Independent Soil Node Sensor Prototype As Part Of Smart Farming System

Roghib Muhammad Hujja, Iwan Ernanto, Muhammad Auzan, Raden Sumiharto

Abstract: Smart farming systems are currently increasingly applied to agricultural production. With the rapid development of industry 4.0, the smart farming system is increasingly popular, and its benefits felt in the optimization of food production. The need for IoT sensors to provide accurate data on smart farming is very much needed. The sensors needed must also be able to withstand the conditions of the agricultural area. In this study, a sensor node prototype was created to collect soil moisture data independently with its energy source to use as input data on the smart farming system.

Index Terms: Sensor, Node, Soil, Moisture, Smart Farming, Prototype, IoT

1. INTRODUCTION

Agriculture is one of the main factors in the availability of food. The availability of food is an important thing needed by humans. The scarcity of food will significantly affect the economic sector in an area. The government has set a policy so that food availability always fulfilled[1]. However, along with the times and development that is increasingly rapid, the need for agricultural production continues to increase. There are ideas to increase agricultural production, one of which is by the existence of smart farming. In the development of industry 4.0, it is essential to have detailed information so that appropriate action can happen taken. In agriculture, too, the condition of the soil needs to be known precisely so that the care can be carried out following plant needs.[2] An example is a humidity. Soil moisture will affect soil growth. By knowing the soil moisture can also be given the right irrigation system and does not interfere with the growth and development of the plant itself.[3] New IoT systems are increasingly popular because of the ease and benefits of data retrieval. The process of collecting environmental data is also essential in the smart farming system so that actions taken on agricultural land following the needs of plants. Therefore the existence of sensor nodes that can conduct data acquisition on agricultural land is essential. Sensor nodes used in agricultural areas must also be robust and durable so they can be used for a long time and provide data that is suitable for the needs of the smart farming system.[4]

2 RESEARCH METHOD

2.1 Previous Research

Research on intelligent farming systems has been widely carried out. Intelligent farming systems use the help of IoT (Internet of Things) to be able to carry out monitoring and control activities to facilitate users in monitoring and controlling large agricultural areas. One of them is Lavanya's research in 2019. The research created an automatic IoT-based system to provide fertilizer regularly on smart agriculture. In general, the IoT system created can carry out the acquisition of sensor data that reads the NPK element content in the soil and then processes it so that farmers can see it via SMS.[5] The following year, Karimanzira and Rauschenbach, developed a realtime monitoring system for aquaponics. A continuous monitoring system will keep the environment stable and allow it to take immediate action in the event of a change in environment. This fast response system has been proven to increase production from aquaponics.[6] Moon, in his research entitled Evaluating fidelity of lossy compression on spatiotemporal data from an IoT enabled smart farm, provides an overview of how data should be sent using IoT on intelligent farming systems. Many variables must be taken into account in sending data, especially on smart outdoor agriculture. Solar radiation and weather conditions are the main challenges in sending data. Compression is needed to ensure the data sent is not too large and can minimize errors.[7] Paulraj, in his research, discussed the design of the IoT system that considers the availability of infrastructure and also the effectiveness of storing data on cloud servers. The use of cloud servers will make it easier for users to be able to access from various locations. Besides, sensors from IoT can also be placed over large areas wirelessly.[8] Severino, in his research, used IoT as a tool to be able to combine irrigation schedules with the geostatistical conditions of soils recorded online. Climate change, which is starting to be trying to predict is the reason such a system is needed. The predicted climate and the information available on the internet can be used as a reference for irrigation so that soil conditions will also be following crop needs.[9]

2.1 Hardware Design

This research begins with hardware design first. The hardware used includes sensors, processors, communication, and energy. After that, the system is designed so that the hardware can work following the objectives. This system will conduct sensor data acquisition, then process the sending of data to the server. After the tools and materials are available, then a prototype system is designed. The completed prototype system will then be installed in the agricultural area and tested for functionality. The hardware that will be used in this system is an IoT sensor node that can function to carry out soil moisture data acquisition. The node to be built has a basic structure like the block diagram in Figure 1. 1.

