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Design of IoT-Based Tomato Plant Growth Monitoring System in The Yard

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Abstract: The development of tomato plants to produce good fruit cannot be separated from environmental factors that affect their growth and development of tomato plants. These factors include soil moisture, soil pH, temperature, or the amount of light received by tomato plants. The need for water in tomato plants is also very important for their continued growth. Monitoring the development of tomato plants in home gardens based on IoT (Internet of Things) is a monitoring system that utilizes IoT technology to collect, transmit, and analyze data about tomato plants in real-time. In this system, sensors connected to the internet network will be installed on tomato plants to measure several parameters such as soil moisture, air temperature, light intensity, and soil nutrient / pH levels in plants. The collected data will be sent to an IoT platform that will be able to analyze the data. The results of the analysis will be used to make decisions regarding plant care, such as providing water or nutrients that the plants need to grow properly. With cameras to monitor the physical development of the plants, plant height, and fruit development. With this system, communities and farmers can grow tomato plants and can monitor and control plant conditions in real-time through smartphone applications. By utilizing IoT technology, monitoring the development of tomato plants becomes more efficient and accurate. Communities and farmers can take preventive measures to avoid plant disorders and diseases before it's too late, to increase the production and quality of crops.

Keywords: Monitoring; Tomato Plants; IoT; ESP32-CAM; Microcontroller

INTRODUCTION

The tomato plant is one of the fruits that is favored by the community both in terms of its benefits and its uses in various dishes. Based on its benefits, tomatoes also contain many useful substances for the human body, such as vitamin C, which is found in tomatoes and helps to improve the body's immunity and enhance the body's immunity, vitamin A, which is also contained in tomatoes, to prevent and treat xerophthalmia in the eyes, the mineral source in tomatoes contains iron, which is useful for the development and formation of red blood cells, tomatoes also have high fiber content, which can improve food absorption, digestion, and potassium content that can help lower high blood pressure.

The development of tomato plants to produce good fruit is not separate from environmental factors that influence the growth and development of tomatoes, such as soil humidity, soil pH, temperature, and intensity of light received by the tomato plant. The water needs of tomato plants are very important for their continued growth and are also not resistant to high rainfall, which can cause their growth and development to be not optimal and easily affected by diseases that cause the tomato plant to rot and eventually die.

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The above problems are experienced by communities that grow tomato plants in their home gardens that are not monitored due to other activities. Based on the research conducted by (Fauzia et al., 2021), who created "*Otomatisasi Penyiraman Tanaman Cabai Dan Tomat Berbasis* IoT", the research was designed to make it easier to irrigate chili and tomato plants by knowing the soil moisture parameters. The research was conducted by (Darwanto et al., 2020), who created "*Alat Perawatan Tanaman Tomat Otomatis Berbasis Arduino Nano dan* NODEMCU". The research is intended and conceived as an automatic watering machine to help the process of tomato plant care automatically. The research conducted by Reza Fahrisi and Fatoni (2018), who created "*Rancang Bangun Sistem Smart Garden Berbasis Mikrokontroler Menggunakan Metode Sdlc"*.This research is doing disciplined plant watering and doing it in the right way and at the right time, the plants will grow well. Discussing the problem of watering plants, of course there are several factors that must be considered, such as when is the right time for us to water the plants.

From the existing problems, the author wants to raise this issue as a thesis by creating a tool that can monitor the development of tomato plants that are planted in the home environment using a soil moisture sensor that responds to the moisture of the tomato plant soil, a light intensity sensor to send data to the sensitivity of the tomato plant to light, a temperature sensor to obtain temperature data so that the tomato plant grows optimally, all of these sensors will be controlled by Arduino and ESP-32 CAM to send information about the development of the tomato plant and photos of the tomato plant.

To work effectively, the environment must already have a canopy to block too intense sunlight and too high temperatures and avoid heavy rain that can flood the tomato plant soil, so the author will create a monitoring system using a camera from ESP-32 CAM, a watering system, and when the tomato plant needs water, the pump will turn on automatically. The camera from ESP-32 CAM will take pictures of the tomato plant and send the data to Telegram.

LITERATURE REVIEW

Based on the research conducted by (Fauzia et al., 2021), who created "*Otomatisasi Penyiraman Tanaman Cabai Dan Tomat Berbasis* IoT", the research was designed to make it easier to irrigate chili and tomato plants by knowing the soil moisture parameters. The results of research on the design of automatic watering of chili and tomato plants were carried out for 5 consecutive days starting at 07:00 WIB until 17:00 WIB. The results of research on the design of watering tools for chili and tomato plants can function properly and can work with ADC values> 600 pumps on to ADC values < 600 pumps off.

