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Design of an Automatic Trash Can Wheel Robot with Bluetooth Navigation Control Through Smartphone Application

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Abstract

Environmental cleanliness is an important aspect that must be maintained, especially in this modern era. The use of appropriate technology can help increase awareness of cleanliness, one of which is by developing automatic trash cans. This research designs and builds a mobile robot in the form of an automatic trash can that can be controlled via an Arduino Uno microcontroller using Bluetooth and controlled via a smartphone application. This research designs a mobile robot in the form of an automatic trash can that can be controlled via an Arduino Uno microcontroller with Bluetooth and a smartphone application. The system receives navigation commands from the app and uses ultrasonic sensors to detect objects in front of the trash can. The microcontroller processes the command and sensor data to drive the DC motor and servo motor. The servo motor opens and closes the trash can lid automatically when an object is detected at a certain distance. The test results show that this robot can move according to instructions from a smartphone and successfully open and close the trash can lid automatically when detecting objects.

Keywords: *Mobile Robot, Automatic Trash Can, Arduino Uno Microcontroller, Bluetooth Controller, Smartphone App.*

1. Introduction

Cleanliness is part of faith, hence the importance of maintaining environmental cleanliness and also personal hygiene to avoid the impact of problems that can be caused. Environmental cleanliness needs to be maintained to create a clean, comfortable and beautiful environment. A clean environment also provides many benefits such as avoiding various dangerous diseases caused by a dirty environment. New innovations need to be made in the development of garbage cans by connecting the latest technology, namely by making automatic control using ultrasonic sensors and servo motors and microcontrollers as tool control. Ultrasonic sensors that control servo motors as opening and closing trash cans automatically [1]. Mobile Robot or mobile robot is a robot structure characterized by a wheel-shaped robot whose entire robot body moves so that the robot can move from one place to another. In this case the mobile robot is designed to move using a controller on an Android smartphone and the right application to move the robot. The connection used is via Bluetooth [2].

This device uses Arduino Uno to connect between Bluetooth-enabled devices and Android smartphones. The device works based on commands given through Android smartphones and applications. Because the DC motor is used as a driving force to run the robot, the Arduino Uno microcontroller requires a program to be loaded into the Arduino Uno microcontroller so that it can send commands to move the robot. By using the c programming language and using the Arduino software (IDE) as an editor to create and upload programs. A robot is a combination of various mechanical devices controlled by electronic devices that can move according to certain functions. Currently, the Electronics Department is needed because there are so many systems in this field that can facilitate one's work. The development of robotics technology can improve the quality and quantity of production in various factories [3]. The background of the problem in this study refers to the number of people who are still less aware of the importance of keeping the room clean. With the innovation of the AUTOMATIC TRASH CAN ROAD ROBOT WITH BLUETOOTH NAVIGATION CONTROL THROUGH SMARTPHONE APPLICATION, which utilizes current technological developments can help increase one's awareness about the importance of disposing of garbage in its place.

2. Literature Review

2.1. Design

The design is carried out to create a planning scheme for the automatic garbage can wheel robot that will be made. By taking into account all aspects needed both hardware, software and Bluetooth network connections as a connecting connection between the robot and the smartphone application as a controlling medium.

2.2. Mobile Robot

Mobile robots are robots that move using wheels. This robot is easy to operate on flat and horizontal surfaces. Wheeled robots are classified into various categories, such as wheeled and omniwheel, depending on the type of wheel used. The application of omni-wheels has been widely used in robots that require more flexible movement. Regular wheels are wheels that have two degrees of freedom: forward motion and backward motion. These wheels are used in robots that do not require much movement. The second type of wheel is the omniwheel. It consists of a large main wheel and other smaller wheels located on the outside of the main wheel with their axes perpendicular to the main wheel. The application of omni-wheels has been widely used in robots that require more flexible movement. The ability of a robot to move in a certain direction depends on its orientation angle. One of them is the use of three omniwheels arranged circularly with a congruent triangle pattern separated by an angle of 120 degrees [2].

