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Modeling of Automatic Door at Railroad Crossing Without Guard Based on Internet of Things in Indonesia

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Abstract: Railroad crossings without doors and guarding are the cause of accidents between vehicles with trains other than human factors, and in Java, Indonesia has 6,000 level crossings. The solution that can be done is to install a door, but if a door is installed, a guard is needed to operate the door, this will cause new problems, namely employment. So the right solution is to design an automatic door, this study aims to create a sensor-based automatic door model and Internet of Things (IoT). The design of a miniature model of automatic railroad doorstop using SG90 9g micro servo with TCRT-5000 sensor based on Arduino Uno ATmega 328 microcontroller. The sensor is used to detect the position of the train, in miniatures that have been made using 2 TCRT-5000 sensors. The function of each sensor is to detect the arrival of the train, activate the speed and detection system that the train has passed through the doorstop. Miniature door bars are driven by 9g SG90 micro servo. Computer monitors in miniatures can function properly, which is capable of displaying train speed and waiting time for train arrival. The results of the miniature performance test for all supporting components can function optimally, namely the TCRT-5000 sensor can function and be accurate in detecting the position of the train and servo that move according to the miniature system program.

Keywords: Unprotected railroad crossing, automatic door modeling, Internet of Things.

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1. Introduction

In Indonesia, train transportation is concentrated on the islands of Java and Sumatra. Until the end of 2018, the railroad length is estimated around 6,061,000 meters where level crossing of 4,855 units with a guarded crossing of 1,239 units, without guards and doors of 2,046 units, and wild (also without guards and doors) of 1,570 units [1]. During the period 2014 to 2108, there were 144 accidents with an average of 29 events per year. Level crossing without doors and guards (Fig. 1) is one of the causes of frequent train accidents with vehicles (Fig. 2) besides other causes such as human neglect and engine damage [2].

Therefore, the obvious solution to dealing with train accidents is by providing doorstop. However, it is requiring a guard to operate the doorstop and standard operation procedures must be complied. So that new problems will arise in labor-management (crossing door operators), for that an innovation needs to be done to design a crossing model automatically by utilizing smart technology and the Internet of Things (IoT) [3]. Based on research by Karthik Krishnamurthi et. al [4] which uses 2 IR sensors and Pwint et. [5] which uses 2 IR sensors and PIC 16F877A Microcontroller, the authors developed the previous research by using TCRT5000 sensor with Arduino Uno Microcontroller and adding Wemos D1 Mini as a wifi access point for data transfer.

Fig. 1 - Railroad crossings without doorstop and guard

Fig. 2 - Railway accidents with vehicles

2. Design of Prototypes and Hardware Materials

2.1 Prototype Design

The prototype design of the automatic door model for railway crossing is developed based on miniature model using rail and toy trains. The crossing of the train crossing is additional security that is used to close the train tracks. Rules for the design of train crossings can be shown in Fig. 4. In this case, we use a 1: 100 scale. Placement of the sensor position on the actual train doorstop with a train speed of 90 km/h and the time of the doorstop closes the desired 4.5 minutes, with a 1-minute division of time the doorstop closes the alarm ON, 2.5 minutes after the doorstop closes the train passes, and 1 minute after the train passes sensor 2, the doorstop will open again. Then the distance between sensors 1 and 2 can be obtained is 1.53 km.

