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Design and Build a Robot for Fertilizer Irrigation in Agricultural Land Using IoT

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Abstract

This research presents the design and development of an IoT-based fertilizing robot to improve efficiency and effectiveness in fertilizing chili crops. The system utilizes the ESP32 microcontroller, TCRT5000 sensor as a line follower, L298N motor driver, ultrasonic sensor for fertilizer tank level detection, and a DC pump for spraying. Control and monitoring are carried out through the Blynk application connected via Wi-Fi, allowing users to operate the robot and receive real-time notifications when the fertilizer tank is nearly empty. The test results show that the robot can follow the designated path, stop at specific points, and spray fertilizer automatically with a functionality success rate of more than 90%.

Keywords*: Fertilizing Robot, Internet of Things, ESP32, Blynk, Smart Farming.*

1. Background

In the agricultural sector, efficiency and effectiveness in the fertilization process have a significant impact on crop productivity and environmental compatibility. However, traditional fertilization methods still face various obstacles, including inaccuracies in fertilizers, limited workers, and high operating costs. In addition to technological development, especially the Internet of Things (IoT), agricultural innovation is increasingly likely to enhance work efficiency through automation.

The fertilization process carried out manually is often not optimal due to factors such as inaccurate dosing, uneven diffusion, and dependence on working conditions at the workplace. This can lead to harmful environmental impacts due to fertilizer waste, increased production costs, and excessive fertilizer use. By leveraging Internet of Things (IoT) technology, the fertilizer application system can be automated and controlled in real time, allowing farmers to adjust the amount of fertilizer according to their needs. This improves work efficiency, saves resources, and supports the smart agriculture concept. It is more modern and competitive.

Building an IoT-based fertilizing robot prototype in agricultural land is an innovative step to integrate technology into agricultural activities. This innovation is expected to increase efficiency, reduce operational costs, and have a positive impact on the welfare of farmers (Widodo, 2024).

2. Literatur Review

2.1. Design Build

Design and build refers to the depiction, planning, and creation of sketches or arrangements of several separate elements into a cohesive and functional unit. Thus, the understanding of design and build is an activity of translating the results of analysis into a software package and then creating the system or improving an existing system (Cahyanti, 2022).

2.2. Robot

A robot is a prototype that can be controlled automatically to support human work. Some key components in the production of robotic systems include building mechanical equipment, hardware, and software. Limited costs in the production of robot hardware and programming functions are major barriers to inspecting and developing robots. The current development of the robot community is to make the Robot Operating System (ROS) Gazebo an interactive medium for learning and creating robot simulations (Jalil, 2018).

2.3. fertilizer

Fertilizer is a substance that contains nutrients, both macro and micro, that are needed by plants. Poultry manure is a type of fertilizer that comes from livestock waste in the form of animal dung that contains nutrients. The purpose of this research is to determine the effect of the combination of chicken manure and goat manure doses on the growth and yield of pagoda, to identify the optimal doses and types of manure for the growth and yield of pagoda, and to understand the interaction between chicken manure and goat manure on the growth and yield of pagoda (Saepuloh, 2020).

2.4. Agriculture

Agriculture is the foundation of farming, with good agricultural development, and a stable economy influencing a stable economy. Vice President Jusuf Kalla stated that the trend of automation in Industry 4.0 must preserve the basic needs of Indonesians, particularly in the field of agriculture. In agriculture, digital technology can be utilized on and in farming. The potential of digital farming systems offers great opportunities to enhance the enthusiasm and creativity of young people in agriculture that has already begun. Young people, especially students from nonprofit university education activities, will be one of the ways to introduce technology to the community (Puspitasari, 2020).

2.5. Internet of Things

The Internet of Things, often referred to as IoT, is an embedded system intended to expand the use of continuously connected internet. Features such as data exchange, remote control, and other functions are related to food, electronic devices, and devices connected to sensors and networks (Susanto, 2022).

