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An IoT-Driven Soil Nutrient Monitoring System for Enhanced Pineapple Farming

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ABSTRACT

This system is optimized to monitor seven soil properties in real-time with an implementation of single soil sensor powered by renewable energy. A dashboard system is designed for accessing information regarding crops anywhere. End users will be able to observe the current condition of crops from any desired location and time. Implementation of a seven in one soil sensor to a Wi-Fi compatible microcontroller module which is configured to a database can be accessed through a designed application. Data collection in this research is carried out manually with a time interval of five seconds. A master unit is feeds real time updates database while the client is placed in the desired observing area. Both units communicate through a long-range wide area network technology. The designed dashboard system retrieves real time data from the connected database. Real-time data feeds will be interrupted if Wi-Fi connection is disrupted under any circumstance. Farmers or any end users will be highly benefitted by this system for agricultural purpose as real-time crop conditions observation ensures that the growth of crops are not affected if maintained accordingly. The dashboard system can be improvised by integrating a data analyzation technique for detailed crop reviews. retrieves real time data from the connected database. Real-time data feeds will be interrupted if Wi-Fi connection is disrupted under any circumstance. Farmers or any end users will be highly benefitted by this system for agricultural purpose as real-time crop conditions observation ensures that the growth of crops are not affected if maintained accordingly. The dashboard system can be improvised by integrating a data analyzation technique for detailed crop reviews.

Keywords: Real-time Soil Monitoring, Renewable Energy Sensors, Agricultural Dashboard System

1. Introduction

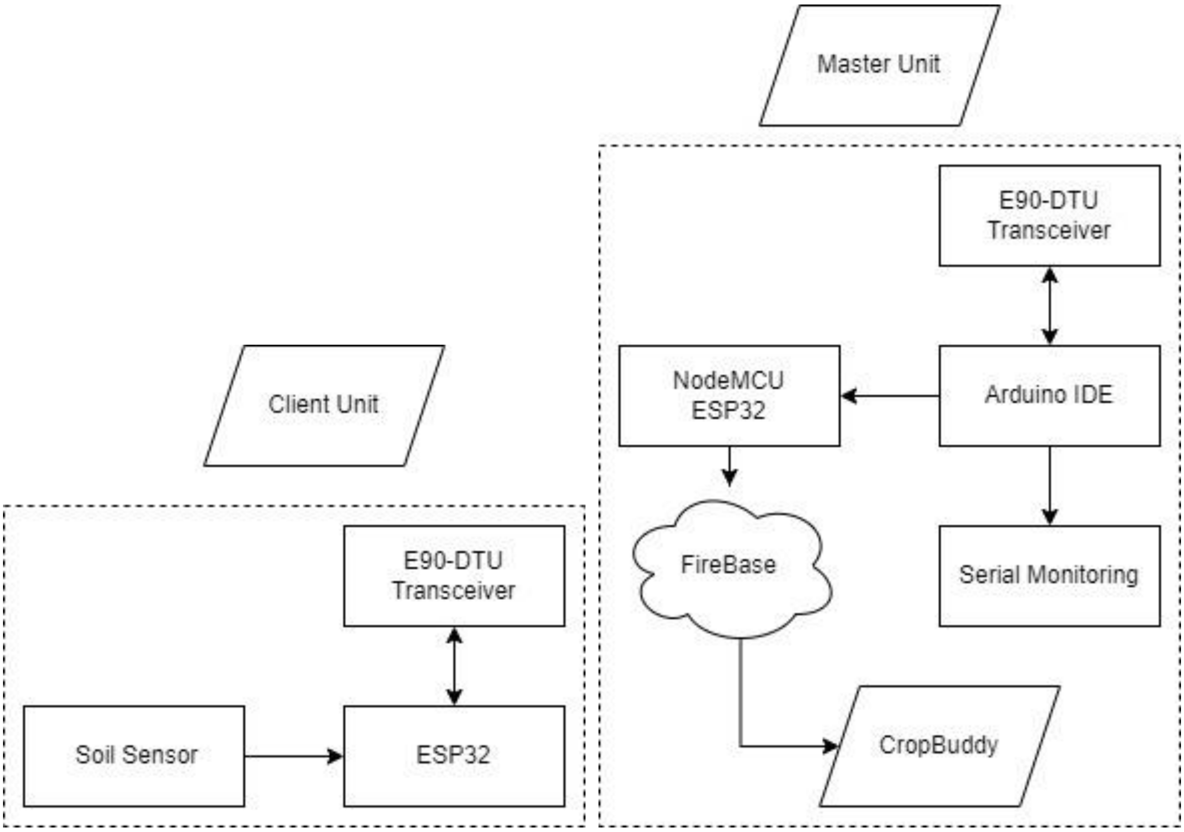
The art and science of nurturing the land, raising crops, and providing people with wholesome food is known as agriculture. Promoting sustainable development was a key strategy to counter the deterioration of the environment through time. Most likely, the area utilized for cultivating crops won't change. Crop production must be steadily raised along with population growth.