The research was conducted by (Darwanto et al., 2020), who created "*Alat Perawatan Tanaman Tomat Otomatis Berbasis Arduino Nano dan* NODEMCU". The research is intended and conceived as an automatic watering machine to help the process of tomato plant care automatically. The purpose of creating a tool with the concept of an automatic watering machine is to help the process of caring for tomato plants automatically. The user or user is only tasked with supervising and ensuring that the machine works properly. Machines and humans are connected via a wireless network which can be called the internet.

The research was conducted by Muhammad and Haryono (2022), who created "Design of Pond Water Temperature Monitoring Built Using NodeMCU ESP8266". The purpose of this research is to make a prototype to detect pond water temperature and increase pond water discharge which is useful for reducing pond water temperature to be cooler and reducing the risk of fish death. The prototype developed is a NodeMCU ESP 8266 micro- controller, a temperature detection sensor in water, a relay as a switch and a mini pump.

The research was conducted by (Simanungkalit et al., 2023), who created "Smart Farming on IoT-Based Aeroponik Systems". This research combines hydroponic plants with the help of Internet of Things (IoT) technology using aeroponic planting techniques. The design of IoT devices uses a microcontroller that is integrated with the Arduino Mega as a center for running supporting sensors such as water level, ultrasonic, ph, tds, and dht22 sensors.

The research conducted by Reza Fahrisi and Fatoni (2018), who created "*Rancang Bangun Sistem Smart Garden Berbasis Mikrokontroler Menggunakan Metode Sdlc"*.This research is doing disciplined plant watering and doing it in the right way and at the right time, the plants will grow well.

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Discussing the problem of watering plants, of course there are several factors that must be considered, such as when is the right time for us to water the plants.

The research conducted by (Putri et al., 2019), who created "*Perancangan Alat Penyiraman Tanaman Otomatis pada miniatur* Greenhouse *Berbasis IoT"*. Greenhouses with modern technology create automatic controls such as sprinklers. Thus, less time is spent on watering the plants compared to the human system.

Based on the above research, the author is interested in conducting a research entitled "Design of IoT-Based Tomato Plant Growth Monitoring System in The Yard". Where it will be discussed monitoring the development of tomato plants using smartphone through the telegram application, which will be able to generate sensor data and photos of tomato plants.

METHOD

This research refers to the action research method, with the stages as shown in Figure 1 below.

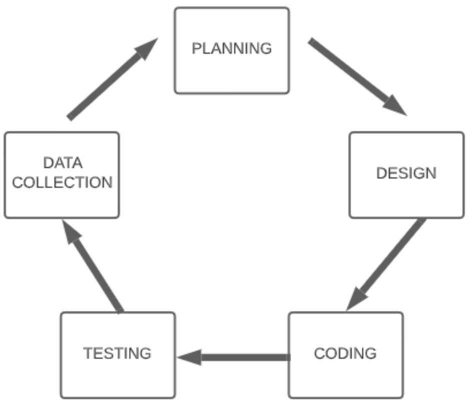

Fig. 1 Research method

Research Method

To improve the clarity and smoothness of the research process, it is important to choose a research method that has clearly defined stages, such as the Action Research Method. This method is a research design that involves stages of observation, Framework of Thought, research design, testing and data collection, and theory development and conclusion to understand and improve the given situation.

1. Planning
   This stage is the first step in system development where planning activities are carried out, namely, identifying problems, and analyzing component needs to determine the schedule for making and testing the system (Apriyani et al., 2022; Haripurna and Purnomo 2017).
2. Design
   The next stage is designed where at this stage modeling activities are carried out starting from system modeling, architecture modeling, to database modeling (Fadli 2021). This design includes schematic design, block diagrams, and steps for using the system.
3. Coding
   Coding is an activity of applying the design model that has been designed previously into the user interface using a programming language.
4. Testing
   After the coding stage is complete, then the system testing stage is carried out to find out what errors arise when the system is running and find out whether the system is feasible with user need (Nasution & Effendi, 2018).
5. Data Collection
   Furthermore, after the test is complete, the system is run to obtain data from each sensor component that has been designed.

Block Diagram

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The design of the tool for monitoring the development of tomato plants and automatic watering has three stages, these three stages will be explained using block diagrams including input, process, and output. These three process sections have equally important functions and require specific components to carry out the processing.