2.3. Arduino Uno Microcontroller

Arduino Uno is a microcontroller board based on the ATmega328P microcontroller. The name of the board is “Uno”, which means “one” in Italian, and it celebrates the launch of the Arduino Uno 1.0 board, the first microcontroller board. The Arduino Uno has 14 digital I/O pins, 6 analog input pins, a USB connector, a reset button, and an ICSP header. All these features allow you to connect this board to your computer to support the microcontroller for other functions. This board can be powered by an AC-DC adapter, USB cable, or battery [4]. The Arduino Uno can be programmed using the Arduino software (IDE), an integrated development environment that supports C and C++ programming languages. Users can write programming code, send it to the Arduino Uno via a USB connection and run it directly on the board.

2.4. Bluetooth

Bluetooth is a wireless technology that allows electronic devices to communicate with other devices using radio signals. Bluetooth uses radio frequency (RF) technology to connect devices over short distances, usually less than 10 meters. Bluetooth is used to connect devices such as headphones, speakers, printers, and other devices such as computers, smartphones, and tablets. Bluetooth is designed to replace cables that connect electronic devices. It allows these devices to communicate directly without a physical connection in the form of wires. Newer Bluetooth standards (such as Bluetooth 4.0 and later) have a working range of up to 10 meters (30 feet) under ideal conditions. Some versions of Bluetooth have a longer range of up to 100 meters and work very well. Bluetooth uses the 2.4GHz ISM radio frequency that is widely used around the world. Data transfer speeds vary depending on the Bluetooth version used, from 1 Mbps (Bluetooth 4.0) to more than 2 Mbps (Bluetooth 5.0 and higherBluetooth has become the de facto standard for wireless connectivity in a wide range of commercial and consumer applications. Its advantages are ease of use, broad compatibility and the ability to support a wide range of electronic devices. As is well known, Bluetooth is a technology developed in response to the need for communication between electronic devices to transfer data over short distances using radio waves with specific frequencies. Bluetooth operates in the 2.4 GHz frequency band using a high-speed router that can provide real-time voice and data communication services between Bluetooth hosts over short distances. The disadvantages of this technology are its short range and low data transfer capacity [5].

2.5. Trash Can

Trash cans are specialized containers designed to hold and manage everyday waste. The main function of the container is to help collect, temporarily store, and manage waste so that it can be disposed of or recycled properly and consistently. trash cans are used to collect waste from various places such as homes, offices, public places and other places. After the waste is collected, the trash can serves as a temporary storage area before being transported. The use of trash cans will prevent the spread of waste, keep the environment clean and prevent soil, water and air pollution. Trash cans play an important role in keeping the environment clean and supporting sustainable waste management practices. With proper use and maintenance, they can help communities create a clean, healthy and sustainable environment.

2.6. Smartphone

A smartphone is an electronic device that has functions as a cell phone, computer, and multimedia device that can be controlled with a finger. Smartphones have touch screens, cameras, GPS, Wi-Fi, Bluetooth, and other features that allow users to perform various tasks such as communicating, browsing the Internet, and responding to requests. Smartphones are the main communication device that can make voice calls and text messages (SMS). Smartphones can connect to the Internet via cellular networks (3G, 4G LTE, 5G) and Wi-Fi. Users can access various online services such as email, social media, web browsing and others. Usually, operating systems such as Android (Google), iOS (Apple), and Windows Phone (Microsoft) are used, which provide user interfaces, application services, and electronic management. A smart phone is a mobile phone with a high level of functionality, sometimes like a computer. There is no manufacturer's standard that defines what a smartphone is. For some, a smartphone is a smartphone supported with operating system software that provides a standard native connection to application developers. To others, a smartphone is simply a phone that offers advanced features such as email, Internet, e-book reading capabilities, and a VGA connection. In other words, a smart phone is a small computer with phone functions [6].

