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Design and Construction of an IoT-Based Room Cleaning Robot

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Abstract

This research discusses the design and development of an Internet of Things (IoT) based room cleaning robot. The background of this research is based on the modern society's need for automated devices that can help maintain home cleanliness efficiently. The system is designed using the ESP32 as the main microcontroller, GP2Y1010AU0F dust sensor for dust detection, ultrasonic sensors for navigation, DC motors and L298N module for actuation, and Blynk application as a medium for remote control and monitoring. The testing results show that the robot can detect dust, perform simple navigation, activate the vacuum for cleaning, and send notifications to the Blynk application when the dustbin is full.

Keywords: *Cleaning Robot, Internet of Things, ESP32, Blynk, Dust Sensor, Automation.*

1. Background

The Internet of Things (IoT) is one of the most important innovations that allows devices to connect through the Internet, exchange information, and control themselves automatically. One application of this technology is robotic devices designed to assist with household chores, such as cleaning rooms. In today's fast-paced modern life, there is an increasing demand for automated devices like room cleaning robots to save time and energy.

This title is based on the need for practical and efficient solutions in maintaining room cleanliness amid an increasingly busy modern lifestyle. Many people have limited time to do household chores such as regularly cleaning their rooms. Therefore, the development of IoT-based cleaning robots becomes very important as it allows for the automatic operation of these devices and provides flexibility in their operation. IoT technology was chosen for its advantages in supporting remote control, data collection, and device management through Internet connections.

The health of residents is determined by the cleanliness of the house they occupy. Dirt that often makes the house dirty, especially, is dust. To maintain the cleanliness of the house, the floors should always be cleaned of dust. The activity of cleaning dust by sweeping the floor is often done with a sense of laziness by the residents because it requires energy and time to do it. Currently, the development of robotic technology has improved the quality and quantity of production in various factories. Robotic technology has also reached aspects of entertaining and educating people. One of the most popular types of robots is room cleaning robots [12].

2. Literatur Review

2.1. Design Build

Design Development is the representation, planning, sketching, or arrangement of several separate elements as a complete functional unit. Therefore, the definition of design is the translation of the results of the analysis into the form of software and creating systems or improving existing systems [12].

2.2. Robot

Robots are tools that are remotely controlled by humans. In this research, robots are used for security and store surveillance. Robots will make surveillance easier for humans [1].

2.3. Internet of Things

The Internet of Things (IoT) is a concept aimed at expanding the benefits of an always-on Internet connectivity. Essentially, IoT refers to objects that can be clearly identified as virtual representatives within an internet-based structure. IoT operates through interactions between machines that are connected at any distance. To achieve the aforementioned operation of IoT, the internet serves as the connection for interactions between two machines, with the user acting merely as a controller and monitor for the direct operation of the devices [3].

2.4. ESP32

The ESP32 is the name of a microcontroller developed by Espressif Systems, a company based in Shanghai, China. The ESP32 provides a standalone WiFi networking solution by bridging existing microcontrollers to WiFi networks. The ESP32 uses a dual-core processor that runs on the Xtensa LX16 instruction set. Looking at the specifications in the table, the ESP32 microcontroller can be used as an option for demonstration tools for microcontroller interfaces. This microcontroller has a complete interface and is suitable for use because it has built-in WiFi. Demonstration and training tools for the Internet of Things [4].

2.5. DC Motor

DC motors are a type of electric motor that operate with a direct current power source. The direction of rotation of a DC motor is determined by the forward or reverse current, or the positive and negative voltage of the DC motor. The speed of a DC motor is determined by changing/increasing the voltage of the DC motor windings. Typically, an H-bridge circuit is used to change the direction of rotation of the motor, and its speed is controlled by a variable resistor or potentiometer. This manual control may not be applicable in certain situations such as automatic doors, automatic garages, automatic gates, etc., where the movement needs to be controlled by a DC motor (actuator) and a control system/microcontroller is required [8].

