Performance Analysis of Smart Farming System Based on IoT

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***Abstract*— Over the past few years, technology and agriculture have come together in an unprecedented way as advances in the internet of things (IoT). The agricultural sector plays an important role in contributing to the economics of a country. The IoT-based agriculture leads to lucrative yields and there are several types of platforms used by farmers in increasing agricultural yields. Although there are many platforms related to modern agriculture, a less specific platform is used to study the types of crops suitable for planting based on the type of soil. Thus, this project system has introduced an IoT-based smart farming system based on the MIT App Inventor. The objective of this project is to develop a smart farming system that can help to monitor and analyze data of temperature (29 °C - 35 °C), humidity (70% - 100%), soil moisture (50% - 100%), and pH (5.5 - 7.0) of crops which been stored in ThingSpeak platform application. In addition to monitoring, the actuator system also can be controlled by application developed in MIT 2 App Inventor. The system was tested on okra plants and their vegetative traits were measured for 30 days. The result revealed good performance which proves that the developed system is suitable for smart farming system.**

***Index Terms*— Farming System; MIT App Inventor; Soil Moisture; Temperature; Thing Speak Platform**

I. Introduction

Over the past few years, technology and agriculture have come together in unprecedented way. The internet of things (IoT) and big data analysis have been widely applied in the production, processing, and marketing of food and other agricultural products [1]. IoT technology applications for the development and improvement of agriculture potential have emerged in many technological terminologies that describe the optimistic present and future status of modern agriculture including precision agriculture (PA) smart farming, satellite farming, or site specific crop management (SSCM) [2]. Several techniques using the internet of things (IoT) have been already adopted to tackle such procedures concerning data collection and properties of farming [3].

Developing an application based on IoT will give some great outcomes for this modern technology. Due to the growth and modernization of current technology farmers are given the privilege to do many things without putting their feet into the field or farm. For instants, they can monitor and control their crops from anywhere. By this system, the farmer can monitor their field condition and control thewater usage of the field. Hence, it will enhance the technology and knowledge for the farmer compared to the manual approach by applying this system.

Malaysian agricultural sector needs structural changes on a large scale to improve and develop the life of the farmers. The Smart Farming System refers to the widespread use and integration of the latest technologies in agriculture, intending to increase the quantity and quality of domestic crop yields. For example, drones can be used to spray pesticides, analyze planting soil and monitor crop yields quickly and without the use of labor [4]. Smart farming is also known as the development that emphasizes the usage of technologies in the management of the crop yields in the farm and there are four layers of architecture model such as Sensor Layer, Network Layer, Service Layer, and Application Layer [5].

Smart farming also involves a hydroponic system that automatically can detect farm temperature, humidity, EC, pH, light intensity, watering, and fertilizing. On the other hand, aquaponics is also a method for smart farming by raising fish and cultivating plants [6]. The advantage of IoT in farming systems is to empower simple gathering and executive's huge amounts of information which are gatheredfrom sensors used and with the help of joining of distributedevaluating administrations such as cloud storage, farming field maps, and more information can be retrieved from any place and everywhere which enables live monitoring and connectivity which is end to end [7]. Besides, farmers could expand the output by 72% up to the year 2050 as delineated by specialists and IoT efficiency level would be further expanded as far as utilization of water, soil, fertilizers, pesticides, and others [4].

Moreover, some related studies had been going through based on the platform that is used for smart farming. According to P.Gomathy (2018), the Blynk application had been used to control the parameters such as temperature, pH, soil moisture, and it was also used for wavering detection [8]. In [7], the GSM Module is used to transfer data from one device to another for communication so that the irrigation system can work automatically. The system helps to notify on the regular basis based on the threshold value such as soil moisture sensor and water level [9]. The [8] had comes out with an idea to develop a web based application with the help of RasberryPi board to detect the temperature and humidity of a farm [10]. With this system, productivity increases, and the cost decreases after monitoring the system by the web application. [9] had researched how to monitor the soil moisture level and calculate the had developed an irrigation system that can be controlled by Bluetooth.

