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DESIGN OF VACUUM CLEANER DUAL MODE ROBOT PROTOTYPE BASED ON ARDUINO UNO WITH BLUETOOTH AND SMARTPHONE COMMUNICATION

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ABSTRACT:

Design of prototype robot vacuum cleaner based on Arduino Uno aims to produce a prototype robot that has the ability as a tool to clean house floor vacuum cleaners quickly and efficiently. Robot Vacuum Cleaner is designed as a vacuum cleaner and dirt on the floor of a room, which is operated using dual mode that is automatically and manually. Automatic mode on the robot vacuum cleaner will cause the robot to move randomly on the floor of a room and automatically avoid obstacles that are in front of the robot. Whereas in manual mode the robot vacuum cleaner moves following commands that are controlled by the user via an Android-based smartphone using the Bluetooth HC-05 communication module. Sharp GP sensor mounted on the robot functioned as a sensor to avoid obstacles when cleaning the floor of the house. The program flow begins by connecting the Android Smartphone to the Bluetooth HC-05 module, then Arduino will read the input data of the mode selected by the user, which is automatic or manual mode. If automatic mode is selected, Arduino will initialize the Sharp GP proximity sensor to detect the distance of objects in front of the robot and activate the vacuum motor. If the distance of the object in front of the robot more than 8 cm the robot will stop and turn directions to avoid the object. If the user chooses manual mode, the robot will wait for the user's command to maneuver and activate the controlled vacuum motor using the application on the user's smartphone.

The prototype robot vacuum cleaner, which operates in dual mode, was designed using Arduino Uno as the control center, has a SharpGP proximity sensor input, Bluetooth HC-05 module and an output in the form of a DC Motor Driver IC L298N to regulate the robot's movements and IRF520 MOSFET IC to regulate the speed of the Vacuum motor. The proximity sensor in the robot vacuum cleaner design has a detection range of 4 cm to 25 cm. This robot vacuum cleaner design can run automatically and can avoid the obstacle which is ≤ 6.5 cm in front of the robot. The results of distance sensor testing (Sharp GP2Y0A41SK0F) on the left side have an average error value of 0.385 cm and the proximity sensor (Sharp GP2Y0A41SK0F) on the right side has an average error value of 0.321 cm. Tests are also carried out to ensure the ability of robot movement through the floor with a slope of 15°, 20° and 25°. From the test results, the robot is not able to move at slopes greater than 25°.

KEYWORDS: Robot Vacuum Cleaner, Arduino Uno, Bluetooth Communication, Dual Mode.

INTRODUCTION:

The development of technology today is so rapid, one of which is in the field of developing assistive technology that makes it easy for humans to clean the floor of their homes quickly and efficiently. Vacuum cleaner is one of the tools commonly used by humans in the activity of cleaning the floor of a room. Existing vacuum cleaners are included in the type of manual robot, which still requires manpower to direct the movement of the vacuum cleaner to be able to go to the target floor to be cleaned. The use of a connecting cable between the vacuum cleaner and the controller, is also a problem of inefficiency that is often experienced by vacuum cleaner users. The condition of the floor with some furniture objects that fill the room is also a problem in designing cleaning tools for the room. Under these conditions, we need a vacuum cleaner that is able to move randomly and avoid obstacles that automatically exist, so that domestic work can be helped well and save energy for its users. With the ability to control movement automatically and manually, this is the advantage of a prototype robot vacuum cleaner compared to research results that have already existed.

