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Implementation of Microcontroller-Based Automatic Waste Bins to Support Work Efficiency In One of The Msmes

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ABSTRACT

Efficient waste management is a challenge for many SMEs, including iced tea businesses, in maintaining cleanliness and operational comfort. This research aims to design and implement a microcontroller-based automatic trash bin system as an innovative solution for waste management. The researchers focus on utilizing Arduino microcontroller technology with ultrasonic sensors to detect objects automatically. This study addresses the fundamental question of how an automated system can enhance waste management efficiency through prototype design and testing. The system successfully opens and closes the trash bin lid automatically with a fast response time, minimizing direct user interaction with the bin. Findings indicate that this system improves cleanliness, reduces the risk of germ transmission, and has potential for further development, such as adding waste capacity sensors and mobile application integration. Thus, this system offers an efficient and cost-effective solution for waste management at the SME scale.

INTRODUCTION

Lendang Nangka Village, located in Masbagik District, Lombok Regency East, has many MSMEs that play an important role in supporting the economy community. MSMEs in this village are engaged in various sectors, such as culinary handicrafts, and agricultural product processing. However, in carrying out their activities, MSMEs often face various challenges, one of which is waste management, especially plastic waste, which is not optimal. Ineffective waste management can lead to environmental pollution, decreased productivity, and creating discomfort in the work environment (Izzah & Wardani, 2024; Maesarani et al., 2023; Sulistiono et al., 2016).

The use of microcontroller-based technology has become a trend in solving waste management issues, especially with the implementation of automated bins. Literature review shows significant developments in the implementation of this system. Perdana and Wellem (2023) show that Arduino-based automated bin control systems and ultrasonic sensors can improve efficiency in management waste. Dandy (2023) developed an automatic litter box using smoke sensors and ultrasonic sensors that are effective at detecting specific types of waste (Amrah et al., 2023) examine the design of the Arduino Uno automated bin bin, which is able to detect the height of waste in real-time. Yudithio et al. (2021) mentioned that the implementation of ultrasonic sensors in automated bins provides high accuracy results for detecting distances.

Furthermore, Yesisanita et al. (2023) examined the efficiency of using the HCSR04 ultrasonic sensor in urban environments, which can be adopted for MSME areas. Kurniawan et al. (2021) and Bere et al. (2021) also discussed the application of microcontrollers with proximity sensors in automated waste management that are cost-effective and easy to implement.

However, these studies have not provided specific solutions for MSMEs, especially in rural areas such as Lendang Nangka Village, which has unique needs in terms of efficiency and sustainability of waste management. Therefore, this study aims to develop a prototype of an automatic microcontroller-based trash can that is in accordance with the needs of MSMEs in Lendang Nangka Village.

METHOD

This research uses a prototyping method to develop an automatic trash can based on a microcontroller. The process begins with the collection of needs the beginning of the user and the developer, where the initial prototype is created to define the needs of the system.

The resulting prototype is then evaluated by the user, and feedback from the user is used to gradually improve the system. This process is carried out repeatedly until the prototype meets the user's needs and is ready for testing.

The final stage is prototype testing to ensure the system works appropriately with predetermined specifications. This method allows the system to be developed flexibly and according to the needs of the user

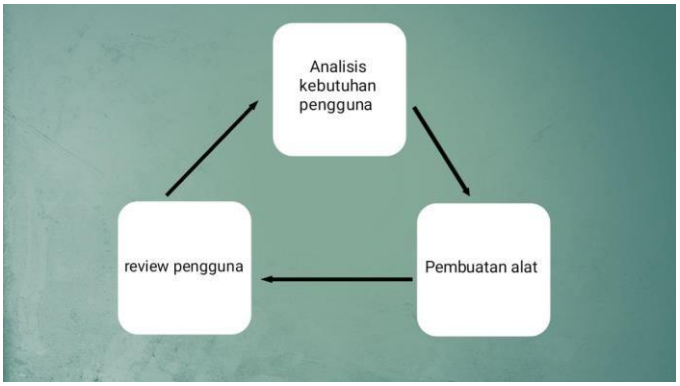

Figure 1 Prototype

A. Prototype Development Method Explained

1. Analysis

At this stage, an analysis was carried out on the need for a microcontroller-based automatic trash bin system that will be applied to one of the MSMEs in Lendang Nangka Village. Data collection was carried out through interviews with MSME owners and workers, literature studies on automatic waste management technology, and observation of waste management conditions in MSMEs. The data obtained will be used to understand the challenges faced by MSMEs in managing waste, such as the type of waste that is often generated, the capacity of the waste bins needed, and the aspects of ease and efficiency of using automated systems. The results of this analysis will be the basis for designing an automatic bin system that suits the needs of MSMEs and can support work efficiency in the environment.