The best natural environment for a plant's growth and development is soil. There has been a lot of study done to identify the reasons why farmers' crops fail to produce as expected. The primary cause of unstable plant development in infertile soil is the imbalance of nature. As a result, soil sensors are often put in greenhouses to track the soil's many properties, including its temperature, moisture content, pH level, soil conductivity, and other nutrients like potassium, phosphorus, and nitrogen. These soil constituents have a significant impact on plant output [1]. Great crop yields, water conservation, labour and fertiliser cost savings, increased farm profitability, and inexhaustible information on the everchanging climate are just a few of the many benefits of soil sensors [2]. Through implementing the Internet of Things (IoT) system by connecting the high precision agriculture sensor to microcontroller, the obtained data can be transmitted to a cloud platform in real time.

2. Materials and Methods

2.1 Block Diagram

The input seven in one soil sensor is implemented on the client unit. It is capable of measuring seven parameters present naturally in soil which is temperature, humidity, pH level, conductivity, nitrogen, phosphorus and potassium. Whereas the output will be displayed in designed application CropBuddy throughfetching data from Firebase Database which is configured with the master unit. Each unit contains a E90-DTU Data Transceiver with an antenna to enable long range communication between them. A NodeMCU ESP32 microcontroller is programmed to be a medium the components in each unit presented. Figure 1 represents the block diagram of the overall system.



(a) (b)

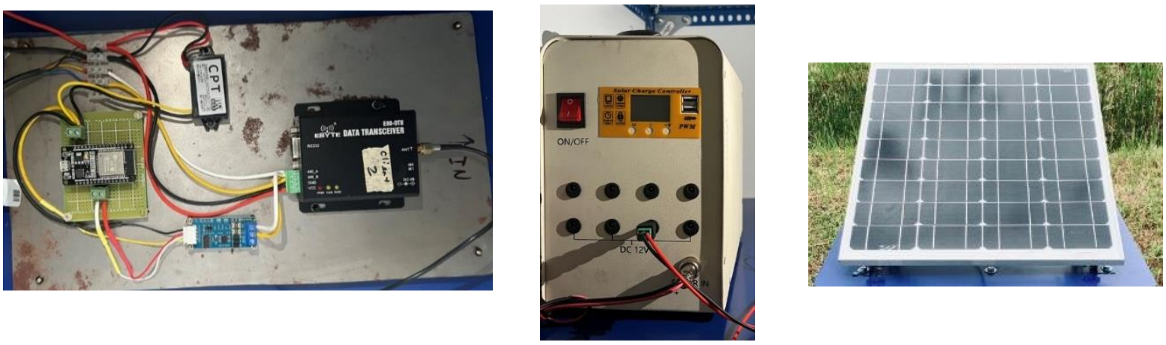
Figure. 1. Block diagram of the system

2.2 Methods

The client unit and the sensor implemented in it will be placed in the desired area. A 12V DC power is plugged in to the master unit while the client unit’s charge controller will be turned on to initiate both units. Real-time data will be collected in the client unit transmitted to the master unit through the data transceiver. Then, Firebase Database receives the updates through the NodeMCU ESP32 and transmits to the CropBuddy Application. Figure 2 represents the breakdown of essential workflow of the overall system.

Figure. 2. Master unit

The client unit has the same components as the master unit with an additional instrument which is the solar charge controller and solar panel as show in figure 3. The solar panel converts sunlight into accessible electricity to power the client unit. Meanwhile, solar charge controller was implemented to allow the flow of electricity from solar panel to the powering device. It avoids any internal damage the battery by providing a safe and efficient battery charging.



(a) (b) (c)

Figure. 3. Client unit

3. Result and Discussion

A soil was prepped without adding any fertilizers or water. The unfertilized or watered soil monitoring purpose was to test the functionality of the system. Soil sensor was placed in the prepared soil. Then, both units are turned on. The outputs are monitored through three output, serial monitor from the Arduino ide, firebase database and CropBuddy Application. Before readings are gathered, the pot was left with the sensor placed in for five minutes to ensure stable data recording. Output example of initial soil state properties is provided in Figure 4.