LITERATURE REVIEW:

At present the robot vacuum cleaner with a design that can move randomly and also can avoid the obstacles that are in front of the robot is not widely available. Several studies have been carried out related to robot vacuum cleaner including making a robot vacuum cleaner that works only manually, where the movement is controlled using an Android smartphone, communication between robots and smartphones using serial communication wirelessly using Bluetooth HC-05 module (Ardhi et al, 2016). In other studies, robot vacuum cleaner that has been moved automatically using an accelerometer sensor to facilitate the direction of movement of the vacuum cleaner robot (Suwanda et al, 2014). Research on robot control systems is also carried out using a closed loop control system and is an auto-navigation control system. In this study, the system is equipped with an ultrasonic sensor, which will make the robot move toward the X axis, but if there is a barrier in front of it, the robot will move towards the Y axis automatically (Rafiudin et al, 2012)

METHODOLOGY:

In this study, a Robot Vacuum Cleaner was designed in the form of a prototype which is operated using an Android-based smartphone through the blynk application that has been installed. Robot Vacuum Cleaner prototype functioned to clean the floor of a room by sucking dust contained on the floor. The robot uses Arduino uno as a control center that has a SharpGP proximity sensor input, Bluetooth HC-05 module and an output in the form of a DC L298N Motor Driver IC to regulate robot maneuvering and IC IRF520 MOSFET to regulate the speed of the vacuum motor.

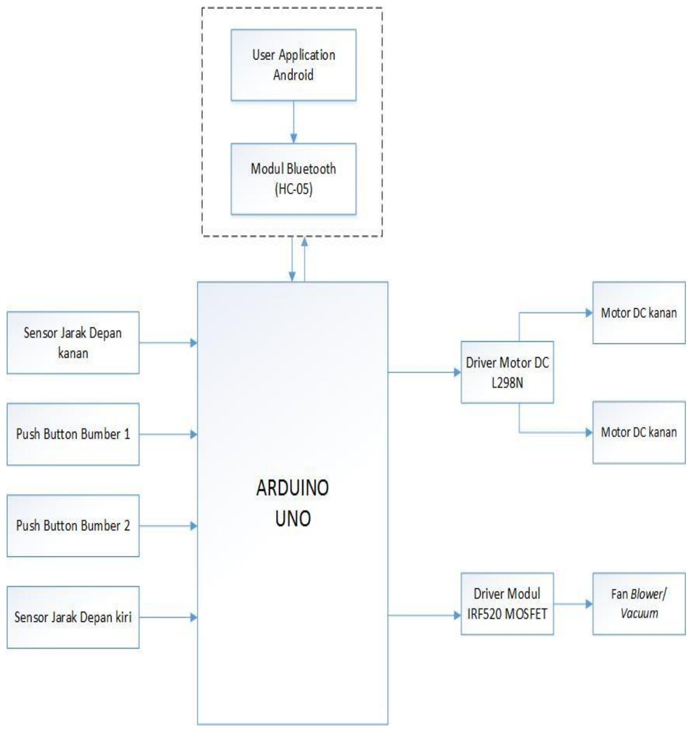
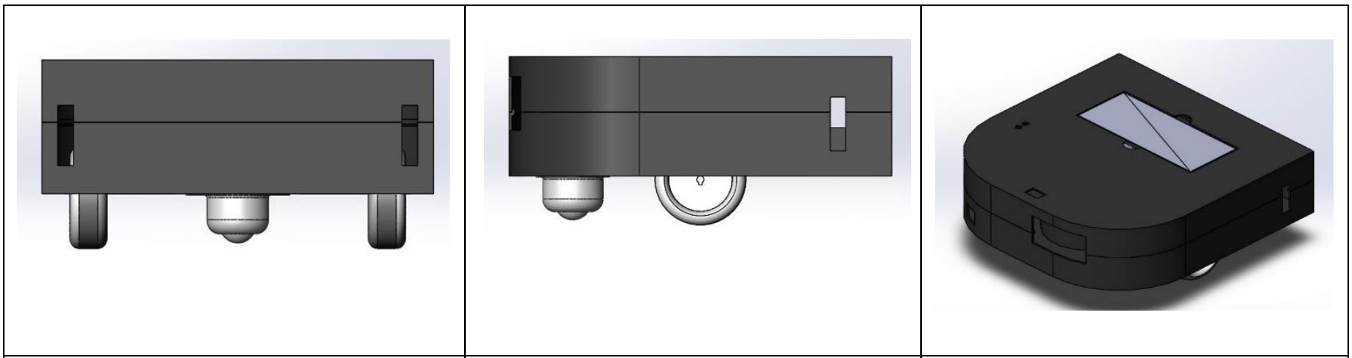


Figure 1. Robot Vacuum Cleaner Block Diagram

The prototype of the Robot Vacuum Cleaner design will be made using a 3D Printer with Plastic PLA measuring 21 cm x 21 cm x 8 cm. In Figure 2, a mechanical design is prepared to build a robot vacuum cleaner.



