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An Internet of Things (IoT) based Plant Irrigation and Monitoring System for Chili Plant

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Abstract: This paper focused on irrigation control and a proper monitoring system to ensure that the plant receives enough nutrients and moisture at all times. Soil moisture and pH level are the two types of parameters that are being monitored. To maintain long-term smart farming solutions, a systematic approach to monitoring and controlling these parameters is required. The main objective of this project is to develop an Internet of Things-based chili plant irrigation and monitoring system (IoT). The implementation of IoT in this project also included using a Wi-Fi node as a connection medium. The data send soil moisture and pH levels to the user via the Blynk app and controls the water pump. Thus, a remote IoT platform could be used to automate irrigation and monitor crop status. It is successfully implemented to solve the problems faced by farmers.

Keywords: Irrigation, Monitoring System, IoT, Soil Moisture, pH Level

1. Introduction

Malaysia's agriculture sector is one of the most important. Due to the emergence of the Internet of Things (IoT), agriculture has evolved tremendously this year. However, the traditional agricultural techniques have become ineffective as a result of population growth. In addition, the irrigation and fertigation systems in the farming sector must be monitored and appropriately managed to ensure that the plant receives enough nutrients and moisture at all times [1]. Water aids plants growth by transporting essential nutrients. The plant takes nutrients from the soil and uses them. Plants droop if there isn't enough water in their cells, so water helps them stand.

As a result, soil and farm characteristics monitoring is an essential tool for increasing crop production. Inefficient manual irrigation systems are a waste of natural water resources in developing countries [2]. An IoT-based automated watering and monitoring system for the chili plant project has been proposed to improve crop productivity and output. Computer and electronics applications in agriculture, particularly irrigation systems, have presented new engineering and research challenges [3].

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The Wi-Fi module will send sensor data to a remote IoT platform over a Wi-Fi connection. The sensor data is sent to the IoT platform, which processes it and returns it. The Wi-Fi module collects sensor data first. Then it sends data of soil moisture and pH levels to the user via the Blynk apps. An IoT-based automatic irrigation system based on sensor readings provides water to the crop. When the soil moisture level is low, the water pump is turned on to provide water to the crops, and the fertilizer is turned on to provide nutrients. A remote IoT platform could be used to automate and monitor crop status.

2. Methodology

This section discussed the research methodology used to develop the IoT of irrigation and monitoring system. It includes the overall project architecture, flowchart, and block diagram of the prototypes.

2.1 Overall Project Architecture

By sensing the soil moisture value and pH soil level of the field without human intervention, the proposed system assists users in improving the quality and quantity of their farm yield. The IoT concept can improve the efficiency of a system. The NodeMCU microcontroller ESP8266 is used to link the complete network wirelessly. Each sensor node comprises a moisture sensor and a soil pH sensor with a NodeMCU to collect the data from the soil. A 5V 2A DC supply powers the sensor nodes.

240AC supply of relay and three-pin power socket connection is connected to switch turn on or off water pump to activate the automatic irrigation. It is divided into two tanks for the tank water and another for fertilizer tank water. The primary proposed system consists of two sensor nodes, which are pH sensor and soil moisture sensor. These two sensors give efficient results while they operate. The main sensor nodes in the proposed system are the pH sensor and the soil moisture sensor. The pH sensor provides the pH value and can read the values from the soil to determine whether the soil is acidic or basic soil.

For this project, the NodeMCU microcontroller plays the role of the brain and the significant parts involved. The irrigation system has been optimized to provide irrigation efficiency, saving water and improving crop quality. The system has benefits to the crop and user. The automatic irrigation and monitoring system can enhance the quality of crops and yield of chili plants. Besides that, the water pump can be turned on and turn off automatically. Therefore, human intervention is avoided by using remote monitoring and control and can help to lower water consumption. The overall project architecture is shown in Figure 1.