Furthermore, [10] had carry out a study with Mobius which is an IoT service platform (oneM2M- compliant) that provides REST APIs which the data collected from sensors (e.g., CO sensor) had been used [12]. The farmer's knowledge based on the farming system had enhanced implement this system. The ThingSpeak platform to gather information about soil moisture levels detected by the sensor.

The okra plant [13-14] has been chosen for this project to analysis on the parameter of temperature, humidity, soil moisture,and pH. The soil pH needed by the okra plant is 6.0 – 6.8 and okra with poorly formed pods can be grown in soilswith a pH of 5.8 or lower. Okra grows best in full sun and well-drained, moist soil. Avoid areas that are muddy and badly drained. Okra thrives in slightly acidic to slightly alkaline soils (pH 6.5 to 7.5), so pH is unlikely to be a problem. The best range of pH for the soil needs by the okra plant should be in the range of 6.5 to 7.0. Okra grows best in soil with a pH of 6.5 to 7.0, but it can grow in soil with a pH as high as 7.6. Okra plants have small vertical stems with spiky or hairless heart-shaped leaves.

Temperatures in the soil should be at least 18.3 °C, with 23.9 °C to 32.3 °C being ideal for plant development. Usually, okra is grown from seed. Seeds that have been soaked in water overnight before planting are more likely to germinate.Seeds are planted in rows 0.65 m–1.0 m (26 in – 40 in) apart in commercial okra production. The ideal soil temperature for seed germination is in a range of 70 oF and 95 oF, so gardeners should check the temperature at a depth of 4 inches before planting. Not only does soil temperature influence seed germination, but it also affects soil chemistry. The release or dissolution of mineral nutrients in soil moisture is related to soil chemistry. Mineral nutrients are needed for the growth and maturity of vegetable plants before harvest. 65 °F to 75 °F (18 °C -24 °C) is the ideal or optimum soil temperature for planting and growing most vegetables.

When the relative humidity level in space is 75% at 80°F, it means that every kilogram of air in that space contains 75% of the maximum amount of water that it can carry at that temperature. The average monthly temperature for the okra plant ranged from 22.1 °C to 32.2 °C, with a relative humidity of 75.3% to 79.0%t. The amount of soil moisture with a percentage of 25% and 50% will higher affect okra plants growth if compared to 75% to 100% of soil moisture content.

Thus this paper aim to introduce an IoT-based smart farming system based on the MIT App Inventor. The objective of this project is to develop a smart farming system that can help to monitor and analyze data of temperature, humidity, soil moisture and pH which been stored in ThingSpeak platform application.

II. Analysis Of Smart Farming System Based On IoT

The methodology is a systematic, theoretical analysis of the methods applied to a field of study. Hardware and software are implemented in this project. Firstly, there will adiscussion with the supervisor to get a title for the project and how to proceed with it. Then, different related work and literature reviews had to go through to get good information on the project. Next, design the circuits and figure out the platforms which going to be used to develop the system. In the end, this system will be integrated with the IoT platform. Soil moisture, humidity, temperature, and pH value are the parameters that going to be analyzed for plants by using this system.

The research was started by conducting a literature survey and background studies related to the smart farming systems. The next stage will be to choose appropriate software and hardware for the investigation. The prototype was then developed utilizing the components and software. The farming method was also developed by arranging eight okra plants that were placed in a polybag. This farming system measured four parameters for vegetative traits dependent on the crop: pH, temperature, humidity, and soil moisture. If the analysis confirms the findings, the followingstep will be taken. Background investigations will be undertaken if necessary in order to obtain the best performing smart farming system. The preceding step beforethe end process by discussing the best results which been obtained from the parameters.