Rear View	Side View	Front View

Figure 2. Mechanical Design of Robot Vacuum Cleaner

HARDWARE DESIGN:

In the hardware design section, Arduino Uno is used with two sensor inputs, namely the SharpGP proximity sensor and the Bluetooth module, while the output consists of an L298N driver IC, a robot-driven DC motor and a DC Vacuum Fan. SharpGP proximity sensor is used to determine the distance of objects in front of the robot. The infrared sensor calculates the distance at the position of the infrared beam received by the photo transistor circuit. The farther the distance is detected, the infrared beam received on the photo transistor circuit produces a smaller output voltage. This output will be received by the ADC before being processed by Arduino.

Arduino is a minimum board microcontroller system that is open source. In the Arduino circuit there is an AVR ATMega 328 series microcontroller which is a product from Atmel. Arduino has its own advantages compared to other microcontroller boards in addition to being open source, Arduino also has its own programming language in the form of C language. In addition to the Arduino board itself there is already a USB loader which makes it easier for us when we program the microcontroller inside Arduino. Most other microcontroller boards still need a separate loader circuit to enter the program when we program the microcontroller. The USB port in addition to the loader when programming, can also function as a serial communication port. (http: /www.arduino.cc, 2019)

SharpGP proximity sensor is used to determine the distance of objects in front of the robot. Unlike the ultrasonic sensor, the infrared sensor does not count the beam time but instead calculates where the returned infrared ray is received by the transistor photo circuit. The farther the distance, the more right the infrared ray is received on the photo transistor circuit and the smaller the output voltage. The results of this output will be accepted by the ADC before being taken by Arduino (M. Sholihul, 2008).

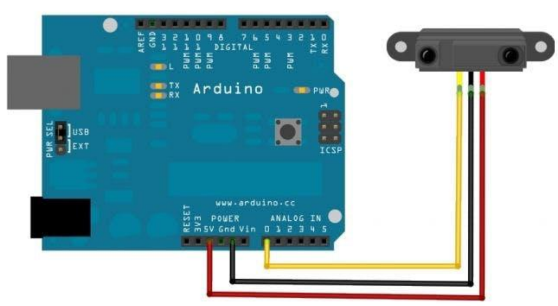


Figure 3. Sharp GP2Y0A02YK0F proximity sensor circuit

The detection range of the Sharp GP2Y0A02YK0F proximity sensor is about 4 cm to 30 cm. This sensor is included in the optical category proximity sensor. Basically, this sensor is the same as a conventional Infra Red (IR) sensor, GP2Y0A02YK0F has a transmitter / emitter and receiver (detector) section. The transmitter will emit an IR signal, while the reflection of the IR (when it hits an object) will be captured by the detector section consisting of a focusing lens and a linear charge-couple device (CCD) array. Linear CCD arrays consist of a series of light-sensitive elements called pixels (Picture element). (Pamungkas, 2017)

Bluetooth Module HC-05 Is a Bluetooth SPP (Serial Port Protocol) module used for wireless serial communication that converts serial ports to Bluetooth [3, 4]. HC-05 uses a modulation of Bluetooth V2.0 + EDR (Enhanced Data Rate) 3 Mbps by utilizing radio waves with a frequency of 2.4 GHz. This module can be used as a slave or a master. HC-05 has 2 configuration modes, namely AT mode and Communication mode. AT mode functions to make configuration settings of HC-05. While the Communication mode functions to make Bluetooth communication with other devices. (Zainuri, 2010)

SOFTWARE DESIGN:

Software Design uses the Arduino IDE program to design a series of program commands on Arduino Uno. The Robot Controller Application Design uses the MIT App Inventor, used to select the robot mode and regulate movement and regulate the suction motor speed. The output design of the robot application is shown in Figure 4.

