IJSR International Journal of Scientific Research

p-ISSN: 1234-5678 e-ISSN: 1234-567x

Received date 8 March 2021; Revised 27 March 2021; Published 10 April 2021

DOI: 10.25299/IJSR.2023.11xxxxxx

Automatic Train Junction Gate Control System Based on Arduino-Uno Microcontroller

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Abstract: Transportation technology plays a vital role in people's lives, one of which is trains. The role of transportation has many positive impacts, but there are also many other negative impacts, one of which is an accident due to the manual operation of the rail junction gate. This works aim to build an automatic system that can control train gate junction without an operator and sense based on train schedule with an additional sensor for detection of a train passing. With the Arduino Uno microcontroller for railroad control device, it changes the manual railroad crossing operating system to become automatic and controlled with certain components. In this case, a microcontroller unit called node Microcontroller Unit (MCU) series ESP 8266 is used in this monitoring system as a tool that sends the information to the platform Telegram for notifications when ultrasonic sensors and vibration sensors detect the arrival of a train. The result shows the system works well based on the plane which has several sensors placed on the train rail and detects vibration for the train crossing. Several scenarios were tested to achieve the correct position of the sensor placement which is not too far or delayed in the instruction of the gate opening and closing. The response time achieve is good with an average is 344 ms for the opening and closing of the junction gate. Future development is to connect a gate crossing system to other gates that can integration and each other for the smooth train schedule.

Keywords: Train junction, Gate, Automatic control, Arduino-Uno, Microcontroller

1. INTRODUCTION

Today support for advances in technology is very important for human life because technology is one of the supports of human life. Many layers of technological society have helped humans in improving the economy, food, and computers. Technological advances produce many tools that work automatically, in other words, operate without any orders from humans in carrying out their duties and functions. This of course will facilitate human work in carrying out activities more efficiently and quickly. Transportation technology plays a vital role in people's lives, be it land, sea, or air transportation. One of its roles is in the socio-economic aspect by having a distribution function between regions and other regions. The role of transportation does not only have a positive impact but also certainly has some negative impacts, one of which is an accident. Automatic railroad crossing doors are a series of technologies in railroads. Railway crossings are divided into two, namely level crossings and not level crossings. A level crossing is where the railroad meets the road. Non-standard of crossings junction of train rail is one of the issues [1].

We can see many traffic accidents that have been claimed by victims, both injured, died, and even quite large material losses. The accident did not only occur on the highway but also at the rail junction or crossing. The Ministry of Transportation noted that the number of accidents at level crossings or intersections between rail lines and roads reached 21 cases of accidents with the number of victims reaching 94 people throughout 2017. In addition to that in previous years, according to data from the Ministry of Railway Transportation from 2013 to 2017 reached 187 accidents occurred. This happened due to collisions between trains, collisions between trains and vehicles collapsed and overturned as in Table 1.

Table 1. Train accident cases in Indonesia 2013-2017 [2]

Accident Cases	Accident Cases (Year)				
	2013	2014	2015	2016	2017
Train to Train	0	1	5	0	1
Train to Vehicles	0	0	0	0	0
Miss Rail	25	33	68	15	17
Collapse	1	0	0	0	0

Flood or Land Slides	7	2	0	0	2
Miscellaneous	6	3	0	0	1
Total	**39**	**39**	**73**	**15**	**21**

An example that has created this automatic control system as discussed in [3][4]. Renova made this automatic control system using only infrared sensors and photodiodes. The infrared sensor will continuously emit light to the photodiode. If the infrared sensor is disconnected then the rail doorstop will close. Likewise to open the latch of a railroad crossing. However, research conducted by Renova is still less efficient. Because, only one pair of sensors is used. That is, if the sensor detects something passing other than a train, it will automatically the latch will close. In order to overcome problems like this, the researchers created an automatic system by utilizing proximity sensors and vibration sensors as train arrival detectors. These two types of sensors will be installed before and after the railroad crossing. When the proximity sensor 1 detects the arrival of a train, the vibration sensor and buzzer will be active and then send data/signals to the Arduino Uno microcontroller. Then the data from the sensor will be processed by the Arduino Uno microcontroller and then the crossing gate will close automatically. Likewise in principle when the train has passed a railroad crossing. The author is interested in conducting further research. Therefore the researcher chose to conduct research in the form of a thesis with the title "Arduino-Uno Based Automatic Railway Junction Gate Control System".

2. LITERATURE REVIEW

Information technology is a technology that combines computing with high-speed communication lines that carry data, voice and video [5]. Information technology can be grouped into six technology groups namely:

(a) input technology,
(b) output technology,
(c) processing/control machine technology,
(d) storage (memory) technology,
(e) software technology,
(f) communication technology.

