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Study of Soil Quality (Moisture and pH) Upon the Growth of Okra Plant Using IoT Technique

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Abstract: The Internet of Things (IoT) is an evolving platform integrating numerous technologies from various fields. For this study, the aim is to implement IoT in the agriculture sector, specifically in monitoring the soil quality upon the growth of the okra plant. The system's design consists of a web-based system, a monitoring system for agriculture, and a communication network. This system is designed to allow the monitoring process of soil quality through mobile phones. The micro-controller that is used to process the data from the sensors is NodeMCU. The micro-controller is programmed using Arduino IDE software to receive the reading from the sensors, process the data, and send it to a mobile phone via an application called Blynk. The ideal value for soil moisture is between 50% to 70%, while for the soil pH value, the range more to the acidic side, which is between 5.0 to 7.5. After experimenting and monitoring for seven days, the results show that the height of the okra plant has increased from 6 cm to 9 cm. The positive output results from controlling and monitoring the parameters, soil moisture and soil pH between the ideal value for seven days. This system is essential to facilitate farmers in managing the crops while increasing the production rate of fresh okra vegetables.

Keywords: Internet of Things (IoT), Agriculture, Okra Plant

1. Introduction

Agriculture is one of the essential industries in Malaysia, apart from petroleum, automotive, and construction. Two aspects must be maintained to produce a good yield: water and fertilizer as the plants depend on the two elements. The idea of IoT can be implemented in the agriculture system, just like other systems in this world. The concept of IoT can be further built to facilitate anyone to communicate at any time or any location, using anything [1]. IoT can therefore be defined as an integration with the internet of a device with self-configuring capabilities based on standard and extensible communication protocols where identities, physical attributes, and virtual personalities have physical and virtual things [2]. This study aims to improve the agriculture sector by designing and developing an IoT-based smart plant monitoring system for the okra plant. In general, this system consists of sensors that will read the parameters, which are soil moisture, soil pH, and plant height to be sent to the database for monitoring

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process through Blynk App on mobile phones. Like most countries, Malaysia can also reach a higher level of production for the okra plant if they apply the IoT-based agriculture technique to their crop.

1.1 Internet of Things (IoT)

Currently, we live with a technology development that utilizes the internet, such as the Internet of Things (IoT) or the Internet of Objects. The definition of IoT is networked links of everyday devices, frequently equipped with omnipresent intelligence [5]. IoT offers various opportunities for research and development in terms of its application. The potential of the IoT allows the result of a large number of applications, only a relatively small percentage of which is already available to our society [6]. IoT is a fusion of smart tools to generate information from sensors to create new data and information to improve human intelligence, efficiency and quality of life.

1.2 IoT in Agriculture

IoT allows farmers to analyse better and observe land changes, allowing harvest and production of their crops to be maximised [7]. Furthermore, farmers can perform similar IoT applications for the agriculture sector in determining the environmental parameters, such as the amount of carbon dioxide and oxygen in the area. Attaining plant growth efficiency, in general, is a vital research component of every country due to the need for food and the expanding population in the world [8]. Strategically positioned sensors can sense and transmits data to the cloud for additional application documentation, prediction or control [9]. A variety of IoT agriculture applications are being employed to develop more effective resources for agricultural productivity. Precision farming, livestock monitoring, and greenhouse monitoring are the three main sectors of IoT agriculture applications. Figure 1 below shows the three divisions of IoT in agriculture.

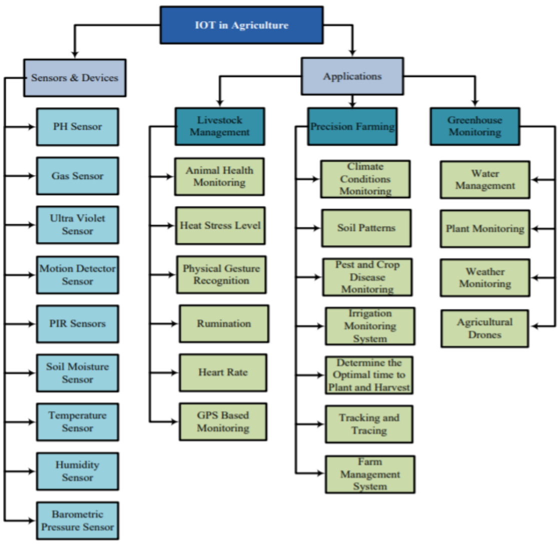

Figure 1: IoT in Agriculture Division [10]

