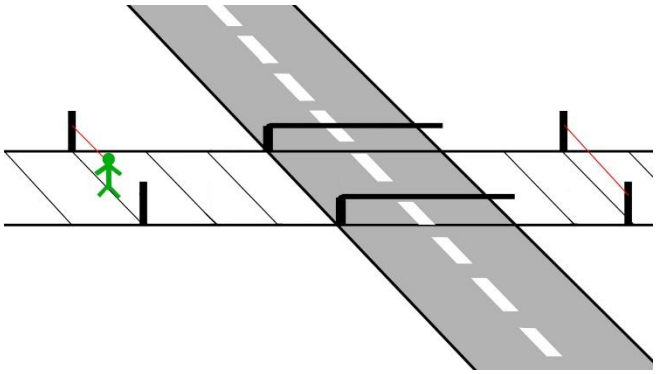

Fig.5 Gate getting closed for obstruction of laser light

Above figure explains the disadvantage of using only one sensor at each side of the gate. Any kind of object having the height to obstruct the laser light that goes towards the LDR may cause unwanted closure or opening of the gate resulting in road service termination or accidents.

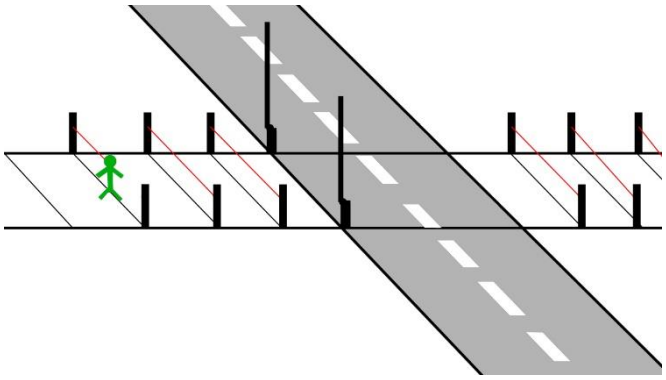

Fig.6 Gate is unaffected by people or any other object passing through the light path.

Above figure shows one simple way of solving the problem of unwanted activation of the automated gate

while using sensors to control the rotation of the gate. Several sensors are placed on either side of the gate and gate will start rotating only when all of the LDR has laser light incidence upon them or when there is no laser light incidence upon them.
There are other safety precautions can be taken such as placing the sensors at such a height that only anything as high as a train can affect it. This step can reduce the probability of unwanted activation of the gate. The sensors can also be placed in a restricted tunnel where the possibility of people or any animal or any other unwanted object intrusion is limited.

4. Program structure of the system

The program at first defines the default position of the gate at the open state. The program is designed for four sensors for the gate. The four sensors pins inputs are then defined which makes the Arduino processing system ready for deciding send signal at the servo output pin to control the servomotor depending on any information of the arrival or departure of the train. After all of the first two pairs of sensors send inputs in the Arduino the control part of the program activates enabling the servomotor to rotate 90 degrees to reach the close position. After that the gate remains closed until all the last two pairs of sensors on the other side of the gate send inputs to the Arduino to reset the system to default open position. The program works for trains coming in either way of the railway gate. The flow diagram here is the basis on which the control system was programmed.
The flow diagram of the system is given below.

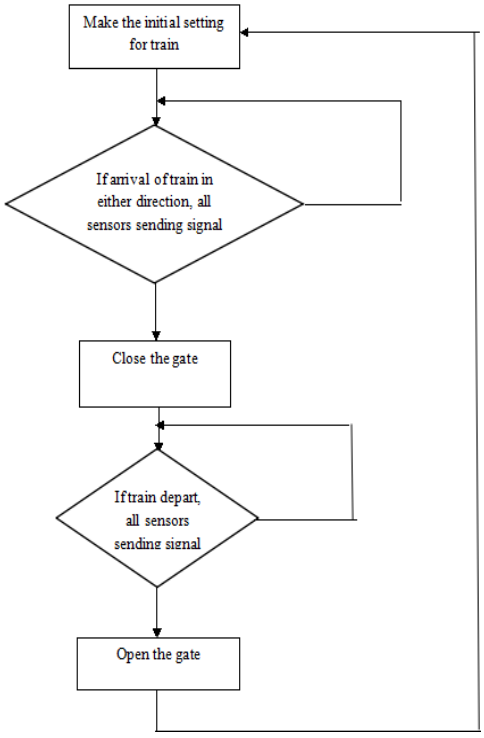

Fig.7 Flow diagram of the system

5. Circuit Diagram

Circuit diagram here is designed for four LDR which is connected with the Arduino at the input port. Necessary voltage regulator with heat sink and transformer with diodes are used to supply power to the servomotor and the Arduino. The lasers are common red light emitting lasers with enough light intensity to create enough high voltage with the LDR to activate the circuit. The program that is loaded in ATmega 328 only execute in laser light. The lasers are powered externally using batteries.