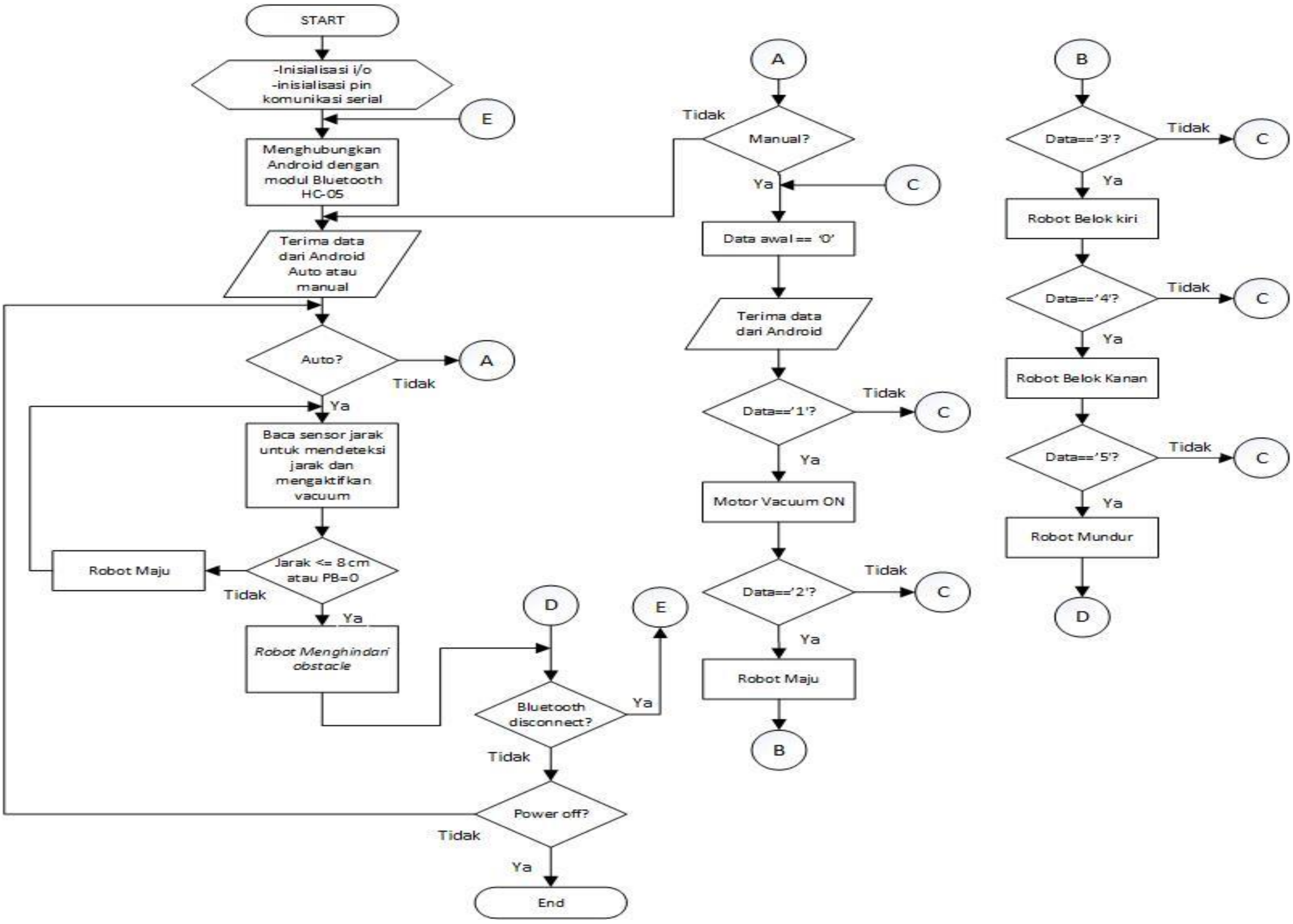


Figure 4. Flowchart of Robot Work Principle

Analysis of system requirements:

This system needs analysis discusses the hardware, software and Robot Vacuum Cleaner Prototype requirements needed to build a system that matches the functions that have been designed.