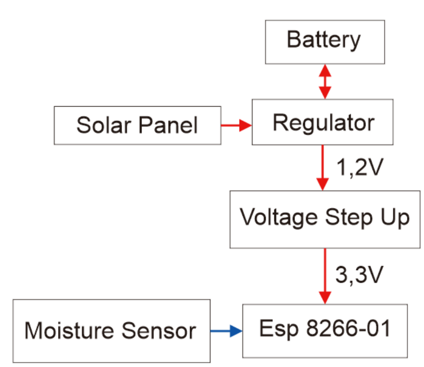

Figure 1.*Sensor node block diagram*

Figure 1 explains the block diagram in which the devices are classified as inputs, processes, and outputs. The input in the block diagram above consists of a moisture meter sensor and is connected to the process using ADC (Analog to Digital). The process consists of ESP266 as a processor as well as for intermediaries for WiFi communication. In the process section, there is also a power block that will energize the whole system. The system energy comes from solar panels that will charge the battery so the system can continue to operate independently through the charge-discharge cycle every day. Voltage steps up are required because the battery used produces an output of 1.2V, while ESP8266 requires a voltage of 3.3V to operate normally. Furthermore, in Figure 2 can be seen as a visualization of the arrangement of the installation of the equipment made. Tools made using structures such as sticks that can be embedded in the ground. The position of the solar panel is above so that the device can get sunlight quickly. The power and processing section is located in the middle, which is protected so as not to be exposed to water and the outside environment. The sensor section is located at the bottom so it can go directly into the soil to conduct soil moisture data acquisition.

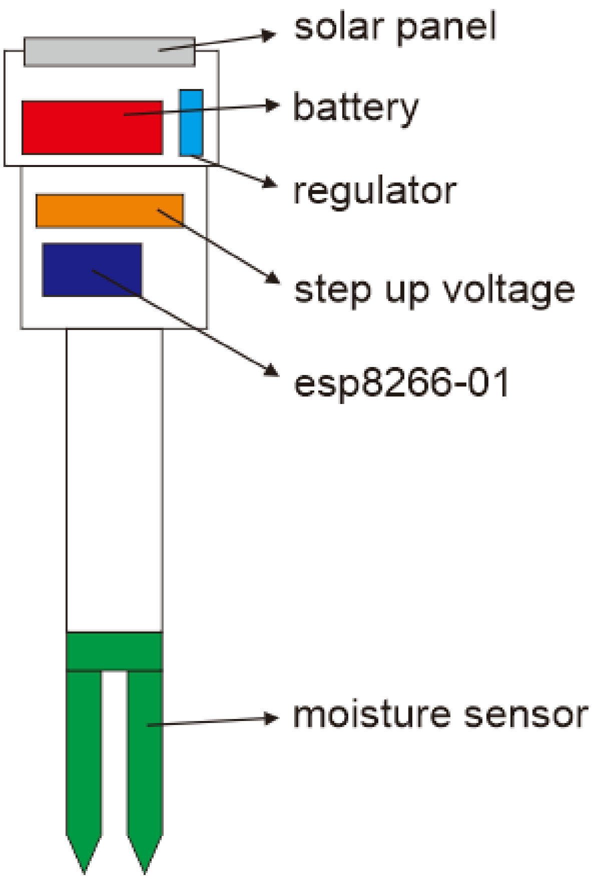

***Figure 2**. Design of the position of the components in the node*

2.2 Software Design

The processing part, ESP8266, is filled with programs designed to send acquisition data to the server via the Http protocol. Figure 3 shows the flow chart of the program included in ESP8266.

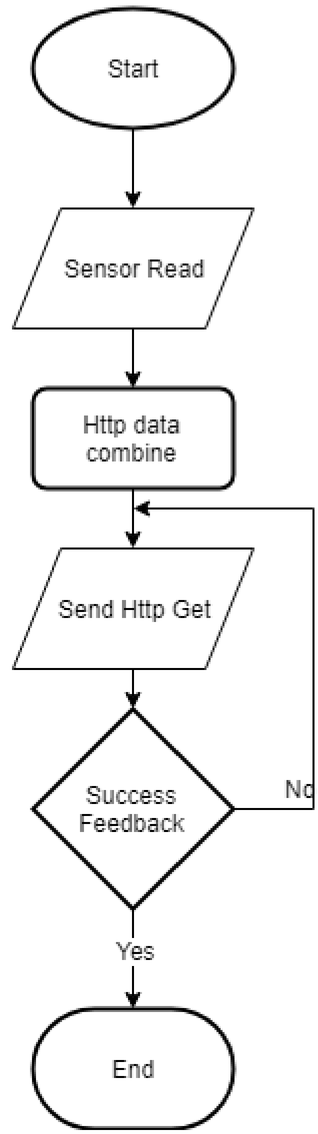

***Figure 3**. Flowchart program on ESP8266*

The program will read the ADC sensor and then merge the data into an Http string, which will be sent to the server via Http GET. Then the program will wait for feedback from Http if it is still not successful, then the sending will be repeated.

2.3 Communication Design

In accommodating sensor nodes in communication, an access point is needed to transmit each sensor data obtained. General communication from the node to the user is illustrated in Figure 4. Data sent by the node is then stored on the server to be seen by the user.