1.3 Okra Plant

Okra (Abelmoschus esculentus (L.) Moench) is well known as lady's fingers in many English-speaking countries [3]. The crop is extensively planted in the southern hemisphere throughout the year. It is tropical to subtropical and is sensitive to low temperature, waterlogging and drought. The cultivation from different countries has specific adapted characteristics unique to their region [4]. To plant an okra plant, few things need to be prepared for the plant to grow. Okra is categorized as a warm-weather crop, and the plant must be exposed to the sun. Okra can grow and adapt in most soils, but it performs best in well-drained soil rich in organic matter. Therefore, the best soil moisture for the okra plant is between 50% and 70%, while the soil pH must be on the acidic side, which is between 5.0 and

7.5. To ensure the okra plant grow well, the seeds must be planted separately to provide the plant an ample room to grow. The seed must be planted inside the soil about half an inch deep and 12 to 18 inches apart in a row. Figure 2 below shows the okra plant.

Figure 2: Okra Plant

2. Materials and Methods

This study is carried out using two approaches: discovering the information and idea through source references such as books, online journals and online articles, and designed system using micro-controller and sensors for the okra plant monitoring. Furthermore, the development of this system can help maintaining the best moisture and pH for the soil to grow the okra plant. Figure 3 below shows the overview of the system.

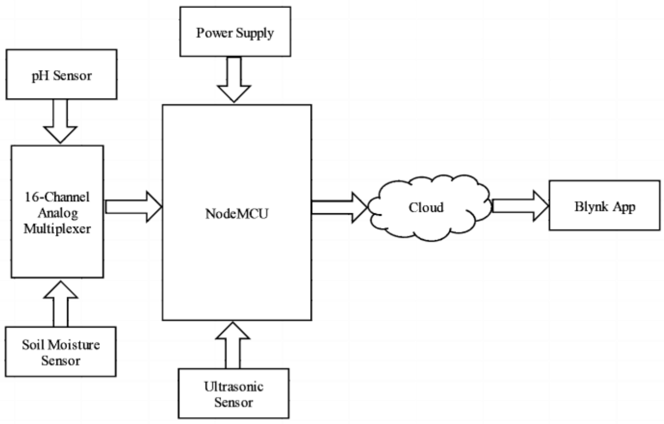

Figure 3: Overview of the System

2.1 Electronic Equipment

The system consists of one micro-controller, NodeMCU, three sensors: soil moisture sensor, pH sensor and ultrasonic sensor, multiplexer, breadboard, and jumper wires. Each of the components and tools has a specific function and is used to complete the monitoring system. Table 1 below illustrates the electronic equipment and its operations.

Table 1: Electronic Equipment and its Function

Equipment	Function
NodeMCU	Acts as a micro-controller to process the sensors data and send it to the Blynk app on a mobile phone.
Soil Moisture Sensor	Detect the presence of water inside the soil of the okra plant.
pH Sensor	Read the pH value of the soil for the okra plant.
Ultrasonic Sensor	Obtain the distance from the sensor to the surface of the okra plant. This sensor is used to determine the height of the plant or the plant growth.
Multiplexer	It is used to add an analog input for the NodeMCU as it only has one analog input.
Breadboard	Functions as a link between the micro-controller and the sensors.
Jumper Wires	It is used to connect the microcontroller and sensors.

2.2 Methods

The study consists of designing and developing the IoT smart plant monitoring system using the information that has been extracted from the past literatures. Next, after system design has been approved, sensors calibration and system test take place. Furthermore, after the sensors has been tested and worked, the next step is to gather the data, analysis the data and discuss the data. Figure 4 below shows the flowchart of the study.