A. System Flow Chart

To develop the prototype, several flows have been executed to ensure that the prototype works well as shown Figure 1. The system will initialize by power on the Arduino Uno and starts to receive the reading from the sensors. The measured value from the sensors will be displayed on the LCD display. The reading also will be transmitted to the Thing Speak data cloud with the help of ESP 8266. Besides, the values also will be displayed in the application after its merge with the Thing Speak cloud. There will be a notification or alert in the application if the pH is more than 8 and if the moisture is low. The water pump can be controlled from the application if the value of the moisture is lower than the threshold value. The process will be repeated every 80 loops of the time cycle.

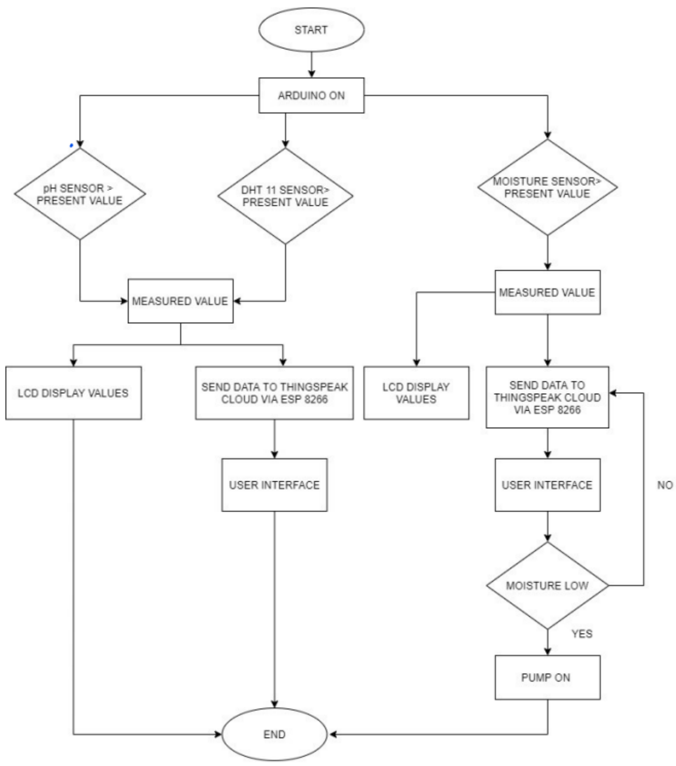

Figure 1: System flow chart

B. Application Design Using MIT App Inventor

The interface of the application had been designed by using MIT App Inventor as in Figure 2. It is an online platform to develop an application by using a block-based programming language.

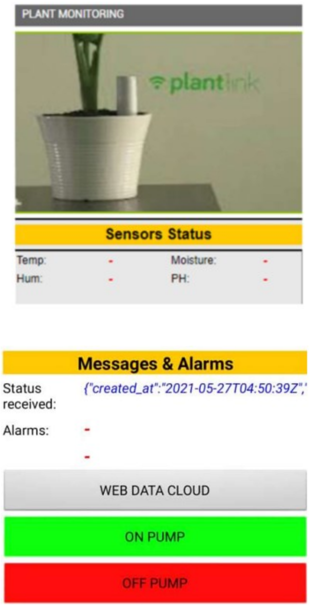

Figure 2: Application interface view

C. Thing Speak

The channel and parameters of temperature, humidity,soil moisture and pH had been configured in Thing Speak platform. The dashboard preview is shown in Figure 3.

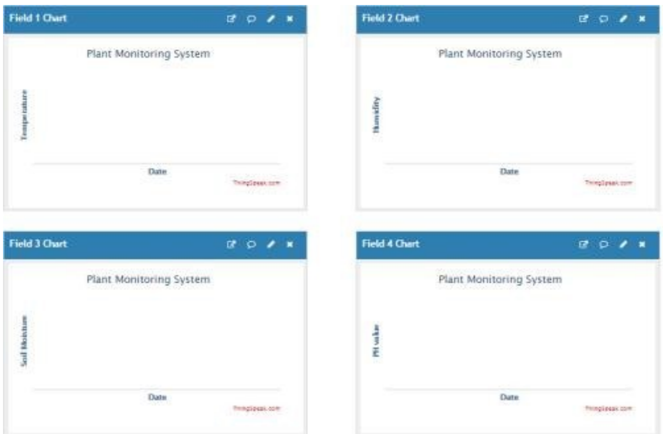

Figure 3: Dashboard parameters preview from Thing Speak

D. Small Scale Farming Setup and Circuit Connection

A small scale of farming had been set up with the system as in Figure 4. The system had been developed with some hardware and sensors as shown in Figure 5.