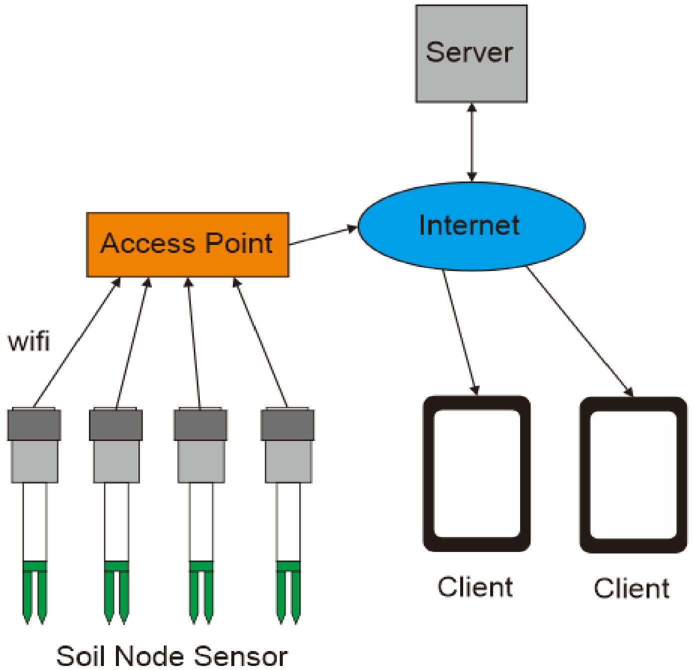

Figure 4. The design of the communication system at the sensor node

3 Implementation

The prototype IoT sensor node system produced in this study can be seen in Figure 5. The IoT system consists of several parts, including solar panels connected to batteries, to be able to maintain energy when installed in outdoor environments. ESP8266-01 is used as the central processor as well as to communicate via WiFi. Parts of the IoT system in the form of controller modules and power management modules are placed in outdoor type containers so that they can be safely placed in the environment despite exposure to heat and rain [10]. The container used is made of plastic and black so it can last longer under the sunlight.

Figure 5. *node sensor implementation*

The humidity sensor is used to determine the level of humidity from the soil. The humidity sensor consists of copper plates on a PCB (Printed Circuit Board) that is used to determine the conductivity of the soil. When the soil is dry, the conductivity level is low. If the soil humidity was increasing, then the sensor will return the higher the level of conductivity — the results of the soil moisture sensor readings in the form of ADC. Sensor reading data can then be translated as humid, regular, and dry conditions. According to the datasheet of the sensor, moist means the ADC value <350, reasonable means between 350-700, and dry value above 700 [11]. Part of the soil moisture sensor is made separately from the processor so that the sensor can read data in the soil while the processor is above the ground. In the power section, a 200mAh li-ion battery and solar panel are used to recharge it every day. This system will send soil moisture data every 10 minutes, whose data can be seen in Figure 6.

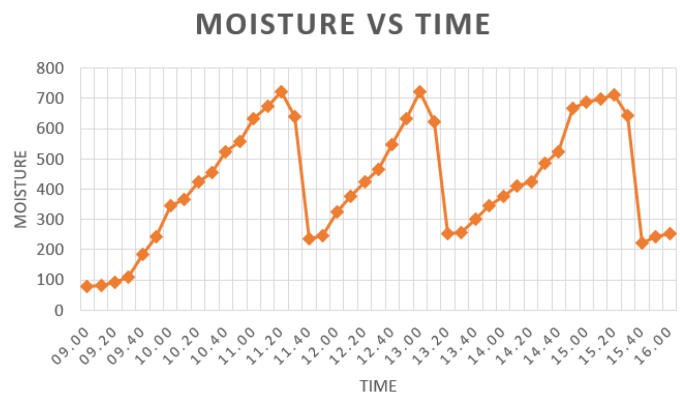

Figure 6. *Soil moisture sensor data*

The prototype of the completed system was then tested for its effectiveness in reading the data. Figure 6 can be seen as the results of humidity sensor readings from 9 to 16 with the initial conditions of the soaked soil so that the humidity reading ranges around 100. If the reading reaches 700, which means that the dry conditions will add water so that the moisture value will drop again. Moreover, the graph in Figure 6 shows that the sensor readings are good enough. Furthermore, in Figure 7 can be seen the graph of power consumption of the tool. Retrieval of power consumption data starts from 9 to 19. Moreover, taken two data in the form of voltage from the solar panel and the battery.