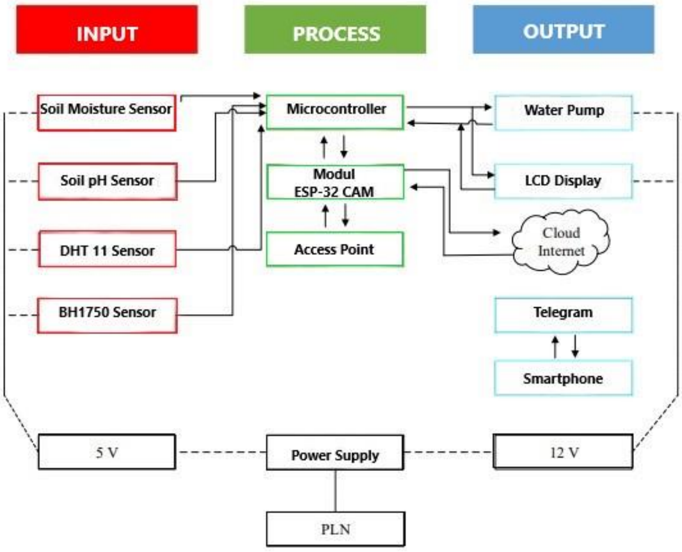

Fig. 2 Block diagram.

Schematic Diagram

The design of the IoT-based tomato plant monitoring system uses several types of sensors, such as a soil moisture sensor that works by detecting the amount of water in the soil. The program is designed such that if the sensor detects a moisture level of less than 60 percent, it will give the information that irrigation must be done. Therefore, the soil moisture sensor must be synchronized with the water pump so that if the program reads a moisture level less than what we have set, the pump will automatically turn on. Then the temperature sensor, light intensity, and pH are useful as comparison data to be applied to tomato plants to get good growth inputs. Furthermore, the ESP32 CAM will be programmed to connect to Wi-Fi and take pictures and send the results to the Telegram bot. This process will be done routinely every 3 times a day, and the time for taking the picture will be determined. To understand the chain and working principles of the device to be designed, the tomato plant monitoring system using ESP32 CAM based on IoT can see the schematic design figure 3 as follows :

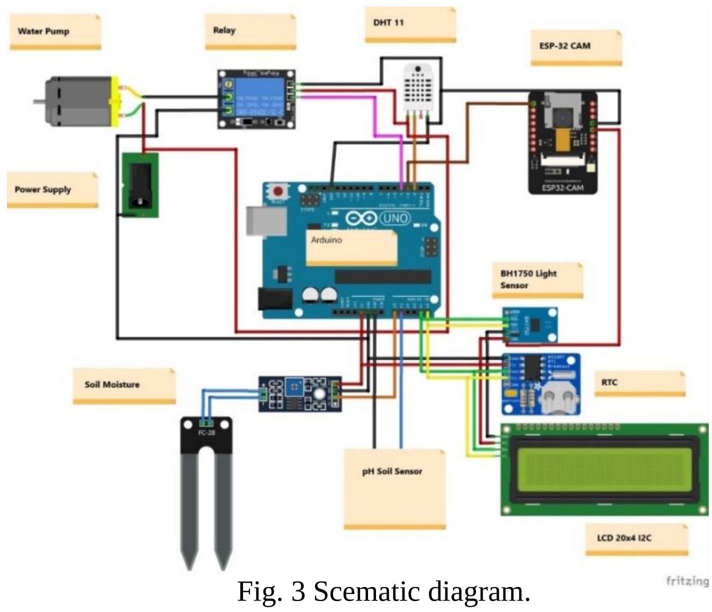

Fig. 3 Scematic diagram.

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RESULT

After analyzing and designing all the processes that have been carried out in the process of designing an IoT-based tomato plant development monitoring system, the results obtained in testing the tools that have been designed are as follows:

Testing The Soil Moisture Sensor and Water Pump

Testing the soil moisture sensor and water pump aims to test soil moisture and automatic water pump ignition, if the soil is too dry, the automatic pump control will water until the soil conditions are declared wet.

Table 1. Soil moisture and water pump testing.

Test Scenario	Watering Estimates (ml)	Expected Result	Result
Dry +	200	The pump is on until enough of water needed	As planned
Dry	100	The pump is on enough of water needed	As planned
Wet	0	The pump is off, no need water	As planned
Wet+	0	The pump off, no need water	As planned

Testing The Soil pH Sensor

The test was conducted to test the comparison of the soil pH sensor with the pH meter tool and to determine the pH value contained in the soil during testing.

Table 2. Soil pH sensor testing.

Component Tested	Test Scenario	pH Estimates	Expected Result	Result
pH Meter (Manufactured)	Soil condition of fertilizer irrigated with acidic water	4.0	-	-
	Soil condition of fertilizer irrigated with destilled water	7.0	-	-
	Soil condition of fertilizer irrigated with alkaline water	9.0	-	-
Soil pH Sensor	Soil condition of fertilizer irrigated with acidic water	3.94	results show there is only a slight difference	Accordin g to which expected
	Soil condition of fertilizer irrigated with destilled water	6.83	results show there is only a slight difference	Accordin g to which expected
	Soil condition of fertilizer irrigated with alkaline water	9.25	results show there is only a slight difference	Accordin g to which expected

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Table 4. Some data has been obtained through the comparison test where 3 times are testing the soil pH sensor and pH meter, where the results issued also have a fairly small difference, this indicates that the soil pH sensor has worked well so that it can be an indication of the soil pH reading.

