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Development of an Internet of Things-Based Garbage Collection Robot

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***Abstract*— The problem of garbage is not a new thing from the past until now, garbage is still the center of attention and a prolonged problem because of the various impacts of the problems that are caused and felt. Many factors are the cause of the increasing amount of garbage every day, including the lack of self-awareness about maintaining cleanliness and disposing of garbage in its place. This study aims to develop an IoT-based garbage collection robot. The method in developing this garbage collection robot is using the Fuzzy Mamdani method. The IoT-based garbage collection robot is designed using the Arduino Uno microcontroller as well as the Node MCU ESP 8266, HC-SR04 sensor, DHT11 sensor, SG90 Servo motor, DC motor and L298N motor driver. The way this robot works is to detect the distance with the HC-SR04 sensor as a distance data input then processed by the Arduino microcontroller and then the SG90 servo motor will move to clamp the garbage automatically and for the robot using control via a smartphone to be directed to the destination garbage. The results of this study are that the robot can clamp or pick up garbage with a distance of less than 5 cm and can control the speed of a DC motor using the fuzzy Mamdani method.**

***Index Terms*— Arduino uno; Fuzzy Mamdani; HC-SR04 Sensor; Node MCU ESP8266; Garbage.**

I. INTRODUCTION

The garbage problem is not a new thing anymore from the past to the present, garbage is still the center of attention and a prolonged problem due to the various impacts of the problems caused and felt. There are many factors that cause the increasing amount of garbage every day, including the lack of awareness in oneself about maintaining cleanliness and throwing garbage in its place. Especially now that there is a Covid-19 pandemic that has hit the whole world, one of which is in Indonesia. The Indonesian government in stopping the pace of Covid-19 has also issued policies and statements in the form of work from home (WFH), Social distancing, Large Scale Social Restrictions (PSBB) and so on, which will affect the joints of people's lives[1].

During the Covid-19 pandemic, garbage can become very dangerous due to the nature of the virus that can last up to several days on inanimate objects [2]. Therefore, it is very important to be able to maintain the cleanliness of the environment by disposing of garbage in its place and also cleaning up scattered garbage to be able to avoid various impacts that occur, especially during the current pandemic, it can minimize the spread of the Covid-19 virus which can live in the inanimate object, one of which is garbage.

In the current era of the industrial revolution 4.0, technology plays an important role in everyday life. Technology is one of the needs and cannot be separated in all activities carried out, because technology makes all activities easier [2], faster, and also efficient [3]. Therefore, it is necessary to have new innovations created to be utilized and used in an effort to improve existing technological advances. In the use of technology to be able to facilitate work and also all activities carried out in the current era of revolution 4.0, robot technology continues to be developed. Developed countries such as Japan use robots to be able to help with human work [4]. Robots are made to facilitate human work which has been burdensome for some humans [5], [6].

Garbage problems can be overcome by utilizing technology, one of the efforts that continues to be carried out, one of which is by developing robot technology to be implemented as a garbage cleaning tool [7], [8]. In this study, an internet-based garbage collection robot of things will be developed which can be controlled via a smartphone, making it easier to clean up garbage and becoming one of the efforts to maintain environmental cleanliness during the Covid-19 pandemic.

II. RESEARCH MODELS AND METHODS

The method in this study used a waterfall model and used the fuzzy Mamdani method [9]. The stages in this method are planning, analysis, system design, design, and testing of results.

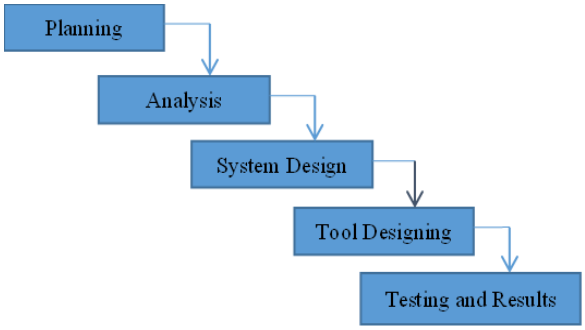

Figure 1. Waterfall model

A. *Planning*

Make plans related to how the performance and benefits of the system will be made. Planning various components of tools and materials that will be used in the manufacture of the Internet of Things-Based Garbage Collection Robot system where this robot will later use two microcontrollers that will control the system of this robot, namely the Arduino Uno microcontroller and also NodeMCu ESP 8266. For the development of this Internet of Things-Based Garbage Collector robot using the Fuzzy Mamdani Logic method.

