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Development of a Dual-Leaf Automatic Door Prototype Based on Arduino using HC-SR04 Ultrasonic Sensor and Servo Motor

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Abstract: This research aims to design and implement a two-leaf automatic door sytem that opens towards the inside by utilizing an arduino microcontroller, HC-SR04 ultrasonic sensor and servo motor. The test results show that the system can work responsively and stably with a good level of detection accuracy and servo movement symmetry. This system has potential to be implemented on a small scale in residential homes, laboratories, or other semi-automatic public spased.

Keywords: automatic door, automation, arduino, HC-SR04 ultrasonic sensor, Servo motor

INTRODUCTION

In the era of automation, microcontroller-based systems have become crucial in supporting innovations across various fields, including building automation and public facilities. One practical implementation of automation systems is the application of automatic doors. Automatic doors not only provide convenience and efficiency but also support hygiene principles, especially in high-traffic facilities such as hospitals, shopping centers, and offices. Because this research is still a prototype, it only uses plywood shaped like a door leaf.

The HC-SR04 ultrasonic sensor is one of the commonly used components to detect the presence of objects without direct contact, utilizing ultrasonic waves to measure distance (Arduinoindonesia.id, 2022). Additionally, the servo motor is an actuator widely used in position control systems due to its ability to produce precise movements (Arduinoindonesia.id, 2022). By combining the ultrasonic sensor, servo motor, and the

Arduino microcontroller as the main control unit, an automatic door system can be designed at a relatively low cost while still being reliable and responsive to user presence.

The development of this dual-leaf automatic door prototype aims to create a practical solution that enhances comfort and efficiency in room entry and exit access. The system is designed to detect a person's presence from a specific distance and automatically open both doors with the help of a servo motor. The integration of sensors and actuators in this system is intelligently controlled by the Arduino Uno, which has proven to be a flexible open-source platform for prototyping and educational technology purposes (Arduinoindonesia.id, 2018)

RESEARCH METHOD

In conducting this research, several steps were taken to complete it. The steps can be seen in the block diagram in Figure 1.

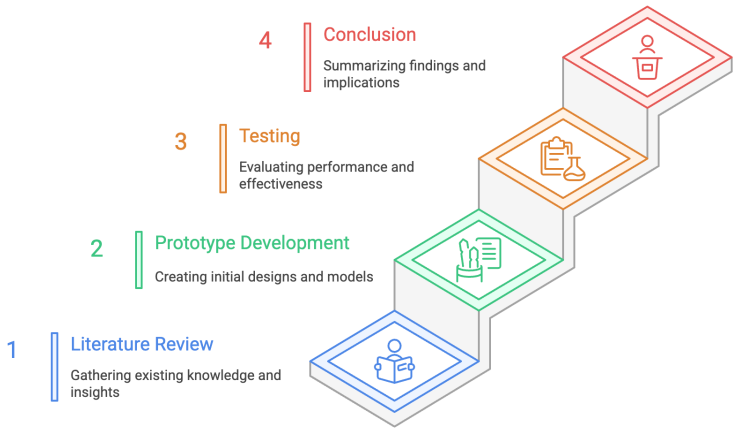

Figure 1. Research Flow Diagram

Figure 1 illustrates the research flow, starting with identifying the existing problem. Manual doors are still inefficient and not hygienic for high-traffic public areas. The solution of a simple and affordable dual-leaf automatic door is still rarely developed. Additionally, the utilization of the HC-SR04 sensor and servo motor based on Arduino has not been optimized for a responsive and practical automatic door system.

After identifying the problem, the next step is to conduct a literature review, which involves gathering data from books, both written and electronic (e-books), and reading several journals to complement this writing.

The next step is to design the system, which involves creating an automation circuit consisting of an Arduino UNO, HC-SR04 ultrasonic sensor, and servo motor, as well as developing the automation system program code using the Arduino IDE and prototype devices such as the door shown in figure 2. After all the processes are completed, the next phase involves testing, implementation, and analysis. Finally, conclusions are drawn from the research.

Figure 2. Door Protorype.

Block Diagram

This hardware design includes all the work on the components of the device. This device is an integration of several interconnected circuits, all controlled through the Arduino UNO microcontroller. The process can be seen in Figure 3.

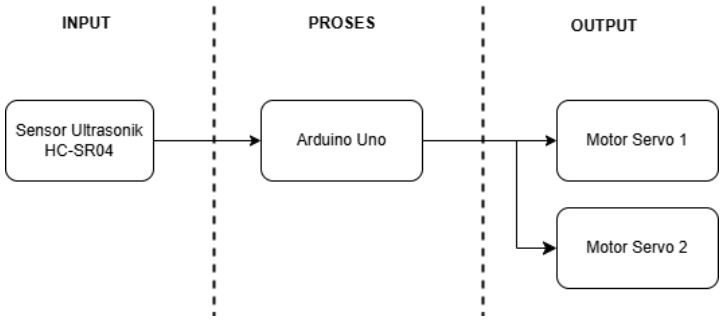

Figure 3. Block Diagram of the Automatic Door System Using Ultrasonic Sensor.