The following system requirements are needed:

- **The main hardware needed in making this system is as follows:**

1. Plastic PLA (3D printing) dimension: L : 21 cm x W : 21 cm H : 8 cm
2. Arduino Uno
3. Modul L298N Driver Motor DC
4. 2 Motor DC Penggerak robot
5. 1 Motor DC Vacuum pump
6. Proximity Sensor SharpGP
7. PCB
8. Modul Driver IRF520 MOSFET
9. Battery Lithium Polimer 3S 11.78V
10. Ball Caster
11. Switch ON/OFF
12. 2 LED

- **This system requires two software as follows:**
  1. Arduino IDE
  2. MIT App inventor

- **Prototipe Robot Vacuum Cleaner**

The prototype of the Robot Vacuum cleaner that will be built in the design of this system will be made using Plastic PLA based materials which are printed using a 3D printer in accordance with a predetermined design.

Tool Specifications, as follows:

1.	Control Unit	: Arduino Uno
2.	Power Supply	: ZIPPY Compact 1300mAh 3S 25C Lipo
3.	Charger Battery	: LiPo Battery Charger 3s
4.	Collision detection sensor	: Push Button
5.	Proximity sensor	: Sharp GP2Y0A41SK0F
6.	On/Off System	: On/Off Switch
7.	Modul Driver Motor DC	: H-bridge L298
8.	Modul Driver Blower	: IRF520 MOS FET Driver Module
9.	DC Motor Drive Robot	: Micro Metal Gearmotor HP 6V
10.	DC Motor Fan Blower	: Fan Blower AVC BA10033B12G 12V
11.	Miniature dimensions(l x w x h)	: 21cm x 21cm x 8cm.

Implementation of designs on Android smartphones:

This application is designed with two modes namely automatic mode and manual mode. If you select automatic mode, the robot will run autonomous and if you choose manual mode, a joystick display will appear to adjust the robot's movement as shown in Figure 5.

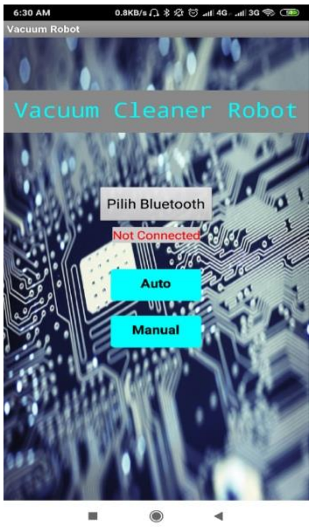


Figure 5. Display Menu of Robot Vacuum Cleaner Robot Application

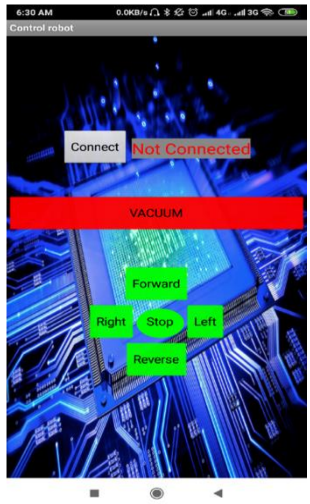


Figure 6. Display Mode Manual

The menu contained in the application consists of 3 buttons namely Select Bluetooth, Auto and Manual. The Bluetooth Select Button is used to select and connect an Android smartphone with the HC-05 Bluetooth module found on the Vacuum Cleaner robot. The Auto button is used to instruct the robot to move automatically and vacuum dust / paper automatically. The Manual button is used to enter manual mode, the screen will shift to manual mode display to provide robot movement instructions.

