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DESIGN OF AN AUTOMATIC WASTE SORTER EQUIPMENT BASED ON THE INTERNET OF THINGS (IoT)

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Abstract
Waste is a serious environmental problem in various countries, including Indonesia. To reduce this problem, one way to overcome the waste problem is to short the waste into organic and inorganic waste to recycle waste. Therefore this research to build an automatic waste sorting equipment by using internet of things (IoT) technology as a remote monitoring system. The research method uses hardware and software design as well as to testing and analysis. This research uses several sensors, namely proximity sensors, infrared sensors, DHT21 humidity sensors and ultrasonic sensors. These sensors are connected to the microcontroller Arduino UNO and send data via the wifi module NodeMCU ESP8266. The output of waste sorter using servomotor MG996R and displaying organic and inorganic waste in Android application based Firebase as a database. The condition monitoring of the trash when it is full and empty using android application on smartphone. The results in this research are for the detection of waste object, the sensors work at a maximum distance of 5 cm. The ultrasonic sensor for detecting waste level is 15 cm for full condition, 15-30 cm for half and 31 cm for empty condition. The result of sending data to smartphone for all level conditionof waste are appropriate.
Keywords: *Waste Sorter Equipment, IoT, Arduino Uno, NodeMCU ESP8266, Smartphone*

INTRODUCTION

Waste is one of the serious environmental problems in various countries including Indonesia country. Waste is leftover goods from human activities and consumption, which have been thrown away and are no longer economically valuable. Indirectly, there is a change in people's consumption patterns which also causes various types of waste to increase. (Ikadek et al., 2022). Continuous development accompanied by population growth and economic growth can have both positive and negative impact. One of them is changes people's consumption patterns which can ultimately give rise to new problems, including the waste problem. This is increasingly becoming with the increasing amount of waste produced every day so that the volume of waste always increase every da. Waste not only creates health and environmental problems, but can also result in significant economic impacts (Irahman et al., nd). In the negative impacts on the community environment, the government has provided rubbish disposal but public awareness in disposing of rubbish is not appropriate. So the waste itself consists of organic or inorganic waste which should be sorted during disposal to make it easier for cleaning staff to select materials that can be recycled or thrown away. One way that can be done is using Internet of Things (IoT) to waste sorting is an automatic. (Mualief et al., 2021).

Another problem that arises in waste management is the problem of disposing of waste which must be disposed of its proper place and transportation waste taht is late cause rubbish to pile up and become scattered. Internet of Things (IoT) technology is a technology that is able to connect various electronic devices to the Internet and form a network that can be accessed remotely. This IoT technology is used in various devices such as household, vehicle, health and industrial devices. In waste management, IoT technology can be utilized and used to facilitate the waste sorting process. (Hani et al., 2019). Based on several problems described above, in this research an automatic organic and inorganic waste sorting system was cerated using IoT technology that can information full and empty waste in smartphone. Waste sorter will be equipped with sensors that can detect the type of incoming garbage and then sort it automatically. Software design is used for interface applications using Android-based smartphones that function as trash can monitoring tools. With this automatic waste sorting tool, it is expected to increase public awareness to sort waste properly and ultimately can help reduce waste problems in the surrounding environment, so as to increase efficiency and effectiveness in waste management. The image of the trash can on the smartphone will be empty, data about the amount and type of waste produced or the capacity of the trash can when it is full will immediately provide information or short notifications to make it easier for users or officers to find out the capacity of the trash can.

RESEARCH METHODS

The steps in research methodology are used to facilitate step-by-step research activities such as collecting data related to research, designing tools, results, discussing and testing and evaluating research related to research objectives.

Waste Sorting System Block Diagram

Hardware design involves the process of designing, developing, and creating the physical components that make up a unified system. This includes component selection, architectural determination, layout planning, material selection, electronic circuit design, and integration of components into a system that can function according to predetermined needs.