In this planning stage, namely by analyzing the hardware needed in the development of IoT-based garbage collection robots, including:

- Arduino Uno
- NodeMCU Esp 8266
- Servo Motor
- DC motor
- Ultrasonic Sensors
- DHT 11 sensor
- L298N driver

The software needed in designing an internet of things-based garbage collection robot is :

- Arduino IDE for programming or coding microcontrollers
- Fritzing to design an electronic scheme for the manufacture of IoT-based garbage collection robots
- Matlab to determine the result of the calculation of the fuzzy Mamdani method

B. *Analysis*

Analyze how the robot works when the fuzzy Mamdani logic method is applied in regulating the speed of the DC motor. In analyzing the fuzzy Mamdani method where in this method there are two sensor inputs, namely the ultrasonic sensor and the DHT 11 sensor, it will then produce an output in the form of a DC motor rate velocity.

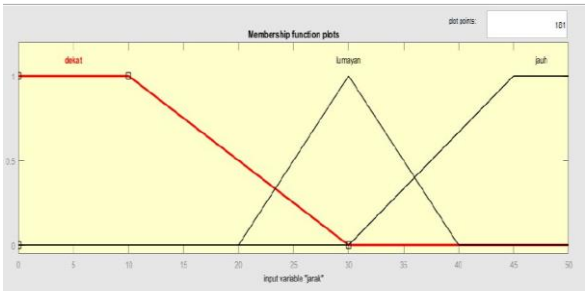

Figure 2. Distance Membership Function

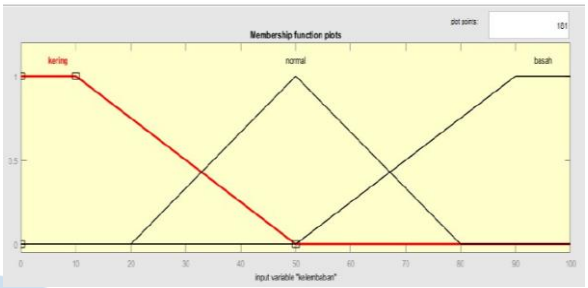

Figure 3. Moisture Membership Function

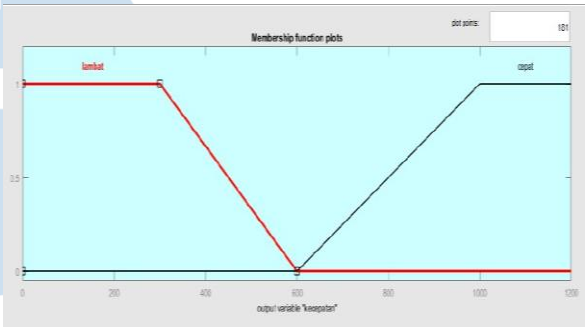

Figure 4. Speed Membership Function

Rules

- R1 : If Near And Wet Then Slow
- R2 : If Far And Normal Then slow
- R3 : If Not bad And dry then slow
- R4 : If Near And Dry Then Quickly
- R5 : If Far And Wet Then Fast
- R6 : If Not Bad And Normal Then Fast

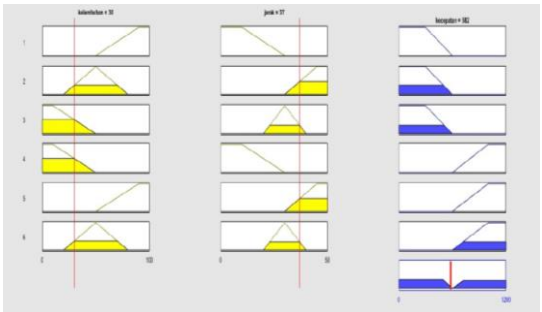

Figure 5. Fuzzy Mamdani Calculation

C. System Design

Designing how the system scheme will be made is by using a fritzing application. The fritzing application itself is widely used to design the design scheme of electronic devices to be made [10]. The following is the result of the design of the robot system using the Fritzing application.