The button in the manual mode is used to instruct the robot to move forward, backward or turn left and right and can activate / deactivate the vacuum to suck dust / paper.

DISCUSSION:

Testing the detection of the left proximity sensor Sharp GP2Y0A41SK0F proximity sensor testing aims to analyze how much the difference between the detection of the distance sensor with the actual distance.

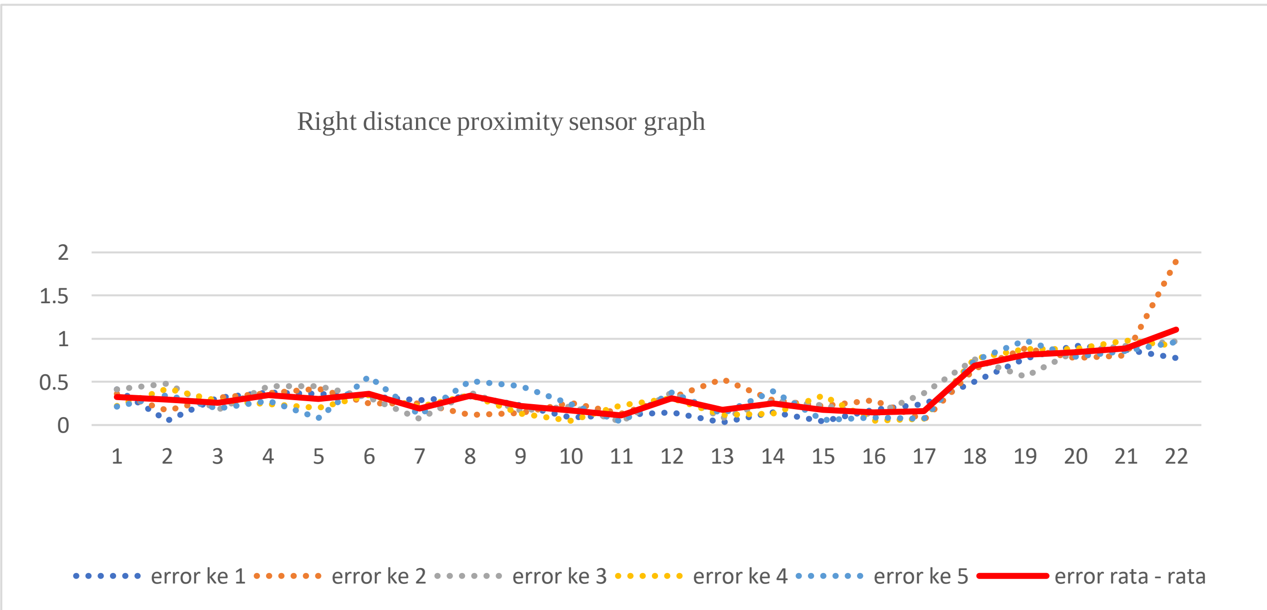


Figure 7. Difference graph / error detection of Left Side Sharp GP2Y0A41SK0F Sensor

Testing the right proximity sensor detection:

Sharp GP2Y0A41SK0F proximity sensor testing aims to analyze the difference between the detection of the distance sensor and the actual distance. The greater the difference (error) sensor readings on the actual distance can affect the maneuverability of the robot.

