Automated Railway Level Crossing Using Microcontroller for Bangladesh

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Abstract

Bangladesh is very far off from automating its railway level crossing. For that reason, accidents keep happening and increasing day by day. This paper concludes the details of how we can automate a rail crossing system using sensors and microcontrollers. For that we have created a model consisting of weight sensors, axle sensors, traffic light signal, siren alert, countdown clock and some machine instructions.

Introduction

A railway level crossing is an intersection where a railway line crosses a road or a path at the same level, as opposed to the railway line crossing over or under using an overpass or tunnel. This process can be completed manually and automatically. In automated railway level crossing, the arrival of a train is detected by sensors placed around the gate/bar. Then the closing – reopening of the bar/gate is done by commands and stopping – resuming of the traffic is done by connected traffic light signals.

The history of railway level crossings depends on the location, but at earlier times, often level crossings had a flagman in a nearby booth who would, on the approach of a train, wave a red flag or lantern to stop all traffic and clear the tracks. Gated crossings became commonplace in many areas, as they protected the railway from trespassing and livestock, and they protected the users of the crossing when closed by the signalman/gateman. In the second quarter of the 20th century, manual or electrical closable gates that barricaded the roadway started to be introduced, intended to be a complete barrier against intrusion of any road traffic onto the railway. Automatic crossings are now commonplace in some countries as motor vehicles replaced horse-drawn vehicles and the need for animal protection diminished with time. Full, half or no barrier crossings superseded gated crossings, although crossings of older types can still be found in places. In rural regions with sparse traffic, the least expensive type of level crossing to operate is one without flagmen or gates, with only a warning sign posted. This type has been common across North America and in many developing countries.

In Bangladeshi railway level crossing, the whole crossing process and traffic control is mostly done manually. A gatekeeper sees that a train is coming, then he signals the traffic police to stop the traffic. After that the gatekeeper pulls down the bar to stop the traffic from going near the train and the railway while the train crosses. The automated railway level crossing is nearly nonexistent in Bangladesh.

Figure: 01, A manned level crossing in Bangladesh

Nowadays Railway level crossing accidents are one of the major problems in our country. Safety issues at railway level crossings are not a serious problem in developed countries. But in a developing country such as Bangladesh, it is becoming a more serious issue. It is continuously becoming a concern in the railway industry for Bangladesh.

According to the calculations of Bangladesh Railway (BR), 175 people died in railway accidents from 2014-2020. Out of these, 145 died at the level crossing, which is 83% of all rail accident deaths. Day by day this rate is increasing rapidly. According to media reports, some 419 people died and more than 2,000 people were injured in 4,914 train accidents that took place at different level crossings throughout the country from 2005-2020 (both legal and illegal).

As per the data provided by the Bangladesh Railway (BR), there are no gatekeepers at 961 legal level crossings, turning them into hotspots for accidents. There are so many level crossing points where there is assigned at least one gatekeeper, but in many cases, we can see that these gatekeepers are not available all the time when trains cross the level crossing. This situation occurs especially after the evening. Most of the gatekeepers go to their own work, and they don’t care about the level crossing. There is no valid train incoming and outgoing tracking system in our country at all the level crossing points. Sometimes some of the gatekeepers don’t identify the incoming and outgoing trains at the level crossing due to any reason. Some of these reasons could be due to extremely bad weather conditions, not properly hearing the incoming train whistle, and so on. For these reasons, accidents are increasing day by day and becoming a serious issue in our country.

The Railways law 1890, states that no one can walk on rail tracks as it is an offense with a maximum punishment of two years in jail. However, this has failed to stop pedestrians from taking the tracks. According to media reports, at present, there are 1,468 authorized level crossings on railways across the country. At least 1,321 unauthorized level crossings were created in different areas, leaving them prone to accidents. Besides, among the authorized level crossings only 564 are manned and 904 are unmanned as they were facing a serious manpower crisis, BR officials were quoted as saying by media outlets.

To reduce such occurrences, we wanted to find a simple yet effective solution. We explained our proposed work in this paper.

Background Studies

In order to prepare this paper, we studied about the different approaches of automated railway level crossing, Infrastructure of Bangladesh railway, microcontroller sensors, human behavior, context-free grammar, early parsing and error handling.