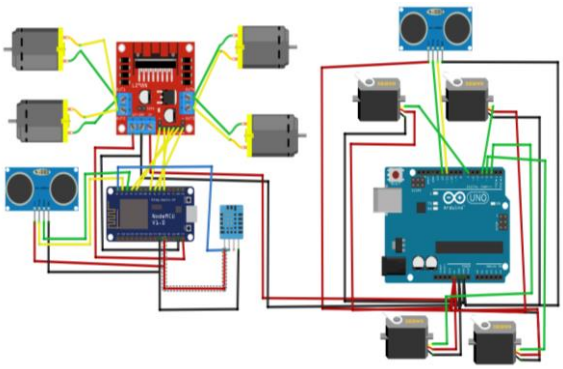

Figure 6. IoT-based Garbage Robot Circuit Schematic Design

From Fig. 6, it can be seen that the system design of the robot uses two microcontrollers, namely Arduino Uno and NodeMCU ESP 8266. There are four SG90 servos as a garbage stamping crust. L298N motor driver that regulates the speed of DC motors, ultrasonic sensors as a detection of obstacles [11] and also garbage, as well as a DHT 11 sensor to measure humidity [12] in the garbage box. Here is the flowchat system (Fig. 8) on the internet of things-based garbage collection robot.

In the garbage collection system, it uses a robotic arm system that functions to stamp garbage. The garbage collection arm uses a 4-servo motor crust that will move to stamp the garbage, while to detect the garbage using the HC-SR04 sensor. On the side of the robotic arm, a box is made that functions to hold the garbage that has been collected (Fig. 7).

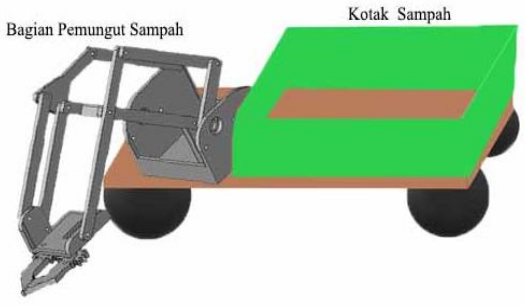

Figure 7. Prototype Design of IoT-Based Garbage Collection Robot

The design of the basic garbage collection robot uses boards to support various components of the garbage collection robot. For the crusting part, it uses 4 displaced wheels to walk the garbage collection robot to the garbage to be collected.

