Design of Organic and Organic Waste Selecting Systems Inorganic Based Microcontroller With Using Proximity Sensors

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ABSTRACT

This study discusses automatic waste sorting devices based on their types, namely organic and inorganic, using inductive and capacitive proximity sensors based on the Internet of Things (IoT). The research background explains that waste is a residual material from industrial or household activities in solid or semi-solid form, both organic and inorganic, which has the ability to decompose or not decompose and is often thrown into the environment because it is no longer useful . To prevent environmental pollution and facilitate the process of recycling waste, it is necessary to sort waste according to its type. Therefore, an automatic waste sorting tool is made using inductive and capacitive proximity sensors. The waterfall system development method is used in this study, namely by carrying out the analysis, design, implementation, and trial stages. The results of this study indicate that automatic waste sorting devices using inductive and capacitive proximity sensors can function properly and sort waste by type with high accuracy. Other research discussed in the literature also contributes to the development of automatic waste sorting tools, such as the use of automatic program logic and ultrasonic.

Keyword : waste sorting; microcontroller; internet of things

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Article history:
Received April, 2024
Revised April, 2024
Accepted Mei, 2024

1. INTRODUCTION

Waste is leftover material from industry or households that is produced in daily human activities or natural processes. According to Akbar, et al (2021), waste can be in solid or semi-solid form and consists of organic and inorganic substances that can be decomposed or cannot be decomposed. Waste that is no longer useful needs to be thrown into the environment.

In the context of waste management, the main difference lies in organic waste and inorganic waste. Organic waste has a relatively fast decomposition process, while inorganic waste tends to take longer. It is important to separate these two types of waste to prevent pollution and facilitate the waste recycling process.

However, in reality, waste sorting is still a problem that often occurs. Especially in developing countries like Indonesia, people still lack discipline in disposing of waste in the right place. This can be seen from the transportation of waste which is still mixed between organic and inorganic waste. Therefore, there needs to be more effective action to overcome this problem.

In research conducted by Hakim (2019), waste sorting has become an activity that should be realized through technological developments. For this reason, it is necessary to develop tools that can automatically sort waste based on type. In this context, Internet of Things (IoT) technology can be used to create more efficient and accurate waste sorting tools.

Based on these problems and needs, this research aims to create an IoT-based waste sorting tool that is able to separate organic and inorganic waste automatically. The method used in this research involves the use of inductive and capacitive proximity sensors. With this tool, it is hoped that it can facilitate the waste sorting process, prevent pollution, and support waste recycling activities.

2. RESEARCH METHOD/MATERIAL AND METHOD/LETERATURE REVIEW

A. Organic Waste
Organic waste is a type of waste that is easily decomposed due to the activity of microorganisms. Organic waste includes food waste, cardboard, cloth, rubber, leather, yard waste, and so on. If managed in the right way, organic waste has the potential to be recycled and provide positive benefits. (Nindya, et al., 2022).

B. Inorganic Waste
Non-organic waste, on the other hand, refers to types of waste that contain materials that are not easily decomposed by microorganisms, such as glass, cans, aluminum and dust. Non-organic waste has the potential to cause environmental damage, and if not managed properly, the amount of waste will increase over time. This contributes to significant waste accumulation.

C. Microcontroller
An Integrated Circuit (IC) containing a CPU, memory, timer, serial and parallel communication channels, input/output ports, and ADC, is known as a microcontroller. Microcontrollers are used to run certain programs and necessary tasks (Widharma, et al., 2022).

A microcontroller can be considered as a computer system where all or some of its elements are packaged in one microcomputer chip. In contrast to computer systems that can handle various applications, microcontrollers are only used for one specific application. One other difference is the comparison of RAM (Random Access Memory) (Zambak, 2022).

The ratio of ROM (Read-Only Memory) and RAM on microcontrollers is generally large, which means that the control program is stored in ROM such as Masked ROM or Flash PEROM which has a relatively larger size. Meanwhile, RAM is used as temporary storage, including registers used by the related microcontroller (Romadhon & Umam, 2021).