The presence of information technology has helped humans in completing tasks and problems at work, especially those that are complex, routine, or dangerous. This can be seen from his role in banking, education, medicine, police, trade, and product design. This means that the use of information technology from time to time is increasingly widespread. Of course, information technology can also play a role in the world of transportation.

According to the Chairman of the National Transportation Safety Committee [6][7][8]. The main causes of accidents are due to human error or human error. the automatic control system can improve safety for traffic users so that the rail gate can run automatically. For sure, this technology can provide a sense of security to all parties. Design of Arduino-based gate junction tracks monitoring system and simulation as discussed in [9][10][11][12]. Discusses infrared sensors found on rail junction tracks and crossings to detect trains that will pass, if correct, the sensor will send data to the microcontroller to send a Short Message Service (SMS) to the driver. The test results show that when the train enters the sensor on the track at a speed of no more than 60 km/hour. Railway crossing security simulation system using LabVIEW as elaborate by [13][14][15].

Discusses automatic rail portal that uses photodiode and infrared sensors. With the results of research on infrared sensors and photodiodes, it can have an effect if objects are blocking it so that it can produce a value of 0 and the sensor cannot be read automatically. Automatic rail junction crossing system with Arduino-based and wireless communication as discussed in [5][16]. The automatic train junction gate uses vibration sensors and infrared sensors to detect incoming trains using the nRF24l01 + PA + LNA wireless module. The test results determine that the main data transmission distance, the longer the delay will be. Based on existing references, no one has made research on automatic doorstops with vibrating sensors and ultrasonic sensors as control aids, as well as buzzers as early warning signs for train arrivals [17]. All those references discussed are only valid for some places of the implementation, to develop and design a system according to Indonesia territory and environment then required to check and validity of the user as well as their behavior in traffic. Furthermore, in Indonesia, the most major user and traffic is motorbikes that one of the causes massy traffic.

3. METHODOLOGY

The research method applies in this work and the development of an automatic gate control system for the train junction is used a smart sensor system to detect trains passing the rail junction. The research method is a research method used to produce certain products and test the effectiveness of these products. These products are not always in the form of objects or hardware, such as books, stationery, and other learning tools. However, it can also be in the form of software [18]. As shown in Figure 1 there are several hardware devices, namely, vibration sensors, ultrasonic sensors, servo motors, Liquid Crystal Display (LCD), NodeMCU ESP8266, and Arduino-Uno. All devices are connected to the Arduino Uno via the pins available on the Arduino Uno board.

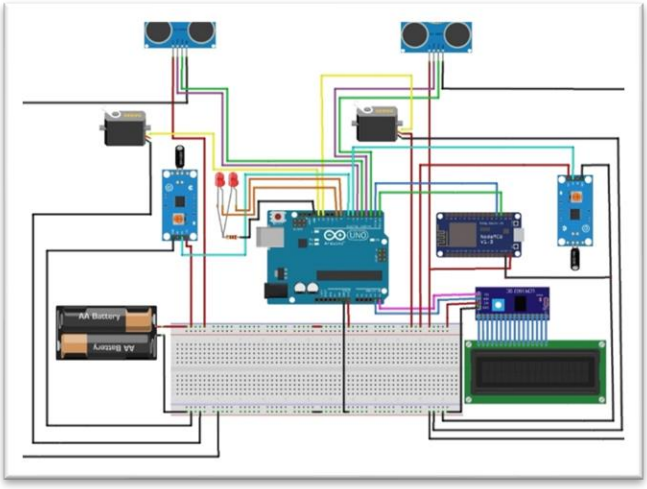


Figure 1. Circuit diagram of the automatic train portal system

There are four sensors to be used, which consist of 4 types of sensors namely ultrasonic sensors and vibration sensors. The first ultrasonic sensor, second ultrasonic, and first vibration will be placed before the railroad crossing. While the second vibration sensor and second vibration sensor will be placed after the position of the train has passed the crossing. It can be seen from Figure 2 as follow.

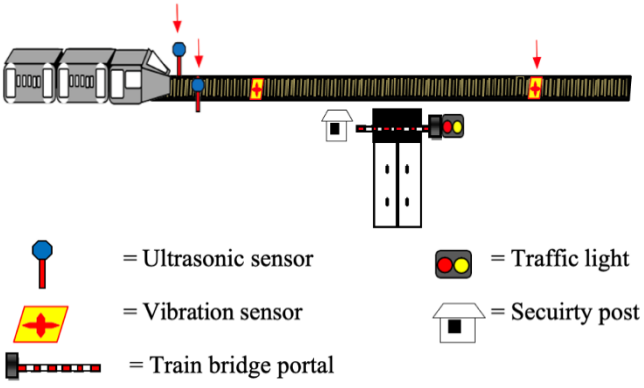


Figure 2. Sensor placement in traffic light

The crossing model that will be designed using this system is a single-track train rail junction or crossing system. This crossing has a gate portal that still works manually. In other words, it still uses labor or work from humans (operators). The crossing model as shown in Figure 3 which both sides is a normal road for vehicles and motorbike. When a train approach to the crossing junction then an alert or signal is detected from the sensor go get ready in the setting distance gate or portal will close to stop traffic. Once the train passed the sensor detected the last car of the train then gate were released to allow vehicle to cross the junction.