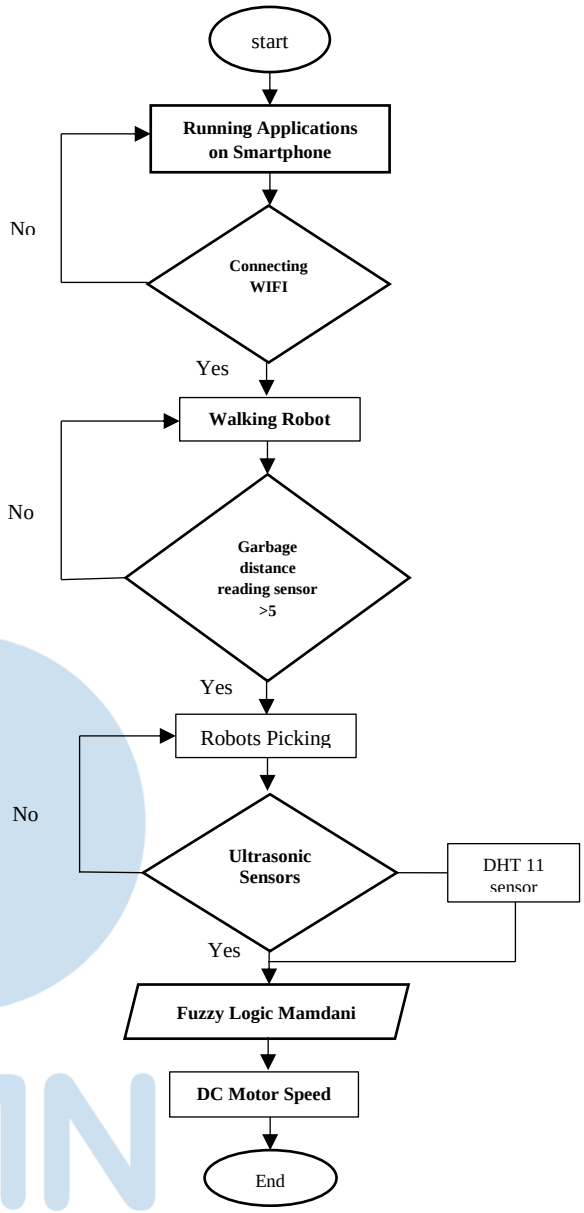

Figure 8. Robotic Flowchart

D. Tool Designing

Designing various components of the tool directly according to the design that has been made. Connects every pin present on the Node MCU Esp. 8266 component, Arduino UNO, HC-SR04 sensor, DHT 11 sensor and SG90 servo motor. In designing the tool, you must be careful to connect each pin on each component, because each pin on the electronic component has its own function.

Hardware design using a prototype model as follows:

- Ultrasonic sensor HC-SR04 as input detection [13] of objects or garbage to be collected
- Using a DC Motor as a wheel crust to run the robot system to the garbage to be collected

- Using the SG90 servo motor as a robotic arm crust that functions as a stamper and lifts the garbage to the garbage box
- Using ultrasonic sensors detects garbage capacity and to be able to regulate the speed of the running DC motor
- As well as a smartphone as a connector and controller of the direction of the running robot.
- DHT 11 sensor as a sandbox moisture counterh.

E. Testing and Results

Testing the IoT-based garbage collection robot that has been made whether it is in accordance with what is expected or needed. Then the results obtained from the experiment will be a reference on how the system works and the functioning of the system. For the due diligence plan of the IoT-based garbage collection robot work system using a scoring table based on user ratings. Furthermore, the results of the validation test assessment are calculated in the following way:

$$\text{percentage score} = \frac{\Sigma \text{ earned score}}{\Sigma \text{ maximum score}} \times 100\% \quad (1)$$

The percentage of score obtained is then measured using the score interpration for the Likert scale [14].

TABLE I. ELIGIBILITY CRITERIA GUIDELINES

Percentage	Interpretation
0%-25%	Very Unworthy
26%-50%	Not Worth It
51%-75%	Proper
76%-100%	Very Worthy

To be able to find out the response of users to develop IoT-based garbage collection robots, you can see from the likert scale table. From this likert scale, you can find out how the assessment of the work system from the robot can be used directly in cleaning up scattered garbage.

TABLE II. LINKERT ASSESSMENT SCALE

Criteria	Value
Less viable	1
Decent Enough	2
Proper	3
Very Worthy	4

III. RESULTS AND DISCUSSION

A. Results

This robot prototype is used to clean up scattered garbage, namely by stamping every garbage that you want to dispose of by being controlled through a smartphone then the HC SR04 ultrasonic sensor detects the object or garbage then automatically the robot picks up the garbage.

Figure 9. Prototype Robot Picking Up Garbage

In the garbage collection robot, the initial appearance of the robot runs using 4 DC motor wheels as a robotic speed booster [15]. As a series of robot supports, there is a rectangular acrylic as the base of the robot system. As a stamping system, it uses arm robots and ultrasonic sensors as inputs for detecting objects or garbage (Fig.10). On the left there is a garbage box as a place to collect garbage that has been collected.