D. Capacitive Proximity Sensor
Capacitive proximity sensors are a type of sensor that allows detecting the presence of objects without having to make physical contact. This sensor can detect various types of objects, both made of metal and non-metal, such as wood, plastic, etc. (Sendari et al., 2021).

E. Inductive Proximity Sensor
Inductive proximity sensors are a type of sensor that allows detecting the presence of objects without having to make physical contact. This sensor can detect various types of metal, such as copper, steel, aluminum, and so on (Sendari et al., 2021).

F. Servo Motor
The servo motor device consists of DC motor components, gear mechanism, control circuit, and potentiometer. Attached to the DC motor shaft, the gear mechanism slows down the rotation of the shaft and increases the torque of the servo motor, while the potentiometer functions as a measure of the rotational position of the servo motor shaft by changing its resistance when the motor rotates. Meanwhile, the angle of the servo motor axis is regulated through the width of the pulse sent via the signal cable at the foot of the servo motor (Sendari et al., 2021).

3. RESULTS AND DISCUSSION

A. Analysis of Hardware Requirements
To design a system that functions well and meets the desired needs, a comprehensive and detailed analysis of hardware requirements is required. In this analysis, all components required in the system must be considered, including the microcontroller, proximity sensors, motors or actuators, power supplies, and other electronic components. The following is a table of hardware requirements in

designing a microcontroller-based organic and inorganic waste sorting system with using proximity sensors.

Table 1. Hardware Requirements

Explanation Tool	Name
ESP32	The ESP32 is useful as a microcontroller that controls a microcontroller-based organic and inorganic waste sensors sorting system using proximity. ESP32 is used to control proximity operations, process data, and make waste sorting decisions. Apart from that, the ESP32 also allows wireless sensors communication, integration with sensors, has a fairly large memory capacity, and has low power requirements.
Proximity	Proximity sensors are useful in microcontrollerbased organic and inorganic waste sorting systems. Proximity sensors are used to detect the presence of objects without physical contact. In the context of waste sorting, proximity sensors are used to detect the type of waste entering the system, such as organic and inorganic waste. Information obtained from the proximity sensor is used to control the waste sorting process automatically. With the proximity sensor, the system can accurately identify and separate organic and inorganic waste, thus facilitating efficient waste processing and recycling.
Ultrasonic	Ultrasonic sensors are useful in microcontrollerbased organic and inorganic waste sorting systems. Ultrasonic sensors are used to detect the distance or presence of objects using ultrasonic waves. In the context of waste sorting, ultrasonic sensors can be used to measure the height of waste piles or detect objects entering the sorting system. The waste sorting system can work more precisely and efficiently.
Servo Motor	Servo motors are useful in microcontroller-based organic and inorganic waste sorting systems. Servo motors are used to drive the waste sorting mechanism with precision. In the context of waste sorting, a servo motor is used to adjust the angle or position of the sorting mechanism, so that waste can be separated according to type. Servo motors are capable of providing accurate and stable movements, and can be controlled with a high level of precision via pulse signals sent by a microcontroller. With the servo motor, the waste sorting system can work effectively and produce precise separation between organic and inorganic waste.
HC-SR04	The HCSR04 sensor is useful in microcontrollerbased organic and inorganic waste sorting systems. HCSR04 is an ultrasonic

	sensor used to measure distance using ultrasonic waves. In the context of waste sorting, the HCSR04 sensor can be used to detect the distance between the sensor and the waste object entering the sorting system. Distance information obtained from the HCSR04 sensor can be used to automatically control waste sorting operations, such as regulating the movement of the sorting mechanism or identifying the position of waste objects. With the HCSR04 sensor, the waste sorting system can work with high precision and accuracy, thus enabling efficient and precise sorting of organic and inorganic waste.

B. System Design

The following is the process flow design of the proposed system.

