An IoT Agricultural System For Harumanis Farm

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Abstract. Internet of Things (IoT) is a revolutionary technology that represents the future of communication and computing. The field of IoT implementation is vast and can be applied in every field. This project is about to develop an IoT system for Harumanis Farm as agriculture is becoming an essential growing sector throughout the world due to the increasing population. The major challenge in the Harumanis sector is to improve the productivity and quality of Harumanis without continuous manual monitoring. IoT improves crop management, cost-effectiveness, crop monitoring and also improves the quality and quantity of the crop. This IoT system completes with several sensors to monitor the Harumanis farm, such as temperature and humidity sensor, pH level sensor, soil moisture sensor, also nitrogen, phosphorous, and potassium (NPK) sensor. The system is a simple IoT architecture where sensors collect information and send it over the Wi-Fi network to the mobile applications.

1. Introduction
Mango is one of the popular tropical fruits in South Asia, including Malaysia. There are many types of mango or Mangifera indica [1]. Harumanis is the most famous mango in Perlis, because of its fragrance, texture and sweetness. The mango tree is an annual fruit tree [2], and the reproductive process of the fruits usually begins in January and ends nearly in June. The market for Harumanis is strong and keeps rising year after year, with sales prices per kilogram almost tripling compared to other varieties [3], [4].

Several IoT will be one of the most advanced technological developments of the next decade, with sweeping consequences for business and policymakers. IoT involves many things interacting with each other to produce actionable information [5]. Basically, for the IoT system, some of the sensors needed will be set up and attached with a microcontroller. The microcontroller then needs to be connected with a Wi-Fi module to send the data to the cloud. With the IoT concept, it will be easier for users to monitor a situation or condition in real-time from anywhere and anytime [6]. In order to track the growth of Harumanis well, several important environmental parameters have been set up to automate the farming activities such as temperature, humidity, moisture, pH level, and fertilizers. The "Big 3" for primary nutrients in commercial fertilizers are nitrogen, phosphorus and potassium (NPK)
as in plant nutrition, each of these fundamental nutrients plays a key role [7]. This project designs a scheduling concept to track real-time plants' growth and ensure that optimal conditions are maintained. This IoT Agricultural System, also known as a smart farm, will make farming easy, cost-effective, reduce labour costs, increase crop yields and improve productivity [8].

However, many important things need to be monitored in order to produce the perfect quality of Harumanis. An IoT Agricultural Sensor for Smart Farming for Harumanis focuses on monitoring nitrogen, phosphorus, and potassium because the content of NPK as the nutrient in the soil is one of the most important things for trees. The data of temperature and humidity surrounding the Harumanis farm is being measured. Besides, water content is important for Harumanis, so that soil moisture is also being monitored in this project in order to get the best quality of Harumanis. Lastly, this project also tries to control pests in the farm. All of the data can be monitored and analyzed in the Cayenne Apps.

2. Methodology

2.1. System Development

This project focused on several parameters that being said as an important parameter from previous researchers for the quality of Harumanis which is based on the temperature, humidity, soil moisture, pH level of soil, and also the content of NPK in soil. Figure 1 below shows the flow charts on how the system works. At the beginning of the system, the system needs to be activated. The system started by measuring all of the data from the sensors. The data included the measured data of temperature and humidity by using DHT22 sensors, measured data of pH level in the soil by using analog pH sensor, measured data of soil moisture by using soil moisture sensors, and the last one is measured data of nitrogen, phosphorus, and potassium in the soil by using NPK sensor. Then, all of the data will be sent to NodeMCU ESP8266. This microcontroller will also send a warning message to users when the temperature is below 25°C or over 37°C. Instead of temperature, a warning message of pH level will also be sent to the user as these 2 important things need to be monitored to get the best quality of Harumanis. The warning message can be sent through messages and emails. It depends on the user, which is best for them. All of the data can be monitored and analysed through Cayenne Apps, either through smartphone or laptop. Lastly, the system will always read the data until it closed. The data will be read in Cayenne Apps every 20 seconds.

![Flow charts of the system](image)

**Figure 1.** Flow charts of the system
2.2. Circuit Connections
The Figure 2 below shows on how the circuit connections for each sensors being attached to the microprocessors.

![Figure 2. Circuit Connections](image)

3. Results and Discussions
All of the sensors that are being set up were tested and being monitored through Cayenne Apps. The result shows the current data that was being tested in School of Mechatronics Engineering, Universiti Malaysia Perlis (UniMAP). The interface of the Cayenne Apps through smartphone and laptop as shown in Figure 3. There are about 9 channels that being declared for monitored each of the parameter in this system which is temperature, humidity, pH level, soil moisture level, button for switching the pest controller, nitrogen, phosphorous, and potassium.

