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A Design and Implementation of Simulation of Microcontroller-Based Automatic Gate Opening System Practice Module Using Fingerprint Control

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Abstract: Practical tools that follow developments are needed. One of the practice modules in the control laboratory is the automatic gate opening and closing system. An automatic gate opening and closing system is made to increase convenience and security. Currently, a practical simulation tool for an automatic gate open and close control system based on the Arduino Uno R3 Atmega 328p microprocessor is made. The process of opening and closing this gate uses the FPM10A fingerprint sensor with the addition of the HC-SR04 ultrasonic sensor and programming the time to close automatically. Fingerprints are used to control the opening and closing of the gate. Ultrasound is used so that the gate does not hit an object that is blocking the gate closing process. Time control is used for the process of closing the gate automatically if the owner forgets to close the gate when the door is left. The designed gate simulation tool has a size of 1000 x 600 mm. With a track length of 2000 mm. The electric motor used is 12-24 Volt DC with a rotation of 150-200 rpm. The control system uses the Aruino Uno R3 microcontroller with operating specifications of 5 DC Volts, Current of 20 mAmpere. The test results show that the tool can function properly. The solenoid for the lock works fine. Gate opening speed 8.2 seconds. Closing speed 8.17 seconds. The distance between the door and the obstacle object will reopen 10 cm. Gate closes automatically when left after 60 seconds. Implemented systems and test data show that all security components/features operate successfully. The test results show that the prototype is running well.

Keywords: Microcontroller, Automatic Gate, Fingerprint, Ultrasonic

1. Introduction

Security, convenience in life is absolutely necessary [1-3]. One of them is in maintaining the security of the house. Protection of the house is carried out by adding a gate so that not everyone can enter without the permission of the homeowner. Therefore, it is necessary to innovate in maintaining home security by providing a touch of technology so that homeowners feel safe, comfortable and easier.

Research on door open and close control systems that have been developed at this time to improve security is a door open and close system using PIN (personal identification number) sensors, RFID (Radio Frequency Identification) and biometric (face, fingerprint) sensors. Among the options available, the fingerprint sensor is the safest and easiest choice to manage. Everyone's fingerprint pattern is different from one another, making it more difficult to forge than using a pin/password that may be forgotten or an RFID card that can be lost or stolen. The use of fingerprints is currently the most widely used because it is very authentic so it cannot be duplicated, there is no risk of losing and forgetting to bring the key.

Control system development tailored to the needs and ease of management. For locking or protection of a personal nature, authentic/personal identification is usually used, such

as fingerprints or faces (biometrics). Security that is semi-personal usually uses a card. Opening and closing doors in public spaces is usually unsafe, the door opens using an LDR (Light Dependent Resistor) sensor.

Research on door open and close control systems using a microcontroller with face sensors or Graphical User Interface (GUI) has been developed by Hasan et al. in his research to simulate magnetic lock opening and closing using face controls made in program the MATLABR2009a [4].

Research on door opening and closing systems using RFID sensors was carried out by G. K Verma et al. and Y. T. Park et al. [5, 6]. The door opening and closing system with this RFID sensor requires the user to bring a card (tag) as a transponder. The use of this tag is also very risky to lose or be left behind.

Research on the open and close door system using the Internet of Things (IoT) or one-time password (OTP) was carried out by Meenakshi et al. [2]. This research was conducted when the owner was away from the unit. Locking using this OTP control requires the user to use the GSM module because the password is sent via SMS.

Research on door open and close control systems using a fingerprint sensor was carried out by Boong Siaw Wee, Fitria Hidayanti, S Mathew et al., Shafayet Hossain et al., and Z Mumtaz et al. [1, 7-10]. Bong Siaw We implement for open close locker [1]. Fitria Hidayanti secured motorcycles with a fingerprint sensor to control the ignition system [7]. S. Mathew et al. increased security by replacing the personal identification system at ATMs with cards as fingerprints [8]. Safayet Hossain et al. conducted research on opening and closing safe doors with double security, namely using a password and a fingerprint biometric sensor [9]. Z. Mumtaz et al. conducting low-cost multi-application Research for smart cities [10]. This includes combining the system of opening and closing doors.