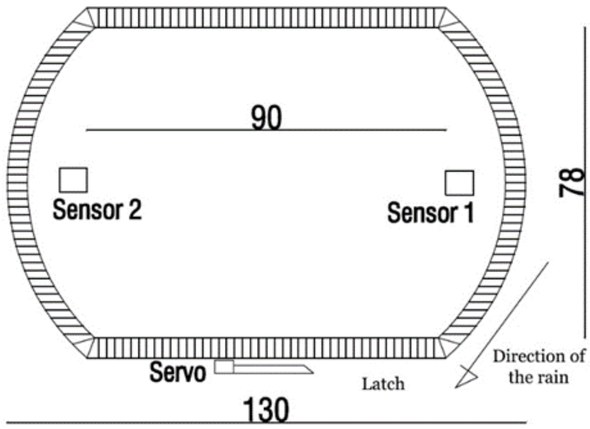


Fig. 3 - Railroad miniature along with sensor placement

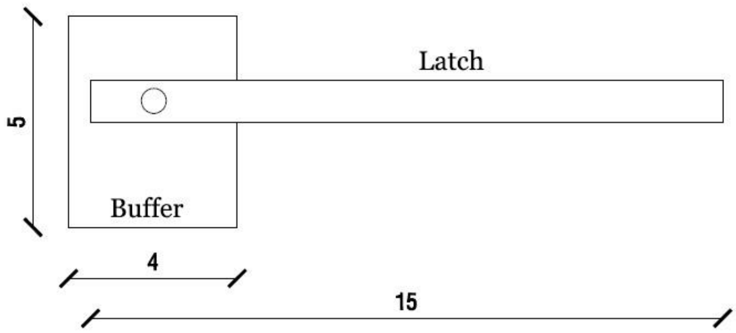


Fig. 4 - Miniature design of a train doorstop

2.2 Hardware Material

2.2.1 Wemos D1 Mini (Chip ESP8266)

Wemos is one of the board modules that can function with Arduino especially for projects that carry the concept of IoT. Wemos be running a stand-alone because there are CPUs that can be programmed via the serial port or OTA and wirelessly transfer program. Wemos has an ESP8266 Chipset which is a chip that has a Wifi feature and supports the TCP/IP stack. This small module allows a microcontroller to connect to a Wifi network and establish a TCP/IP connection using only a simple command, in serial interface mode, CH340 sends a connecting signal commonly used on the modem [3]. In the Wemos module, there is a digital pin which is one of the Wemos module I/O ports that can be configured either as input or output and an analog pin that has a 10-bit resolution with a maximum value of 3.2 volts [6].

Fig. 5 - Wemos D1 Mini

2.2.2 Frequency 433 MHz

The 433 MHz frequency wave propagation system is not sensitive to reflection phenomena, especially on wall barriers, metal structures, and water. [7] The narrowband operation of 433 MHz radio at the sub-GHz allows the transmission distance range to reach a distance of several kilometers with a small power requirement. This is better than the 2.45 GHz frequency which results in lower distances with the same power budget. In terms of power consumption, the frequency of 433 MHz requires lower energy per bit than the higher frequency. Also, the cost of building a system is low and does not require repeaters. The 433 MHz system also uses a small antenna; 433 MHz has an attenuation that is relatively lower than other ISM frequencies [8].

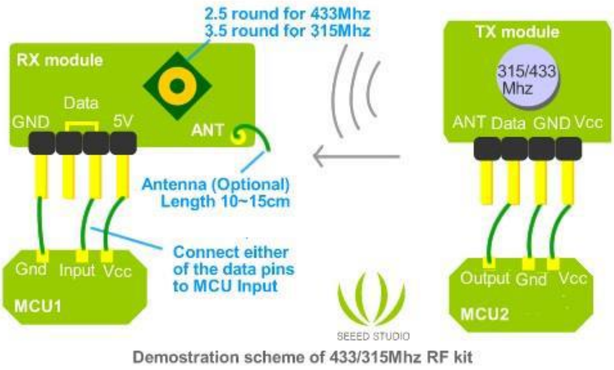


Fig. 6 - How to RF 433 MHz Module Connection.

2.2.3 Arduino Uno

Arduino Uno is an ATmega328 based microcontroller board (datasheet). It has 14 input pins from digital output where 6 input pins can be used as PWM, oscillator, USB, a power jack, ICSP header, and a reset button. To support the microcontroller so that it can be used, it is enough to simply connect the Arduino Uno board to the computer using a USB cable or electricity with the AC-to-DC adapter or battery to run it [8], [9]. This Arduino Uno is used to operate sensors and servo motors that were previously programmed using the Arduino Uno application [4].

Fig. 7 - Arduino Uno.

2.2.4 Micro Servo 9g SG90

The 9g SG90 Servo motor as shown in Fig. 3, basically is a DC motor with several components that have a special purpose. There is no standard specification agreed to state that a DC-MP motor is a DC-SV motor. But in general, it can be defined that the DC-SV motor must have good capability in overcoming very rapid changes in position, speed, and acceleration. The DC-SV motor is also desired to be reliable in operating in a changing torque range. Some types of DC-SV motors that are sold together with the driver circuit package have a speed control circuit that is integrated into it. Motor rotation is no longer based on the supply voltage to the motor, but based on a special input voltage that serves as a reference to the output speed [10][11]. The function of Tower Pro 9g SG90 Pin are as following: (i) Red cable = positive pole on the battery/power rail, (ii) Brown cable = negative pole on the battery/ground, and (iii) Orange cable = input control signal.