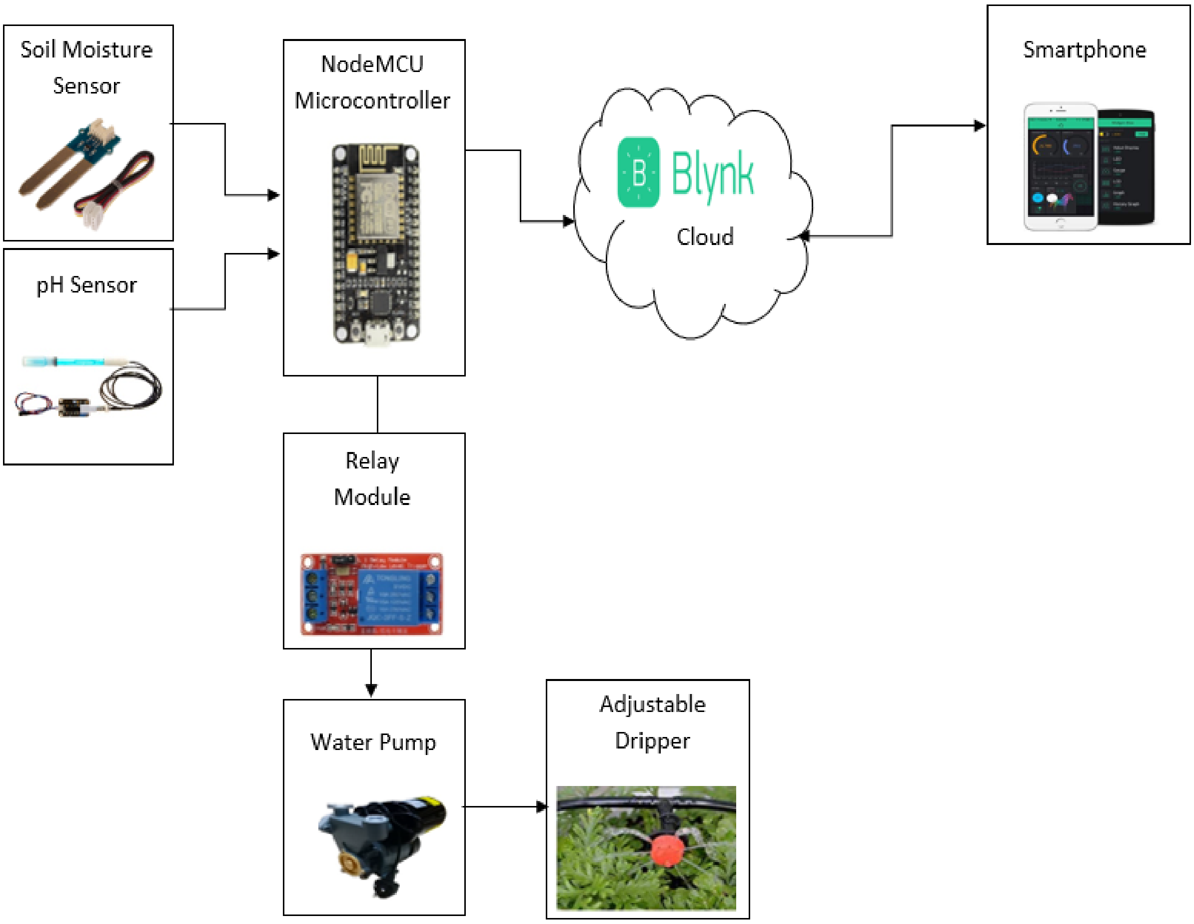

Figure 1: Design architecture of project

2.2 Hardware Development

Figure 2 depicts the automatic irrigation and monitoring system as a block diagram. Block diagram connections will be used to design the electronic circuit. The first block displays an analogue input signal from the pH sensor and soil moisture sensor integrated with the Arduino IDE Software. It will be processed in the second block for the NodeMCU microcontroller ESP8266. As a result, the input sensor was connected to the controller, a NodeMCU. This component for NodeMCU serves as a device to connect the system to a smartphone. The water pump uses as an output device for the controller, allowing the solution to flow out. The Blynk apps display the data from sensors, including the water pump control for three automatic or manual buttons on/off.

