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Low-cost on-line monitoring system for agriculture based on raspberry pi zero

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Abstract. Based on data from the National Defense Agency, the trend of conversion of agricultural land in the 1990s reached around 30,000 ha/year. However, in 2011 there was an increase of 110,000 ha/year and reached 150,000 ha/year in 2019. In fact, with the growing human population, the need for food is increasing from year to year. On the other hand, the slow regeneration of farmers and the lack of dissemination & technological innovation to increase agricultural productivity are challenges in realizing food security. In line with the ongoing industrial revolution in the industrial era 4.0, it has brought very significant changes, not only the type of technology that has shifted, but more importantly a change in mindset in this industrial era. This has a real impact on the direction of national development and has an impact on the agricultural system. The agricultural system is no longer just a cultivation activity, but agriculture is also part of the industrial system which is characterized by a transformation, both in terms of raw materials, economy, social and environment. The development of modern agriculture is marked by mindset changing of using biological and non-biological resources by the needs. The precise use of resources in agricultural production systems is then called precision agriculture. Precision agriculture is an agricultural concept with a systems approach towards low-input, high-efficiency, and sustainable agriculture. In a previous study, a CNC-based precision farming system (Farming-BOT) was developed. The device could perform vegetable crop cultivation automatically. To properly observe the development of cultivation, an online monitoring device based on the minicomputer was developed. The Raspberry Pi Zero, equipped with a 5MP camera and a temperature & humidity sensor, is used. The device is placed on the top of the Farming-BOT device. Image data, temperature, and humidity are sent to the cloud database periodically every day. Users can access the data through the website and Android application. Based on the testing result, with a stable internet connection, data on environmental conditions can be monitored perfectly.

1. Introduction

The driving wheel of the country's economy in the agricultural sector is still one of the important aspects and can lift Indonesia's image in the eyes of the world, especially as an agricultural country that is quite productive. Indonesia has very supportive climatic conditions and natural and human resources, but many farmers are still using conventional methods. It can be said that currently conventional agriculture is mostly practiced in developing countries such as Indonesia, while modern agriculture is mostly practiced in developed countries. These differences in agricultural systems affect the productivity of the results[1]. Productivity for conventional agriculture and modern agriculture is different because the inputs used for agriculture are also different, for example in terms of the tools used in conventional agriculture are still very simple such as hoes, sickles, or plowing using animals and human power as well as planting, maintaining and harvesting. In conventional agriculture, the resilience of production only lasts in the short term. This causes a country to be very dependent on imports because the availability and sustainability of agriculture are ignored. Seeing the enormous development of agriculture and this is a potential that must be maximized by all parties. However, there are challenges in increasing the potential of agriculture, several parties involved, both the government and agricultural sector actors must be more prepared to face challenges in the era of advances in information technology[2].

In line with the ongoing industrial revolution in the industrial era 4.0[3][4] and now towards the industrial era 5.0, it has brought very significant changes, not only the type of technology that has shifted, but more importantly a change in mindset in this industrial era. This has a very real impact on the direction of national development to have an impact on the agricultural system. The agricultural system is no longer just a cultivation activity, but agriculture is also part of the industrial system which is characterized by a transformation both in terms of raw materials into agricultural products that are ready to be utilized and have added value, both in terms of economic, social and environmental aspects. The development of modern agriculture is marked by a change in the mindset of using biological and non-biological resources following the needs. The precise use of resources in agricultural production systems is then called precision agriculture. Precision agriculture is an agricultural concept with a systems approach towards low-input, high-efficiency, and sustainable agriculture[5]. Or it can be said that precision agriculture is an agricultural system that optimizes the use of resources to get maximum results and also reduces the impact on the environment. The concepts that are considered include a systems approach that pays attention to inputs, processes, outputs, and outcomes.

The challenge for farmers in the era of precision agriculture is to have the ability in terms of management, be it the management of land, crops, agricultural tools, and machinery used from pre-harvest to post-harvest or processing[6], as well as human resource management. This will greatly affect the level of success in the implementation of precision agriculture. The acceleration of the development of precision agriculture in Indonesia is also inseparable from the use of modern technology today. The technology applied must be able to detect what is on agricultural land, then decide what to do, and provide treatment following the decisions that have been made so that it can provide benefits in the stages of the agricultural production system. Currently, various types of technology that can support the implementation of precision agriculture and several types of technology in precision agriculture include; (i) Geographical Position System (GPS), (ii) Geographic Information System (GIS), (iii) Variable Rate Application (VRA), (iv) Remote Sensing System, (v) Yield Mapping, (vi) Database Management System (DBMS), Spatial Variability[7].