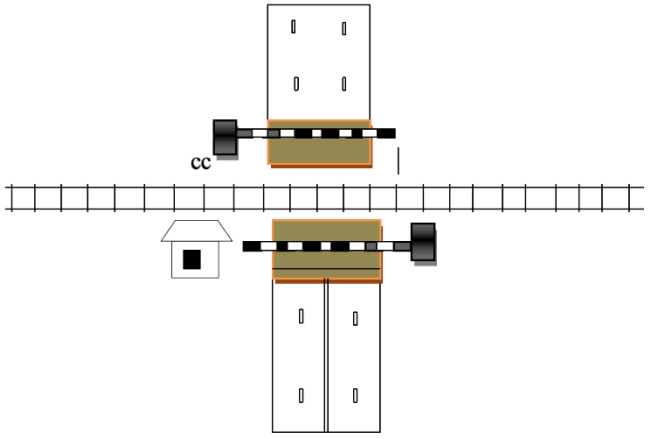


Figure 3. Model of Train crossing bridge

4. RESULTS AND DISCUSSION

The research conducted refers to the communication between the smartphone and the Arduino microcontroller via the NodeMCU ESP8266 to receive notifications, and the communication between the microcontroller and Telegram for monitoring automatic Gate [19]. A miniature flowchart of automatic train doorstops using Arduino-uno, shown in Figure 4.

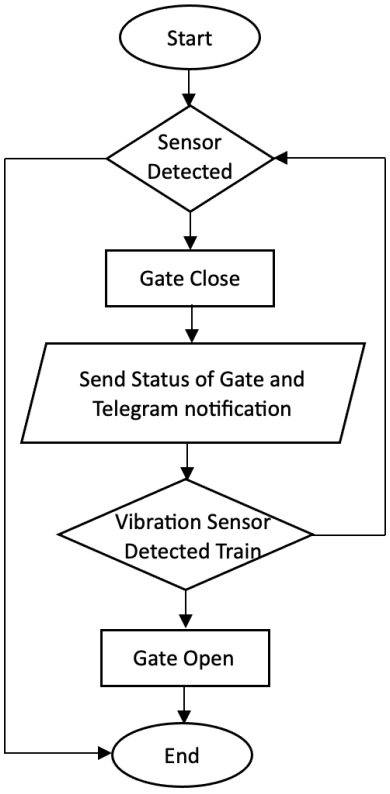
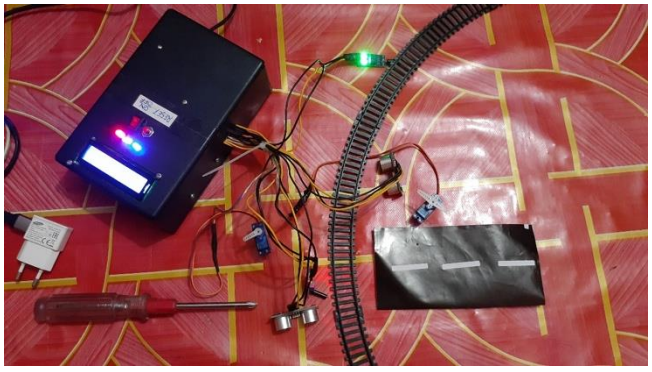
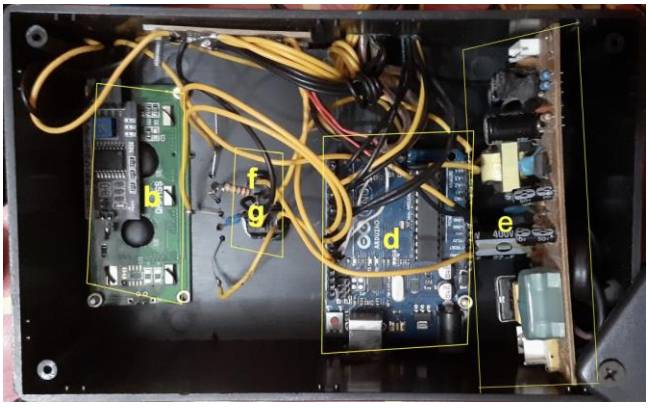