2.7. Motor DC

A DC motor is an electric motor that uses direct current (DC) to rotate on its shaft. This motor is based on the principle of electromagnetic induction, where the magnetic field generated by the electric current in the coil interacts with the static magnetic field and produces mechanical motion. DC motors can be found in a variety of sizes and capacities, ranging from small models used in electronic toys to large motors used in industry. The main part of a DC motor is a coil of copper wire wrapped around a core, usually made of iron or other ferromagnetic material. This winding is also called the field winding or armature winding. DC motors remain one of the most widely used electric motor technologies because they are simple, easy to control, and suitable for a variety of applications that require precise speed and torque control.

2.8. Motor Driver

Motor Drivers are electronic devices used to control electric motors in various applications such as robotics, automation, and other electronic devices. The motor driver acts as an intermediary between a controller (such as a microcontroller or microprocessor) and the motor itself, directing electric current to the motor to control the speed, direction and torque of the motor. A motor driver module is a circuit consisting of motor driver ICs in the form of a ready-to-use module. This module has I/O pins that are neatly packaged and easy to use.

2.9. Bluetooth Module

The HC-05 Bluetooth module is an electronic component that functions as a Bluetooth receiving device. With this module, we can connect electronic devices to other devices wirelessly via Bluetooth. This module uses the HC 05 series Bluetooth chip developed by JY-MCU in China. The HC-05 Bluetooth module is very suitable for wireless electronic projects. The applications are control system applications, monitoring or a combination of all. The connections of this module are TXD, RXD, VCC and GND series. And the LED light (built-in) indicates Bluetooth connection with other devices, such as other modules, Android phones.

2.10. Ultrasonic Sensor

Ultrasonic sensor is a type of sensor that is used to measure the distance between the sensor and the object in front of it. This sensor works on the principle of ultrasonic waves that can reflect off solid objects and return to the sensor. The frequency of these ultrasonic waves is higher than the range of human hearing, so humans cannot hear them. Ultrasonic sensors are very useful in various applications such as robotics, automotive, and distance measurement. The design of the arduino-based automatic trash can opening and closing uses 1 ultrasonic sensor, the distance required to open the trash can, when there is an object in front of the trash can, the height of the trash can is less than 10 cm, so the trash can opens and when the ultrasonic sensor no longer detects the object or the distance of the object is more than 10 cm, the trash can will close automatically [7].

2.11. Micro Servo

Micro servo is one type of servo motor that is relatively small and compact. Micro servos are smaller than conventional services, making them suitable for applications that require little space. Micro servos have the same function as regular services, which is to control the position of the device very precisely. Micro services can be used to control axis positions, angles, or other movements with high precision. Microservices are very popular in electronic hobbies such as small robot models and DIY projects that use microcontrollers like Arduino.

2.12. Battery Holder/Battery

Battery holder is an electronic component that functions as a battery container in an electronic device. Battery holders are usually made of materials such as plastic, metal, or rubber and are designed to fit the size and shape of the battery used. The battery is an electronic component that functions as a source of electric current to produce the electrical energy needed in electronic devices.

2.13. Jumper Cable

Jumper cables are cables used to transmit signals or voltages from one electronic system component to another. Jumper cables usually have a plug or pin at the end that can be used to connect to other components. Jumper cables are widely used in prototyping and testing, such as breadboards, to transfer signals to other components without soldering. Jumper cables are also used in radio frequency (RF) applications to transmit radio signals between components and devices under test.

2.14. On/Off Switch

The on/off switch or better known as the on/off switch is an electronic device used to disconnect or connect an electrical network. This switch consists of two metal blades mounted on a circuit and can be connected or disconnected depending on the on or off state of the circuit. The on/off switch serves to connect or disconnect the flow of electricity in a circuit. This is very important in various applications, such as use in lamps, lights and other electronic devices.

2.15. Bluetooth Controller Application

Bluetooth Controller is a technology that enables remote controls that use Bluetooth technology to control electronic devices such as robots, drones or other devices. In this application, the user can use his smartphone or tablet as a remote control to control Bluetooth-equipped electronic devices.