Fingerprints are the lines on the skin of the fingertips of a person's right hand and left hand [11]. Human fingerprints are used for identification purposes because no humans have exactly the same fingerprints. Fingerprint patterns are always present on every hand and are permanent.

To improve student abilities in the field of up-to-date technology, it is necessary to teach learning practices that are currently developing and are urgently needed at this time. One of them is by providing learning about control systems. The results of this study can later be applied and used as a practice module in the control laboratory.

The current research is the design and simulation of an automatic gate open and close control system using a fingerprint sensor with the addition of ultrasonic control to prevent the door from hitting a track barrier object and the current automatic gate opening and closing system is also designed to close and lock automatically in a few seconds. after leaving.

2. Research Materials and Methods

With improvements of technology, life can be made easier and more comfortable. An example is to open and close the gate of the house automatically. The block diagram of the automatic gate opening and closing system with a fingerprint sensor is shown in Figure 1.

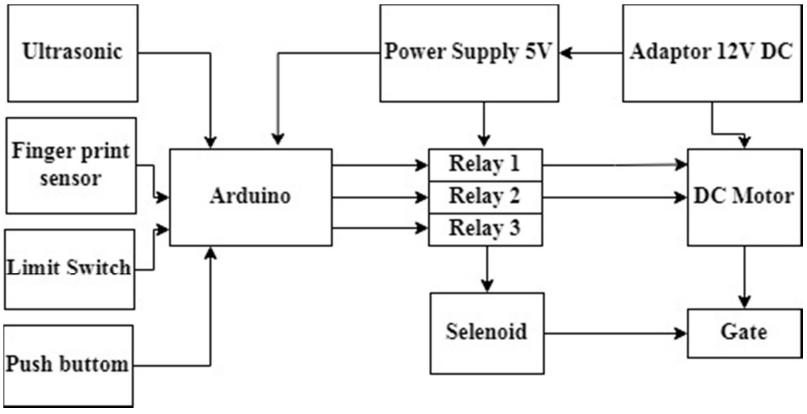

Figure 1. *Research block diagram.*

2.1. Materials

The main components of the designed automatic gate opening and closing system are:

a. Breadboard power supply
   Breadboard power supply is a board module specifically designed for use or use on project boards, this module is capable of providing two DC supply voltages, namely 5V and 3.3V. [12]
b. Arduino Uno R3
   The Arduino Uno used a microcontroller device that utilizes the ATMega328P processor as a command processing center, which can be used freely for any application using the C programming language [13-15]
c. DC Motor
   DC motor is a type of electric motor whose use requires a type of DC (direct current), so in a DC motor, the resulting direct current will later be converted into mechanical energy in the form of rotation or motion.
d. Fingerprint

Fingerprint is a device that can read the pattern of strokes on the skin of the human hand. The fingerprint sensor works by capturing fingerprint data for the first time and is used as a reference. The fingerprint data is then stored in a database. When someone tries to access a device that has a fingerprint sensor, the system will scan again and then the results will be matched with the fingerprints that have been stored in the database. This biometric system is widely used because it has high accuracy, is easy to use and each individual's fingerprints are different, so applications for security or access control are very appropriate to use. One type of fingerprint is Fingerprint FPM10A, it is this fingerprint module that is used in this study.

e. Limit Switch
The working principle of the limit switch is the same as the ON/OFF push button switch, which will only work if the actuator part is pressed by an object at the specified limit or area, so that there will be a disconnection or connection of the device circuit. When the actuator is pressed, the actuator will move and be forwarded to the inside of the limit switch so that it touches the micro switch to connect the contacts.

f. Ultrasonic Sensor
Ultrasonic sensor is a sensor that functions to convert physical quantities (sound) into electrical quantities or vice versa. The ultrasonic sensor consists of a series of ultrasonic transmitters called transmitters and ultrasonic receiver circuits called receivers. In general, this tool will emit ultrasonic waves towards an area or a target. When the wave hits the surface or target area, the target will reflect the wave. The reflected wave from the target will be captured by the sensor, then the sensor calculates the difference between the time the wave is sent and the time the wave is received.

g. Adaptor power supply
The power supply adapter is a circuit that converts an AC power source (high voltage) to a DC power source (low voltage). The power supply adapter is an alternative to a DC voltage source (battery and accumulator).

