Design of a Water Sprinkler System and Monitoring of Soil Moisture in Potato Cultivation of the Kledung Horticulture Seed Center based on the Internet of Things (IoT)

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Abstract—Potato is one of horticultural commodities that plays an important role to assure food security, mostly upper place such as plateau. Monitoring soil's moisture and soil's pH in potato plant tendance is the key point for good growth and development of potatoes. Soil moisture in a land is affected by the level of water contain in the soil. For that reason automatic monitoring system is needed to observe the land condition where the potato seedling is planted and a moisture control system that can ease the work. 40% to 70% of soil moisture is ideal for potatoes plant. The development of this design make use of wireless fidelity (wifi). This device keep the dampnes know less than 40%. If it's less than 40%, the sensor will detected so the watering system will running and system will stop if reaching 70%. This design can monitor pH, temperature and humidity through the android application. With an accuracy level of the pH sensor for measuring 95.85% of acidity, the capacitive sensor for measuring soil moisture is 96.6% and DHT11 for measuring temperature and humidity at 99.75%.

Keywords—*Internet of Things, Monitoring, Potato, Water Sprinkler System*

1. Background

Potatoes are a horticultural commodity that plays an important role in the realization of food security. Potatoes are known as an alternative source of carbohydrates that can substitute people's basic. High photosynthate production is advantageous for potatoes plants to produce a larger tuber weight per plant so as to produce a larger total tuber [2].

Monitoring soil moisture and soil pH in potato plant care plays an important role in potato growth and development. Soil moisture in a land highly appreciates the highest level in the soil. Ground water content is the amount of water content that is retained in the soil. Soil moisture is one of the main factors in determining the level of dryness of a land. Optimal moisture for potato is 40%-60% (2). The higher the soil moisture level in a land, the greater the chance of drought on that land.

The human-powered watering and fertilizing system, which is carried out by turning the lever connected to water pump, it will require energy and costs more. Therefore an automatic monitoring system is needed to see the condition of the potato seed field and a soil moisture control system so that it can make it easier for seed garden workers.

2. . Theoritical Framework

Internet of Things (IoT) is a development of Wireless Sensor Network technology that allows control, communication, and integration with various devices via the internet network. This technology has a concept similar to Machine to Machine (M2M) Communication which allows devices to be able to communicate with each other on a network using wired (Wired) or wireless (Wireless) media based on Peer to Peer and Client-Server topologies utilizing Cloud, Sensor Network, and Wireless.

Internet of Things (IoT) is a concept that allows communication between devices via the internet network. There are several standard protocols that are used as communication protocols in IoT devices. Some considerations when choosing a protocol to use include IoT devices that have limitations (such as computing ability, have limited power, etc.), the IoT devices used can be of various types, and reliable communication lines between devices and Smartphone Appication based on Android architecture [4]. The IoT protocols used include Hypertext Transfer Protocol (HTTP), Extensible Messaging and Presence Protocol (XMPP), Constrained Application Protocol (CoAP), Advanced Message Queuing Protocol (AMQP), and MQ Telemetry Transport (MQTT) [1].

TCP / IP is a data communication standard used in the process of exchanging data from one computer to another. TCP / IP is an open network that is independent of the transport mechanism on the physical network used, so it can be used anywhere. This protocol uses a simple addressing scheme known as an IP address (IP Address) which allows multiple computers to be able to communicate with each other on the Internet. This protocol is also routable, which means it is suitable for connecting different systems to form a heterogeneous network [3].

3. Research Methods

Principle of this system is that when the sensors installed on the land in each sensors receive data of the moisture and PH level of the soils and the air temperature, the data will process by NodeMCU ESP8266 to read the voltage value from the sensor can be seen in Fig.1 below.