2. Related Work

Some of the technologies that led to the development of the concept of precision agriculture, one of which was the creation of a GPS by the US Department of Defense in the late 1970s. GPS can pinpoint exact locations 24 hours a day, up to several meters. This information can provide field processing with reasonable accuracy. The application of precision agriculture is also made possible by developing sensor technology that can be combined with appropriate agricultural management measures such as cultivation, seeding, fertilization, herbicide application, and harvesting. Advances in precision farming systems have progressed along with the development and improvement of Global accuracy

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Navigation Satellite System (GNSS) has also been developed since 1999. GNSS technology[8] is widely used in many livestock businesses to perform tasks related to automated control systems and geographic reference information. GNSS helps to improve the quality of auxiliary work machines, automatic controls and controlled Traffic Management Systems. In agriculture, another essential component of precision farming is Variable Rate Technology (VRT)[8] which enables precise seeding, optimization of plantings, density and better application rates, the efficiency of herbicides, pesticides and nutrients. As a result, cost efficiency and reduction of environmental pollution can be achieved. VRT can recognize various wavelengths of multi-spectral and hyperspectral cameras onboard drones and provide information on vegetation indices, such as monitoring chlorophyll content, stress levels, and their variations in space and time data. Particular attention is paid to the use of low-cost crewless aerial vehicles (UAVs)[9], or drones as they are often called. Existing and new technologies such as the Internet of Things & Big Data [10] can make processes more efficient and lead to the creation of new products and services.

An essential part of precision farming technology is the farmer and his perception. This process was started in the early 1990s by enthusiastic farmers with the best orientation, followed by despair due to lack of support and relatively low profitability. The current adoption of this approach is based almost entirely on the private sector, which offers farmers tools, products and services. Unfortunately, national advisory services in agriculture are minimal [11].

3. System Design

3.1 Hardware Design

The monitoring system is based on Raspberry Pi Zero. The Raspberry Pi Zero is a small ARM microprocessor-based mini-computer for $25. The Raspberry Pi Zero type W has a Wifi device so it can connect to the internet. In this study, the sensors used for the monitoring system are Pi Camera and DHT22. The Pi Camera is used to capture images of the environment, while the DHT22 is used to measure the temperature and humidity of the environment. Figure 1 is a system block diagram of the monitoring device used.

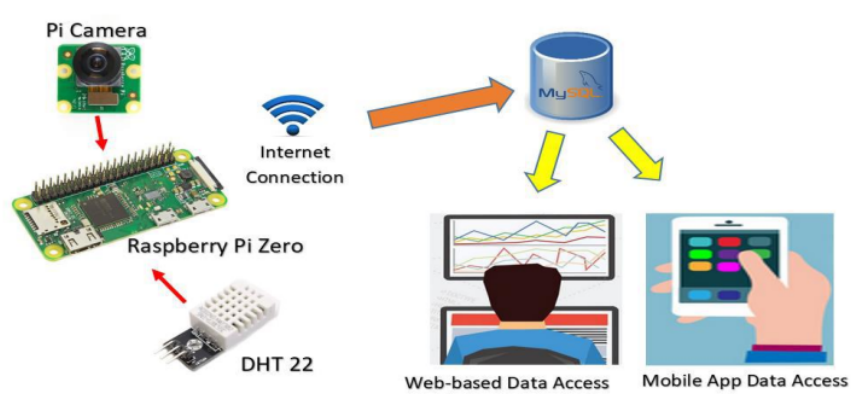

Figure 1. Block Diagram System

The Pi Camera is connected to the camera slot on the raspberry pi Zero. Whereas DHT 22 is connected to pin I2C of the Raspberry Pi Zero. DHT22 data access using one-wire serial communication. The Raspberry Pi zero connects to a wifi network that is used to remotely ssh, as well as send data to a cloud database. The whole device is powered by a 5volt DC adapter. The device is mounted on a case that is printed using 3D printing.

3.2 Software Design

For the monitoring system, there are 3 kinds of programming used: Python programming for raspberries, HTML programming for web-based monitoring, and Android programming for mobile-device-based programming. First, the raspberry pi will check the internet connection by pinging google. If an internet connection is detected, the raspberry will access the NTP server time data (GMT+7). There are 2 kinds of data sent to the database, direct data, and daily data. Live data will be sent every 10 minutes. While the daily data is sent to the database every 16.00. Direct data is used as data that is displayed on Android devices in the form of numeric values and images. While the daily data is used for web-based display in the form of graphs and images. Daily data can be used to observe the process of plant development from the beginning of planting to harvest. Figure 2 is a flowchart of raspberry pi programming. The device is also reset every 12 AM to avoid errors due to memory being full.