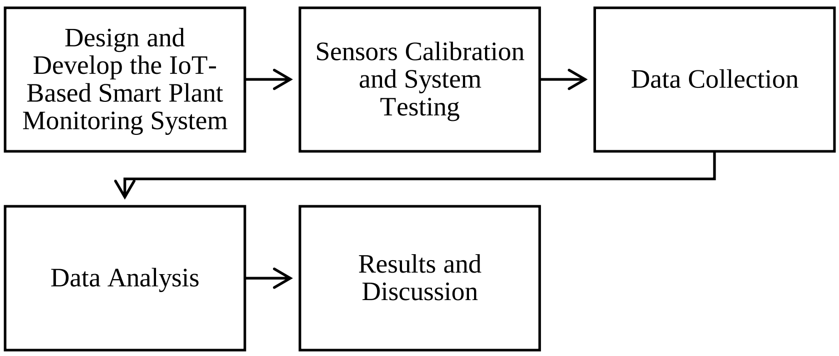

Figure 4: Flowchart of the Study

The electronic equipment calibration will determine how the devices and sensors connect and interact with each other. The plan was designed based on the literature study and research according to their specification and function. This step is significant to ensure the devices and sensors can be appropriately programmed so that there will be no error and accurate results can be obtained. The sensors are connected to the port on the NodeMCU accordingly to ensure it is running correctly. Figure 5 below illustrates the design overview of the system.

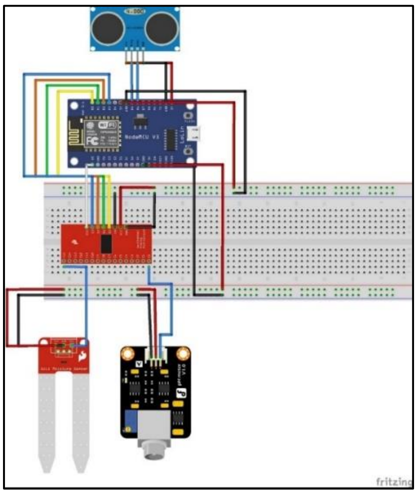

Figure 5: The Design Overview of the System

2.3 Experimental Setup

The setup is placed at the back of a house where there is an access to the power supply. The position of the experimental setup is considered properly to ensure the Wi-Fi connection is stable and can be reach by the NodeMCU. Figure 6 below shows the experimental setup.

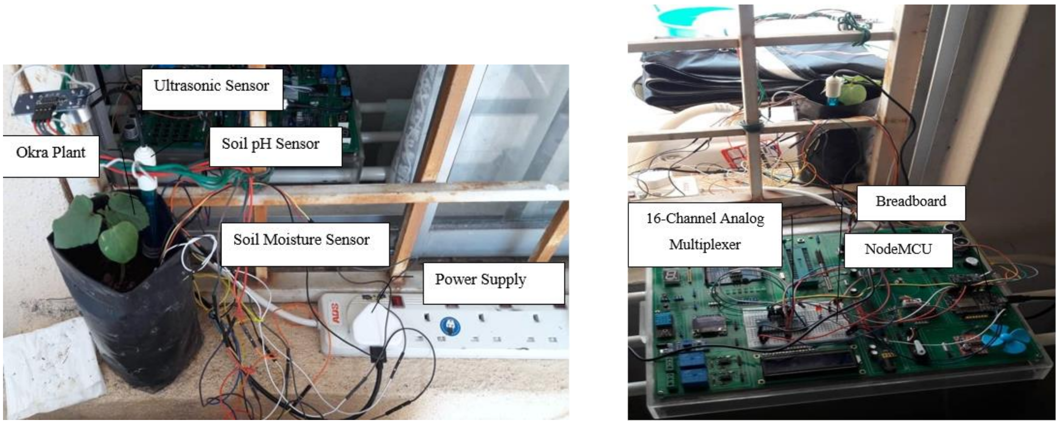

Figure 6: (a) Experimental Setup at the Okra Plant, (b) Experimental Setup at the Micro-Controller

3. Results and Discussion

The chapter discusses any findings that are relevant to achieving the goal of the research work. This chapter also explains the results obtained through the monitoring process on mobile phones and analysis on Microsoft Excel. In addition, the data is analysed based on the monitoring of the parameters during the night for seven days.