2. Prototyping

At this stage, the developers prototype an automated bin using microcontroller (e.g. Arduino). The prototype is equipped with an ultrasonic sensor that functions to detect the proximity of someone who wants to dispose of garbage.

How it works:

- When a person approaches a garbage can, the ultrasonic sensor will detect the distance between the sensor and the person.
- If the person is close enough, the sensor will send a signal to the microcontroller to activate the servo motor.
- The servo motor will then open the lid of the trash can automatically, so people can dispose of the trash without having to touch the lid.

At this stage, the developer will also write a program to connect all the components in order to work properly. The prototype was designed at a low cost and easy to install in MSMEs, so that it can help manage waste more efficiently and hygienically.

3. Prototype Testing and Evaluation

Once the prototype is complete, the next stage is live on-site testing MSMEs. The prototype will be tested to ensure that the ultrasonic sensor can detect approaching people precisely, and the servo motor can open the lid of the bin automatically. MSME managers will provide feedback on system performance. If there is a problem, the developer will make repairs,

such as adjusting the sensor or servo motor. This process will be repeated until the system is functioning properly. In this way, it is hoped that the automatic garbage can help MSMEs in the village Lendang Nangka to be more efficient in managing waste and creating a clean environment.

B. System Planning

1. Flowchart

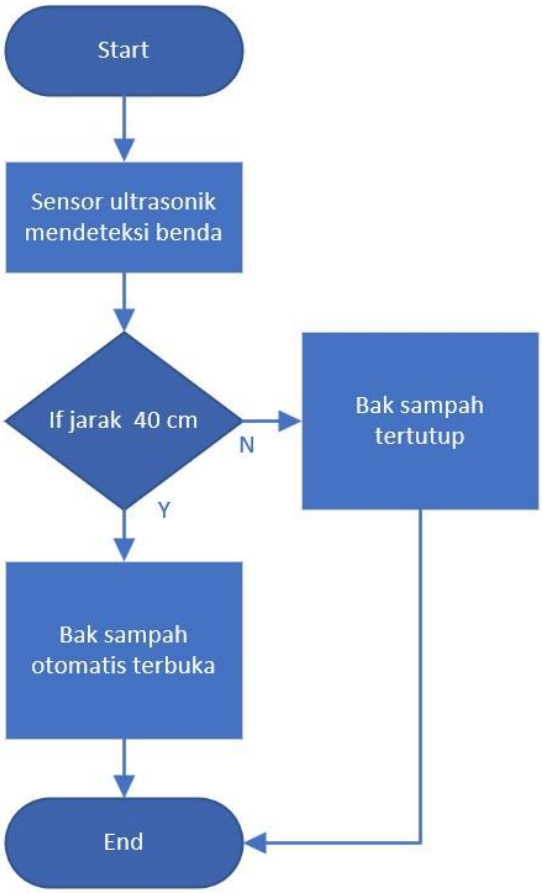

Figure 2 Flowchart

The flowchart above explains the system flow contained in the microcontroller-based automatic trash can system, the explanation related to the flowchart in figure 1,2 above is as follows:

a. The flowchart starts with an ultrasonic sensor that functions to detect the presence of objects around it. This sensor measures the distance between the sensor and the object (for example, objects that are near the trash can)
b. Here, the system checks the distance detected by the sensor. If the distance is greater than 40 cm (for example, there are no objects close enough to the sensor), then the bin remains closed.

c. If the sensor detects an object that is less than 40 cm (for example, when someone approaches the trash can or there is an object close to the sensor), the trash can will open automatically.
d. This process ends after the bin is open or remains closed based on the conditions detected by the sensor.

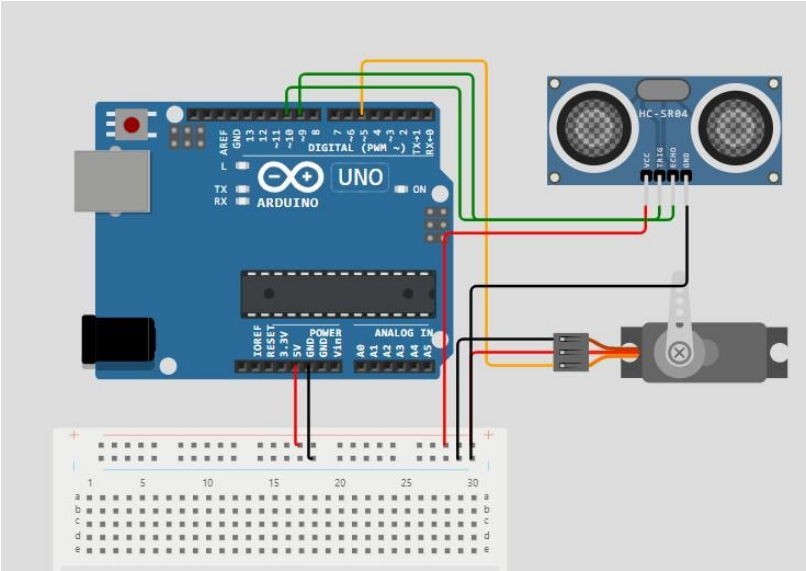

Figure 3 Network Schema

Based on the diagram of the circuit diagram in Figure, it can be explained that this circuit consists of several components that have their respective functions, namely:

a. Arduino Uno: A microcontroller board that serves as the control center of this circuit. The Arduino will receive the input from the ultrasonic sensor and provide the output to the servo motor.
b. HC-SR04 Ultrasonic Sensor: This component functions to measure distance by emitting ultrasonic waves and measuring their reflection time. This sensor has two main pins, namely the TRIG pin to initiate the measurement and the ECHO pin to receive the bounce signal. The results of the distance measurement will be processed by Arduino.
c. Servo Motor: This component serves to perform movements based on the commands given by the Arduino, which are influenced by the data received from the ultrasonic sensor. The servo motor can move the object to a certain angle according to the requirement.
d. Breadboard: Used to temporarily assemble components and connect the components of the network using jumper cables.

Connections and Workflows:

- The Arduino acts as the center controller by receiving signals from ultrasonic sensors and providing instructions to the servo motor.
- The HC-SR04 ultrasonic sensor measures the distance of the object in front of it and transmits the information to the Arduino via the ECHO pin.

- Based on the results of the distance measurement, the Arduino will command the servo motor to move to a certain position.

3. System programming

Automatic bin system program

```
#include <Servo.h>

Pin const configuration int trigPin = 9; const int echoPin = 10; const int servoPin = 5;
const int distanceDetection = 40;  Detection distance in cm

Servo servo motor;

void setup() { pinMode(trigPin, OUTPUT); pinMode(echoPin, INPUT);

//Initialize servo servoMotor.attach(servoPin);
servoMotor.write(0); Servo starts in the closed position

Serial.begin(9600); For distance debugging in Serial Monitors
}

Function for calculating distance using ultrasonic sensor long readDistance() {
long duration, distance;

//Send signals from trigPin digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);

//Read the bounce time on echoPin duration = pulseIn(echoPin, HIGH);

Calculating distance (cm)
distance = duration * 0.034 / 2;

return distance;
}

void loop() {
Call the function to measure the distance length distance = readDistance();


Debug: Show distance in Serial Monitor
Serial.print("Distance: "); Serial.print(spacing); Serial.println(" cm");
```

```
Open close if the distance is below the if threshold (distance <= distanceDetected) {
servoMotor.write(180); Open and close (180 degree) delay(4000);          Wait 5
seconds to keep servoMotor.write(0) open;   Close again after the wait time
} else {
servoMotor.write(0);   Close in the absence of objects in front
}

delay(200); Reduce distance reading frequency
}
```

The program code is created to integrate ultrasonic sensors and servo motors with Arduino. This program is designed so that the sensor detects objects within a certain distance and gives commands to the servo motor to open the cover, as explained by the code above:

1. Pin and Servo Initialization:
   - trigPin (pin 9) to send signals from ultrasonic sensors.
   - echoPin (pin 10) to receive signal reflection from the ultrasonic sensor.
   - ServoPin (5 pins) to control the servo motor opening and closing.
   - Detection distance is the distance that is the limit for opening the servo (in cm).
2. Distance read function: This function measures the distance by transmitting the signal from the ultrasonic sensor and calculates its bounce time to get the distance in cm.
3. Setup function:
   - Set trigPin pin as output and echoPin as input.
   - Initialize the servo motor and start the servo position at 0 degrees (closed).
   - Open serial communication to display distance measurement results in Serial Monitor.

4. Loop function:
   - Measure distance using the Distance read function.
   - If the distance is smaller than or equal to the detection distance, the servo will be open for as long as

4 seconds, then close again.

   - If the distance is larger, the servo remains closed.
   - There is a 200 ms lag between distance readings to avoid reading too fast.

With this code, the servo will move open if any object is detected within a certain distance and re-close after a few seconds.

RESULTS AND DISCUSSION

A. Preparation of the work environment

1. Software Installation

The results of the software test showed that the Arduino IDE was successfully installed on the operating system used. After downloading the installer from the official website, the installation process runs smoothly without any significant obstacles. Users can open the Arduino IDE and start a new project easily. Through the Library Manager on the Arduino IDE, the installation process of libraries such as Servo and Ultrasonic is also successfully carried out

without problems, which allows communication between hardware and software to run smoothly.