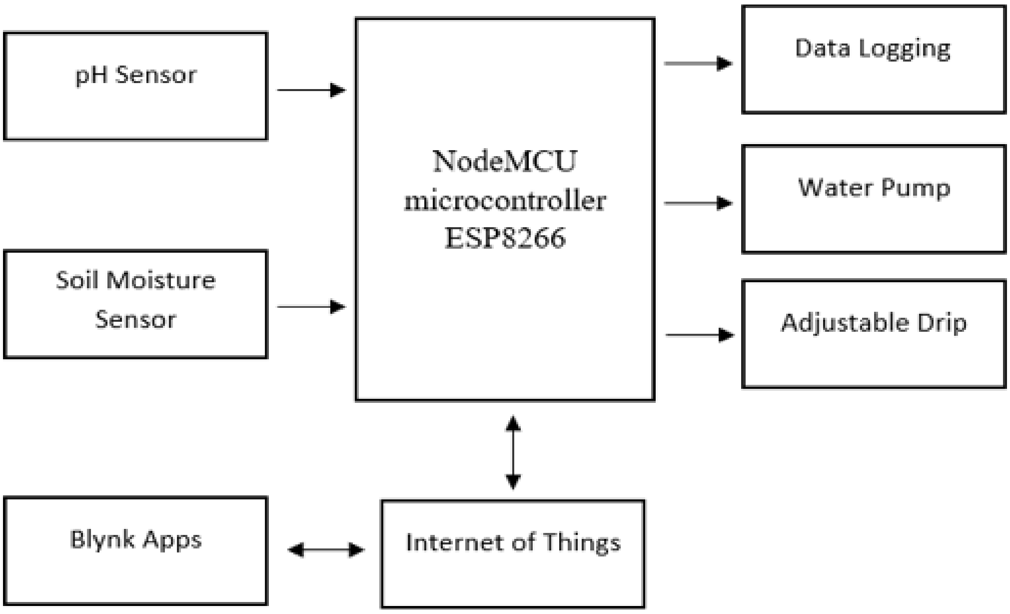

Figure 2: Automatic irrigation and monitoring system block diagram

2.3 Apps Display

This project used Blynk apps to monitor the condition of input for pH soil and soil moisture, which was displayed on a mobile phone. The pH soil is only for monitoring purposes, whereas the soil moisture activates irrigation if the value is less than 40% or exceeds the water content. The graph will show the pH value and moisture content as they change over time. The mobile phone was connected to the NodeMCU via Wi-Fi to get the most recent update on the plant's soil condition. The user can also select one of three buttons to control the water pump: AUTOMATIC mode or manual mode in mobile apps to turn ON and OFF the water pump. Figure 3 shows the display in Blynk application.

Figure 3: Display in Blynk application

3. Results and Discussion

This section analyses and explains the results that have been obtained throughout the project. The repeatability of the developed automatic irrigation and monitoring system for chili plants was then tested for durability and performance to study and evaluate the performance to meet the objective. The information is gathered in the morning and evening sessions. Data is collected from 7.00 am to 8.00 am and 5.00 pm to 6.00 pm for the testing process.

3.1 Repeatability Testing Day 1

Data for automatic and manual mode is being collected on day 1 in the morning and evening sessions. On and off modes are selected for the manual controller. The ON mode can be selected if the soil moisture content is less than 40% or the soil is too dry due to a lack of water. The OFF mode should be selected to prevent root disease and plant drowning if the soil moisture level exceeds water.

Table 1 shows that the analysis and result for morning session day 1 for OFF mode. This morning session for OFF mode starting from 7.00 am, 7.20 am, and 7.40 am. The water pump control is set to OFF mode because the water content in the soil is high. The water pump control is set to OFF mode because the water content in the soil is high. The percentage content of soil moisture from 7 am was 96.0%, while the soil pH rate was 8.7. At 7.20 am, the soil moisture rate decreased by 9%, while the soil pH rate remained unchanged. Soil moisture began to change reading at 7.40 am, making the soil moisture 84.0%, and the soil pH also decreased to 8.5. The data show that the reading for soil pH is 8 and above.

Table 1: Analysis and result for morning session day 1 (OFF Manual Mode)

Time Set	Soil Moisture (%)	pH Soil	Water Pump Control
7.00 am	96.0	8.7	OFF
7.20 am	87.0	8.7	OFF
7.40 am	84.0	8.5	OFF

Table 2 shows that the analysis and result for morning session day 1 for AUTO mode. This morning session for AUTO mode starting from 7.10 am, 7.30 am, and 8.00 am. The water pump control is set to AUTO mode to control if the soil moisture is less than 40% or too dry due to lack of water or if the soil moisture is more than 50% or exceeds water. The percentage content of soil moisture from 7.10 am was 93.0%, while the soil pH level was 8.6. At 7.30 am, the soil moisture rate decreased by 7%, making it 86.0%, while the soil pH level is increased to 8.7. Soil moisture began to change reading at 8.00 am, making the soil moisture 81.0%, and the soil pH also decreased to 8.5.

Table 2: Analysis and result for morning session day 1 (Automatic Mode Controller)

Time Set	Soil Moisture (%)	pH Soil	Water Pump Control
7.10 am	93.0	8.6	AUTO
7.30 am	86.0	8.7	AUTO
8.00 am	81.0	8.5	AUTO

Table 3 shows that the analysis and result for morning and evening session day 1 for ON mode. This morning session for ON mode is chosen at 7.05 am. The soil condition is moist in the morning. The evening session is set from 5.00 pm to 6.00 pm. The water pump control in ON mode at 7.05 am with the soil moisture is 96.0% and pH soil is 8.3. It is controlled in ON mode because it will not water the plants if set in AUTO mode. The soil moisture content from 5.00 pm was 35.0%, while the soil pH level was 8.3. At 6.00 pm, the soil moisture rate increased by 22%, making it 57.0%, while the soil pH level is increased to 8.5.