2.2.5 TCRT-5000 sensor

The TCRT5000 sensor principle is to detect colors based on the absorption of color and the intensity of the infrared ray emitted by the transmitter (IR led) and received by the receiver (phototransistor). The difference in identity is used as a bias on the base of the phototransistor contained in the TCRT5000 sensor. [12]

Fig. 8 - Micro Servo 9g SG90.

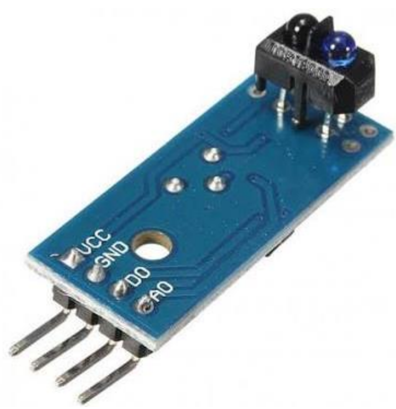


Fig. 9 - TCRT-5000

2.2.6 Buzzer

A buzzer is an audio, mechanical, electromechanical, or piezoelectric signal device. Buzzers include alarm devices, timers, and input confirmation [10]. The working principle of the buzzer is almost the same as the loudspeaker, the buzzer also consists of a coil that is attached to the diaphragm and then the coil is flowed so that it becomes an electromagnet, the coil will be pulled in or out, depending on the direction of current and magnetic polarity, because the coil is installed in the diaphragm, each movement of the coil will move the diaphragm back and forth to make the air vibrate which will produce sound [11], [13].

Fig. 10 - Buzzer

3. Methodology

3.1 Hardware Designing

The hardware design is done by assembling the components used consisting of TCRT-5000 sensor, Arduino Uno ATmega328 micro-controller, 9g SG90 micro servo, LED, Buzzer. TCRT-5000 sensor as a sensor for detecting train arrivals and when the train has passed through the doorstop, sensor identification will be received by Wemos D1 mini which will then be transmitted wifi to the Arduino Uno Atmega328 microcontroller which is received as info the train will pass through the crossing door. Then Arduino Uno will order a micro servo to close the crossing door. The complete block diagram is shown in Fig. 11 and the hardware connection model is shown in Fig. 12.

3.2 Software Designing

In the software designing, Microcontroller programming uses the help of the Arduino desktop software as shown in Fig. 13.

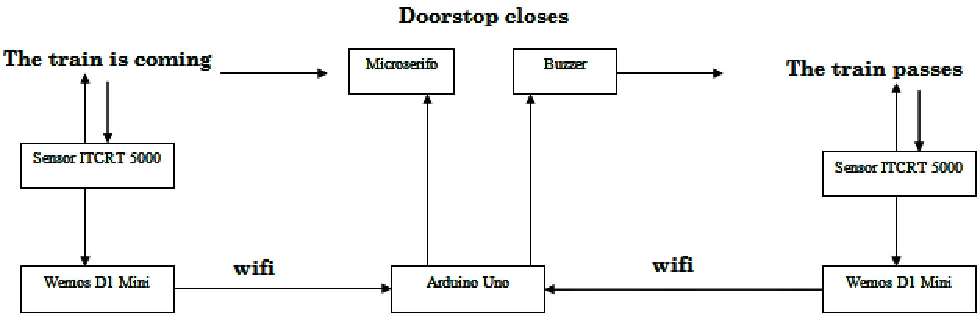


Fig. 11 - Blok diagram.

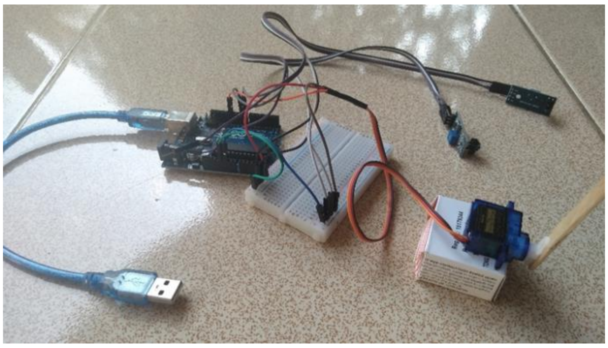


Fig. 12 - hardware connection Model.