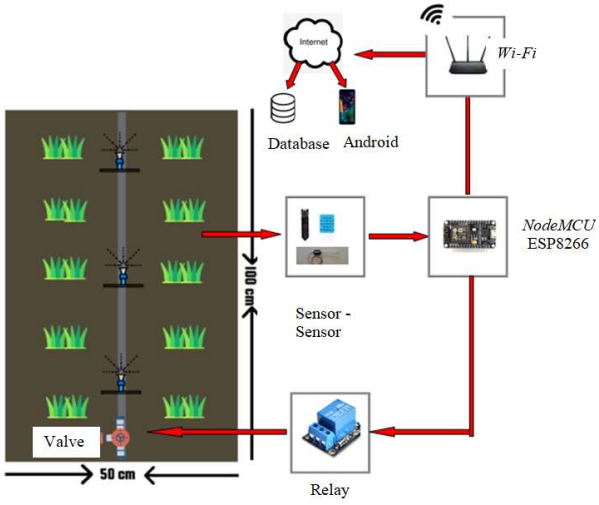

Fig. 1. Design of System

After successfully reading it, the data will be requested resulting in certain conditions. On the humidity sensor, if the data shows a value less than 40%, it will recognize the soil as a dry one. If it shows more than 40% then the soil is moist. Normal soil conditions are indicated by a humidity value between 40% to 70%. Meanwhile, the pH sensor is formed from quantitative information which states the acidity or alkaline level of the soil. The normal soil condition to grow a potato seed is 6. DHT11 detects air temperature and humidity around the land. The optimal temperature for potatoes to grow well and healthily is at 15-20^{o}C. The humidity sensor, ph sensor, and DHT11 sensor then send the obtained data to the server.

The data that has been sent and stored on the server will be displayed on the Android dashboard. The communication system for monitoring and automatic sprinkling in the potato seed field, in sending and receiving data, uses NodeMCU ESP8266 to communicate with wifi network technology.

The reading process uses NodeMCU ESP8266 from sensors and sends the data to the internet as well as reads or accesses data on the server to activate the control function on the sprinkler installed in the seed field. The potato plant sprinkler control system can work after receiving the output from the sensor. When the microcontroller receives a HIGH signal from the sensor, the solenoid valve will be active and then turn the sprinkler on to water the plants.

Process of turning off the sprinkler is done when the soil moisture reaches a good condition for the sprinkler potato plant will continue to burn until the soil capacitive sensor as a soil moisture sensor has detected optimal soil moisture conditions. If the capacitive soil sensor has detected optimal soil moisture, the solenoid valve will close and the sprinkler will shut off.

Soil capacitive sensor calibration design is tested by comparing the measurement results of the sensor with the soil meter. Furthermore, the soil capacitive sensor and soil moisture measuring instruments are placed at the same time and conditions in the potato seed field.

DHT11 sensor calibration design is tested by comparing the measurement results from the DHT11 sensor with the Thermo Hygrometer and Weather Meter. Two measuring instruments for comparison are used in order to obtain a more accurate comparison result. Furthermore, the DHT11 sensor and temperature and humidity measuring instruments are placed at the same time and conditions in the provided potato fields.

Design of the soil pH sensor calibration is tested by comparing the measurement results from the soil pH sensor with the Thermo Hygrometer. Furthermore, the soil pH sensor and pH meter are placed at the same time and conditions in the provided potato fields. E. Android testing Android smartphones are used for automatic watering monitoring. Testing is done by testing the android application, including the appearance and function of the menu in the application.. The purpose of testing is to find out which application runs in accordance with the function of the android application.

At this stage, it is discussed the design system of a water sprinkler system and monitoring of soil moisture in Potato cultivation of the Kledung Horticulture Seed Center based on the Internet of Things (IoT) architecture as shown in Fig.2.