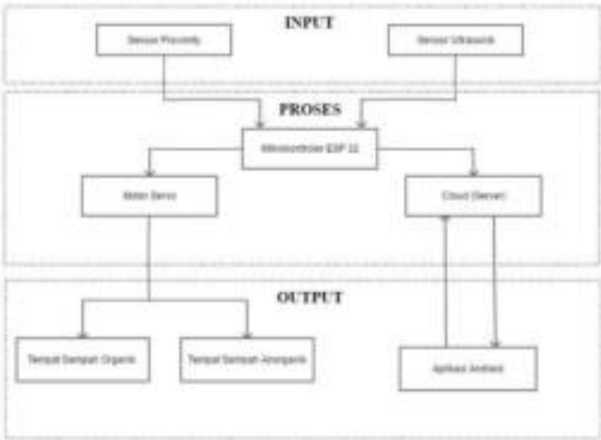

Figure 1. Process Flow

There are 2 inputs to this system, namely a proximity sensor and an ultrasonic sensor. These two sensors will detect the distance and proximity of objects.

Then the data obtained is then processed by the microcontroller, where the microcontroller will detect the type of waste which is then sorted into each type of waste bin. Apart from that, the microcontroller also provides a process for providing information to users via an Android application which will later be sent via the cloud.

Fig 2. Waste Sorting Flowchart

In the given flowchart, the process starts with the proximity sensor as input. This sensor is tasked with detecting the presence of objects, in this case rubbish. Proximity sensors can use inductive or capacitive methods, depending on the type of sensor used.

After the proximity sensor detects the object, the next step is to check the type of trash detected. In the flowchart, there are conditions that differentiate between organic waste and inorganic waste. This condition is useful for making decisions based on the type of waste detected.

Namely moving the servo motor. Servo motors are used to move organic waste storage areas. In this context, the servo motor will be opened to the left, indicating that the organic waste storage area is ready to receive organic waste that has been detected. However, if the proximity sensor does not detect organic waste, it means that the waste detected is inorganic or non-organic waste. In this condition, the process will enter an alternative step, namely moving the servo motor to the right. This shows that the inorganic waste storage area is ready to accept this type of waste. With this flowchart, the system can detect waste automatically using a proximity sensor and moving the servo motor according to the type of waste detected. This will make it easier to sort organic and inorganic waste and ensure that the type of waste entering the storage area is appropriate.

There are several components that play a role in the system. First, the microcontroller that is connected to the internet will function as the main processor in the system. This microcontroller can be the brain of the system, taking data from connected sensors and carrying out data processing and decision making.

Furthermore, the waste volume sensor becomes an important component as input in the system. This sensor is responsible for detecting the height or volume of waste in the storage container. Waste volume sensors usually use technology such as ultrasonic sensors or optical sensors which can measure the height or level of waste with certain precision.

When the waste volume sensor detects that both types of waste containers (organic and inorganic) have reached the full limit, the system will send the data to the cloud server. Cloud servers function as data processing centers that can receive and store information from various devices connected to the network.

After data about the state of the full trash container is sent to the cloud server, the next step is that the cloud server will issue a notification to the user. This notification can be a message sent via a mobile application, email, or text message, depending on the notification mechanism that has been determined. The purpose of this notification is to notify users that the organic and inorganic waste containers are full and need to be emptied immediately.

With this system, users can easily know when a waste container has reached its full limit without having to manually check each container periodically. This simplifies the waste management process, reduces the risk of waste leaks or spills, and allows users to take appropriate action, such as emptying waste containers at the right time.

The microcontroller will process the data and send notifications to users via app or text message. This notification will notify the user that the organic waste container needs to be emptied.

The second use case is that the user receives a notification if the inorganic waste container has reached maximum capacity. In this system, proximity sensors are also installed on inorganic waste containers to monitor the level of waste inside. When the container reaches the full limit, the sensor will detect the change and send a signal to the microcontroller. The microcontroller will process this information and send notifications to users so they know that inorganic waste containers are needed emptied.