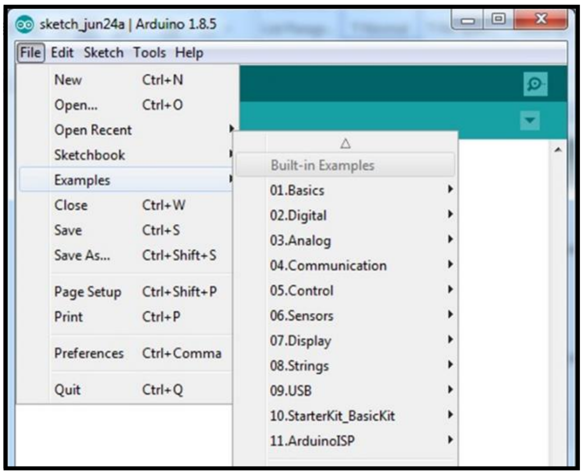


Fig. 13 - Arduino desktop software.

3.3 Testing and Indicators of Success

Miniature testing is done to get research data. There are two tests that were carried out, namely as: (i) Functional test, where the testing is done by testing each miniature part based on the characteristics and functions of each. On the other hand, this testing is done to find out whether each part of the device has worked according to the function, and (ii) Test miniature performance, where miniature performance testing is done by looking at miniature performance. Things observed include TCRT-5000 sensor, display of train speed on the monitor. From this testing, the performance of the miniatures made can be observed.

4. Analysis and Discussion

The application of the R & D method produces a miniature automatic train doorstop. The hardware used in miniature consists of TCRT-5000 sensor, Arduino Uno ATmega328 micro-controller, 990 micro servo SG90, LED, Buzzer. Miniature drawings of railway bars can be seen in Fig. 14 and the hardware devices can be seen in Fig. 15. The functions of each sensor are as follows, sensor 1 as an input for the closing gate, sensor 2 as input for opening the door, and determining the waiting time for the arrival of the train. The position of the sensor is based on the time desired to process the door bar will close until the door bar opens.

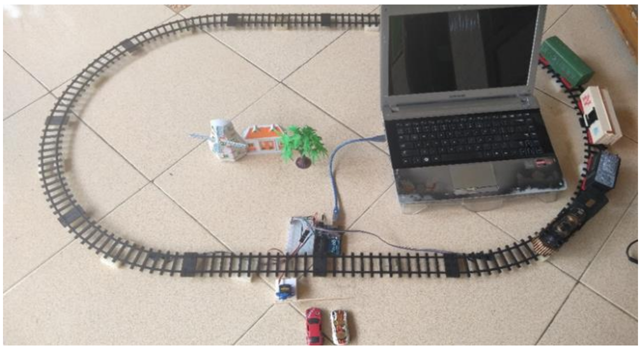
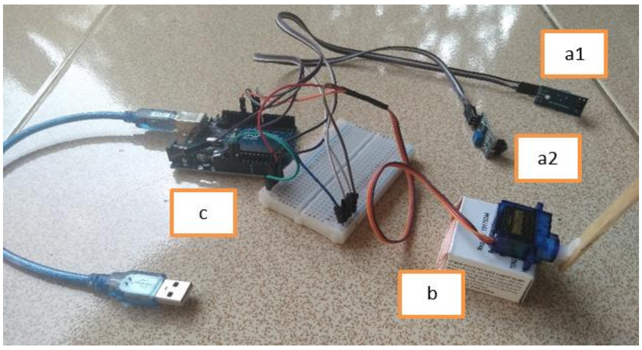


Fig. 14 - automatic crossbar miniature.



a1, a2 =TCRT-5000 Sensor
b =Doorstop with 9g SG90 micro servo drive
c =Micro controller ATmega 328 (Arduino Uno)

Fig. 15 - Hardware device.