Figure 4. A flowchart of process automatic gate

In the flowchart you can see the workflow of the system created, after being given an electric voltage, the ultrasonic sensor detects a train, the doorstop will automatically close and then a notification appears to Telegram so that the training officer can monitor the status of the doorstop when the vibration sensor detects a train moving away then the bar will automatically open again. The design of this hardware is to achieve the goal of a prototype that has the same function as the actual one. Figure 5 is a prototype circuit. A data flow diagram (DFD) will explain the flow of the system, this DFD will also visually describe how the data flows. The application of the works method produces a miniature automatic train portal system. The hardware used in the miniature consists of sensors, Arduino-uno, ATmega328 microcontroller, servo, buzzer, and LCD. Miniature pictures of the railroad bars can be seen in Figure 5(a) and Figure 5(b) the main control unit was fabricated.



(a)



(b)

Figure 5. Arduino Uno connected to the system
(a) mini rail prototype (b) main control system

Table 2 shows several trials of the miniature trains system that passed to all 4 sensors and showed the working status of the automatic train doors. Testing with toy trains was carried out to test the accuracy of the sensors. Testing for interference with the miniature system is carried out with 3 variations of the tools that have been designed as shown in Table 2. Testing the gate manually is enough to press the on/off button so that the doorstop can be moved manually.

Table 2. Results of gate prototype testing

No	Sensor Status (Blocked)				Status LCD	Gate Status	*Buzzer*
	Sensor 1	Sensor 2	Sensor 3	Sensor 4			
1	Yes	-	-	*Off*	Gate Closed	Open	Active
2	-	Yes	-	*Off*	Gate Closed	Close	Passive
3	-	-	Yes	*On*	-	Open	Passive

Based on testing the accuracy of the SRF-04 sensor, there is a difference between ruler measurements and sensor measurements which can be seen in Table 2. In testing the SRF-04 ultrasonic sensor that can see triggers and echoes, calibration on the volt/div Ch1 and Ch2 oscilloscopes are set to 200mV. The high echo signal will be longer if the distance between the sensor and the wall is also getting farther. The maximum distance that can be read by this sensor is 360 cm. An example of calculating the sensor distance using the formula.

$$t = 3 \times 1.10^{-3} = 0{,}003 \text{ second}$$

$$s = v.t/2$$

$$s = 344 \text{ m/s} \times 0{,}003 \text{ s} / 2$$

$$= 0{,}516 \text{ m } (51{,}6 \text{ cm})$$

where:

T = periode of time
v = speed of light
t = waktu
s = distance (meter)

The benefits and understanding of the data that has been concluded determine the application of the appropriate automatic train doorstop performance.

4.1 Functional Test

This test includes the entire speed measurement system test. The whole miniature system has been tested and produces data as results in table 2, the data shows that when the train passes the sensor, the rail will be closed, then when the train crosses the rail, the rail will automatically open. Table 2 also results shows when the sensor gets interference it will affect the miniature system, while the manual control has been tested and can be operated after pressing the on/off button so that it can be controlled manually. The results also show the difference in the average error in measuring the speed of miniature trains and manual measurements using a stopwatch with a time difference of 1.284 cm/s. These results were obtained because of the difference between the timer using a stopwatch and manual measurements. This difference can appear when the stopwatch test is not used properly, both at the start and finish of the test.

4.2 Miniature Work Test

Miniature work tests include testing the power supply, servo, ultrasonic sensor and Node MCU ESP8266.

- Ultrasonic sensor

The accuracy of ultrasonic sensor testing has a difference between the ruler and the measurement sensor which can be seen, the maximum readable distance is 360 cm.

- Servos

The displays the results of the servo angle accuracy test, the experiment was carried out 10 times from an angle of 10° to 90°. The results of the measurements shows have an average of 0.45°, so the miniature train doorway program has a tolerance of 0.45°.

5. CONCLUSION

The design of miniature automatic rail doors using Arduino Uno, HC-SR04 sensors, vibration sensors, and LCD. Sensors are used to detect the position of the train with 2 HC-SR04 sensors used. The miniature that has been made is also equipped with manual controls so that when a failure occurs in the system it can be operated manually. The results of the miniature work test of all components can function optimally, namely, the adapter circuit can provide a stable voltage supply for all components, the hc-sr04 sensor can function accurately in detecting the position of the train and servo that moves according to the system program. Ultrasonic sensor 1 detects the arrival of a miniature train towards the crossbar with a distance of 5 cm, then ultrasonic sensor 2 detects a train passing through the barrier with a distance of 4 cm. The process of automatic rail doors starting to close and then closing until the train passes is 4.5 seconds with a miniature train speed of 20 cm/s.

ACKNOWLEDGMENT

This research was supported by the Department of Informatics Engineering, Islamic University of Riau, Indonesia.

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