2.16. C Programming Language

C programming is a programming language whose reliability is unquestionable and is widely used to create programs in various fields, including assembly and operating system development. Until now, C is still a popular and desirable programming language. At the same time, C inspired the creation of new programming languages such as C++, Java and so on. Therefore, these three languages can be said to be equivalent in terms of mastery of the grammar of the subject. The C programming language is very flexible and portable and can be installed and used on multiple operating systems. In general, C is mainly used to interface between devices so that they can communicate with each other. C++ is a programming language invented by Bjarne Stroustrup in 1983 at Bell Labs. C++ is a programming language that is often used in software development and is very popular in the development of desktop applications, games, and embedded systems. It has the same syntax as C, but has added new features that allow programmers to create more complex and powerful programs. Some of the key features of C++ include the ability to organize code into objects, the ability to use pointers, the use of classes to create objects, and the ability to overload operators. In addition, C++ also supports the concept of generalized programming, which is the ability to write code that can be used to create different types of data. C++ is a fairly complex programming language, but offers greater flexibility in developing complex applications. It can be used on various platforms including Windows, Mac OS and Linux [8].

3. Analysis and Design

3.1. System Design

In designing a system entitled "Automatic Trash Can Wheel Robot Design With Bluetooth Navigation Control Through Smartphone Applications" which in making the robot there are several problems that must be solved. The problems are among others:

1. How to design an automatic garbage can wheel robot using Arduino Uno with Bluetooth navigation control via an application on a smartphone?
2. How to innovate the development of garbage cans automatically?
3. How to combine an automatic garbage can wheel robot with Bluetooth navigation on a smartphone application?

3.2. Automatic Trash Can Wheel Robot System

The automatic garbage can wheel robot system circuit can be seen in the following figure:

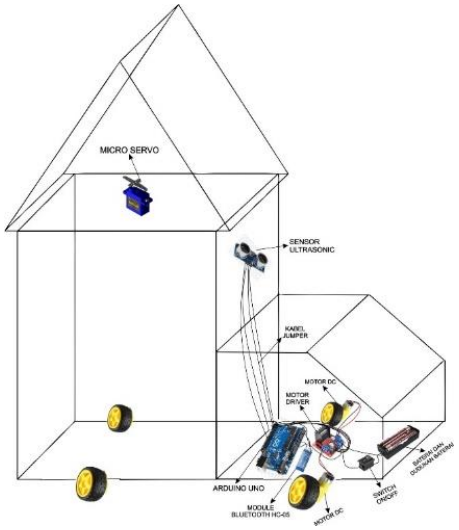

Fig. 1: Automated Trash Can Wheel Robot System Circuit

The series of automatic garbage can wheel robot systems on the main component used in this system is Arduino Uno as a microcontroller that regulates this system. The way this tool works can be seen where the Arduino Uno is powered by electricity through a battery with the connecting media using a motor driver, with a power of 12 volts connected to the arduino uno vin pin. After that, the Arduino Uno sends a signal to activate Bluetooth hc-05 so that it can be connected by the Bluetooth RC Controller application on the smartphone. After Bluetooth hc-05 is connected to the smartphone, the user can navigate the microcontroller to send a signal to the motor driver, so that the dc motor can move according to user instructions through smartphone navigation. Then for automatic trash cans, the Arduino Uno microcontroller gives control to the ultrasonic sensor so that the ultrasonic sensor can detect movement at a distance of 30 cm, which then the microcontroller signals the micro servo to open the trash can lid automatically according to the command signal from the ultrasonic sensor.

3.3. Tool Circuit

In this tool circuit serves to run the tool system so that it can work according to program commands.