h. Relay
Relay is a switch that is operated electrically and is an electromechanical component consisting of 2 main parts, namely the coil and the mechanical. The relay uses the electromagnetic principle to move the switch contacts so that with a small electric current (low power) it can conduct electricity with a higher voltage.

i. Solenoid
Solenoid door locks are electronic devices that work on the electromagnetic principle. Solenoid door locks generally use a working voltage of 12 volts. Under normal conditions this tool is closed (locking the door), when given a voltage of 12 volts the lock will open. To control solenoid door locks from the Arduino, an interface or driver circuit is required. One of them can use a 5 volts relay. By using this relay, the door lock solenoid can be controlled by the microcontroller on the Arduino Push Bottom
Push button is an electronic component that can cut off and conduct electric current in an Arduino project circuit.

2.2. Methods

The research method used is the experimental simulation method. Namely the creation of a simulation of an automatic gate opening and closing system for the practice module. In the simulation, a gate is made with a length of 1 m and a height of 0.6 m. The required track length is 2 m. The process of opening and closing the gate from outside the gate is carried out by pressing the fingerprint sensor button using a registered fingerprint. The process of opening and closing the gate from inside the gate is carried out with the push bottom. The limit switch is used to turn off the DC motor when the door reaches the end of the circuit. Solenoid is used to lock the door when the door closes. Ultrasonic is used to detect objects when there are obstacles on the path of the gate. If the door is not closed and left just like that, the door will close itself within 60 seconds. The process flow chart for designing or manufacturing a door lock with fingerprint control can be seen in Figure 2.

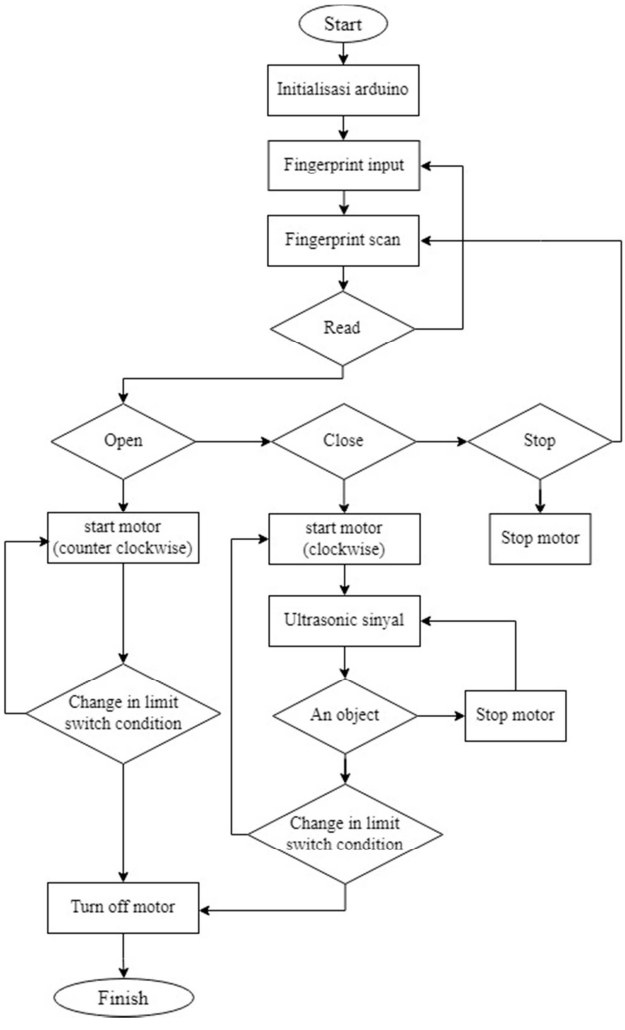

Figure 2. *Research Flowchart.*

3. Results and Discussion

The process of opening and closing the gate manually is done by pushing and pulling the gate. This process has a weakness because it requires effort when pushing and pulling the gate, insecurity because everyone can enter without any selection and discomfort because there is no guarantee that the gate will close automatically if one forgets to close. Based on these observations, the authors designed a practical simulation tool that can ease the burden on gate owners and provide a sense of comfort. Figure 3 shows the wiring diagram of the automatic gate opening and closing system using the Arduino Uno microcontroller. Figure 4 shows an image of the gate after it's finished.