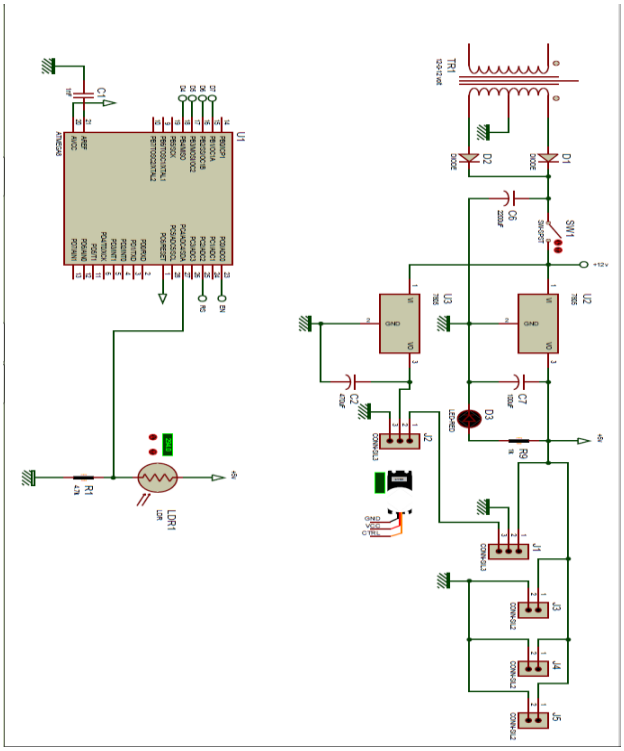

Fig. 8 Circuit Diagram of the system.

6. Discussion

An automated railway gate control system has three important factors that control the accuracy of the whole system. The accuracy of the sensors to fully determine the position of the train on the rail, swiftness of sending feedback to the control unit, in this case, micro-controller based Arduino(UNO) and swiftness of the motor activation to close or open the barrier. Any fault in any of these parts can result in fatal accident. For these reasons Lasers are used instead of infrared, sonar or pressure sensors. To avoid unwanted activation the easiest solution of using multiple sensors is followed. To reduce the closing and opening time and considering practical implementation of this system servomotor is used for the accurate control of motions. The whole system can also be designed by using Programmable Logic Controller (PLC) which is more costly in initial state. But micro-controller is more reliable than PLC and using Arduino makes the whole system simpler, while keeping an easier way of improvement.

7. Conclusion and future scope of work

This project completes the design and construction of an automated railway gate having more reliable sensor design that has the focus of avoiding unwanted activation of the gate control system. But the reliability of this system can be further increased by using global position system (GPS) to monitor the position of the train more accurately that will reduce the closure time of the gate even more. This will also reduce the possibilities of any level crossing related accidents. One major advantage of this system would be the facility of measuring the current speed of a moving train and comparing it the required speed that is needed for it reach destination within the schedule.

To complete this system another sensor system can be added to detect any traffic on the railway track before closing the gate and adjust the speed or direction of the motion of the gate.

To increase the safety measurement the gate can be made movable horizontally to create space for any traffic that is obstructed in the enclosed area after closing the gate to let it reach a safe zone, away from the railway track.

Implementing automated gate control system at the level crossing can be a huge challenge to take because the total cost for this would be quite high even though the designed system is economical in many senses. But on the other hand our country is hugely dependent on railroad transport system so any negligence in this sector will result in high financial loss in the long run. Finding a cost effective method to implement the system quickly without heavily affecting the transport system can be helpful for this regard. Automated railway gate system has already been implemented in several countries successfully. Even though regular maintenance for this system is required but interruption of the operations does not occur due to fatigue and negligence of the operator. That is why it is possible that the percentage of accident due to collision at level crossing will decrease greatly after implementing it.

REFERENCES

[1] http://arduino.cc (10 September, 2014)

[2] Hobby Servo Fundamentals by Darren Sawicz (8 September, 2014)

[3] diffenderfes, Robert (2005). Electronic devices: system and applications. New Delhi: delimar. p. 480. ISBN 978-1401835149.