2.6. ESP32

ESP32 is a low-cost system-on-chip (SoC) microcontroller from Espressif Systems, which is also the developer of the popular ESP8266 SoC and NodeMCU. The ESP32 is a successor to the ESP8266 SoC, using a 32-bit Xtensa LX6 Tensilica microprocessor along with Wi-Fi and Bluetooth capabilities. The ESP32 is designed for use in IoT applications such as control functions, monitoring, and sleep light features to save power by turning off unused parts. Overall, the ESP32 is a great WiFi module for various IoT projects. With all its features and affordable price, the ESP32 is the right choice for your wireless communication needs (Anggraini, 2024).

2.7. Battery

A battery is a canister filled with chemical substances that can produce electrons. The chemical reaction that generates electrons is called an Electrochemical Reaction. If we observe, we can see that a battery has two terminals. The first terminal is marked Positive (+) and the second terminal is marked Negative (-). Inside the battery, a chemical reaction occurs that produces electrons. The speed of this process (electrons, as a result of electrochemistry) controls how much electron can flow between the two poles. Electrons flow from the battery to the wire, moving from the negative pole to the positive pole where the chemical reaction is taking place. In general, a battery functions as a medium for storing and supplying electrical energy. The electrical source used as a generator is in the form of direct current (DC) (Muhlisin, 2015).

2.8. L298N

The L298N motor driver is the most popular motor driver used to control the speed and direction of motor movement, especially in line follower / line tracer robots. The advantage of the L298N motor driver is its sufficient precision in controlling motors. In addition, the advantage of the L298N motor driver is that it is easy to control. To control this L298N driver, 6 microcontroller pins are needed. Two pins for Enable (one for the first motor and another for the second motor, as the L298N driver can control two DC motors) and 4 pins to adjust the speed of these motors. The schematic of the L298N motor driver circuit needs additional components to function. The first is a regulator circuit located at the top of the schematic, and the second is a supporting circuit for the motor driver consisting of several diodes. The output of this circuit already provides two pins for each motor. In principle, this L298N motor driver circuit can (Fikriyah, 2018).

2.9. TCRT5000 Sensor

The TCRT5000 is an integrated electronic component made by Vishay that houses an infrared (IR) emitter and detector in a single integrated unit. The compact construction of this component is arranged such that the infrared light emission source and the sensor/detector component are aligned in the same direction, allowing it to detect the presence of approaching objects by detecting the reflection of the emitted red light off the object's surface. The sensor/detector component is a phototransistor, with optimal detection performance when the object is at a distance of 2.5mm (the detectable range is from 0.2mm to 15mm). The phototransistor is coated with a special layer to block light other than infrared to increase the sensor's accuracy. The average output current (Ic) is 1mA (Setiawan, 2021).

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:

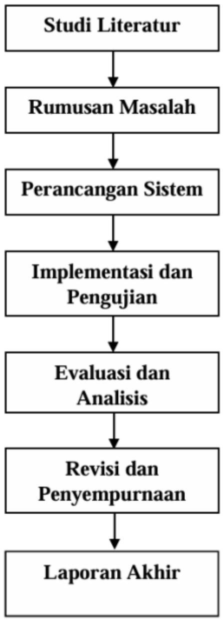

Fig.1 : Research Methodology

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 : Flowchart Monitoring System

The following is an explanation of the Robot Fertilization Control System Flowchart 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 issues with the sensor.
5. The process of filling fertilizer into the tank carried by the robot is done manually.
6. This fertilization process is done automatically with the robot moving along a line, where at each predetermined distance, the robot stops and dispenses fertilizer to the plants.
7. Next, if the robot does not follow the direction of the line, perform a re-check of the sensor.
8. Finished.