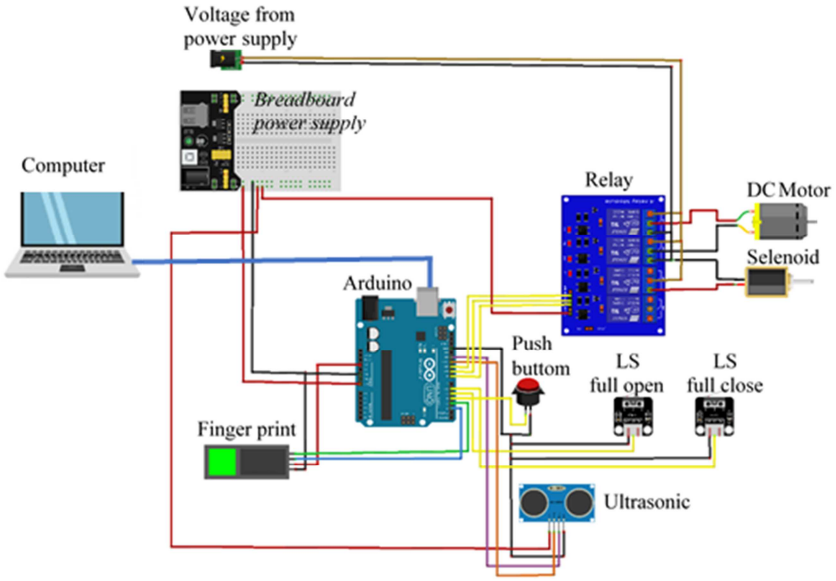

Figure 3. *Wiring diagram.*

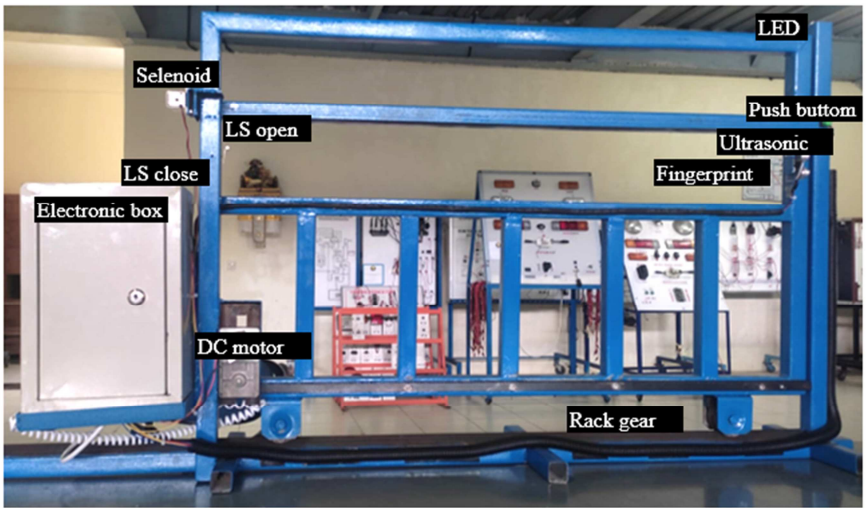

Figure 4. *Gate after finishing.*

The process of opening the door is done by attaching a fingerprint registered on the fingerprint sensor. If the fingerprint is not registered, then the door will not open. If the registered fingerprint is attached to the fingerprint sensor, the solenoid will open, and the motor will rotate CCW so that the door moves open until the open limit switch is touched. If the limit switch is touched, the motor will turn off, and the door will stop moving. The test results show the time it takes when the fingerprint is removed from the fingerprint sensor until the door stops when fully opened, which can be seen in Figure 5 of the programmed 1 second.