2.6. Relay

A relay is a switch that is controlled electrically. The relay has a low voltage coil wound around a core. It has an iron armature that is drawn towards the core when current flows through the coil. The armature is attached to a lever that has a spring. When the armature is attracted, the common path contacts change their position from normally closed to normally open [9].

2.7. Vacuum

The vacuum in this study is a dust removal device that is smaller and lighter than traditional vacuum cleaners. This tool also uses a battery as its power source, making it more flexible to use without the need for long electrical cords.

2.8. Battery

A battery is a device that can convert the chemical energy contained in the active material components of the battery into electrical energy through reduction and oxidation electrochemical reactions. In a reduction reaction, electrons are gained and the oxidation state decreases, while in an oxidation reaction, electrons are released and the oxidation state increases [7].

2.9. GP2Y1010AU0F Dust Sensor

The GP2Y1010AU0F dust sensor is an electronic device designed to detect dust particles in the air. This sensor operates based on the principle of light scattering, where the infrared light emitted within the sensor is scattered by dust particles passing through the detection area. The intensity of the scattered light is then measured by a photodiode, producing a signal that represents the dust concentration.

3. Design and Analysis

3.1. Research Methodology

The method used in this research is the design method (prototyping). This method includes several main stages, namely:

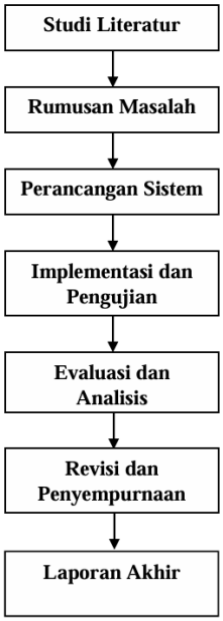

Fig. 1: Research Methodology

3.2. Control System Flowchart

The design of this tool begins with the creation of a flowchart to facilitate the planning and development of the program on the microcontroller. The creation of a flowchart is useful for simplifying the understanding of the working process of the tool. The program flowchart from this research includes the control system of the tool's operation, which can be seen in Figure III.2:

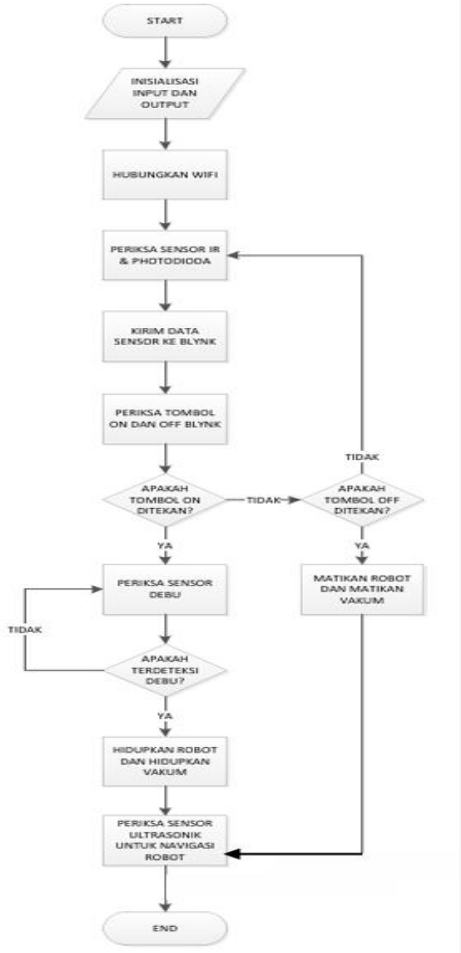

Fig. 2: Control System Flowchart

The following is an explanation of the Flowchart for the Control System of the room cleaning robot as follows:

1. Start.
2. Initialize Input/Output.
3. Connect the device to the internet such as wifi, etc.
4. Check if the Sensor is active or if there are any problems with the sensor.
5. Next, the sensor will detect dust and the command to activate the robot is done manually via the Blynk application.
6. The navigation on the robot uses Ultrasonic sensors.
7. Done.