The main components involve in this project can be seen in Table 1. The hardware pins and Arduino pins for the components are tabulated in this table.

Figure 4: Set up for small scale farming

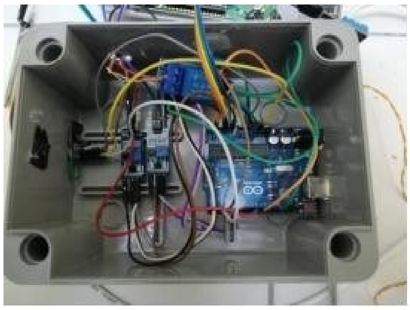

Figure 5: Circuit connection of the system

Table 1
Pin configuration of the system

Hardware Component	**Hardware pins**	**Arduino pins**
Soil Moisture sensor	A_0	A_0
	GND	GND
	VCC	5V
DHT11 sensor	Output	8
	VCC	5V
	GND	GND
PH sensor	Output	A_1
	VCC	5V
	GND	GND
LCD	SCL	A_5
	SDA	A_4
	VCC	5V
	GND	GND
Esp 8266	3v3	3.3V
	Rx	Tx 1
	GND	GND
Relay	Common Contact	Connect to pump
	VCC	Connect to power supply
	Input	A_{10}
Pump	Connect to relay module	

The system will initialize by power on the Arduino Uno and starts to receive the reading from the sensors. The measured value from the sensors will be displayed on the LCD display. The reading also will be transmitted to the Thing Speak data cloud with the help of ESP 8266. Besides, the values also will be displayed in the application after its merge with the Thing Speak cloud. There will be a notification or alert in the application if the pH is more than 8 and if the moisture is low. The water pump can be controlled from the application if the value of the moisture is lower than a threshold value. The process will be repeated every 80 loops of the timecycle.

III. Results and Discussion

The project had been designed and implemented in the okra plant to obtain data and monitor the parameters such as temperature, humidity, soil moisture, and pH. The data had been tabulated and analyzed the parameter which such as temperature, humidity, soil moisture, and pH value which have been gained from the okra plant will display in the application as in Figure 6.

DHT 11, Soil Moisture, and pH sensors were used to analyze the optimum parameter for the okra plant. Figure 7 shows the graphical representation of the values obtained and stored from the sensors via the Thingspeak platform. The four field shows data for 30 days' analysis on temperature, humidity, soil moisture, and pH.