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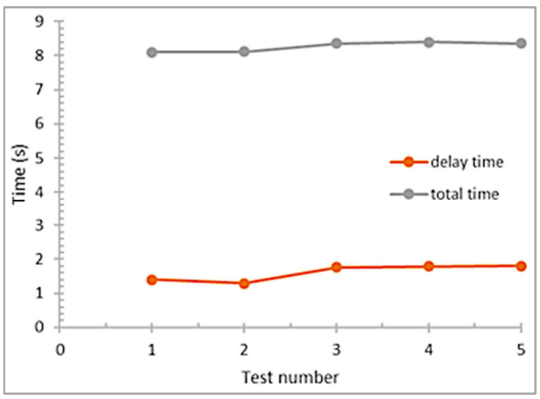

Figure 5. *Time needed to open the gate.*

Figure 5 Shows the delay time and the time it takes to open the door. The average delay time is 1.61 seconds from the programmed 1 second. There was a delay of 0.61 seconds. This is caused by the presence of cable resistance, the longer the cable the greater the resistance value which will increase the delay time. Another thing that causes deviation is the change in time that is very fast so that it is missed in the reading.

Total time is the delay time plus the time required when the door starts to move open until the door is fully opened. The average total time is 8.26 seconds.

The process of closing the door from inside the gate is done by pressing the push bottom switch. The process of closing the door from outside the gate is done by placing a fingerprint on the fingerprint sensor. If the fingerprint is not registered, then the door will not close. If the fingerprint is registered, then the door will move to close. If no object is blocking the door, it will move until it closes and the solenoid locks.

Figure 6 graphically shows the time it takes to close the door by pressing the fingerprint sensor button. The time needed to close the gate is an average of 8 seconds.

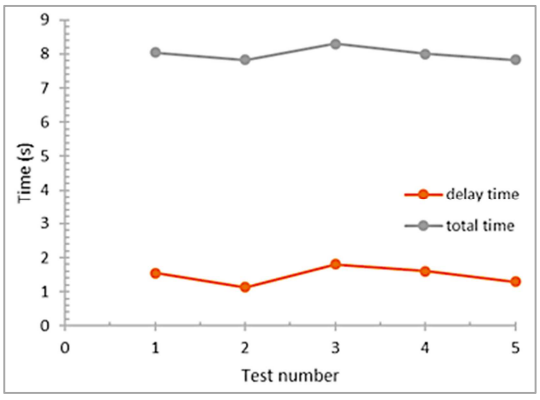

Figure 6. *Time needed to close the gate.*

Figure 7 shows the comparison of the time needed to open and close the gate. The time needed to open and close the gate is the same. Fluctuations in the speed of opening and closing are caused by inaccurate data readings due to the rapid change of numbers on the stopwatch, which is every ten seconds.

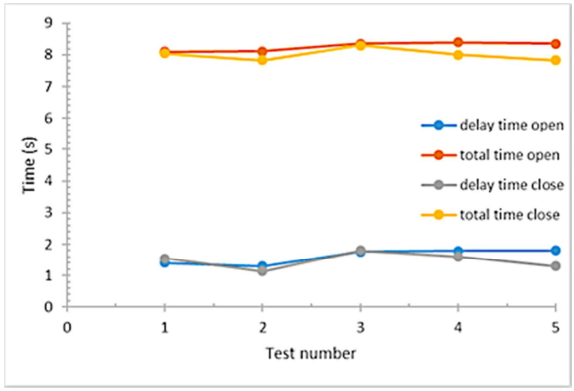

Figure 7. *Comparison of the time needed to open and close the gate.*

If there is an object blocking the track when the gate moves to close, then the gate will move until it reaches a distance of 100 mm from the object who blocking the track, then the gate will move backwards until it is fully open. If the obstruction is removed the door will stay in the open position and must be pushed again to close. If it is not re-keyed then the event is the same as if the door forgot to close, the gate will automatically close after 60 seconds.

The test results when opening and closing the gate on the operating conditions of the electric motor can be seen in Figure 8 and Figure 9.

Figure 8 shows the amount of current and rotation that occurs when the gate is opened. In the graph, it can be seen that the amount of current and rotation that occurs increases with an increase in voltage.