In block diagram figure 1 it is E18-D80NK infrared sensor, inductive and capasitive proximity sensor, DHT21 humadity sensor and HC-SR04 ultrasonic sensor are the input for waste sorter which detects organic and inorganic waste whether full or empty waste. The Arduino UNO as a microcontroller will receive data and transmit data by ESP8266 wifi module via the internet. The Firebase application will sent data to smartphone. MG996R

motorservo as actuator will carry out movements in sorting organic and inorganics waste into the container provided.

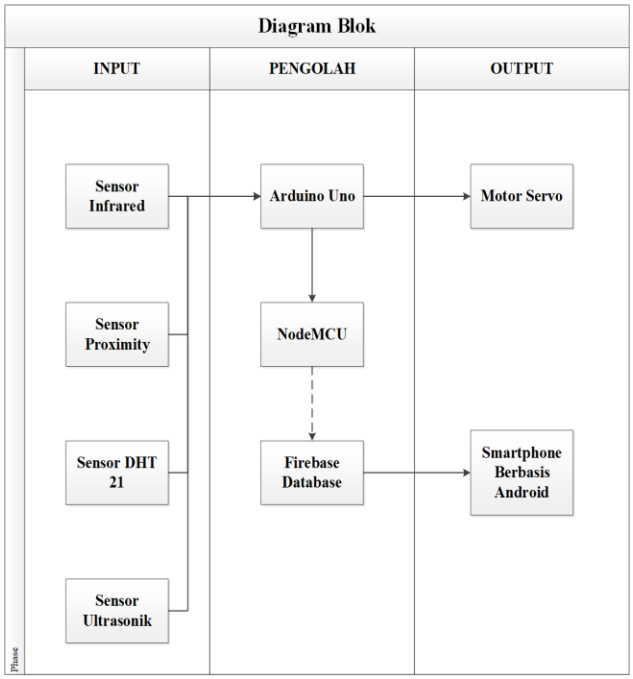


Figure 1. Waste separation system block diagram

Hardware Design

This section is part of the hardware design in the electronic components for this waste sorting system. The components used consist of the E18-D80NK infrared sensor, PL-05N proximity sensor, DHT21 humidity sensor, HC-SR04 ultrasonic sensor, Arduino UNO R3 microcontroller, NodeMCU ESP8266 and MG996R servo motor.

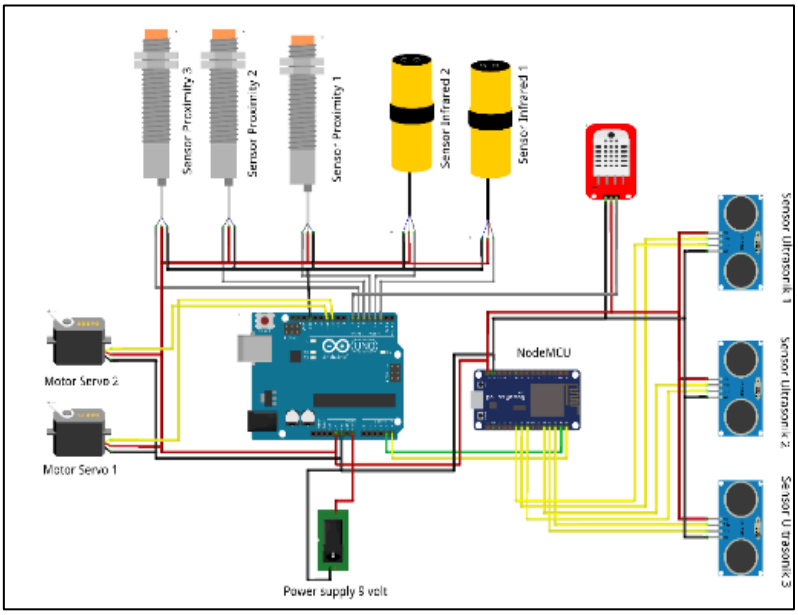


Figure 2. Waste separation device circuits

Software Design

The program that will be embeded into the Arduino UNO and NodeMCU ESP8266 microcontroller. Each Arduino UNO and NodeMCU pin that will be used must be defined when the program is compiled and uploaded it will be able to read and to commands as expected. (Andi et al., (2021). This programming determines whether the components that have been assembled are capable of operating or not in accordance with the design that has been made. In Figure 3, a flowchart is given which describes the algorithm of the software system being created.