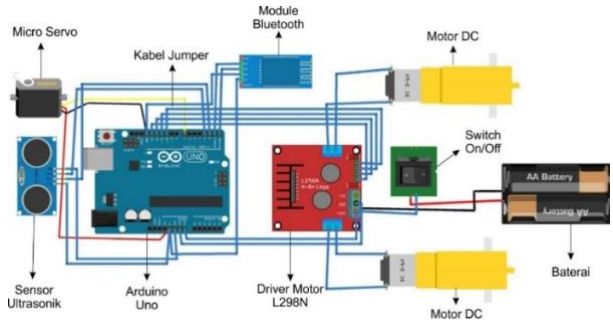

Fig. 2: Tool Circuit

In this robot circuit, the main device is the Arduino Uno Microcontroller, where arduino uno is the main control device that regulates the robot design. By providing electrical power through the battery to connect the arduino uno which is assisted by a motor driver as an electric power regulator, by providing a voltage of 12 volts that connects the arduino uno through pin vin. Then, to move this robot, a DC motor is needed as a driving wheel which is connected to the pin out on the motor driver. In remote control, a Bluetooth module is needed as a link between the robot and the Bluetooth RC controller application on a smartphone. After that, for the control of this automatic trash can, an ultrasonic sensor is needed to detect motion and then give a signal to the Arduino Uno to be able to move the micro servo as an open and close trash can cover.

3.4. System Flowchart

In the system flowchart, you can see the flow from the start of the robot design working until it is finished.

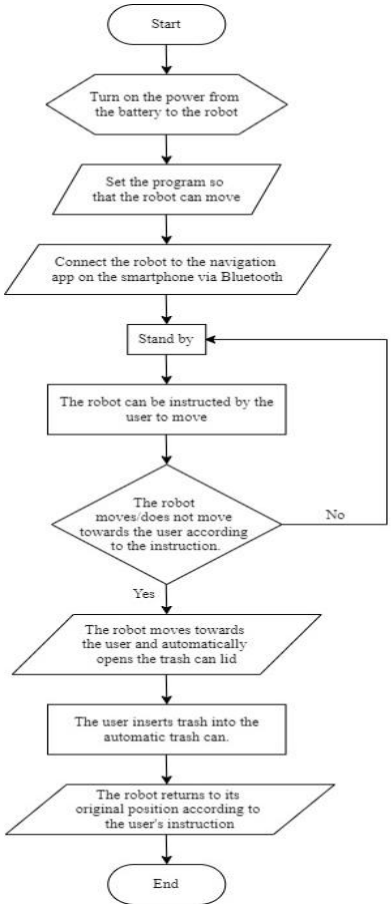

Fig. 3: System Flowchart

Description:
In the flowchart above, it can be explained that the design of the automatic garbage can wheel robot consists of several flows, namely: Start. Turn on the electrical power on the battery to the robot so that the Arduino Uno can be run. Setting the program so that the robot can move according to instructions. Then connect the robot to the navigation application on the smartphone via Bluetooth connection. Arduino Uno will stand by if it is on. The robot can be instructed by the user to move. The robot moves or does not move towards the user according to the instructions. If the robot does not move according to the user's instructions then, the robot will be in the stand by position. However, if the robot moves according to the user's instructions, the robot will approach and open the trash can lid automatically. Then the user puts the garbage into the automatic trash can. Then the robot will return to its original position according to the user's instructions. Done.

4. Discussion and Implementation

4.1. Discussion

This chapter will explain and also show how the results of testing the design of the tools made and the discussion. The results of the submission carried out are tools made, designed and programmed using the Arduino IDE application. This tool will later be used in the design of an automatic garbage can wheel robot with the provision of tools and devices.

4.2. Component Testing

To find out whether the Arduino Uno microcontroller circuit has run well, testing will be carried out by giving a command program to the microcontroller by inputting data from the computer into the microcontroller. In doing the installation, first connect the microcontroller between computers with a downloader via a USB Type-A to USB Type-B cable to the microcontroller circuit. To test the tool with commands can be done with a few steps that must be considered, among others:

1. Running The Arduino IDE Application

The first step is to run the Arduino IDE software, after the application is opened it will appear to create a program.