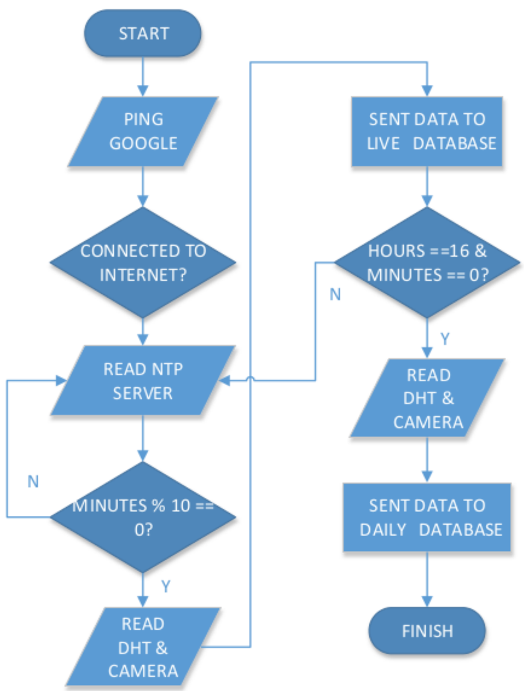

Figure 2 Flowcart system

4. Result and Discussion

4.1. Hardware Realization

The overall placement of the devices is shown in figure 3. In this study, the device is used to monitor the environmental conditions of FarmBOT [12]. The monitoring device is placed 2 meters above the FarmBOT so that the camera can capture the entire FarmBOT land. The device is also connected to the UPS as backup power in the event of a power outage.

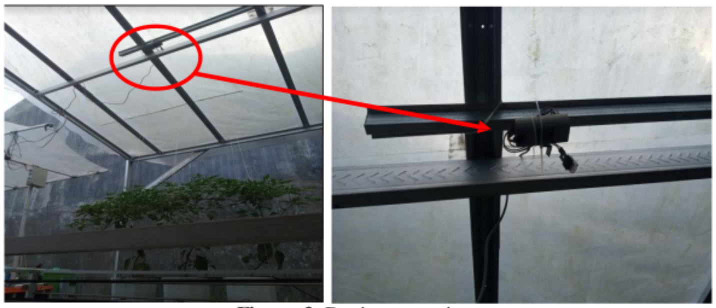

Figure 3. Device mounting

4.2. Testing result

Once the device is installed in the FarmBOT environment, it runs for 24 hours non-stop. For direct data, the system will update the data on the MySQL database. As for daily data, the system will insert data into the MySQL database. For image data, the captured results from the pi camera are processed to DB64 format first. Figure 4 is a daily data display on an Android mobile application. The data on the mobile application will be updated every 10 minutes according to the rules on the Raspberry Pi.

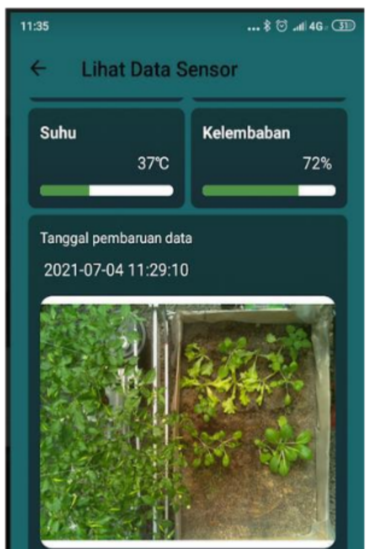

Figure 4 Android based on-line monitoring system

Figure 5 is a daily data display on the web. Daily temperature and humidity data is displayed in graphical form. While the image data is displayed in RGB format per 2 days. Users can view the data on the previous day by pressing the date button displayed on the web browser. The data can be accessed at the address http://gh1.rumahkuhidroponik.com via a standard web browser..

Figure 5. Web based monitoring system

The system has been running since February. However, sometimes it is still problematic. As seen in the graph there is a data storage lag from February - April. This is caused by the condition of the Raspberry which hangs every 3-4 days. On effective planting in May, the program to reset the raspberries every 12 AM had a good impact on the system. During the months of May to July, the system can store data periodically every day without experiencing a hang. Without an automatic reset system, the processing memory on the Raspberry will be full, so it can hang after 3-4 days of being turned on for 24 hours non-stop. To precision sensor measurement results, calibration is also carried out with the manufacturer's sensor. Table 1 is a comparison of measurement data between online monitoring devices and manufacturer's measuring instruments.

Table 1. Sensor data

Day	Temperature			Humidity		
	Sensor	Factory	Error	Sensor	Factory	Error
1	33	33.5	1.52	80	81	1.23
2	30	31	3.33	92	92	0.00
3	32	31.5	-1.56	82	83	1.20
4	29	29	0.00	95	96	1.04
5	29	30	3.45	95	97	2.06
6	34	34	0.00	78	78	0.00
7	31	30.5	-1.61	80	80	0.00
		Ave	0.73		Ave	0.79

5. Conclusion

Based on the research that has been done, the raspberry pi zero-based monitoring system can be an option for the low-cost version of the monitoring system. With a total price of around $50 (for pi zero, pi camera, DHT22 & 5V DC adapter) the device can fulfill the need to take sensor readings and transmit data to sensors. The system has been able to work 24 hours non-stop for more than 3 months. Power and memory management needs to be done to avoid hangs during processing. A fan can also be added to help maintain the performance of the raspberry pi, especially during the day. A stable internet connection is also required so that the process of storing data in the online database does not occur disturbances.

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