Software visualization, flowcharts are used to illustrate the flow of the expected system or application. Flowchart of the garbage separation application. The activity begins with the initialization of program code on Arduino and NodeMCU, then the internet network connection. After connecting to the internet, the reading of the type of metal or non-metal waste. If the waste is metal, the servo motor is on the metal barrel container, and if the type of waste is non-metal, the servo motor drops the waste on the second container to sort whether the type is organic or non-organic. Ultrasonic sensor readings to find out the trash can container is full or cannot be seen in the monitoring application, if it is full then a full notification appears

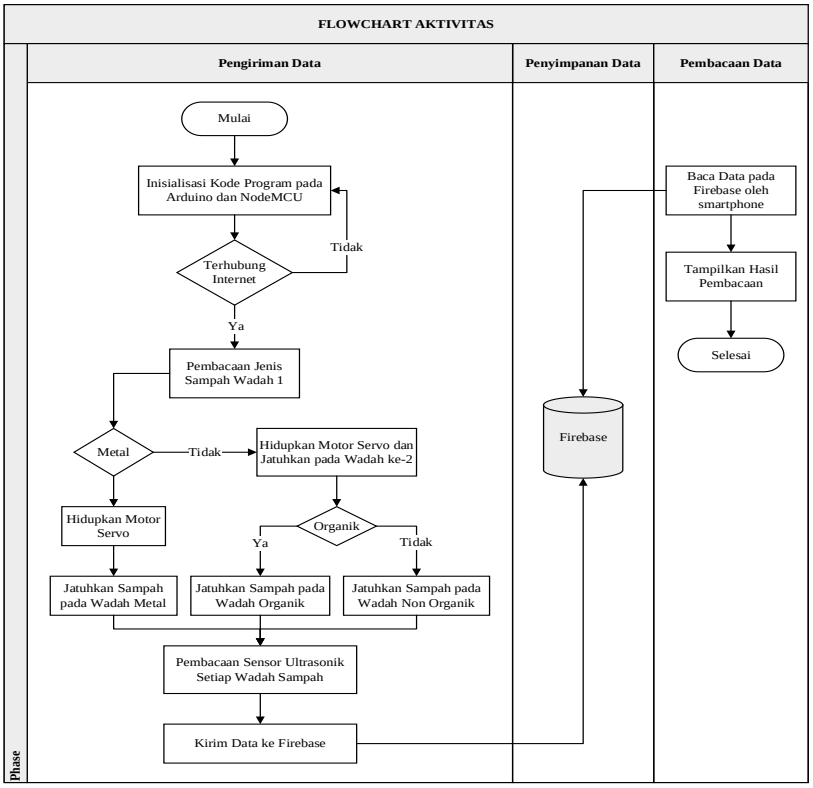


Figure 3. Flowchart software design

Designing application interfaces using Kondular. Concordular as one of the platforms that can make it easier for users to create user interfaces (UI), organize business logic, and connect it with various services and resources such as databases, cloud storage, or other third-party services. In designing flow diagrams, making interface applications to facilitate coding application programs. begins with "Screen Initiation". This stage can include initial display setup, and other preparation before reading data from Firebase. After the "Screen Initiation" stage, the next step is "Read Firebase data"