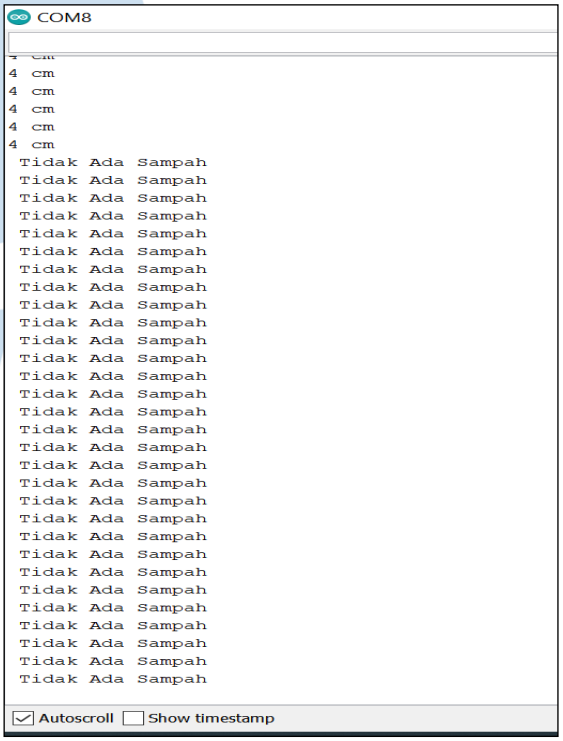

Figure 10. Ultrasonic Sensor Testing Monitor

At the testing stage, this tool aims to find out whether the system can pick up garbage that has been directed through an IoT-based smartphone, then the system picks up the garbage automatically through reading the distance of the garbage with the robot. The test results of this tool get the results in Table 3 and Table 4.

TABLE III. ULTRASONIC SENSOR TESTING

Testing	Distance (*cm*)	Garbage Detected
1	20	Undetectable Garbage
2	15	Undetectable Garbage
3	10	Undetectable Garbage
4	<5	Garbage Detected

TABLE IV. MAMDANI FUZZY TESTING

No	Humidity	Distance (*cm*)	DC Motor Speed
1	35	40	261
2	20	25	490
3	30	37	582
4	50	25	950
5	80	50	970

In testing the Fuzzy Mamdani method implemented in this IoT-based garbage collection robot (Fig. 11), it produces an output, namely the speed on the DC motor which will run quickly and slowly depending on the two inputs obtained from the ultrasonic sensor and the DHT11 sensor.