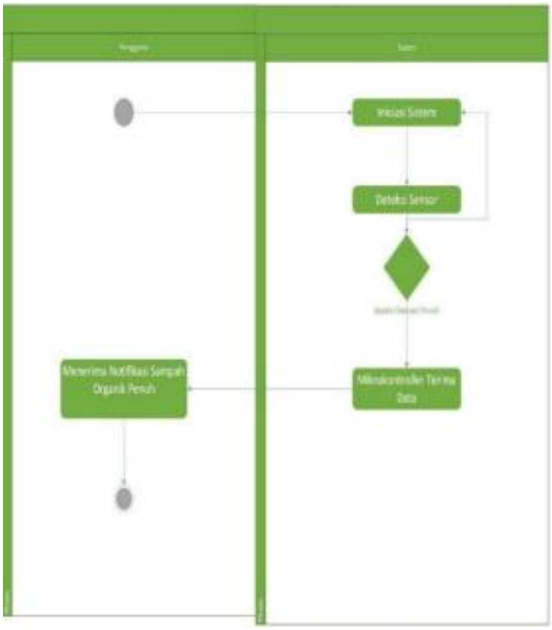

Fig 3. Activity Diagram for Organic Waste

The following is an explanation of the Activity Diagram for the use case "Receive Notification if Organic Waste is Full":

a. The user initiates interaction with the system
b. The system monitors organic waste levels using sensors.
c. The system continuously checks whether the organic waste level has reached the maximum limit.
d. If the organic waste level has not reached the maximum limit, the system continues to monitor.
e. If the organic waste level reaches the maximum limit, the system sends a signal to the microcontroller.
f. The microcontroller receives signals and processes notifications that will be sent to user.
g. Full organic waste notification sent to user.
h. Users receive notifications and respond as needed (for example, emptying organic waste containers).
i. Activity completed.

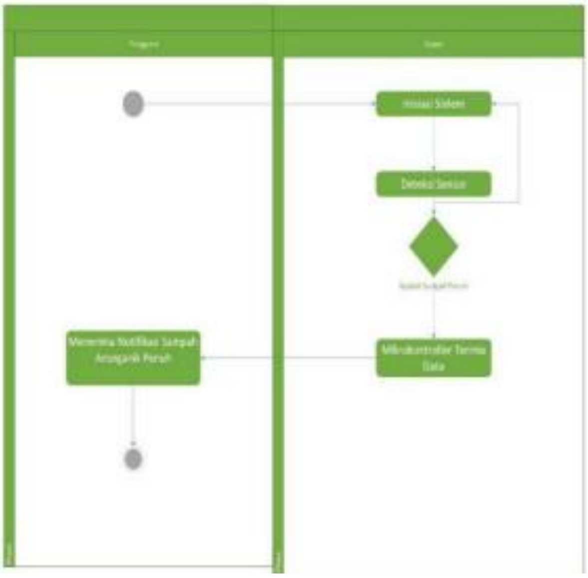

Fig 4. Inorganic Waste Activity

The following is an explanation of the Activity Diagram for the use case "Receive Notification if Garbage Fully Inorganic":

a. The user initiates interaction with the system
b. The system monitors inorganic waste levels using sensors
c. The system continuously checks whether the inorganic waste level has reached the maximum limit
d. If the inorganic waste level has not reached the maximum limit, the system continues to monitor.
e. If the inorganic waste level reaches the maximum limit, the system sends a signal to the microcontroller.
f. The microcontroller receives signals and processes notifications that will be sent to user.
g. Full inorganic waste notification sent to user
h. Users receive notifications and respond as needed (for example, emptying inorganic waste containers).
i. Activity completed.

C. Tool Design

Cal design of organic and inorganic based waste sorting system design microcontroller using a proximity sensor.

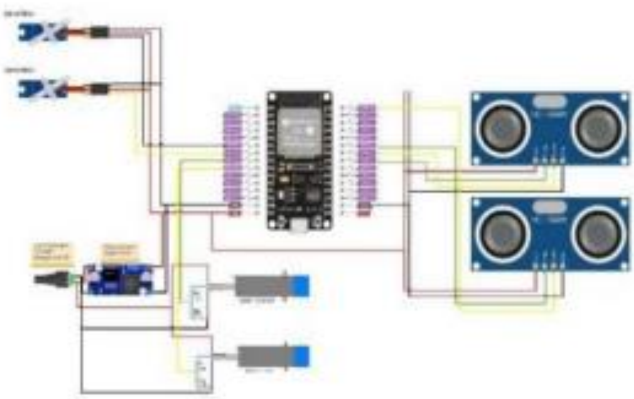

Fig 5. Tool Design

D. ESP 32

ESP32 is a microcontroller used in this system. The ESP32 microcontroller has quite high processing capabilities, allowing the system to perform a variety of complex operations. In addition, the ESP32 is equipped with WiFi and Bluetooth features that allow the system to connect to internet networks and other devices. This allows the system to access online resources, communicate with other devices, and expand its functionality.