Monitor

Monitoring System

pH: 5.75

Moisture: 0.5 %RH

Temperature: 29.2°C

Conductivity: 625 µs/cm

Nitrogen: 32mg/kg

Phosphorus: 44mg/kg

Potassium: 104mg/kg

Figure. 4. Output from CropBuddy Application

The soil contents were observed for 50 seconds with a time interval of 5 seconds. A total of ten data were collected and presented in table 1.

Table 1. Monitored soil content

Data	pH	Moisture (%RH)	Temperature (°C)	Conductivity (µs/cm)	Nitrogen (mm/kg)	Phosphorus (mm/kg)	Potassium (mm/kg)
1	5.75	0.5	29.2	625	32	44	104
2	5.75	0.5	29.2	625	32	44	104
3	5.75	0.2	29.2	625	32	44	104
4	5.75	0.2	29.2	625	32	44	104
5	5.75	0.2	29.2	625	32	44	104
6	5.75	0.9	29.2	625	32	44	104
7	5.75	0.9	29.2	625	32	44	104
8	5.75	0.2	29.2	625	32	44	104
9	5.75	0.2	29.2	625	32	44	104
10	5.75	0.2	29.2	625	32	44	104

Throughout the time that data were collected, the soil's nitrogen, phosphorus, potassium, conductivity and temperature remained constant. Whereas the pH and moisture levels in the soil varied in a small amount. The pH ranged from lowest of 5.75 to highest of 5.78. Lowest recorded moisture level was 0.2%RH, while the highest was 0.9%RH. For comparison, figure 5 displayed the gathered data as a bar chart.

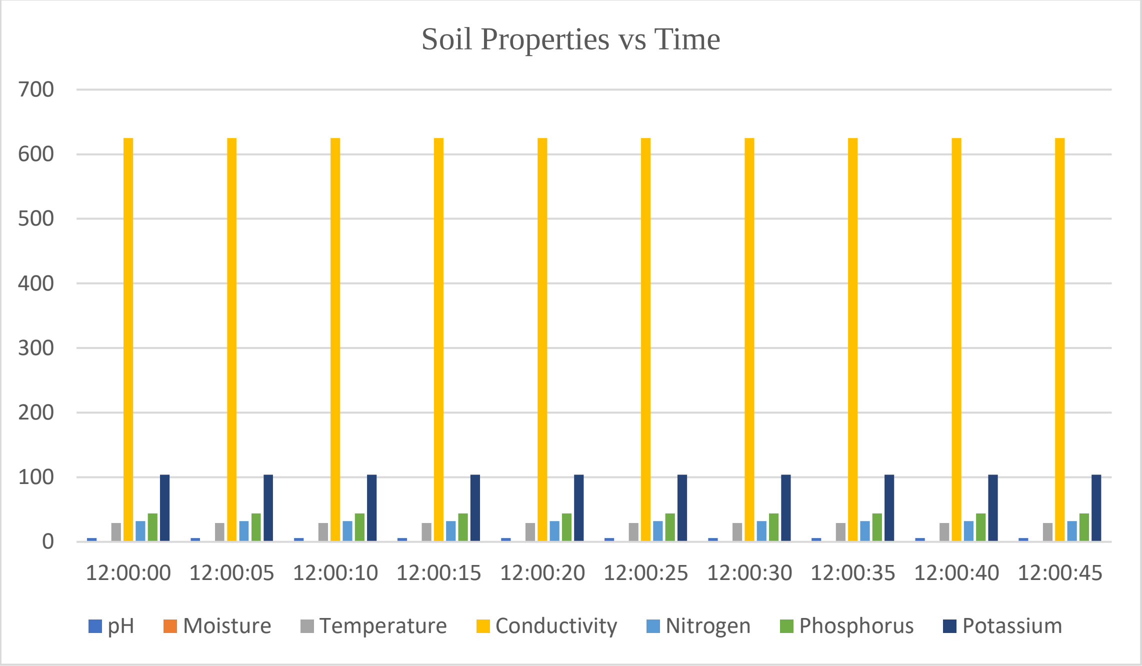


Figure. 5. Bar chart of soil properties vs time

4. Conclusion

Compared to the design of mobile applications, the hardware configuration was more difficult. A client unit in the hardware is continually in communication with the master unit. To achieve the intended result, a variety of components, including soil sensors that can sense numerous parameters and microcontrollers, have been used. To establish consistent and reliable long-range communication between the master and client unit, LoRaWan was deployed. The master unit interacts with the Firebase Database via the mobile application, allowing farmers or end users to check crop status in real-time whenever and wherever they want. The free version of the Firebase real-time database is presently setup since it has sufficient capacity to complete this project. Three applications, Serial Monitor of the Arduino IDE, Firebase Database, and CropBuddy allow users to examine the parameters' results. Only Android users may access the mobile application.

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