Input Block

The input block is a component that allows users to interact with an electronic device. In the system design, the sensor used is the HC-SR04, which functions to measure the distance of an object. The ultrasonic sensor will emit ultrasonic sound waves from the

transmitter. These waves will bounce off the target or object, and the reflected waves will be received by the sensor receiver. The data from the sensor receiver will then be processed and sent to the Arduino microcontroller.

Process Block

The process block is a component that processes the input data and sends the processed results to the output block. In the system design, the Arduino UNO serves as the process block. In this circuit, the Arduino UNO microcontroller processes the data received from the ultrasonic sensor (HC-SR04). The microcontroller will process the data to calculate the distance. The processed data will then be sent to the servo motor at the output stage.

Output Block

The output block is a component that executes the results of the data processing from the process block. In the system design, the servo motor serves as the output block. The servo motor will open the doors simultaneously according to the condition after receiving the signal from the Arduino.

Schematic of the System Circuit

In the complete circuit schematic, which can be used as a basis for creating the circuit, is shown in Figure 4 below:

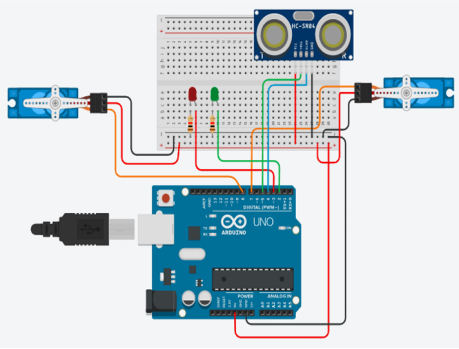

Figure 4. Overall Schematic of the Automatic Door Prototype.

In Figure 4, the entire circuit of the system to be created is illustrated. The components used include: the HC-SR04 ultrasonic sensor as the input, the Arduino Uno microcontroller as the processor, 2 servo motors, and 2 indicator LEDs as outputs.

For the HC-SR04 ultrasonic sensor, the echo pin is connected to Digital Pin 4 on the Arduino UNO, while the trigger pin is connected to Digital Pin 5 on the Arduino UNO. The data pin of Servo Motor 1 is connected to Digital Pin 7 on the Arduino UNO, and the data pin of Servo Motor 2 is connected to Digital Pin 8 on the Arduino UNO. The positive leg of the green LED is connected to Digital Pin 2, and the positive leg of the red LED is connected to Digital Pin 3 on the Arduino UNO.

Automation System Design

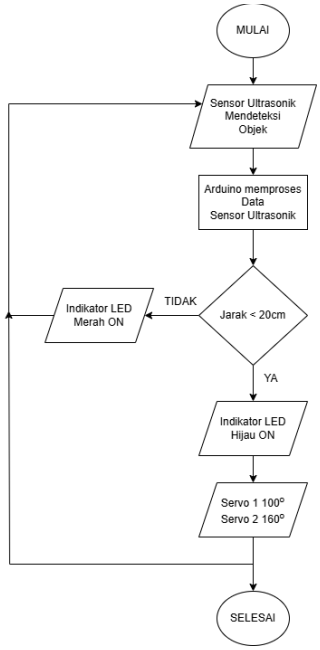

Figure 5. Flowchart of the Automatic Door System Design.

Figure 5 shows the flowchart of the automatic door system design. The automatic door system will begin operating once power is supplied, and the Arduino system is powered on. The ultrasonic sensor mounted at the front of the door will become active and start monitoring the area in front of it. When the sensor detects the presence of a person at a certain distance (for example, less than 20 cm), the Arduino will process the data from the sensor and activate the green indicator light and the two servo motors.

These servo motors are mounted on each door leaf (left and right). Upon receiving the signal from the Arduino, the servo motors will move to open the doors inward simultaneously. Then, after a few seconds, if the sensor no longer detects a person within less than 20 cm (according to the delay time in the program, 5 seconds), the system will send a command to the servo motors to return to their initial position, causing the doors to

automatically close. The system will continue to operate automatically every time the sensor detects movement in front of the door.

RESULT AND DISCUSSION

In the results and discussion section, the testing will analyze the system based on the automation design that has been created. This test is conducted to determine whether the system aligns with the initial design.