3.3. Block Diagram Series

The design of the block diagram circuit is the design of electronic components in such a way that it has the desired function. Generally, the planning of the tool design is as follows:

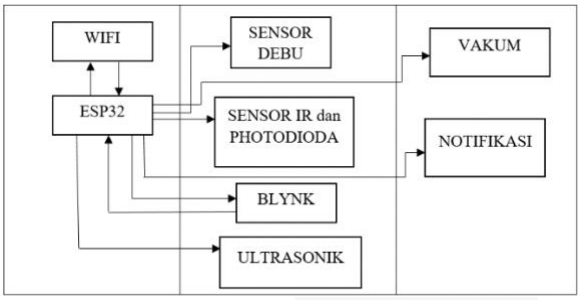

Fig. 3: Blok Diagram Series

The block diagram series in image III.2 shows that the first process is connecting the hardware used, such as a smartphone or computer, to Wi-Fi. In the next process, the sensor detects dust. Then, the data from the Infrared and Photodiode sensors is sent to the ESP32, which will later send notifications to Blynk, and Blynk will issue commands to turn on the system, allowing the robot to work automatically.

3.4. Electronic Circuit Scheme

Schematic of an electronic circuit using ESP32 as a microcontroller that receives data from Infrared sensors and Photodiodes. The ESP32 design functions as a connection between hardware and the internet. The output of the ESP32 will be connected to Blynk for notifications. Below is an illustration of the electronic circuit scheme for the IoT room cleaning robot:

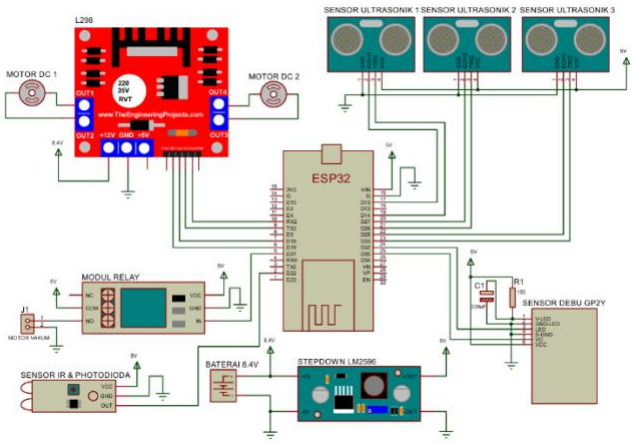

Fig. 4: Electronic Circuit Scheme

4. Results and Discussion

In this chapter, the author outlines and explains the research results by conducting tests. The tests to be conducted are software and hardware tests. Here is the explanation:

4.1. Software Testing

To conduct the program test, the initial steps in this experiment are as follows:

Fig. 5: Initial Display of Arduino IDE

4.2. Hardware Testing

After all the programs are typed, design the hardware as shown in Figure IV.2.

