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Internet of Things-Based Automatic Trash Can Prototype Using Arduino Mega 2560

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ABSTRACT

The development of Internet of Things (IoT) technology encourages the creation of various smart device innovations that can be applied in everyday life, one of which is an automatic waste management system. This research aims to design and implement an IoT-based automatic trash can prototype using an Arduino Mega 2560 microcontroller that is able to detect the presence of people who will throw away garbage, open and close the lid of the tub automatically, and provide notification if the trash can is full. This research uses an experimental method by combining ultrasonic sensors, servo motors, and LED indicators as the main components. The test results show that the device works well and in accordance with the researcher's expectations. Ultrasonic sensor 1 can detect the presence of objects in front of the trash can and trigger the servo motor to open and close the lid automatically. Ultrasonic sensors 2 and 3 are also able to detect the height of the garbage and activate the servo motor while the indicator LEDs also function as designed: LED 1 blinks when someone approaches to take out the trash, while LED 2 and LED 3 light up when the sensors detect that the trash has reached a certain height limit. In addition, the system is energy efficient as it only activates when an object is detected, making it suitable for households and educational institutions.

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1. INTRODUCTION

Currently, technology has developed more rapidly and sophisticatedly, many people are utilizing digital devices [1]-[5] so that they can help in doing complicated things [6], one of which is in the field of IoT technology, for example in the world of cleaning such as garbage bins to regulate the opening and closing of trash cans or sorting garbage automatically. With IoT technology, sorting garbage can be easier and more efficient by using sensors controlled by a microcontroller that will control these sensors [7],[8].

Most of the latest technologies today are part of the Internet of Things. The Internet of Things (IoT) is a concept in which an object can transfer data over a network without requiring interaction from humans to computers. IoT can also include other sensor technologies, such as wireless technology or QR codes that are often found in many places. Examples of its application in real-world objects are for food processing, waste

recycling, electronics, and various other machines or technologies that are all connected to local and global networks via embedded and always-on sensors. IoT technology refers to machines or devices that can be identified as virtual representations in their Internet-based structure [9].

Waste is leftover material or material that is unused and no longer considered valuable to individuals or society. Waste is the result of various human activities, including household, commercial, industrial and other activities. Waste can be in the form of various types of materials, such as metal, glass, plastic, tissue, rotten fruit, rotten vegetables, and so on, this waste is divided into two types: organic and non-organic [10].

Waste management in the community has been poorly managed. A lot of people throw garbage in random places, even on the edges of the road, causing odors and an unhealthy and clean environment. This is because many people have low awareness to dispose of waste in its place. Garbage is often disposed of carelessly by the community which can pollute the environment, especially non-organic waste such as plastic bottle waste which is difficult to decompose. On the other hand, when the Covid-19 pandemic occurred, there were many people who were harmed, for example, people who lost their jobs. This has an impact on decreasing community productivity so that an alternative economic sector is needed so that people can still get a decent income. One solution that can be offered is to utilize waste to be used as rupiah value, such as organic waste after the waste decomposes, it will produce maggots commonly called maggots to be used as fishing bait or as fish feed. Non-organic waste such as plastic bottles and the like can be made into papping, or plastic bricks [11].

Research conducted by Rio Ramadhan with the title "prototype of intelligent waste sorting tools based on the Internet of Things". To reduce the amount of waste, you can utilize the waste itself by recycling inorganic and organic types of waste. So that waste can be recycled, it can be used as compost and fertilizer and used as raw material for waste power plants. With the results of the research, the prototype of an intelligent waste sorting device based on the Internet of Things has been successfully carried out. Making a program that is connected between the microcontroller board and the Blynk application runs according to the commands given. The tools or microcontrollers used are WeMo's D1 microcontroller, Arduino Nano, HC-SR04 Ultrasonic sensor module, Inductive Proximity Sensor, Servo Motor, Infrared Sensor. The difference between this research and previous research is in some of the tools used. Previous research: WeMo's D1 microcontroller, Arduino Nano, HC-SR04 Ultrasonic sensor module, Inductive Proximity Sensor, Servo Motor, Infrared Sensor. This research: Arduino mega 2560, bred board, ultrasonic sensors, servo motors, LEDs [12].