This project measures three parameters, soil moisture, soil pH, and plant height. Two parameters that need appropriate calculation are the soil moisture and the plant height. The results obtained from the soil pH sensor can be directly put into the table for analysis. As for the soil moisture, reading from the sensor is processed using Analog-Digital Converter (ADC). The output from the soil moisture sensor varies over the ADC value range of 0 to 1023. Using the formula below, this can be expressed as a moisture value in percentage.

$$Analog\ Output = \frac{ADC\ Value}{1023} \qquad \text{(Eq.1)}$$

$$Moisture\ (\%) = 100 - (Analog\ Output\ \times 100)\ \ \text{(Eq.2)}$$

$$Plant\ Height\ (cm) = Distance\ between\ ultrasonic\ sensor\ and\ soil - Sensor\ Output \quad \text{(Eq. 3)}$$

After seven days of experimenting and monitoring, the results and readings are gathered and compiled together. The average readings from the soil moisture sensor, pH sensor and ultrasonic sensor are calculated to conclude the seven days of the experiment. Figure 7 shows the results of the experiment for seven days.

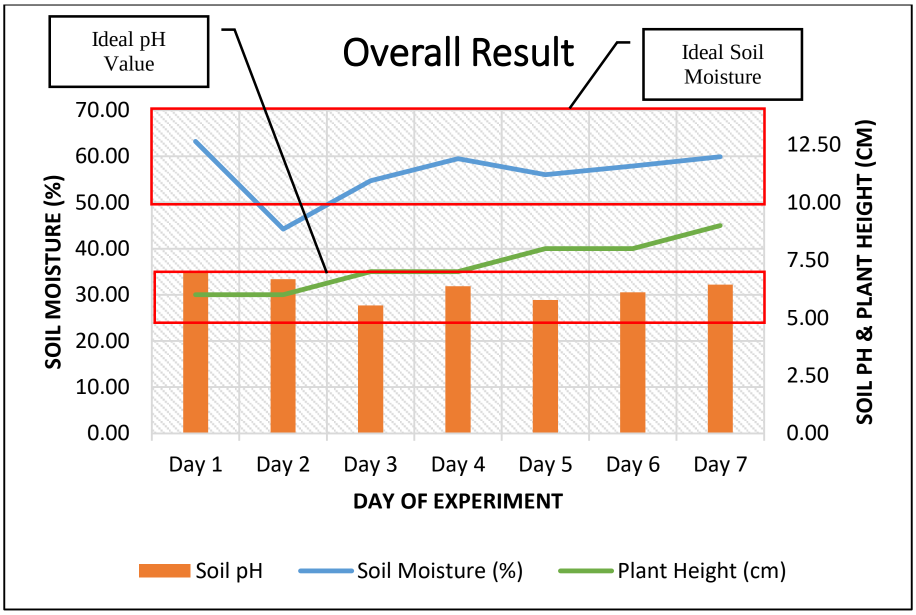

Figure 7: The Experiment Results for Seven Days of Monitoring

The parameters, soil moisture and soil pH are maintained and controlled within the ideal range of value except for the second day for the soil moisture. The okra plant was not watered enough, therefore the soil moisture sensor sends a low reading to the Blynk App. The okra plant height increased 3 cm which shows the parameter control is important for the growth of the plant. Table 2 below presents the results in table form.

Table 2: The Experiment Results for Seven Days of Monitoring

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Soil Moisture (%)	63.20	44.27	54.70	59.49	56.03	57.92	59.90
Soil pH	7.02	6.68	5.54	6.38	5.77	6.10	6.44
Plant Height (cm)	6	6	7	7	8	8	9

4. Conclusion

The objective of this study is achieved, which to develop the IoT smart plant monitoring system. This study focuses on the okra plant by monitoring the soil parameters, soil moisture and soil pH value. The final result presents that if the soil parameters, particularly soil moisture and soil pH, are maintained between 50% and 70%, and 5.0 and 7.5 respectively, the okra plant can grow in height and the number of leaves. The monitoring system can help farmers observe their crops from distance using the Blynk App. This system is beneficial in many aspects, such as cost, human energy, and time. This intelligent system improves sustainability in terms of the environment. The farmers do not need to go to their farms every day, so petroleum usage from a vehicle can be reduced.

This study can be further improved by interfacing automation with the system, for example, automatic irrigation for the plant. Automation in irrigation can help the farmers provide water and nutrients to the plant only using mobile phones. The system design and calibration will include the pump, relay, water supply and nutrient supply. The farmers can set a threshold or a limit for the soil moisture and pH value, where if it reaches a certain point, a notification will come out on the farmers' mobile phone to notify them to turn on the pump.

Acknowledgement

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