Table 3: Analysis and result for morning and evening session day 1 (ON Manual Mode)

Time Set	Soil Moisture (%)	pH Soil	Water Pump Control
7.05 am	93.0	8.6	ON
5.00 pm	86.0	8.7	ON
6.00 pm	81.0	8.5	ON

3.2 Repeatability Testing Day 2

On day 2, automatic and manual mode data is collected in the morning and evening sessions. The manual controller can be switched between on and off modes. The ON mode can be selected if the soil moisture content is less than 40%. To avoid root disease and plant drowning, select the OFF mode if the soil moisture level exceeds 40% of the water content in the soil or exceeds water.

Table 4 shows that the analysis and result for morning session day 2 for OFF mode. This morning session for OFF mode starting from 7.00 am, 7.20 am, and 7.40 am. The water pump control is set to OFF mode because the water content in the soil is high. The soil moisture percentage from 7.00 am was 92.0%, while the soil pH rate was 8.3. At 7.20 am, the soil moisture rate decreased by 3%, while the soil pH rate is increased by 0.2 to become 8.5. Finally, soil moisture began to change reading significantly at 7.40 am, making the soil moisture is lower to 77.0%, and the soil pH is increased to become 8.7.

Table 4: Analysis and result for morning session day 2 (OFF Manual Mode)

Time Set	Soil Moisture (%)	pH Soil	Water Pump Control
7.00 am	92.0	8.3	OFF
7.20 am	89.0	8.5	OFF
7.40 am	77.0	8.7	OFF

The analysis and results for morning session day 2 in AUTO mode are shown in Table 5. This morning's AUTO mode session begins at 7.10 am, 7.30 am, and 8 am. If the soil moisture is less than 40% or too dry due to lack of water or the soil moisture is more than 50% or exceeds water, the water pump control is set to AUTO mode. The soil moisture content was 91.0 percent at 7.10 am, and the soil pH was 8.7. At 7.30 am, the soil moisture rate dropped by 9%, to 82.0 percent, while the soil pH remained unchanged. Soil moisture began to change reading significantly at 8.00 am, making the soil moisture 74.0%, and the soil pH remained 8.7. The data show that the reading for soil pH is 8 and above.

Table 5: Analysis and result for morning session day 2 (Automatic Mode Controller)

Time Set	Soil Moisture (%)	pH Soil	Water Pump Control
7.10 am	91.0	8.7	OFF
7.30 am	82.0	8.7	OFF
8.00 am	74.0	8.7	OFF

The analysis and results for morning and evening session day 2 for ON mode are shown in Table 6. At 7.05 am, this morning session for ON mode is selected. In the morning, the soil condition is moist. At 7.05 am, the water pump was turned on with the soil moisture level at 92.0 percent and the pH level at 8.3. It is set to ON mode because it will not water the plants if it is set to AUTO mode. Because the sun is at its lowest in the morning, this is the best time to water the plants. For the water to reach the roots without evaporating, it is considered an ideal time. At this time of day, plants are ready to absorb a lot of water, and they need to stay hydrated to get through the day. Watering before 10 am allows the water to seep more effectively. From 5.00 pm, the soil moisture content was 37.0 percent, with a pH of

8.3. At 6.00 pm, the soil moisture rate had risen by 37% to 74.0 percent, and the soil pH is 8.2. The reading for soil pH is eight and above, according to the data. As a result, no fertilizer is required. The chili plant will be harmed if it is over-fertilized.

Table 6: Analysis and result for morning and evening session day 2 (ON Manual Mode)

Time Set	Soil Moisture (%)	pH Soil	Water Pump Control
7.05 am	92.0	8.3	OFF
5.00 pm	37.0	8.3	OFF
6.00 pm	74.0	8.2	OFF

4. Conclusion

Finally, for the conclusion, this project is capable of achieving all of the mentioned objectives. The water pump was in good working order for the irrigation of the crops. This project can successfully integrate with IoT. The Blynk application now has a manual water pump control setting that allows the farmer or user to set the water needed for their crops. The monitoring process was successful due to the user's involvement every time sensor data was received. The real-time system will work correctly when the internet connection is faster. The real-time system will not function properly without an internet connection. It is no longer necessary for the farmer or user to visit the farm to monitor soil conditions and pH nutrient content. They can monitor the state of their soil crop from anywhere, including at home.

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