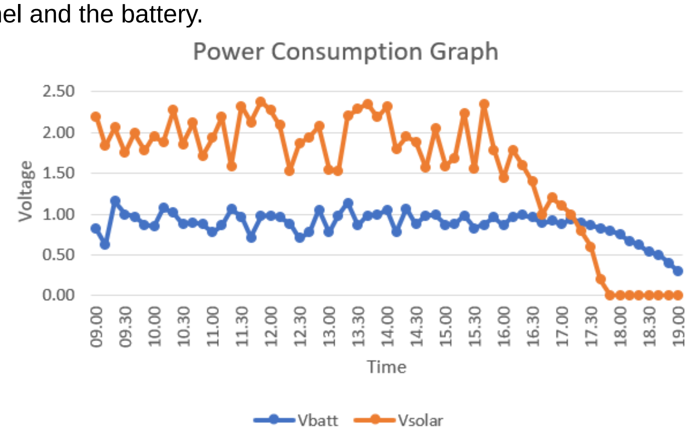

Figure 7. *Data voltage reading at the sensor node*

Voltage data for 10 hours in Figure 7 sensors for seven hours shows that in conditions exposed to sunlight, solar panels can obtain voltages above 1.5V and can charge batteries. In conditions exposed to sunlight, the battery is in stable conditions, which is in the range of 0.7V to 1V and can still be used for ESP8266 power sources with voltage step up. Then in the afternoon until the evening, the input voltage from the solar panel starts to drop and then disappears, so the battery starts to drop. At this point, it can be seen that the battery can only last for approximately 2 hours to be able to turn on ESP8266 and send data to the server.

4 CONCLUSION

Based on the activities and research data obtained, it can be concluded that the prototype node sensor for measuring soil moisture can function and can be used as input for the smart farming system. However, further research still needs to be done because there are still shortcomings of the device, which is low battery life and cannot be used for one-day cycles.

ACKNOWLEDGMENT

The author would like to thank the UGM Research Directorate for providing "financial support" to this research through funding assistance from the legal entity research institute of Universitas Gadjah Mada in the 2019 budget year.

REFERENCES

[1] J. Muangprathub, N. Boonnam, S. Kajornkasirat, N. Lekbangpong, A. Wanichsombat, and P. Nillaor, “IoT and agriculture data analysis for smart farm,” Comput. Electron. Agric., vol. 156, pp. 467–474, Jan. 2019.

[2] H. Suyama, S. E. Benes, P. H. Robinson, S. R. Grattan, C. M. Grieve, and G. Getachew, “Forage yield and quality under irrigation with saline-sodic drainage water: Greenhouse evaluation,” Agric. Water Manag., vol. 88, no. 1, pp. 159–172, Mar. 2007.

[3] M. Ji-Hua, W. Bing-Fang, and L. Qiang-Zi, “A Global Crop Growth Monitoring System Based on Remote Sensing,” in 2006 IEEE International Symposium on Geoscience and Remote Sensing, 2006, pp. 2277–2280.

[4] A. Khanna and S. Kaur, “Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture,” Comput. Electron. Agric., vol. 157, pp. 218–231, Feb. 2019.

[5] L. G, R. C, and G. P, “An automated low cost IoT based Fertilizer Intimation System for smart agriculture,” Sustain. Comput. Inform. Syst., Jan. 2019.

[6] D. Karimanzira and T. Rauschenbach, “Enhancing aquaponics management with IoT-based Predictive Analytics for efficient information utilization,” Inf. Process. Agric., Jan. 2019.

[7] A. Moon, J. Kim, J. Zhang, and S. W. Son, “Evaluating fidelity of lossy compression on spatiotemporal data from an IoT enabled smart farm,” Comput. Electron. Agric., vol. 154, pp. 304–313, Nov. 2018.

[8] G. J. L. Paulraj, S. A. J. Francis, J. D. Peter, and I. J. Jebadurai, “Resource-aware virtual machine migration in IoT cloud,” Future Gener. Comput. Syst., vol. 85, pp. 173–183, Aug. 2018.

[9] G. Severino, G. D’Urso, M. Scarfato, and G. Toraldo, “The IoT as a tool to combine the scheduling of the irrigation with the geostatistics of the soils,” Future Gener. Comput. Syst., vol. 82, pp. 268–273, May 2018.

[10] J. R. dela Cruz, R. G. Baldovino, A. A. Bandala, and E. P. Dadios, “Water usage optimization of Smart Farm Automated Irrigation System using artificial neural network,” in 2017 5th International Conference on Information and Communication Technology (ICoIC7), 2017, pp. 1–5.

[11] P. J. Mahesh, M. Naheem, R. Mubafar, S. Shyba, and S. Beevi, “New aspect for organic farming practices: Controlled crop nutrition and soilless agriculture,” in 2016 IEEE Global Humanitarian Technology Conference (GHTC), 2016, pp. 819–824.