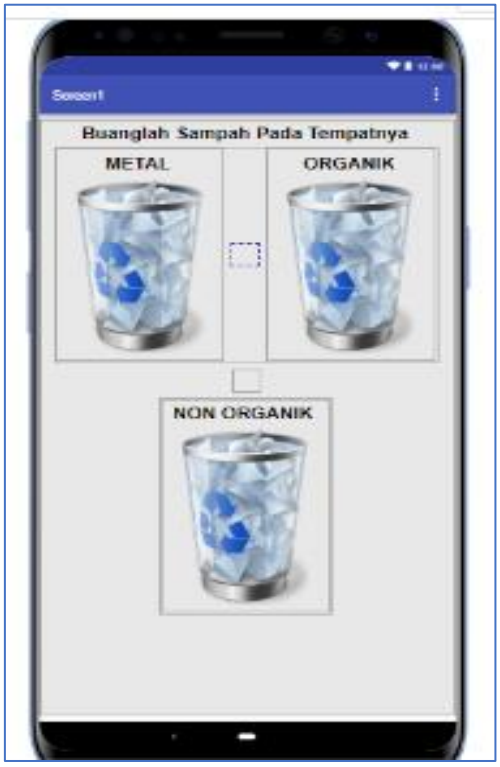


Figure 4. App design *interface*

It will access Firebase database and read the data it needs. Once the Firebase data is read, the system displays the read data that has been obtained from Firebase and will be displayed on the screen or user interface, in which this section will involve processing the data, setting the display, or formatting the data before it is displayed to the user. After the "Show reading data" stage, there are several possible streams, namely "Full Organic", "Full Metal", and "Full Non-Organic". The stream retrieved depends on the results of the data readings that have been displayed previously.