Testing The DHT11 Sensor

At the DHT11 sensor testing stage, testing is carried out with the aim of comparing the design tool with the tool that has been assembled by the manufacturer.

Table 3. DHT11 sensor testing.

Minute to-	HTC – 2 (ºC & %RH)		DHT11 (ºC & %RH)		Result
1	27, 8	54	28, 4	52	As Planned
2	27, 8	57	28, 7	56	
3	27, 6	53	28, 6	54	
4	27, 6	54	27, 9	55	
5	27, 4	56	27, 6	54	
6	27, 5	58	27, 8	57	
7	27, 6	52	28, 4	53	
8	27, 3	56	27, 8	54	
9	27, 4	54	27, 5	56	
10	27, 3	55	27, 4	52	

From the test results in table 3 there is a difference in difference actually, the test results on this temperature sensor are following the situation, which makes the difference only when testing some different positions and conditions seem to change.

Testing The Sensor BH1750

The BH1750 sensor test is carried out using a comparison with a lux meter to measure the light intensity level of the device.

Table 4. BH1750 sensor testing.

No.	Test Scenario	Lux meter	BH1750	Result
1	Bright condition (inside)	110 – 500	110 – 500	The difference is not too significant
2	Bright condition (outside)	700 – 1200	700 – 1200	The difference is not too significant
3	With *LED flash handphone*	2000+	2300	The difference is not too significant
4	Dark condition (inside)	100 – 250	100 – 250	the difference is not too significant

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5	Dark condition (outside)	40 – 100	40 – 100	The difference is not too significan t
6	Sensor closed	0	0	As planned

From the results of table 4. There is test data with a total of 6 tests on the BH1750 sensor and lux meter, the results show that the BH1750 sensor tested in comparison with the lux meter has almost the same output value, this indicates that the BH1750 sensor that has been designed has worked well so that it can be an indication of the light intensity sensor reading.

Testing The ESP32-CAM

This test aims to be able to send information data, notifications, and images to the telegram application when requested or automatically which will automate taking pictures periodically for 3 days a week so that differences in tomato plant growth can be seen.

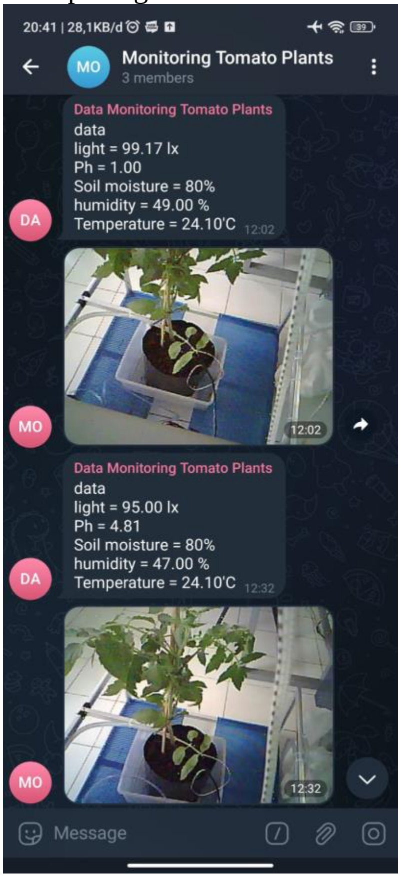

Fig.4 Data dan photo from telegram.

DISCUSSIONS

After getting the test results by conducting several experiments, namely testing the soil moisture sensor, testing the soil pH sensor, DHT 11 sensor, BH1750 sensor, ESP-32 CAM as a link to the internet and telegram and taking pictures, it can be concluded that the system has worked well and all sensor components and other components have been utilized following their functions.

To determine the success of the system that has been designed, the results obtained are under what was hypothesized at the beginning of the research, so that this system works well starting from the system can monitor and control plant watering, as well as automation in sensor data capture and take pictures using the ESP-32 CAM camera and sent to the telegram application. The comparison with the

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previous test is in the use of soil sensors and the utilization of the camera from the ESP-32 CAM. The many research results that have been carried out, can provide a variety of good perceptions and fresh new ideas in terms of making systems and allowing for renewal and development in the future.

Fig.5 Testing the overall system

CONCLUSION

From the discussion on "Design of a tomato plant development monitoring system in an IoT-based home environment" can be concluded as follows. All components used in making this tool work well as their functions. The output value generated from each component has a value that is in accordance with the existing datasheet and is still within the range of capabilities of the components used, which is what makes all components work well. The output of this system is automatic watering, dc motor, and sending information to telegram.

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