4.1. Functional Test

This step is carried out to determine the performance of the miniature automatic train doorstop. Thus, the performance of each part of the miniature train doorstop automatically can be analyzed. The tests include a miniature system test as a whole and a speed measuring system test. The overall system performance is tested by passing the toy train on the system that has been made. For this reason, a 40 cm long toy train that can move with a battery of energy sources and a toy railroad track is needed. Table 1 shows the results of system performance when the train is detected on sensor 1 and sensor 2.

Table 1 - Test model system

Train Position	Door Cross Status
Sensor 1	Close
Sensor 2	Open

Testing the speed measuring system is done with a toy train that has a length of 40 cm. Data from the results of testing the speed measuring system directly with a miniature system and manually measured data (using a stopwatch) can be seen in Table 2.

Table 2 - Speed measurement.

Measured Time Using Stopwatch (s)	Manually Measured Speed (cm/s)	Average Speed Measurement (cm/s)
1.97	90/1.97 = 45.68	43.71

4.2. Performance Test

Miniature performance test was carried out to determine the performance of each miniature component including the manufacture of power supply circuits and TCRT-5000 sensor testing as well as to testing the accuracy of angles on the servo. The testing involves:

(i) Testing the TCRT-5000 sensor
TCRT-5000 sensor is the main sensor used in miniature automatic train doorstop. This sensor acts as a sensory detector for miniatures. The testing of sensors is done to determine the level of accuracy and accuracy of the sensor.

(ii) Testing the accuracy of angles on the servo
Testing the accuracy of the servo angle is done to analyze the angle of the servo motor by using an arc to determine the accuracy of the servo microcontroller control. Testing is done by programming the microcontroller to move the servo.

4.3. Comparison with Previous Studies

This study has successfully produced a miniature automatic train doorstop with an ATmega 328 microcontroller (Arduino) as the main control. This miniature automatic train doorstop able to display train speed and waiting time. Previous studies on automatic train doorstop used different microcontrollers which yield different results (depending on type of microcontroller). Putri et al. [14] developed automatic train doorstop with a sound indicator using AT89S51 microcontroller based early warning. Meanwhile, Dimas et al. [15] used AT89S51 microcontroller based automatic railroad track doorstop. A comparison in term of the availability of parameters between current study and previous works can be seen in Table 3. Meanwhile, Table 4 shows the specifications for each parameter used in the development of miniature automatic train doorstop.

Table 3 - Availability of parameters in miniature automatic strain doorstop.

No.	Parameter	AT89S51 microcontroller based railroad track doorstop [14]	AT89S51 microcontroller based early warning [15]	Current study using ATmega 328 microcontroller (Arduino)
1	Sensor	Yes	Yes	Yes
2	Microcontroller	Yes	Yes	Yes
3	Speed Detection	No	No	Yes
4	Waiting Time	No	No	Yes

Table 4 - Comparison of specifications.

No.	Parameter	AT89S51 microcontroller based railroad track doorstop [14]	AT89S51 microcontroller based early warning [15]	Current study using ATmega 328 microcontroller (Arduino)
1	Sensor	Infrared	Fototransistor	Ultrasonic TCRT-5000
2	Microcontroller	2	2	2
3	Speed Detection	AT89S51	AT89S51	ATmega 328
4	Waiting Time	Motor DC stepper	Motor DC stepper	Servo 9g SG90

5. Conclusion

The miniature design of automatic railroad doorstop uses SG90 9g micro servo with TCRT-5000 sensor based on Arduino Uno ATmega 328 microcontroller. The sensor is used to detect the position of the train, in miniatures that have been made using 2 TCRT-5000 sensors. The function of each sensor is to detect the arrival of the train, activate the speed and detection system that the train has passed through the doorstop. The miniature doorstop is driven by 9g micro servo SG90. Computer monitors in miniatures can function properly, which is capable of displaying train speed and waiting time for train arrival.

The results of the miniature performance test for all supporting components can function optimally, namely, the TCRT-5000 sensor can function and be accurate in detecting the position of the train and servo that move according to the miniature system program. In this system, the servo has a tolerance of 0.90°. The 4.5 seconds is the process of starting the door from closing, closing until the train passes. The time division is that the a1 sensor detects the coming train and 1 second the door bar closes, the a2 sensor detects the train 1 second to the time the train bar is open and 1 second after the doorstop closes the train will pass.

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