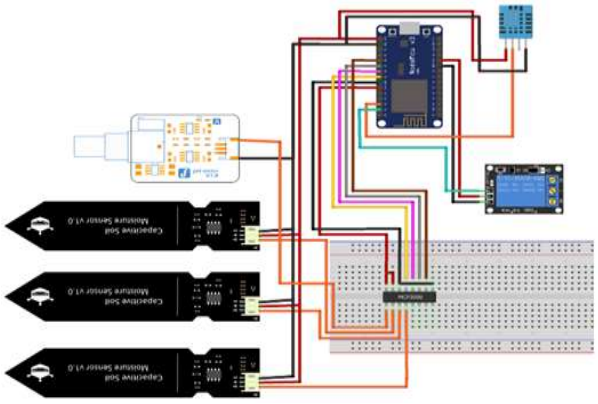

Fig. 2. Controlling and monitoring system

Figure 3.2 describes the workflow of the potato plant watering system starting from initializing the data and reading the data on the sensors. In the humidity sensor, the value is below 40%, so the solenoid will be active and the sprinkler will light up. When the humidity sensor detects conditions above 70%, the solenoid valve will close and the sprinkler will shut off. Then the data from the sensor will be sent to the database

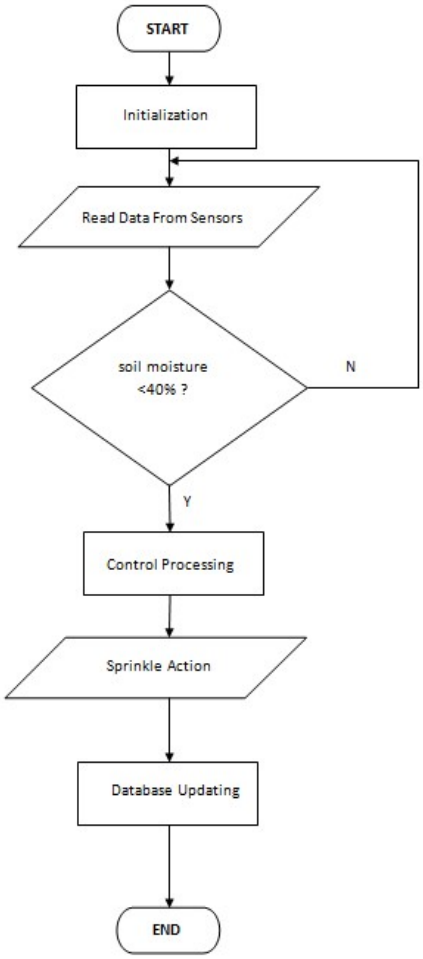

Fig 3. Flowchart of controlling and monitoring

4. Results and Discussion

This chapter discusses soil moisture measurements and humidity comparison between capacitive soil sensor and soilmeter, air temperature comparison between DHT11 and weather meter, PH measurements, Android application testing.

4.1 Capacitive Sensor Test Results

The soil capacitive sensor calibration design is tested by comparing the measurement results of the sensor with the soil meter. Furthermore, the soil capacitive sensor and soil moisture measuring instruments are placed at the same time and conditions in the potato seed field.

The results of the soil capacitive sensor test are shown in Table 1. it is known that the average difference or deviation result of the scale of the soil moisture value with a sensor accuracy level of 96.6% is 2.85%. Graphically the comparison of soil moisture with measurements using a soil capacitive sensor and Soilmeter is shown in **Fig 4.**

Table 1. Soil capacitive sensor testing

No.	Capacitive Sensor (%)	Soil Meter (%)	Difference (Absolut)	Accuracy (%)
1.	67%	65%	2	97,01%
2.	65%	70%	5	92,85%
3.	65%	67%	2	97,01%
4.	65%	66%	1	98,48%
5.	65%	61%	4	93,84%
6.	67%	62%	5	92,53%
7.	64%	66%	2	96,96%
8.	63%	60%	3	95,23%
9.	64%	65%	1	98,46%
10.	65%	60%	5	92,30%
11.	66%	70%	4	94,28%
12.	65%	70%	5	92,85%
13.	66%	64%	2	96,96%
14.	63%	61%	2	96,82%
15.	64%	61%	3	95,31%
16.	61%	61%	0	100%
17.	63%	63%	0	100%
18.	63%	70%	7	90%
19.	65%	61%	4	93,84%
20.	63%	61%	2	96,82%
21.	64%	65%	1	98,46%
Average			2,85714286	96,666667%