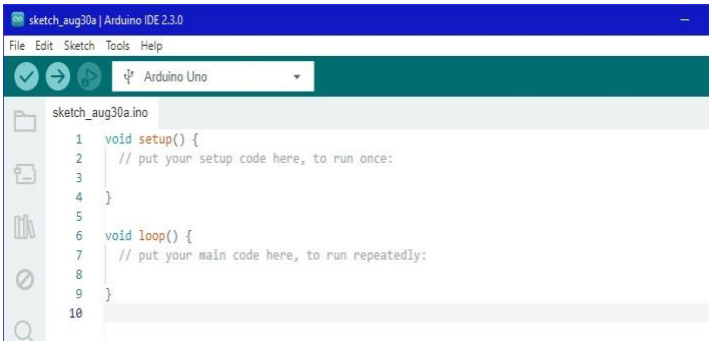

Fig. 4: Arduino IDE Software Testing Display

2. Creating a Robot Program

Furthermore, to program the Arduino Uno microcontroller, namely by creating a program according to the functions and needs of the robot being made.

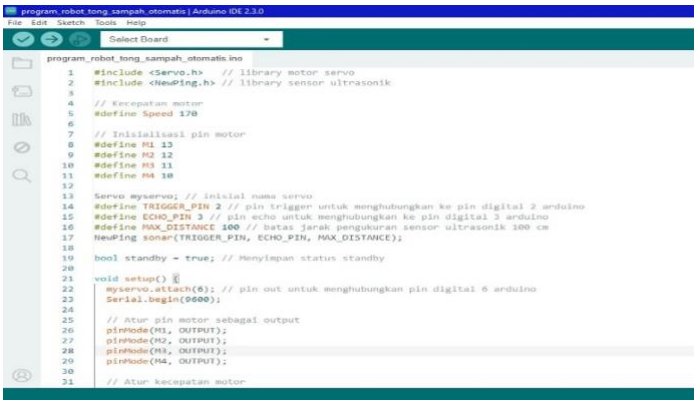

Fig. 5: Program Display

3. Saving The Robot Program

Before continuing the microcontroller work stage on the program that has been completed, the program is first saved before compiling.

Fig. 6: File Storage Display

4. Robot Program Trial

At the next stage is the stage of installing the microcontroller program, where the program must be checked first by verifying or compiling whether the program is logically correct in its creation, if there is an error in the program it will notify that there is an error by providing an error message notification in the program.

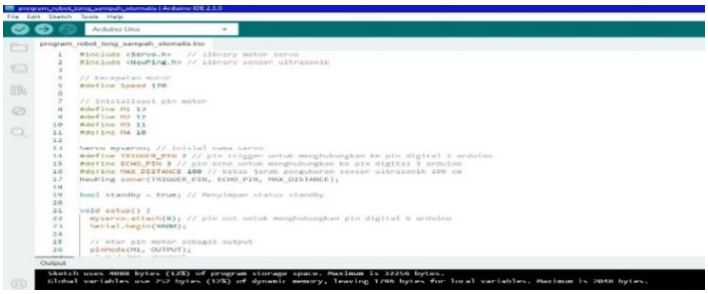

Fig. 7: Display of Compile Results

5. Upload Robot Program to Arduino Uno Microcontroller

Next, upload the program to the Arduino Uno microcontroller by selecting the upload menu in the Arduino IDE, make sure the upload process goes well until it's finished.

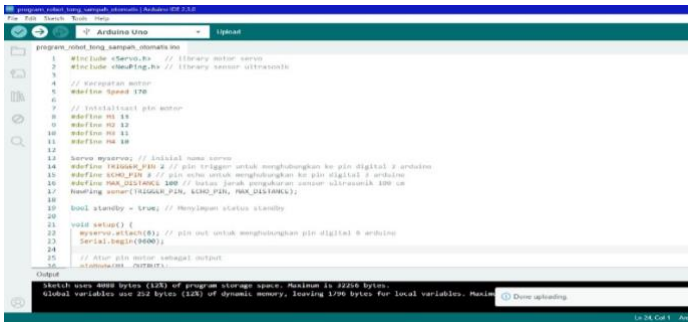

Fig. 8: Display of Completed Upload Process

6. Hardware Testing

After all the circuits that have been designed are completed on the robot "Automatic Trash Can Wheel Robot Design With Bluetooth Navigation Control Through Smartphone Application". Furthermore, the unification of all robot circuits is carried out.