Scientifically, the use of the Arduino IDE as a development environment for Arduino microcontrollers has proven to be effective due to its open-source nature and extensive community support. This makes it easier to program and integrate components in microcontroller-based projects like this. The Arduino IDE also provides sufficient functionality for development with dedicated libraries that facilitate the control of servo motors and ultrasonic sensors.

2. Hardware Settings

At the hardware setup stage, initial testing is carried out by connecting the Arduino Uno microcontroller, ultrasonic sensors, servo motor, and power supply. Initial testing showed that each component performed according to the expected specifications. The ultrasonic sensor is capable of detecting objects within the appropriate distance and the movable servo motor opens and closes the bin cover smoothly.

Scientifically, the success of this hardware test shows that the built circuit has followed the basic principles of electronics, in particular in terms of splices between components. The ultrasonic sensor works by utilizing

Ultrasonic waves are used to measure distance, while servo motors work on the principle of angular position control using PWM signals transmitted from Arduino. The success of these early tests proved that the system was working as expected, but technical challenges arose at some point.

3. Problem Resolution

During the hardware testing, several technical issues were found that affected the performance of the tool. The first problem is the servo motor that does not respond well to commands. Based on the analysis, this problem occurs due to insufficient power supply to drive the servo motor optimally. This can happen if the voltage provided does not match the specifications of the motor or if there is a fault in the wiring connection. After ensuring sufficient power and fixing the connection, the servo motor can work properly.

The second problem is the ultrasonic sensor that is unstable in detecting distance. This can be caused by external factors such as signal interference or the quality of the sensor itself. After resetting the parameters in the program code, the sensor can provide a more stable distance reading. This problem can be explained by a basic phenomenon in the use of ultrasonic sensors, which is inaccuracies in readings that often occur due to environmental conditions such as temperature or objects that do not have perfect reflections.

B. Model Making

1. Physical Design of Automatic Trash Bins

At the modeling stage, the physical design of the automatic bin is designed so that the system functions according to its purpose. The trash can cover is designed to move smoothly using a servo motor. The placement of electronic components such as Arduino and ultrasonic sensors in the enclosure also allows for more efficient operation, as it makes it easier to dispose of waste when the bin is full.

Scientifically, this physical design utilizes the basic principles of mechanics and electronics. The placement of the servo motor on the closing mechanism allows for efficient use of power to open and close the bin. The integration of ultrasonic sensors in the lid helps in distance detection to detect objects that are near the bin, so that the system can work automatically.

Figure 1, 4 Final bin

C. System Testing

1. Ultrasonic Sensor Testing

The ultrasonic sensor is tested to detect objects at various distances with the following results:

- The optimal detection distance is between 5 cm to 30 cm, which is the best detection range for the HC-SR04 sensor.
- Accurate output is obtained when there is no interference or interference from external factors such as light or objects that can affect sound waves. Tests show that the sensor can detect objects well within a specified range of distances without interference.

2. Servo Motor Testing

The servo motor is tested to test its ability to open and close the bin lid automatically. The test results of the servo motor are as follows:

- The opening time of the cover is about 2 seconds, and the servo motor successfully closes again after 4 seconds.
- The servo motor functions stably without any mechanical interference that impedes movement. This indicates that the motor can operate properly according to the instructions provided by Arduino.

3. System Integration

Integration testing is carried out by connecting all components (ultrasonic sensors, servo motors, and Arduino). The test results show that the system works properly when all components are integrated:

- Object detection is carried out by an ultrasonic sensor that provides a signal to the Arduino.
- Arduino then processes the signal and sends commands to the servo motor to Open the trash can lid.
- After 4 seconds, the servo motor closes the trash can cover again automatically. This process went smoothly without any significant delays.

CONCLUSION

The conclusion of this study illustrates that the automatic garbage bin system Microcontroller-based successfully fulfills the goal set in the research hypothesis, which is to create an effective and efficient automated system in managing the opening and closing of the garbage can. The scientific findings obtained show that the system successfully integrates key components such as ultrasonic sensors, Arduino Uno, and servo motors well. The ultrasonic sensor can detect objects within the appropriate distance, while the servo motor is able to open and close the trash can cover with a quick response and without major obstacles. The system is proven to reduce direct contact with the bin, improve time efficiency, and is reliable for everyday use. Although there were some technical issues related to the accuracy of the sensor and power supply, the improvements made, such as adjustments to the program code and increased power supply capacity, successfully overcome the constraints and improved the stability of the system. Overall, the study successfully realized an automated bin system that functioned according to the research objectives, with some minor improvements needed to achieve optimal performance.

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