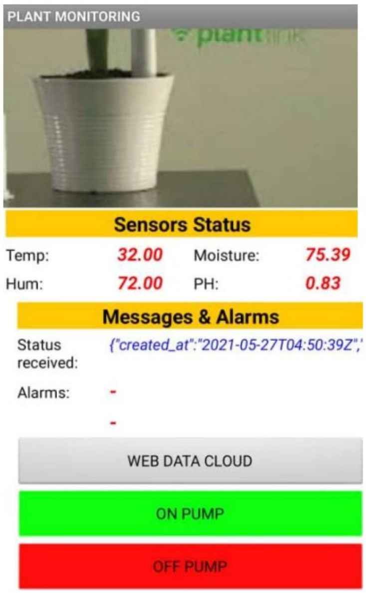

Figure 6: Parameters value from the application

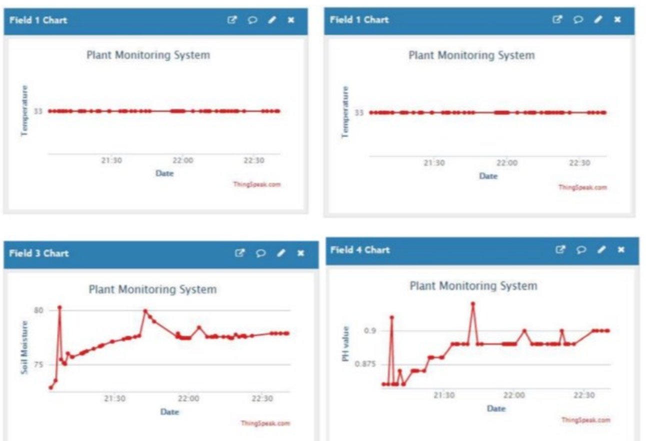

Figure 7: Reading of parameters from Thing Speak

A. Parameter Analysis

The analysis based on suitable surrounding temperature and humidity value of okra plant for the first 30 days were tabulated.

During this project, the temperature value was kept constant for 30 days according to the okra plant requirement which is (29 °C - 33 °C). There is a slight change in temperature during raining season. The good atmospheric occurs when the temperature has a constant value of 31 °C as shown in Figure 8. The highest temperature value reached was 33 °C which was on a warmer day and the lowest reading that been recorded was 30 °C.

The average reading for humidity value and soil moisture value had been plotted as in Figure 9. According to the analysis, a humidity level above 70% is considered a good level for okra plant. The highest recorded humidity level is 85% and the lowest measured level was 70%. The soil moisture value had been also measured and tabulated for 30 days based on okra plants needed. Soil Moisture content is a crucial parameter when talking about the farming system. Every plant needs enough moisture in this soil to have good healthy growth. According to the analysis, the amount of soil moisture for okra had retained more than 70%. The highest value has been recorded was 90% and the lowest value was 70%. If the level of moisture is less than 40% the okra plant leaves will turn yellowish due to lack of water for the roots. From this analysis, soil moisture depends on the amount of precipitation intensity of water consumption by plants. If the soil has a higher level of moisture it could help the crops to have a faster growth rate compared to before.

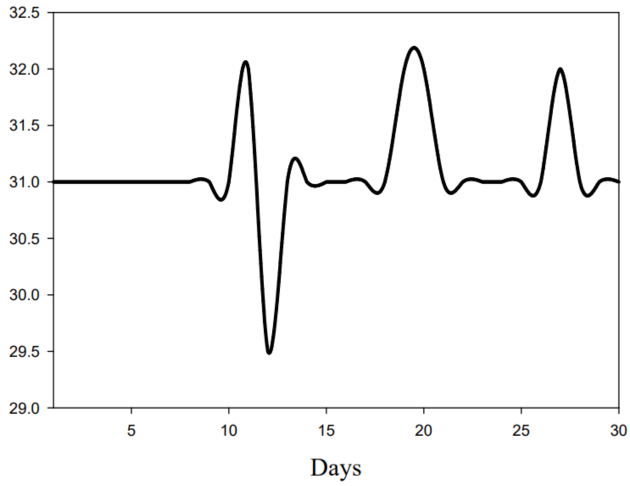

Figure 8: Graph of temperature value (in degrees)