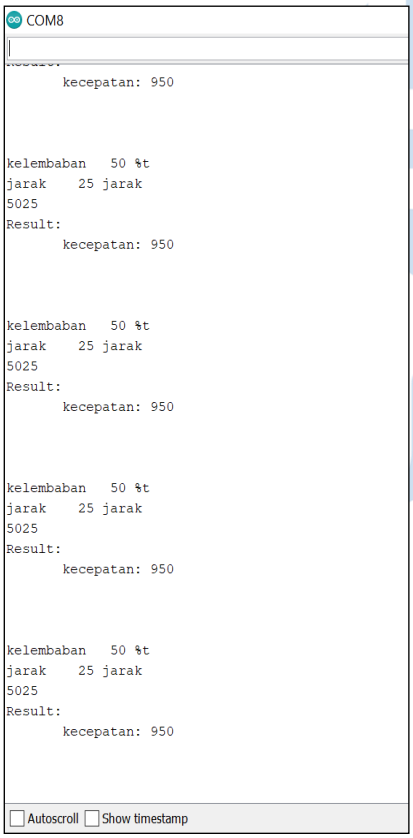

Figure 11. Serial Results of The Mamdani Fuzzy Test Monitor

B. *Discussions*

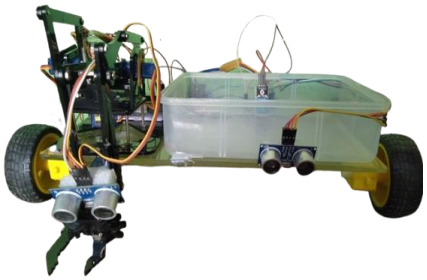

Figure 12. IoT-based Garbage Collection Robot

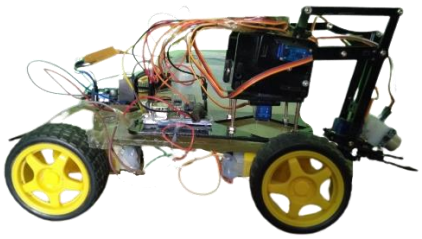

Figure 13. Robot View From The Side

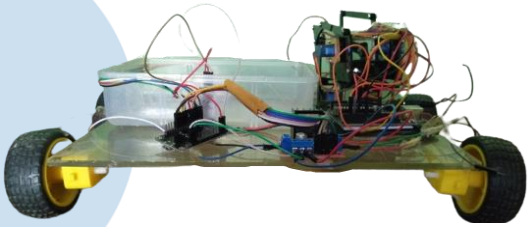

Figure 14. Robot View From Behind

This Internet of Things-based garbage collection robot is able to pick up garbage automatically with a garbage distance of less than 5 cm (Table 3). Then the garbage that has been collected is then put in the trash box. In the servo, the delay duration of each servo that moves to pick up garbage is set, which is for 5 seconds for a time lag for each servo movement. For the HC-SR 04 sensor as a garbage detector, the time is for 3 seconds every time it detects garbage. After the robot picks up and puts the garbage, then the robot will move to its original position to be able to pick up the detected garbage. Besides being able to pick up garbage, this robot can also detect various objects that you want to pick up or collect. This IoT-based garbage collection robot is able to pick up garbage with a load of up to 400 grams.

The method used in the development of iot-based garbage collection robots is the fuzzy Mamdani method, where there are 2 inputs [16], namely the ultasonic sensor and also the DHT 11 sensor and for the output, namely the speed of the DC motor [17]. The voltage used in this robot uses 2 lithium-ion batteries with a maximum voltage of 7200 mAh [18].

The feasibility test aims to find out how feasible the system of this internet of things-based garbage collection robot is to be used and utilized. In the feasibility test of this robot system, 6 respondents were

presented, including the principal of Klepek Islamic High School and Klepek Islamic High School Teacher. The results of feasibility testing can be seen in Table 5 of the Feasibility Test Results.

From the feasibility test in the table above, the prototype of this IoT-based garbage collection robot was calculated using a linker scale and got a result of 95.83%, which means it is very feasible.

TABLE V. DUE DILIGENCE RESULTS

No	Statement	Earned Score	Max Score	Percentage (%)	Category
1	Turn on the robot	24	24	100	Very Decent
2	Connecting a smartphone to the internet network	24	24	100	Very Decent
3	Controlling the robot using a smartphone	22	24	91,66	Very Decent
4	Picking up existing garbage	22	24	91,66	Very Decent
5	The appearance of the robot system is simple	23	24	95,83	Very Decent
6	Can pick up trash detected by sensors	23	24	95,83	Very Decent
7	Can run according to the controls on the smartphone	23	24	95,83	Very Decent
Earned Score		161			
Max Score			168		
Percentages and Categories				95,83	Very Decent

IV. CONCLUSIONS

The development of a garbage collection robot based on the Internet Of Things has been made with various electronic components namely arduino microcontroller, NodeMCU ESP 8266, ultrasonic sensors as well as DHT 11 sensors, L298N Motor Drivers, SG90 Servos, and also DC Motors. Ultrasonic sensor testing resulted in the sensor being able to detect garbage with a distance of less than 5 cm. For the method used in this IoT-based garbage collection robot using the fuzzy Mamdani method, which uses 2 inputs, namely the DHT 11 sensor and the ultrasonic sensor, it will then produce an output in the form of a speed of the DC motor on the Robot wheel.

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