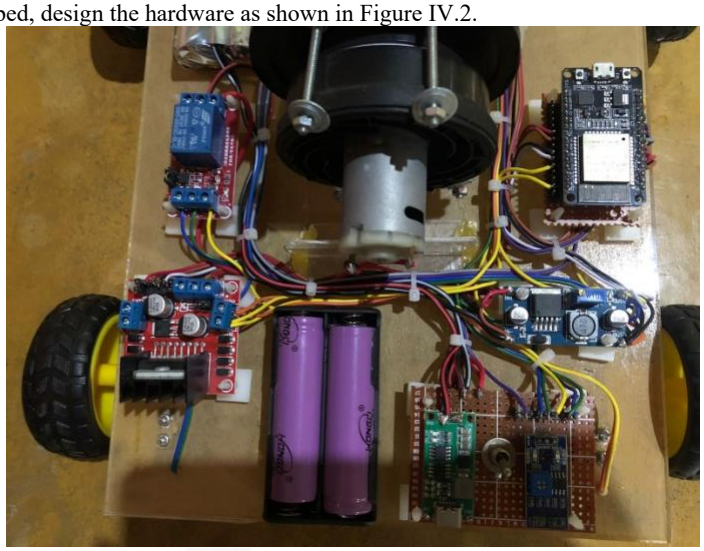

Fig. 6: ESP32 Hardware Design with all tools

Next, the test for the device's activity, based on the indicators in the active/on circuit:

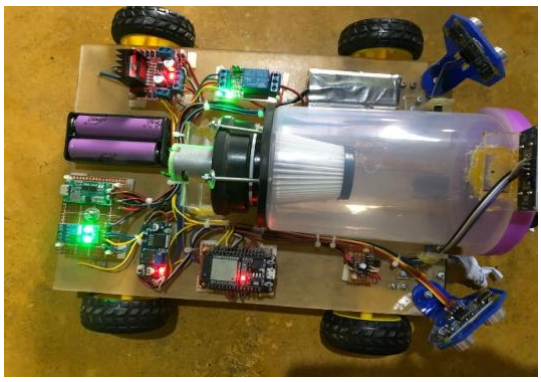

Fig. 7: Position of the tool when active

4.3. Blynk Testing

In this Blynk testing, we create a new template with widgets as shown in the image below:

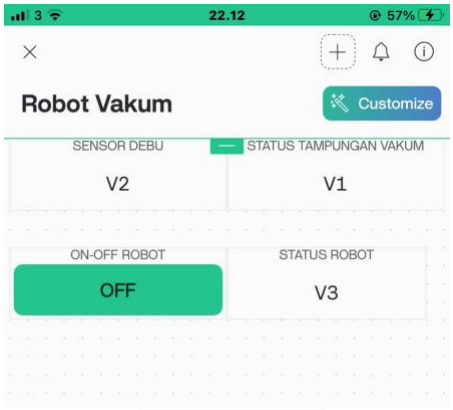

Fig. 8: Blynk Display

After the program has been fully typed, the next step is to input the program code into the circuit by clicking the Bar menu on the Arduino IDE and then clicking upload, with the note that the Board and Port in the Arduino IDE Bar menu are already set. Next, wait a moment until the upload process is complete, then the program that has been uploaded will automatically be saved to the microcontroller.

4.4. Implementation of Overall Testing Using a Bridge Prototype With Load Cell and Gyroscope Sensors Connected to Blynk

The implementation of this test is conducted to determine the performance of the components that will be used in this thesis, with the output being Blynk which will monitor the on/off status and notifications on the vacuum storage container by sending sensor data generated when the storage is full, with notifications sent in Real-Time. With an internet connection, Blynk can receive data sent by the microcontroller. This experiment is carried out by placing dust in the area closest to the sensor, after which the robot will be activated through Blynk when the dust is detected by the sensor, allowing the robot to automatically move and clean the room. The real-time notification experiment on Blynk is done by filling the contents of the storage container. Then, a navigation trial is conducted on the robot to avoid obstacles such as walls in front of it. After all circuits have been designed in the 'Design and Construction of an IoT-Based Room Cleaning Robot,' here are the details:

Fig. 9: Overall Circuit Results

5. Conclusion

Based on the findings of the research and implementation of the "Design and Build of an IoT-based Room Cleaning Robot," it can be concluded that:

1. This research successfully designed and built a prototype of an IoT-based room cleaning robot using the ESP32 as the main controller, GP2Y dust sensor, ultrasonic sensor for navigation, and the Blynk application for remote monitoring and control.
2. The robot is capable of detecting dust, moving automatically to clean the room, and providing notifications through the Blynk application when the dust container is full.

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