One approach to automated railway level crossing is wheel approach. The level crossing solution with Wheel Sensor is a Fail-Safe solution that uses a SIL4 train detection system following all AREMA standards. The Wheel Sensor solution detects the approaching train through an axle sensor where the maximum speed of the train is calculated and, with the detection of the train, the timing is triggered for the activation of the bell at the intersection. As well as flashing the lights.

Another approach includes a combination of multiple aspects of data communication. Where there will be a system featuring active train detection using global navigation satellite system (GNSS), coordination and obstacle detection at level crossings using long range infrared; automatic signaling and gate control at level crossings using light emitting diodes (LEDs) and servo motors; automatic and manual communication between trains and level crossings using global system for mobile communication (GSM) technology.

Some key information about the infrastructure of Bangladesh Railway are, The Bangladesh Railway system had a total length of 3,600 kilometers in 2009. By 2007-2008, 44 civil districts were connected by railway in Bangladesh. Bangladesh railway is divided into two zones East zone and West zone. There are 5 kinds of level crossing in Bangladesh: - Special class, ‘A’ class, ‘B’ class, ‘C’ class and ‘D’ class. Special classes are the most busy type of level crossings for the road users. Most of the busy level crossings on National Highway are special class level crossings. ‘A’ Classes are also busy level crossings for the road users. `B’ class level crossings are relatively less busy ones. `C’ class level crossings are mostly provided on unmetalled roads. 'D’ class level crossings are provided for cattle crossings and normally used by cattle or pedestrians. Bangladesh Railway presently has about 2541 (1413 Approved & 1128 Un-approved) level crossing gates.

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip. We studied some microcontroller sensors that we used in our proposed work. A weight sensor is a type of transducer, specifically a weight transducer. It converts an input mechanical force such as load, weight, tension, compression, or pressure into another physical variable, in this case, into an electrical output signal that can be measured, converted and standardized. Axle load sensor is designed for axle load control and cargo weight control in vehicle tracking systems. Axle load sensor can be connected to the analog input of the tracking device. With an axle load sensor, a vehicle tracking system gets valuable information about the location and time of loading and unloading the vehicle.

Figure: 02, Weight Sensor

Figure: 03, Axle Sensor

Context-free grammars(CFG) are named as such because any of the production rules in the grammar can be applied regardless of context—it does not depend on any other symbols that may or may not be around a given symbol that is having a rule applied to it. In a context-free grammar, every production rule has the form $A \longrightarrow w$, where ‘A’ is a single symbol and w is a string of zero or more symbols. The grammar is" context-free” in the sense that ‘w’ can be substituted for ‘A’ wherever ‘A’ occurs in a string, regardless of the surrounding context in which it occurs. The symbols that occur on the left-hand sides of production rules in a context-free grammar are called non-terminal symbols. An Earley parser is essentially a generator that builds leftmost derivations of strings, using a given set of context-free productions. The parsing functionality arises because the generator keeps track of all possible derivations that are consistent with the input string up to a certain point. As more and more of the input is revealed, the set of possible derivations (each of which corresponds to a parse) can either expand as new choices are introduced, or shrink as a result of resolved ambiguities. In describing the parser, it is thus appropriate and convenient to use generation terminology.

Error handling is the process of anticipation, detection and resolution of application errors, programming errors or communication errors. Getting familiar with error handling improved our patience and decision making.

Proposed Work

The solution that we are offering requires some sensors to be installed in the rail line. We need two different sensors; the Wheel sensor and the Axel sensor. For the sake of simplicity, we are naming them W_n and Axl_n (where n =1, 2, 3… determining the number of sensors). Let's imagine two rail lines; L1 and L2, where a train will be going from northbound to southbound in the L1 line and the opposite in the L2 line. We will also need a microcontroller to process multiple signals at the level-crossing. Let's assume the microcontrollers are Control L1 and Control L2 for L1 and L2 rail-line respectively. We will be using CL1 and CL2 instead of Control L1 and Control L2 for simplicity.

We are taking 60Km/h as the standard speed of the train given the maximum speed of a train in Bangladesh is approximately 70 Km/h [1]. Exactly 7 Km before the level-crossing, we will install the W_1 sensor. Then we will install the Axl_1 sensor 1 km ahead of the W_1 sensor. We will also install the W_2 sensor with a 15 second weight press timer, 200 meters ahead of the level-crossing. We can get a view of the whole installation in Figure 02.