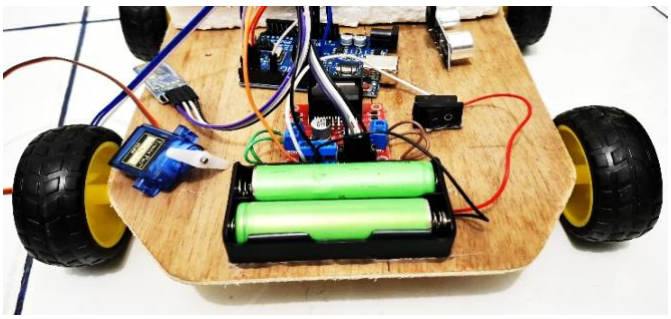

Fig. 9: Display of Hardware Testing Results

7. Bluetooth Controller Application Testing

For the results of testing the navigation control of the automatic garbage can wheel robot controlled by the Bluetooth controller application on a smartphone successfully carried out. The controls that can be performed are divided into three types: manual control, where control is done manually using control buttons such as forward, backward, left, right, and stop; voice control, where control is executed through voice commands spoken by the user; and gesture control, where control is achieved by moving the smartphone, which directs the robot according to the user's desire.

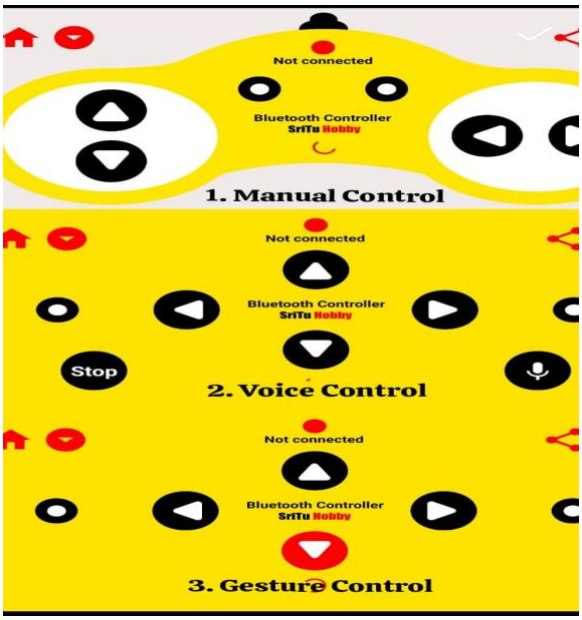

Fig. 10: Display of Robot Navigation Testing Results on Smartphone

8. Overall Robot Testing

The testing results for the automatic trash can robot with Bluetooth navigation control via a smartphone application require a Bluetooth controller application to operate the robot. Then, the robot control system offers three types of control: manual control, gesture (movement via smartphone), and lastly, voice control.

Pig. 11: Display of Overall Robot Testing Results

5. Conclusion

Based on the results from the discussion, which has completed the design and system creation stage, the process moves on to the Testing and analysis stage. From all these stages, the conclusions drawn are as follows:

1. The automatic trash can robot system has been successfully designed, implemented, and tested. The robot's navigation control system uses a Bluetooth connection linked to a smartphone application. This application allows users to control the robot using three different methods: manual control (through navigation buttons in the app), voice control (based on the user's voice commands), and gesture control (by moving the smartphone to direct the robot). The flexibility in these control methods enables users to navigate the robot easily and smoothly. This robot integrates several key electronic components such as an Arduino Uno microcontroller, DC motors, ultrasonic sensors, micro servos, and the HC-05 Bluetooth module, which work together to achieve the desired functionality. The system's automation is achieved through the use of ultrasonic sensors that detect movement within

a 30 cm range. The sensor sends signals to the microcontroller, which then activates the micro servo to automatically open and close the trash can lid.

2. The tests conducted showed that the system works well according to the designed specifications. The robot can move according to the commands given through the application and can automatically open and close the trash can lid when it detects movement in front of it. The smartphone navigation application testing also successfully ensured that all control functions work properly. This makes it easier for users to dispose of trash without directly touching it. This innovation is expected to raise awareness of the importance of maintaining a clean environment.

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