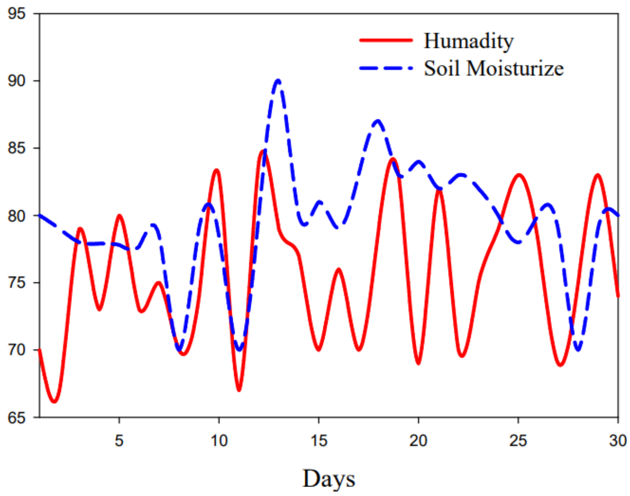

Figure 9: Graph for humidity value and soil moisture

During this project, a range of pH value (5.5 - 6.5) was kept constant for 30 days as shoen in Figure 10 to measure the vegetative traits of plants which is the leaf length and leaf width in cm. The vegetative traits of the plant were gradually increased to the applied pH value. According to the chart when pH moves to both ends, the ability of the plants to absorb the nutrients is severely affected. So, the ideal spot where plants absorb a lot of minerals is in the range of 5.5 – 6.5pH. This is also the range that is commonly used for crops in the farming system. Even though different plants may require different pH values, the okra plants in this farming system safely grew within this range.

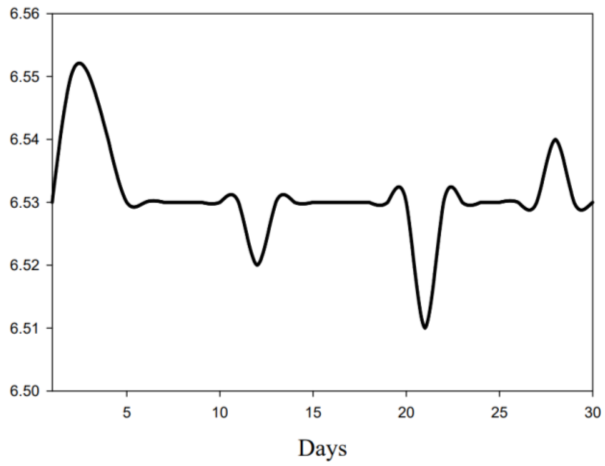

Figure 10: Graph for pH value

B. Measurement of Vegetative Traits of the Plants

The vegetative traits of an okra plant had been analyzed for 30 days and it gives out a good response as shown in Figure 11. This wireless system had helps to give a good output which the leaf length and leaf width had better in the growth compared to traditional farming. The average full growth of the okra plant will be approximately 60 to 75 days but when using this system, the okra plant had a good growth within 55 days. The measurement of the vegetative was noted in the centimeter unit because can easily observe.

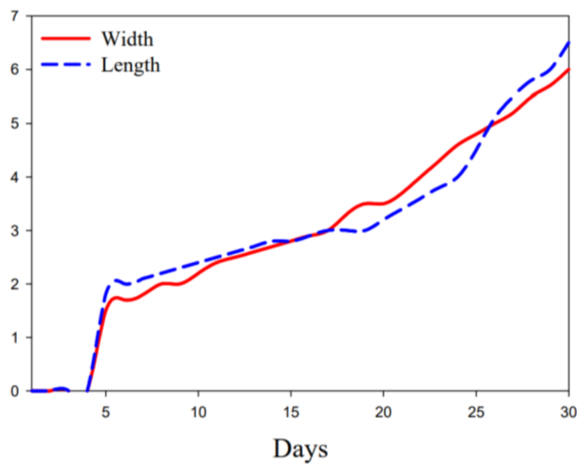

Figure 11: Graph of leaf Length (cm) and width Vs (cm) versus days.

IV. CONCLUSION

After completing this project, it can be concluded that the system works perfectly as planned. It fulfills the two objectives stated at the beginning of this project which is to develop a smart farming application that can monitor the parameters such as temperature, humidity, soil moisture, and pH value, to optimize the use of water by using the controlling system and to analyze vegetative traits of plants using the suitable value of temperature, humidity, soil moisture and pH using Thing Speak. Furthermore, the smart farming system is an efficient method of applying nutrient solutions in which the irrigation system is used as the carrier and the distributor for the plants. In a nutshell, the smart farming system using IoT is well suited for commercial agriculture to maximize profits and yields.

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