Research conducted by Rifa Hanifatunnisa et al, with the background of the problem of waste management in the community is not well managed. A lot of garbage has accumulated in the trash can and causes odors and an unhealthy and clean environment. then research was made with the title "Digitalization of home waste monitoring systems based on the Internet of Things". Based on the test results on the tool, it can be concluded that the load cell sensor for metal waste is able to weigh the garbage with good accuracy based on 12 experiments with different weight garbage, the average percentage error is 2.89%. The load cell sensor for non-metal waste produces an average percentage error of 2.47%. The device built can send test results to the website software using WIFI. The website application can provide information on the weight of the garbage, the capacity of the trash can and the balance. The data displayed by the website application is 100% accurate with the data in the database. The difference between this research and previous research lies in the title. previous research: "Digitalization of home waste monitoring systems based on the Internet of Things". this research: automatic smart trash can prototype based on Internet of Things using Arduino R3 mega 2560 [13].

Research conducted by Wahyuni et al, with the background Along with the growth of the human population in the world, of course, it greatly affects the necessary lifestyle needs, which are followed by a lot of mixed waste so that the separation of metal and non-metal waste becomes very difficult ". So the researcher made a study with the title "Metal And Non-Metal Detection Tools In Smart Trash Can" with the results The speed of the system process depends on the internet connection, the ultrasonic sensor can read the depth of the trash volume of 25 cm, if the contents of the trash volume detect 4 cm then the remaining space of the trash volume is 21 cm, the website system that has been made can monitor the volume of garbage by showing data on the addition of garbage and full garbage data from ultrasonic sensors displayed graphically. The difference between previous research and this research lies in the garbage that is detected. Previous research was used to detect metal and non-metal while this research is only automatic opening and closing because there are 2 trash cans, namely organic and non-organic [14].

The purpose of this program is as an educational material and to optimize environmental pollution caused by garbage that is not disposed of in its place so as to create the impression of a bad, smelly, and dirty environment so that it is not pleasant to look at but on a small scale, another goal of this program is also to facilitate the recycling process by sorting and providing 2 mini trash cans that can open and close the trash can lid automatically and will turn on the LED if the trash can is full through the internet of things-based automatic smart trash can prototype project using Arduino R3 mega 2560. This program is expected to be the first step

to make people care about waste, because this trash can will be able to sort, open and close the trash can lid automatically [15].

2. METHOD

The research method used by researchers is the experimental method, namely by trying to observe and write the results, before the tool is assembled the researcher first designs or designs the components and sensors so that they are connected to each other and the cables must also be connected to any pin.

a. Method

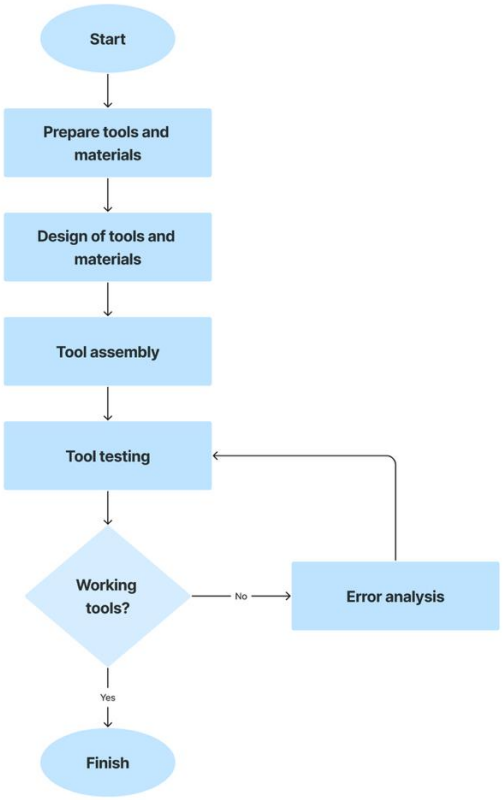

Fig 1. Research flow diagram

In Figure 1 explains the sequence carried out in the research, in the first stage, starting with preparing tools and materials. The second stage is the design stage at this second stage where the researcher determines which pins the sensors must be connected to. The third stage is the stage for assembling the tool. Furthermore, the fourth stage is testing the tool to find out whether the tool works or not, if the tool does not work as desired then the researcher will analyze the error of the tool, but if the tool works as desired then the research is complete.