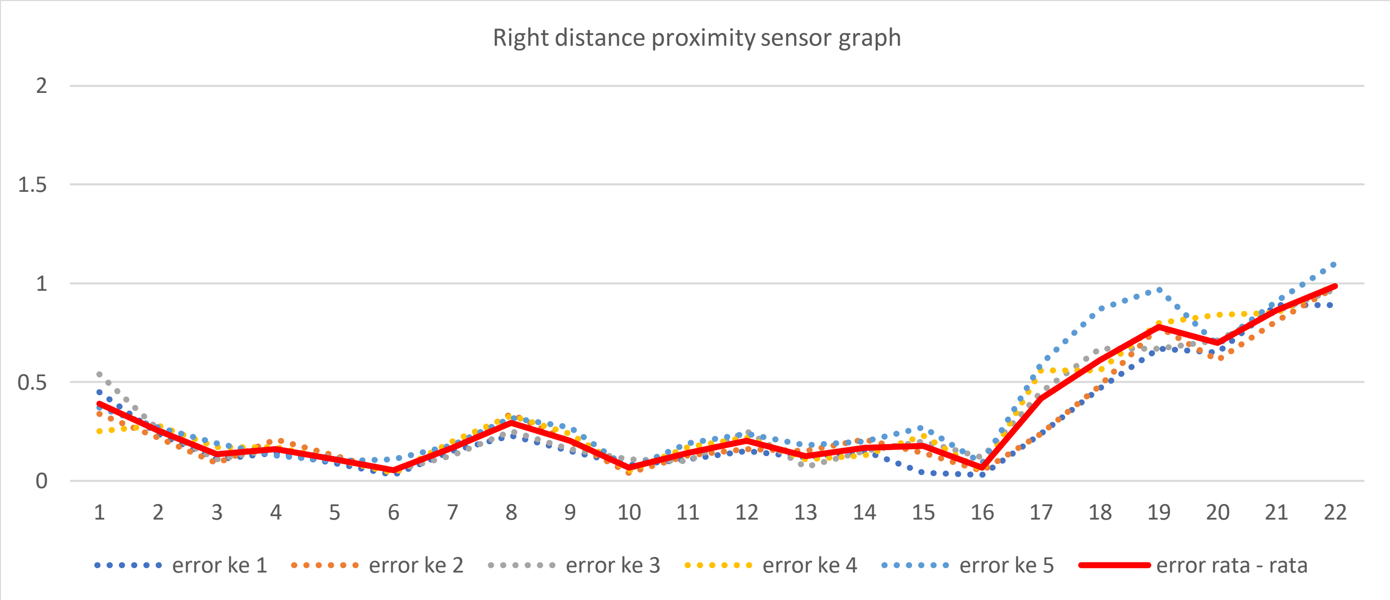


Figure 8. Difference graph / error detection of Right Side Sharp GP2Y0A41SK0F Sensor

Analysis of the tests that have been carried out are:

- The results of testing the Sharp GP2Y0A41SK0F sensor on the left and right of the robot at a distance of 4 cm to 25 cm with an increase every 1 cm obtained the value of the distance of the sensor compared with real measurements. The output value of the Sharp GP2Y0A41SK0F sensor with a test range between 4 cm to 25 cm produces a linear tendency. There is a difference value (which is assumed to be an error) between the left and right Sharp GP2Y0A41SK0F output data with the distance measured in real terms.
- Based on the test graph the error value in Figure 7. shows the average error value on the left Sharp Sharp GP2Y0A41SK0F test with a test range of 4 cm to 25 cm is 0.385 cm. The graph of testing the error value in Figure 8 shows the average error value on the right Sharp GP2Y0A41SK0F test with a test range of 4 cm to 25 cm is 0.321 cm. Conditions that occur in the two Sharp GP2Y0A41SK0F proximity sensors can affect the maneuver and response of the robot when it encounters an obstacle in front of it.Pengujian Daya Hisap Robot Vacuum Cleaner

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Vacuum suction testing aims to analyze how much the ability of robots to suck objects that are usually present in the room of the house. In this study conducted on objects such as pieces of paper and pieces of tissue. This test is carried out within 90 minutes. The robot maneuvers automatically in a 70 x 50 cm space

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Table 1. Robot Vacuum Cleaner Suction Power Testing

Testing	Amount of paper	The Results	Test Picture
Testing Robot with 70cm x 50cm space sucking 2x2 cm paper for 1 minute 30 seconds	10 pcs (2 x2 cm)	1 paper left	
Testing Robot with 70cm x 50cm space sucking 1x1 cm paper for 1 minute 30 seconds	10 pcs (1 x 1 cm)	0 left	