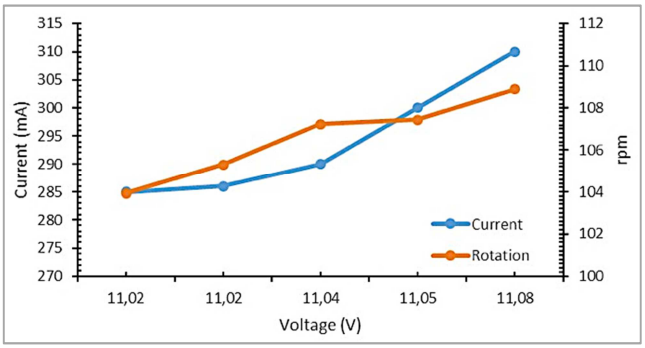

Figure 8. *The current and rotation that occurs when the gate is opened.*

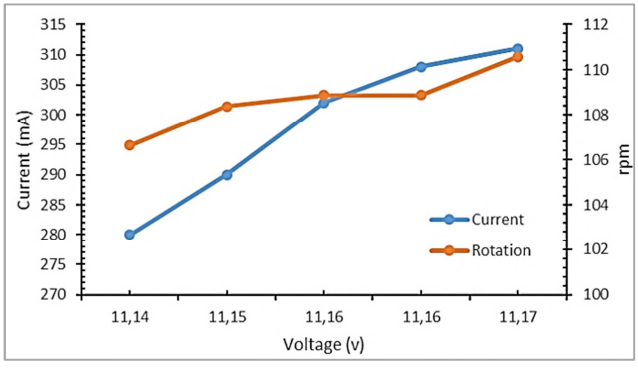

Figure 9. *The current and rotation that occurs when the gate is closed.*

The graph of the motor characteristics, namely the current and rotation that occurs when the gate is closed, can be seen in Figure 9.

Figure 9 shows fluctuations in current, voltage and motor rotation when closing the gate. The tendency occurs the same as when opening the gate. That is rotation increases with increasing voltage.

From Table 1 the test results show that if the fingerprint sensor is pressed with a valid fingerprint, the solenoid will open, this triggers the rotation of the CCW rotating drive motor so that the door will open. Movement of the door until it is fully opened will touch the "limit switch open" resulting in the drive motor off and the door stops moving. When the gate moves open, whether or not there is a barrier object in the path, the door still moves open. When the gate is open, if the fingerprint sensor is pressed with a valid fingerprint, the drive motor will rotate CW and the door will move to close, if there are no obstructing objects in the path of the gate it will fully open and touch the "limit switch close" so that the motor is off and the door stops moving, then the solenoid will lock. When the door moves to close, if there is a barrier object in the path, the ultrasonic sensor triggers the CCW motor to rotate so that the door moves to open until the door touches "limit switch open" and the drive motor turns off and the door opens. If the fingerprint is not valid the turnstile will remain locked.

Table 1. *Test results of the gate working system using fingerprint control.*

Fingerprint		Solenoid		Object on the Track		Driving Motor		Touch LS	
		Open	Lock	Object	No Object	CW	CCW	Stop Open	Stop Close
Valid	Open	√			√		√	√	
		√		√			√	√	
	Close		√		√	√			√
		√		√			√	√	
Invalid			√						√

4. Conclusion

An automatic gate opening and closing system is made to increase convenience and security. Currently, a practical simulation tool for an automatic gate open and close control system based on the Arduino Uno R3 Atmega 328p microprocessor is made. The process of opening and closing this gate uses the FPM10A fingerprint sensor with the addition of the HC-SR04 ultrasonic sensor and programming the time to close automatically.

Fingerprints are used to control the opening and closing of the gate. Ultrasound is used so that the gate does not hit an object that is blocking the gate closing process. Time control is used for the process of closing the gate automatically if the owner forgets to close the gate when the door is left.

The designed gate simulation tool has a size of 1000 x 600 mm. With a track length of 2000 mm. The electric motor used is 12-24 Volt DC with a rotation of 150-200 rpm. The control system uses the Aruino Uno R3 microcontroller with operating specifications of 5 DC Volts, Current of 20 mAmpere. The test results show that the tool can function properly. The solenoid for the lock works fine. Gate opening speed 8.2 seconds. Closing speed 8.17 seconds. The distance between the door and the obstacle object will reopen 10 cm. Gate closes automatically when left after 60 seconds. Implemented systems and test data show that all security components/features operate successfully. The test results show that the prototype is running well.

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