b. Tools and Material

The tools used in this research consist of two main software, namely Arduino IDE and Fritzing. Arduino IDE is software that functions to write, edit, upload, and manage program code on Arduino-based microcontroller devices. This software plays an important role in the overall system programming stage. Fritzing is an open-source Computer Aided Design (CAD) software designed specifically for creating electronic hardware designs, such as Internet of Things (IoT) projects. Fritzing is widely used by developers, hobbyists, and art practitioners engaged in technology, because of its ability to visualize and document electronic circuit designs systematically.

The materials used in this research include several hardware components, namely Arduino Mega 2560, SRF-05 ultrasonic sensor, servo motor, and jumper cables. Arduino Mega 2560 is an ATmega2560 microcontroller-based developer board that functions as the main control unit in the system being built. The SRF-05 ultrasonic sensor is used as an object detection tool through the principle of sound wave reflection, where in this study three units were used. Servo motors are used to generate high-precision rotational motion, making them suitable for applications that require accurate directional control, such as in robotic systems; two

of these components are used. Meanwhile, jumper cables serve as a medium for connectivity between components without the need for soldering, thus supporting flexibility and efficiency in the process of assembling and testing the system.

c. Tool Design

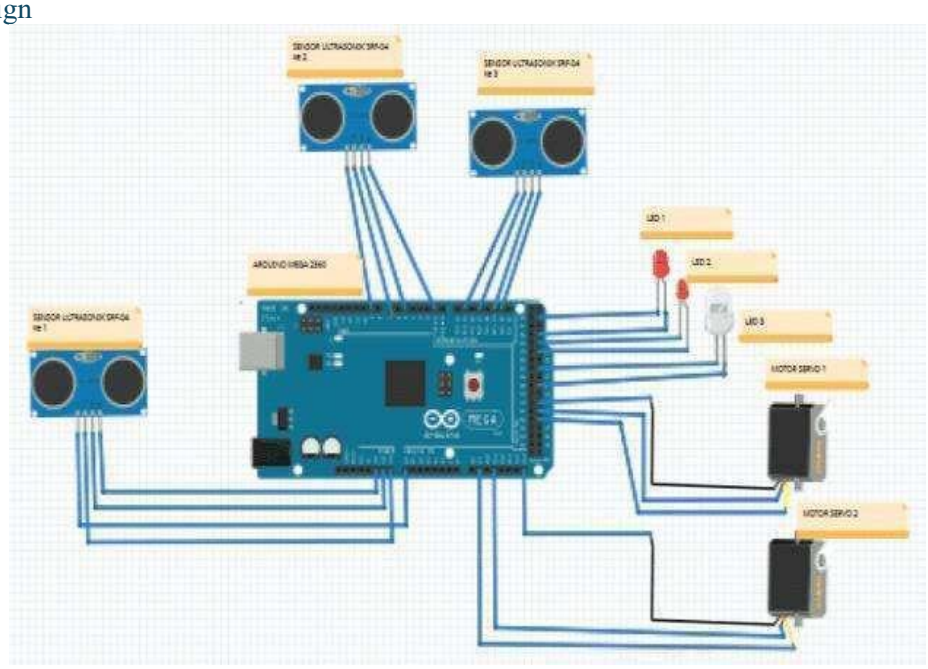

Fig 2. Tool Design

Figure 2 shows the hardware system design, where all components are connected to each other through the pins on the NodeMCU microcontroller board. NodeMCU acts as the control center or main processing unit in this system. The ultrasonic SRF-04 sensor is used to detect the presence of individuals approaching to dispose of garbage. When the object is detected to be within a certain distance, the sensor will send a signal to the microcontroller, which then triggers the activation of the first servo motor to open the trash can lid automatically.