![Figure 3. Interface of the Cayenne Apps](image)

Theoretically, the best ratio of NPK for Harumanis tree of 6th year onward was 1:1:1.5 (kg/year). The content of NPK in soil depends on the phase of mango tree itself. NPK fertilizer for Harumanis tree has 2 types which is the ratio of 15:15:15 and 12:12:17. For 12:12:17, if being added it all up, it's about 41%. This is because the excess of 59% is an inert material or 'filler' used to hold and reduce the
heat of each component. In the process of investigating the soil nutrient, an analysis on the reading of NPK is done. Figure 4, Figure 5, and Figure 6 below shows the graph on the reading of NPK collected on 6th July 2021 at 8 p.m. until 7th July 2021 at 8 p.m.. The results shows the ratio is about 11:12:28. It seems like a bit different from theoretical but still the content of K (potassium) can be up until 46% for the quality of flowers and fruits. K is high because it is an essential nutrient in the production and development of plant cells for photosynthesis, respiration, and growth. Potassium's impact on the structure of the soil and its ability to capture water.

Figure 4. Reading of Nitrogen

Figure 5. Reading of Phosphorus

Figure 6. Reading of Potassium

Figure 7 shows that the temperature of Harumanis Farm that being tested started 8 p.m. on 6th July until 7th July 2021 showed quite low at night which was around 25°C. It is because the weather on that day is raining all the day. While on 27th July it raising slowly until peak of 33 °C at 2.00 p.m. The
result shows that Harumanis tree can grow well as the average temperature even raining also still higher than 25°C.

![Figure 7. Temperature of Harumanis Farm](image)

Figure 7. Temperature of Harumanis Farm

Figure 8 below shows on the relative humidity of the farm on 6th July shows steadily constant at night around 77% which is quite high due to raining. Then, started 8.00 a.m., it is decreasing until the lowest, 57% at 2 p.m. The humidity at night is higher than noon.

![Figure 8. Humidity of Harumanis Farm](image)

Figure 8. Humidity of Harumanis Farm

Dry weather is conducive to profuse flowers before blossoming. So, soil moisture also important parameter that needed to be considered. Figure 9 shows on the soil moisture of the Harumanis tree in UniMAP is in controlled condition. Perlis that well known with the extreme surface heating, cumulus and cumulonimbus clouds form early in the afternoons almost every day make it excellent for mango production. The graph of the soil moisture below shows it do not contain excessive of water where it will affect the quality and reduce crop yield.

![Figure 9. Reading of Soil Moisture](image)

Figure 9. Reading of Soil Moisture
The pH level on the Figure 10 below shows that pH level for soil of Harumanis plantation is maintain constantly around 6.9. In the graph below also shows that there are some slight at 6 a.m. where the data of pH level raising about 7.5 due to some error of reading from pH sensor. But still, at the range of 6.5 to 7.5 pH range, it has been estimated that most plant nutrients are optimally acceptable to plants, and this pH range is usually very consistent with plant root growth. This shows that the Harumanis mango produced in good quality as the pH level is in the range that also will maximize nutrient availability.

![Figure 10. PH Level of Harumanis Farm](image)

4. Conclusion

Successful development of an IoT-based monitoring system on Harumanis farm has been demonstrated. The system was able to collect real-time data of the important parameters for Harumanis plantation automatically and monitor their development. This development monitoring is available to the farmers so that corrective actions can be taken if non-compliance is detected. This project also well function by measuring the pH level, temperature, humidity, and moisture of Harumanis farm. The surrounding temperature and humidity greatly influence the growth of the mango. Farmers can predict the timing for the mango to begin flowering by knowing the temperature, moisture, and soil moisture. Humidity also affects the turgor pressure of plants, which is an indicator of the quantity of water in plant cells.

Third objective for this IoT Agricultural System for Harumanis Farm is achieved by acquire the nitrogen, phosphorus, and potassium (NPK) inside the soil. Lack of NPK nutrient in soil will become complication on the production of the best Harumanis mango. The result of NPK from the recorded data at Harumanis plantation in UniMAP showed quite same with the theoretically proved that the Harumanis well grown with the content of NPK ratio 12:12:17. Last objective of this project is achieved by analyzing the data from Cayenne Apps. Farmers can keep track of the daily development of the tree anytime and anywhere through their smartphone or laptop as long as they has Internet connection. The data collected can be used to monitor of the growth rate of Harumanis tree to enables the rectification of problems as soon as any discrepancies are detected. Problems such as insufficient or poor distribution of NPK fertilizer that affected the production and quality of Harumanis mango also the occurrence of disease can be rectified at an early stage. The value of the project has been demonstrated with it winning the Silver Award in the Virtual Research and Innovation Exhibition UniMAP (E-REKA 2021).

5. References

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