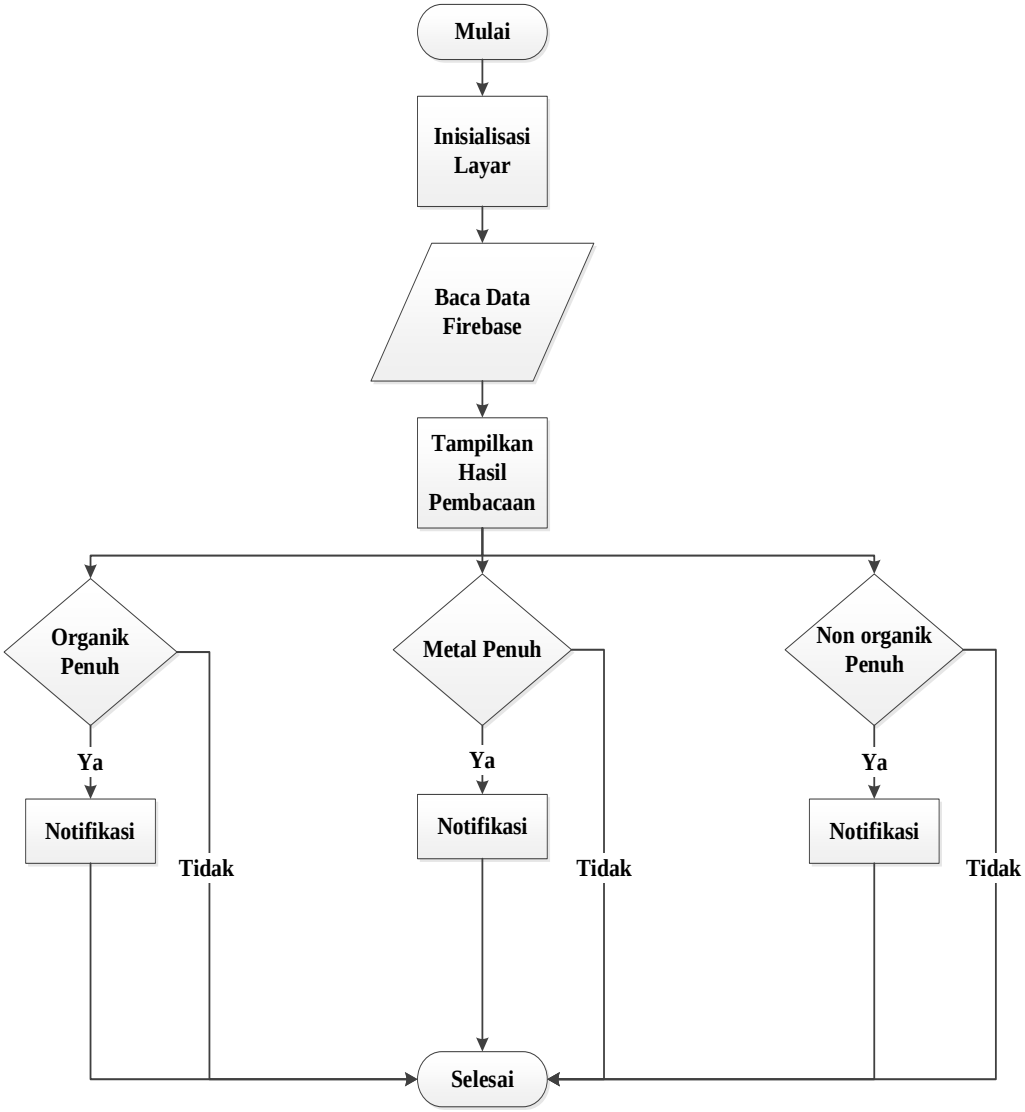


Figure 5. Application flowchart *interface*

RESULTS AND DISCUSSION

The design results of IoT-based automatic waste sorting consist of two main parts: first, mechanical design in the form of a waste sorting device equipped with an automatic sorting mechanism to detect and sort types of waste efficiently. Second, integration with user interfaces or applications that allow waste separation equipment to provide direct notifications to users when the trash can has reached full capacity.

Mechanical Design

The mechanical design of the waste sorting device is designed with a more efficient mechanical system. In addition, there is an automatic sorting system by sensor infrared E18-D80NK to detect and sensor proximity to recognize the type of incoming waste.

Figure 6. Top view design

Figure 7. Front view design

Electrical Design

The following describes each part or component contained in the tool that has been developed.

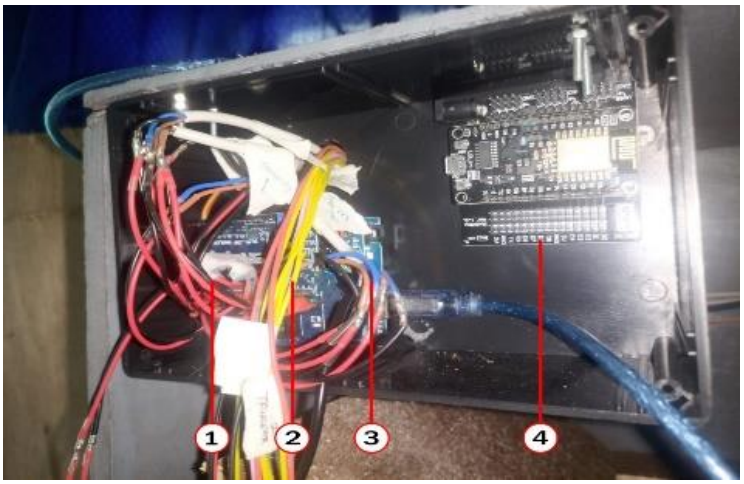
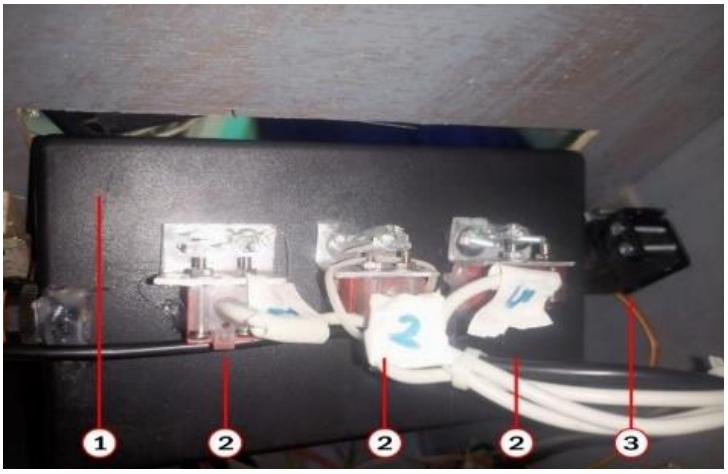


Figure 8. Electrical circuit design

In the picture above, this part is a control circuit consisting of four main components: Sensor Shield, Servo Shield, Arduino Uno and NodeMCU. Here are the functions of each component contained in the control circuit.