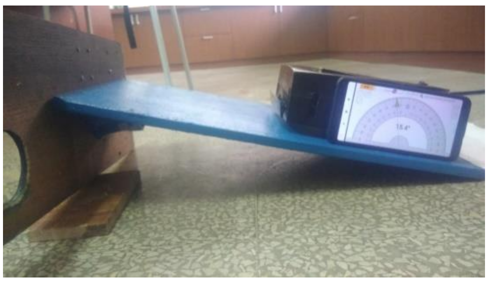
Analysis of the tests that have been carried out are:

- The results of the vacuum cleaner robot suction test on the first try of 10 papers with a size of 1 cm x 1 cm in a room with an area of 70 cm x 50 cm with 90 seconds can be sucked without remaining by the robot vacuum cleaner.
- In the second experiment, 10 pieces of paper with a size of 2 cm x 2 cm in a room with an area of 70 cm x 50 cm with 90 seconds were able to be smoked by a robot vacuum cleaner, but there was still 1 piece of paper that was not sucked. Based on these experiments it can be concluded that the robot vacuum cleaner can suck up maximum on paper with an average size of 1 cm x 1 cm.

Test the slope of the path that the robot can pass:

Testing the ability of robots to pass the path with a certain slope angle aims to analyze the slope of the floor that can be passed by the robot on the floor of the house. The test is carried out with several tilt angles that are commonly found on the floor of a house.

Table 2. Floor Slope Testing

Testing	Slope Angle	The Results	Test Picture
Robot Testing passes the path that is uphill at a slope angle	15º	succeed	

Robot Testing passes the path that is uphill at a moderate angle	20º	succeed	
Robot testing through the uphill path	25º	Not Succeesful	

Analysis of the tests that have been carried out are:

- The results of the tilt angle that can be passed by the robot in Table 2. show the tilt angle that can be passed by the robot including the tilt angle of 15º and 20º.
- At a slope angle of 25º the robot is unable to pass the path with that slope. Based on the test in Table 2. it can be concluded that the robot is able to pass the path with a slope of 0º to 20º while at an angle of 25º or more cannot be passed by the robot.

CONCLUSION:

Based on the results of tests that have been carried out on the prototype design of this Robot Vacuum Cleaner it can be concluded the following matters:

1. The design of the Robot vacuum cleaner is able to carry out the function to clean the floor using dual mode that is manually and automatically connected to the application on an Android smartphone.
2. The proximity sensor in the robot vacuum cleaner design has a detection range of 4 to 25 cm. This robot vacuum cleaner design can run automatically and can avoid the obstacle which is ≤ 6.5 cm in front of the robot.
3. Based on the results of testing the proximity sensor (Sharp GP2Y0A41SK0F) the left side has an average error value of 0.385 cm and the proximity sensor (Sharp GP2Y0A41SK0F) the right side has an average error value of 0.321 cm. The test is carried out on a scale of 4 cm to 25 cm.
4. Based on the results of the suction capability test, the robot vacuum cleaner is able to suck objects in the form of tissue and paper with a maximum size of 1 cm x 1 cm, beyond that size the robot cannot suck up to the maximum.
5. Based on testing the inclination angle that can be passed by the robot, it can be concluded that the robot can pass the path with a slope of 0º to 20º while in the test angle 25º or more cannot be passed by the robot.

LIMITATION AND STUDY FORWARD:

With the robot size of 21 cm x 21 cm x 8 cm, this robot vacuum cleaner cannot clean the floor in a narrow gap with a size of less than 21 cm x 21 cm. Robots also have limitations reaching locations under furniture that require thin dimensions of less than 8 cm. Dust cleaning with micron size was not carried out directly in this study. The ability to be able to clean objects with new suction ability is tested using pieces of paper and pieces of tissue with a maximum size of 10 x 10 cm, so that further testing is needed with a variety of impurities in different forms. In the movement of robots with slope conditions above 25°, the robot is unable to pass through it. Although it is rare to find a floor with a slope above 25°, further research is still recommended to overcome various robot constraints and this problem is still not solved.

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