Furthermore, when the waste has been put into the sorting container, the capacitive proximity sensor will detect the type of waste, whether it is organic or inorganic. Based on the detection result, the second servo motor will be activated to direct the sorting container to the left or right side according to the waste classification. In addition, the system is also equipped with additional ultrasonic sensors (second and third sensors) that function to monitor the capacity of the container. If the volume of waste collected exceeds a predetermined threshold, the sensor will provide information that the bin is full, so that it can be emptied immediately.

3. RESULTS AND DISCUSSION

a. Tool Assembly

The tool assembly stage is an important process in system development, which aims to integrate all electronic components into a single working system in accordance with the initial design. This process is carried out systematically to ensure that each component can function optimally in accordance with their respective roles. The assembly is carried out based on the logical sequence of device operation, starting from the input component (sensor), controller (microcontroller), to the actuator (servo motor). Visual documentation of each stage is also included to facilitate understanding and replication of the system. The assembly of the device can be seen in Figure 3.

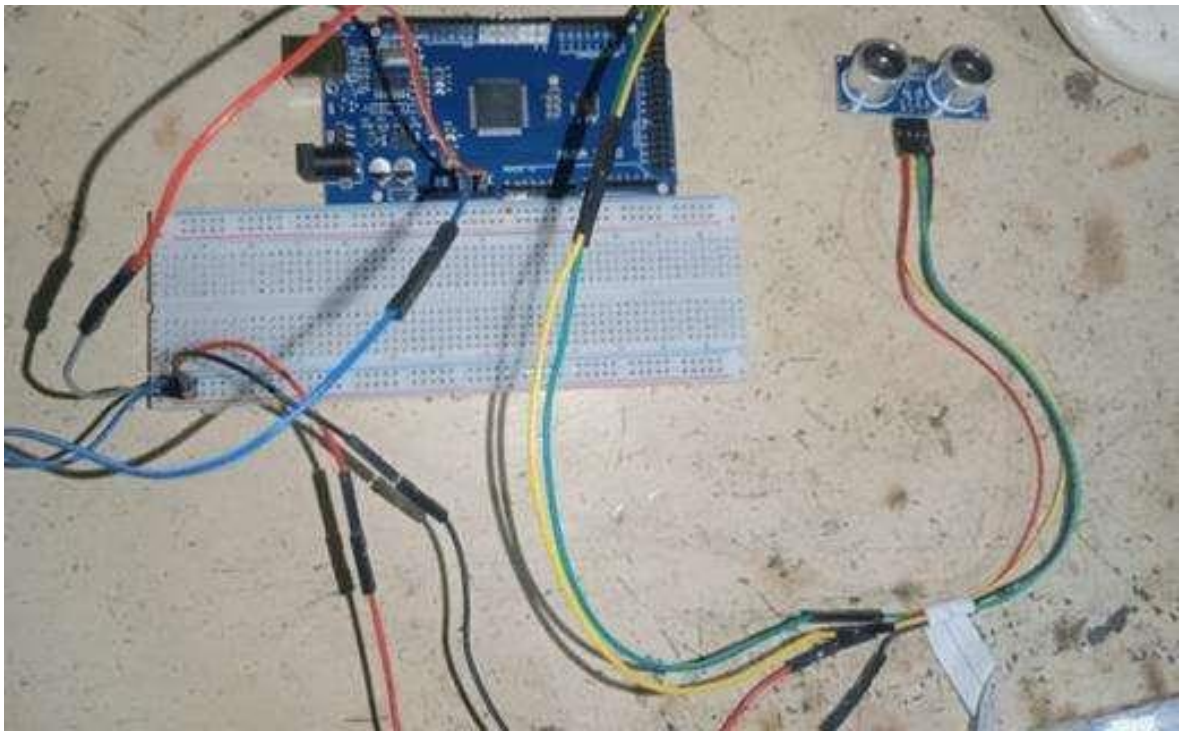

Fig 3. Tool Assembly First Step

The first step in the assembly process is to connect the SRF-04 ultrasonic sensor to the Arduino Mega 2560 microcontroller board. This sensor functions as a detector of the presence of objects around the trash can. The sensor VCC cable is connected to the VCC pin on the Arduino, GND cable to GND, TRIG cable to digital pin D22, and ECHO cable to pin D24 on the Arduino Mega. This wiring aims to ensure that the sensor can transmit and receive ultrasonic wave signals appropriately to detect approaching objects.