Picture 9. First sorting network

In the picture above, this section is the first series of sorting or as the first container to sort or distinguish types of waste that contain metal and types of waste that do not contain metal.

Figure 10. Second sorting network

In the figure above, this section is a second series of sorting controls or as a second container to sort or distinguish types of waste containing Organic and Non-Organic. If the DHT sensor detects (warm temperature and high humidity), it will move to the left which indicates the type of waste is Organic. Conversely, if the DHT sensor does not detect temperature and humidity, it will move to the right which indicates that the waste is a type of Non-Organic waste.

Figure 11. Shelter container

In the picture above, this part is an ultrasonic sensor that is used to measure the depth of the garbage can (cm), and three garbage cans with the division of different types of waste.

Application Interface Design Results

The result of designing a user interface or Android-based application as a liaison used to provide short notice to users regarding the capacity of the trash can. To get a brief notice regarding the capacity of the garbage can, in this section an ultrasonic sensor is functioned with a simple algorithm, where if it is smaller or equal to 15 cm, then the image of the trash can on the smartphone is empty. Conversely, if it is greater than or equal to 14 cm, then the image of the trash can on the smartphone will be full. Here's what the application looks like, shown in the image below.

Figure 12. Application image in smartphone

A brief notification of the application looks like when the waste cans capacity is full, shown in the image below.

Figure 13. Full waste cans notification

Test Results

At this stage the tool testing process includes several parts such as, set point testing which aims to determine the set of numbers to light up, waste sorting testing, and electricity consumption testing.

Table 1. Testing *set point*

Test	Sensor	Level	ReadingSensor	Voltage	Status
1	Infrared Type NPN	Distance 21 - 80 cm	1	0 V	Off
		Distance 11 - 20 cm	1	0 V	Off
		Distance 3 - 10 cm	0	5 V	ON
2	Ultrasonic	Distance 31 - 400 cm	31 - 400 cm	5.0 V	Not Detecting
		Distance 15 - 30 cm	15 - 30 cm	5.0 V	The trash can is not full
		Distance 2 - 15 cm	2 - 15 cm	5.0 V	Full Trash

Table 2. Garbage sorting testing

No	Type	Infrared 1	Proximity 1	Proximity 2	Proximity 3	Infrared 2	DHT	Result
1	Tin bottle	detecting	detecting	detecting	detecting	Not detecting	Not detecting	metal waste
2	Plastic bottle	detecting	Not detecting	Not detecting	Not detecting	detecting	Temp < 35^{o}C humidity < 80	non organic
3	Vegetable plastic	detecting	Not detecting	Not detecting	Not detecting	detecting	Temp < 38^{o}C humidity < 81	organic
4	Cup	detecting	Not detecting	Not detecting	Not detecting	detecting	Temp < 35^{o}C humidity < 90	non organic

CONCLUSION AND SUGGESTION

Based on the research findings it can be concluded that: This waste sorter equipment is build with sensors to detect the type of waste and sort it automatically, so it is expected to increase public awareness about proper waste sorting, to reduce waste problems and increase efficiency in waste management. The results in this research are for the detection of waste object, the sensors work at a maximum distance of 5 cm. The ultrasonic sensor for detecting waste level is 15 cm for full condition, 15-30 cm for half and 31 cm for empty condition. The result of sending data to smartphone for all level conditionof waste are appropriate.

Thus, several suggestions that can be put forward are to development tool project, it is necessary to conduct in-depth research on IoT technology and its application in waste management. Choosing the right sensors and safe and stable IoT technology is key in designing this tool. Controlled trials in relevant environments and collaboration with relevant parties will help validate the performance of these waste separation equipment and ensure the necessary support for their implementation. Public education about the importance of waste sorting and the benefits of this waste sorting tool will be key in increasing community participation in waste management.

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