E. Capacitive Sensors

Capacitive sensors are used in this system to detect the presence of waste. This sensor works on the capacitance principle, where a change in capacitance occurs when a non-metallic object, such as plastic and paper, interacts with the sensor. Capacitive sensors are very sensitive and capable of detecting objects with high accuracy. Therefore, this sensor is suitable for use in organic and inorganic waste sorting systems, where the recognition and separation of non-metallic objects is an important category.

F. Inductive Sensors

Inductive sensors are used in this system to detect the presence of waste. This sensor works on the principle of electromagnetic induction, where changes in the magnetic field occur when metal objects, such as cans and bottles, are near the sensor. Inductive sensors also have high sensitivity and are able to detect metal objects with good accuracy. Therefore, this sensor is suitable for use in organic and inorganic waste sorting systems, where the recognition and separation of metal objects is an important category.

G. Servo Motors

Servo motors are used in this system to move the organic and inorganic waste storage area. Servo motors are a type of motor that has the ability to control position the angle accurately. By using the control signal provided, the servo motor can drive the storage mechanism with high precision, thus enabling the waste sorting system to place organic and inorganic waste in the desired position. The accuracy and control of servo motors makes them suitable for use in waste sorting systems.

H. HC-SR04

HC-SR04 is used in this system as a proximity sensor. This sensor uses ultrasonic waves to measure the distance between the sensor and an object in front of it. HC-SR04 has good accuracy and is able to detect a distance of up to 4 meters. In a waste sorting system, this proximity sensor is used to detect the presence of a waste object and measure its distance to regulate the next action, such as moving the storage mechanism. The accuracy and distance measurement capabilities of the HC-SR04 make it suitable for use in waste sorting systems that require accurate detection and distance measurement.

4. CONCLUSION

Separating organic and inorganic waste is an important step in preventing environmental pollution and facilitating the waste recycling process. In order to achieve this goal, it is necessary to develop Internet of Things (IoT) based tools that are capable of automatically sorting waste based on type. Several studies have been carried out to create an effective waste sorting tool using proximity and microcontrollers. Proximity sensors such as capacitive and inductive sensors are used to detect the presence of organic and inorganic waste with a good level of sensitivity. A microcontroller, such as the ESP32, is used as the brain of the system which controls sensor operation and makes decisions to separate waste according to type. In developing an IoT-based waste sorting system, the waterfall system development method is used. This method consists of several stages, namely analysis, design, implementation and testing. The analysis stage aims to understand system requirements, including required sensor specifications, connectivity features such as WiFi and Bluetooth on the microcontroller, as well as integration with IoT platforms. The design phase involves designing the overall system architecture, including sensor layout, data processing logic, and interactions with users. The implementation phase involves the physical construction of the system based on the design that has been designed, including installing sensors, connecting microcontrollers, and setting up communications with other devices. The trial phase was carried out to ensure that the system works according to a previously determined design. If problems or deficiencies are found, an evaluation is carried out and improvements are made to improve system performance and quality. Apart from that, analysis of hardware requirements is also carried out in the development of waste sorting tools. This aims to design a system that is able to function well and meet the desired needs. This analysis includes selecting the right sensor, selecting a microcontroller that has adequate capabilities, as well as planning resources such as electrical power and computing power needed. By developing an IoT-based waste sorting system and applying the waterfall system development method, it is hoped that we can create a waste sorting tool that is efficient, accurate and functions well. It is hoped that this tool can facilitate the waste sorting process, prevent environmental pollution, and support waste recycling activities to achieve sustainability goals and better waste management.

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