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:

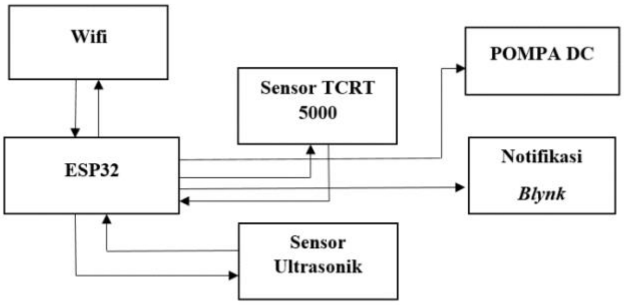

Fig.3 : Blok Diagram Series

The block diagram sequence in Figure 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 the line. Then, the data from the TCRT 5000 sensor is sent to the ESP32, which will then command the DC pump to water the fertilizer according to the detected line. If the Ultrasonic Sensor detects that the fertilizer tank is empty, then a notification will be sent via Blynk.

3.4. Electronic Circuit Scheme

Schematic of an electronic circuit using ESP32 as a microcontroller that receives data from the TCRT 5000 sensor. The ESP32 design functions as a connection between hardware and the internet. The output of the ESP32 will be connected to a DC pump to perform watering. The following is a description of the electronic circuit scheme of the IoT fertilizing robot:

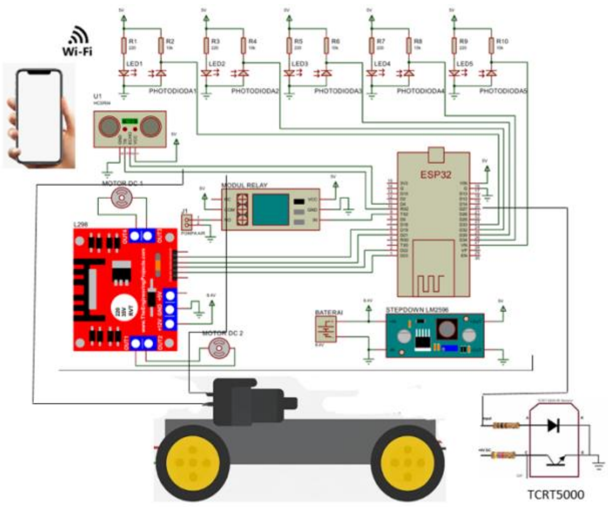

Fig.4 : Electronic Circuit Scheme

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:

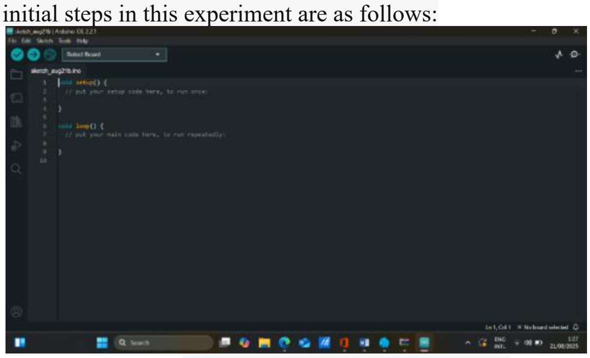

Fig.5 : Initial Display of Arduino IDE

4.2 Hardware Testing

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

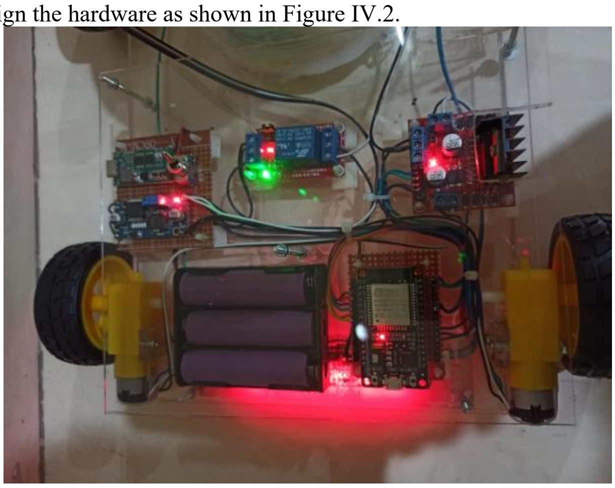

Fig.6 : ESP32 Hardware Design Connected to Other Components

Next, the test for the activation of the Line following sensor is based on the indicator of the sensor being active/on:

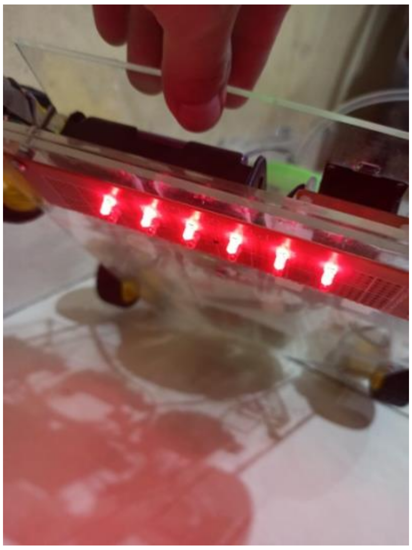

Fig.7 : Active Tool Position

4.3 Blynk Testing

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

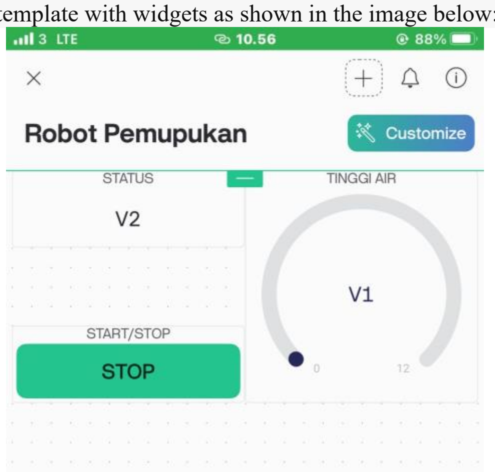

Fig. 8: Blynk Display

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 Line Following Robot with Ultrasonic Sensor Connected to Blynk

The implementation of this test is carried out to determine the performance of the components that will be used in this thesis, with the output in the form of a Blynk notification that will control and monitor the contents of the irrigation tank sent in Real-Time. With both connected to the internet, Blynk can receive data sent by the microcontroller. This experiment is conducted with a robot's line-following test that performs spraying automatically for 3 seconds, and a real-time notification experiment on Blynk. After all the circuits have been designed in 'Design and Construction of a Fertilizer Irrigation Robot in Agricultural Land Using IoT', below is the image of the successful testing of the automatic plant irrigation robot using IoT in Figure IV.5:

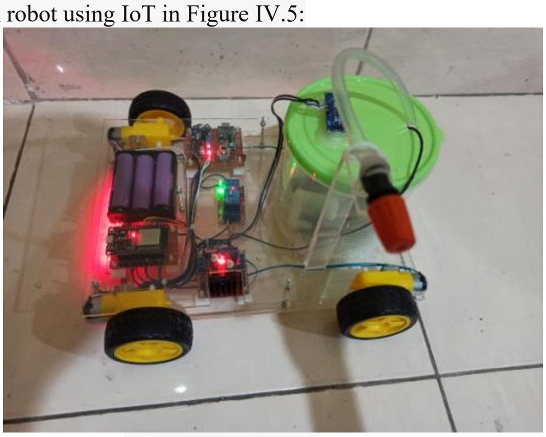

Fig. 9: Overall Circuit Results

5. Conclusion

Based on the results of the design, implementation, and testing of the IoT-based fertilizing robot, several conclusions can be drawn as follows:

1. The fertilizing robot has been successfully designed and implemented using the ESP32 microcontroller, TCRT5000 sensor as a path detector, L298N motor driver, DC pump, and ultrasonic sensor to detect fertilizer capacity.
2. The IoT system with the Blynk application has proven to provide real-time control and monitoring of over 90%, and the IoT system also provides notifications when the fertilizer in the tank is nearly empty.

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