The second step connects the first servo motor to the Arduino Mega 2560. This servo motor is tasked with opening and closing the main trash can cover automatically when the ultrasonic sensor detects the presence of people. The connection circuit is done by connecting the motor VCC cable to the Arduino VCC pin, the GND cable to GND, and the signal cable to digital pin D26 on the Arduino. This connection allows the microcontroller to provide control signals to the servo motor precisely.

The third step involves the integration of a second servo motor into the system, which serves to set the direction of waste sorting based on organic and inorganic classification. This motor is connected to the Arduino with a similar wiring configuration: VCC to the Arduino's VCC, GND to GND, and signal output to digital pin D28. This motor will receive a signal from the microcontroller to rotate the sorting container in the appropriate direction based on the readings from the proximity sensor.

The fourth step is the installation of the second and third ultrasonic sensors, which respectively function to detect the height of the garbage pile in the main container and organic container. The second sensor relates to the cable configuration VCC to VCC, GND to GND, TRIG to pin D30, and ECHO to pin D32. While the third sensor relates to TRIG to D34 and ECHO to D36. These two sensors will send data to the microcontroller to determine whether the waste container is full and needs to be emptied, thus supporting the effectiveness of the system.

b. Tool Testing

Table 1. Tool Testing

No.	Tool Name	Function	Working Tools yes/no
1	SRF-04 Ultrasonic Sensor (1)	Detect people who will throw garbage with 20 cm	Yes
2	LED (1)	It blinks twice if the ultrasonic sensor (1) detects a person taking out the trash	Yes
3	Servo motor 1	Will rotate (open the trash can cover) if the ultrasonic sensor (1) detects a person who will throw away the trash with a delay of 3 seconds	Yes
4	Servo motor 2	Will also rotate (open the trash can cover) if the ultrasonic sensor (1) detects a person who will throw away the trash with a delay of 3 seconds	Yes
5	SRF-04 Ultrasonic Sensor (2)	Detect the height of organic waste	Yes

Table 1 shows the system tests carried out to ensure that all components of the device function in accordance with the design and objectives that have been set. Based on the table of test results, it is known that all devices operate properly and respond according to the instructions that have been programmed on the microcontroller.

The first SRF-04 ultrasonic sensor successfully detects the presence of an object (in this case a person who is about to throw garbage) within 20 cm. This detection triggers the rest of the components to start working. As a visual response, the connected LED blinks twice each time the first ultrasonic sensor detects the presence of an object in the garbage disposal area, indicating that the sensor is active and the system is receiving good input.

Furthermore, the first servo motor showed optimal performance by automatically rotating and opening the trash can lid after a delay of 3 seconds from the time the object was detected. Similarly, the second servo motor also worked simultaneously, rotating the mechanical part of the garbage disposal system to complete the process of opening or moving the lid as per the command given by the microcontroller.

Finally, the second SRF-04 ultrasonic sensor works well in detecting the height of the organic waste pile inside the container. The data from this sensor can be used as an indicator of whether the container is full and needs to be emptied. The success of all components in responding to the test scenarios shows that the system has been assembled and programmed effectively and is ready to be implemented in a wider context.

4. CONCLUSION

This tool successfully works according to its purpose, which is to open and close the trash can lid automatically if the ultrasonic sensor detects people who will throw away the trash. This tool is also able to activate LED 1 which will flash if ultrasonic sensor 1 detects objects or people who will take out the trash, LED 2 and 3 can also be active, if ultrasonic sensors 2 and 3 detect the height of the garbage. This device also saves power because it is only active when an object is detected, making it suitable to be applied at home or school places.

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