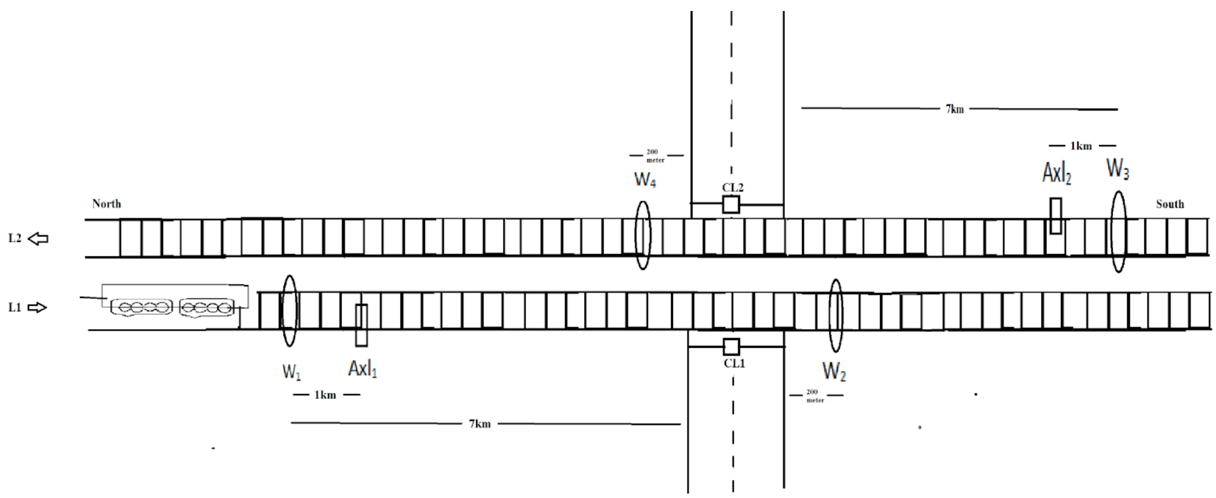

Figure: 04, Top Down View of the Model

Now say a train is traveling from the northbound to the southbound in L1 line. When the train is on the W_1 sensor, it will signal the CL1 at the level-crossing. Then the train will be on the Axl_1 in approx. 60 seconds, it will signal the CL1. The CL1 will check if both the W_1 and Axl_1 sensors have been activated or not. Once the check is true, the CL1 and CL2 will then turn the traffic signal which is mounted to it to yellow from green, a timer will start which will be counting from 60 seconds to 0 and an alert siren will be on. When the timer will reach 0, the traffic signal will become red and the bar will come down to stop the road. The train will be approx. 5 km away from the level-crossing which will take 5 minutes to arrive. Once the train crosses the level-crossing and the front wheels of the train are on, the W_2 sensor will activate the timer. The timer will start when the weight is off the sensors. The timer will reset each time when a weight of bogie of the train will be on the W_2 sensor. Timer will count from 15 to 0. When the train crosses the W_2 sensor, the timer will not reset and it will reach 0. At the exact time CL1 will check if both the W_3 and Axl_2 are activated or not. If true, CL1 will hand over the control to CL2 and reset the values W_1 and Axl_1, otherwise the process will end. The same process will occur if the train is coming from southbound to northbound in the L2 line.

The Full approach can be demonstrated with simple flowchart below:

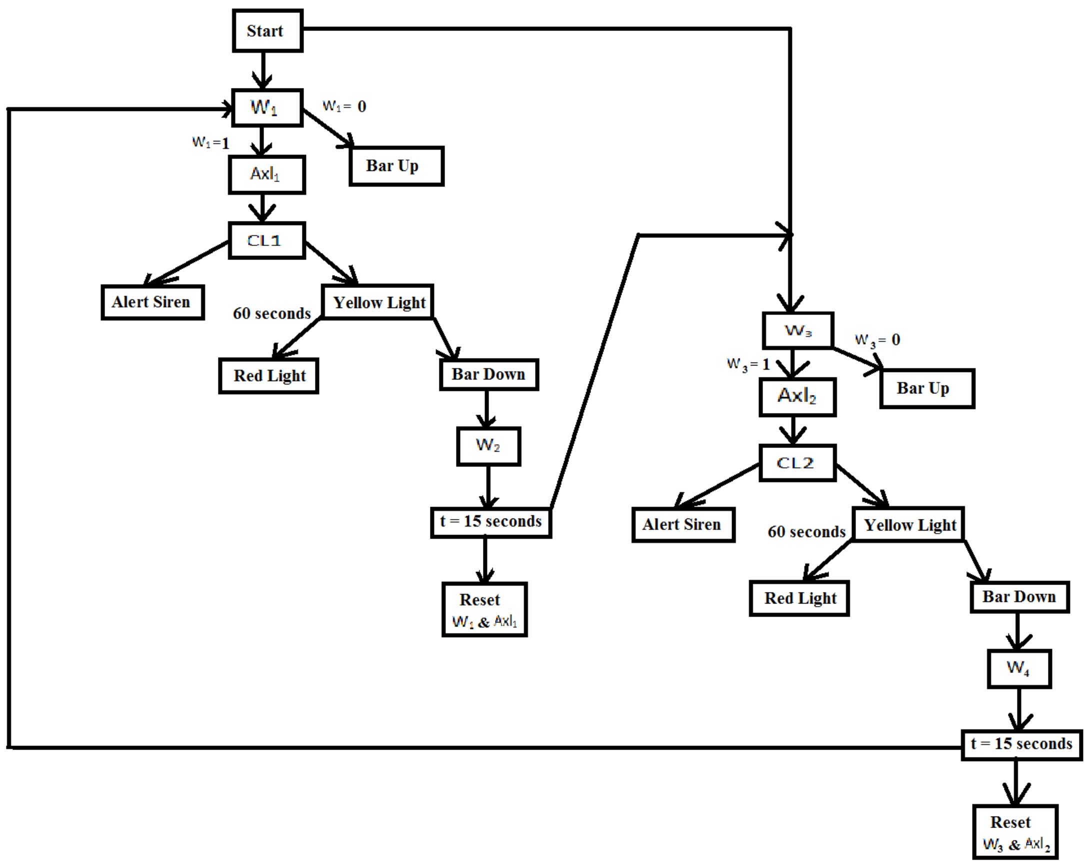

Figure: 05, Flowchart of the Model

Limitations

Like every other model, there are some limitations to our model of automation. Our work has been concluded in a very short period of time. That is why a thorough background study and literature review was not possible. Also, proper data of train speed, atmosphere, train line and other issues were not taken into account while proposing this paper, because of the limitation of time and lack of data gathered from the ministry of railways. For simplicity, the standard speed of the train has been 60km/h, which is not stationary all the time. The sensors have been installed at a precise point taking the speed in mind. When the speed is less than what we have taken, the cross sectional traffic light will be red for more than 5 minutes which will create massive traffic in the road. Also, in this model we have assumed that the train will not stop in after crossing the Axel sensor. But in reality the train might stop. But the CL1 or CL2 will start its procedures, which will create congestion. Also, in case of emergency there is no backup for the cross-bar to go up once it is down which will be a problem for emergencies like fire-trucks or ambulances etc. In the case of having a human presence under the crossbar, the speed of it going downwards cannot be controlled at this moment; this can be harmful for the human. As there are a lot of sensors involved, there is a chance of sensor failure. There can be malware which is even more dangerous than the failure because it will send data to CL1 and CL2 with faulty values that may create a big problem. There are a lot of things that can go south but the promising point here is that the model is still under study and the limitations are still in mind and we are consistently trying to minimize the limitations of this model and make it more friendly but smart at the same time and updating it regularly to make the model more efficient.

Future Work

The number of limitations on an ongoing model is huge in number. There are a lot of things that can be taken in mind before starting to develop the model. There are a lot of flaws in the model for instance, the sensors may not work. It can be resolved. The sensors may produce faulty values due to malware. As all the data from the sensors are going to the CL1 and CL2 microcontroller, there is a chance that these may fail or may fall victim to malware. The placement of sensor installation can be changed based on appropriate research of the velocity and nature of the train. The cross bar cannot be controlled in the presence of humans under the crossbar. Manual control of the crossbar is another scope of work because sometimes there are necessities like fire or medical emergencies when the crossbar may need to be manually maneuvered.

Conclusion

Railway accommodating accidents will keep happening around our country. Without automated railway level crossing this problem will not go away. Ignoring the imitations, our model shows a possible and feasible way to automate all the railway level crossings in Bangladesh. In order to reduce accidents our proposed work will help massively. All the modern countries have automated railway level crossing, even India has set their goal to automate their level crossings by 2023. It is high time Bangladesh follows that path.

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