Ultrasonic Sensor Testing

Table 1. Results of Ultrasonic HC-SR04 Sensor Distance Testing in the Automatic Door System

No.	**Object Distance** (Cm)	**Object Status**	**Door Status**	**Description**
1	>30	Sensor Detection	Closed	Exceeds the Minimum System Distance
2	25	Sensor Detection	Closed	Exceeds the Minimum System Distance
3	20	Sensor Detection	Open	Door Opens Normally
4	15	Sensor Detection	Open	Door Opens Normally
5	<10	Sensor Detection	Open	Door Opens Normally

Table 1 shows the results of testing the HC-SR04 ultrasonic sensor in the system that was previously developed. The test results indicate that the HC-SR04 ultrasonic sensor detects objects at various distances and the corresponding system responses.

When an object is detected by the HC-SR04 ultrasonic sensor at a distance of more than 30 cm or 25 cm, the door will remain closed because the distance exceeds the minimum threshold set by the system. However, when an object is detected by the HC-SR04 ultrasonic sensor within a distance of 20 cm to less than 10 cm, the system recognizes it as an active condition to open the automatic door.

The system's response to the ultrasonic sensor HC-SR04 readings is within normal limits, indicating that the system is capable of accurately identifying the presence of objects and issuing the command to open the door automatically.

Servo Motor Control Testing

Table 2. Results of Servo Control Testing in the Automatic Door System

No	Servo Command	Left Servo Angle (Degrees)	Right Servo Angle (Degrees)	Movement Symmetry	Description
1	Close Door	0	0	YES	According to Program
2	Open Door	100	160	YES	According to Program

Table 2 shows the results of the servo control testing for opening and closing the automatic door. For the "Close Door" command, both servos (left servo and right servo) move to the 0-degree position, indicating that the door is closed. Meanwhile, for the "Open Door" command, the left servo moves to a 100-degree angle, and the right servo moves to a 160-degree angle, indicating that the door is fully and symmetrically open. These results demonstrate that the servo motors operate synchronously and in accordance with the program of the automation system.

Automatic Door Closing Delay Testing

Table 3. Results of Automatic Door Closing Delay Testing in the Automatic Door System

No	Program Delay Time (Seconds)	Actual System Time (Seconds)	Door Control Status	Description
1	10	10,00	Automatically Closing	Accurate According to Program
2	15	15,00	Automatically Closing	Accurate According to Program
3	20	20,00	Automatically Closing	Accurate According to Program

Table 3 shows the results of testing the system's accuracy in executing the automatic delay to close the door. In each test with delay times set at 10, 15, and 20 seconds, the system demonstrated accurate timing with no deviations. In addition to showing accurate timing, the system successfully closed the door automatically after the delay period elapsed, proving that the delay logic in the programming works correctly.

Overall System Testing

Table 4. Results of Overall Testing in the Automatic Door System

No	Test Conditions	Servo Active	Servo Moving	Response Time (Seconds)	Door Closes	Description
1	Person Approaches (Distance 20 cm)	YES	YES	1,00	YES (After 5 Seconds)	System Functions Normally
2	No Movement	YES	NO	-	-	System Standby
3	Object Moves Quickly (Distance 20 cm)	YES	YES	0,80	YES (After 5 Seconds)	System is Very Responsive

Table 4 shows the results of the overall system testing, which includes distance sensor detection, servo movement, response time, and automatic door closing. In the condition when a person approaches the automatic door at a distance of 20 cm, the system detects the presence of the object/person, and both the left and right servo motors move to open the door within a response time of 1 second. The door then automatically closes after 5 seconds, as per the delay setting in the system.

When no movement/object is detected, the distance sensor remains active, but there is no movement from either servo, indicating that the system is in standby mode. Meanwhile, when an object moves quickly in front of the door, the system is still able to respond quickly (with a delay of 0.80 seconds) and close the door automatically. This demonstrates that the system has a high response speed.

Manual and Automated System Testing

Table 5. Manual and Automated System Testing

No	Test Conditions	Manual	Automated
1	Person Approaches (Distance 20 cm)	-	Closes Door
2	No Movement	-	-
3	Object Moves Quickly (Distance 20 cm)	-	Closes Door

Based on the test of the comparison between the manual system and the automatic system as shown in table 5, namely that if there is movement in the automatic system, the

door will close, but in the manual system, the door does not take action even if there is movement or not

CONCLUSION

Based on the design and testing results, it can be concluded that the Arduino-based automatic door system with two servo motors successfully works as intended. The ultrasonic sensor is capable of detecting the presence of objects (humans) within the specified distance and sending signals to the Arduino responsively.

The Arduino-based dual-leaf automatic door system with HC-SR04 sensors and two servo motors has been successfully built and tested. The system is able to accurately detect objects and move the two servo motors to open the door inward synchronously. The door closure also operates according to the programmed delay time. This system is suitable for use in home environments, laboratories, or small-scale semi-automatic rooms.

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