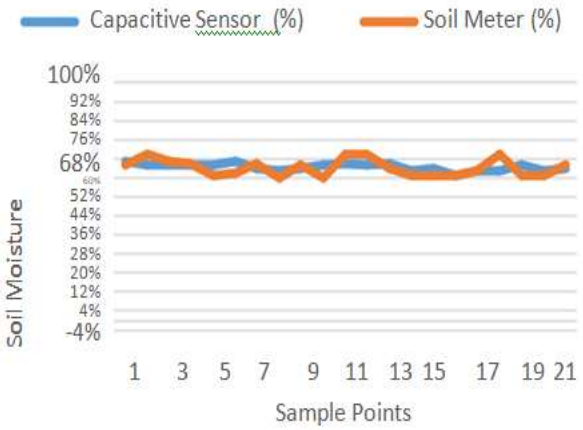

Fig 4. Humidity comparison chart using capacitive soil sensor and Soilmeter

4.2 DHT11 Sensor Test Results

DHT11 sensor testing is done by comparing the results of DHT11 sensor with a weather meter and thermo hygrometer to determine the accuracy of the sensor. The results of the DHT11 sensor air temperature test with a weather meter can be seen in Table 2.

Table 2. Result of air temperature measurement DHT11 and weather meter

No.	Air Temp (^{O}C)	Weather meter (^{O}C)	Difference (Absolut)	Accuracy (%)
1.	32,40 ^{O}C	32.2 ^{O}C	0,2	99,37%
2.	32,10 ^{O}C	32,0 ^{O}C	0,1	99,68%
3.	32,10 ^{O}C	32,4 ^{O}C	0,3	99,07%
4.	32,40 ^{O}C	32,5 ^{O}C	0,1	99,69%
5.	32,30 ^{O}C	32,3 ^{O}C	0	100%
Average			0,14	99,56%

Sensor test results in the difference and accuracy between the DHT11 and the weather meter. The average temperature difference or deviation obtained is 0.14 OC and the sensor accuracy value is 99.56%. Graphically, the temperature comparison between DHT11 and weathermeter as shown in Fig. 5.

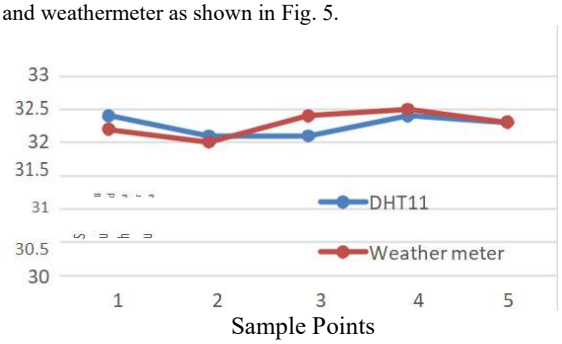

Fig 5. Graph of air temperature measurement DHT11 sensor and weather meter

The results of the DHT11 sensor air temperature test with a Thermo Hygrometer can be seen in Table 3.

Table 2. Result of air temperature measurement DHT11 and thermo hygrometer

No.	Air Temp (^{O}C)	Thermo Hygrometer (^{O}C)	Difference (Absolut)	Accuracy (%)
1.	32,3	32,4	0,1	99,69%
2.	32,4	32,4	0	100%
3.	32,3	32,4	0,1	99,69%
4.	32,3	32,4	0,1	99,69%
5.	32,4	32,3	0,1	99,69%
6.	32,3	32,5	0,2	99,38%
7.	32,4	32,4	0	100%
8.	32,4	32,5	0,1	99,69%
9.	32,4	32,5	0,1	99,69%
10	32,4	32,4	0	100%
Average			0,08	99,75%

Test result shows a difference and accuracy between DHT11 and thermo hygrometer. The average value of the difference in values obtained is 0.08 OC and the average accuracy value obtained is 99.75%. Graphically, the comparison of the air temperature on DHT11 with the thermo hygrometer can be seen in Figure 6.

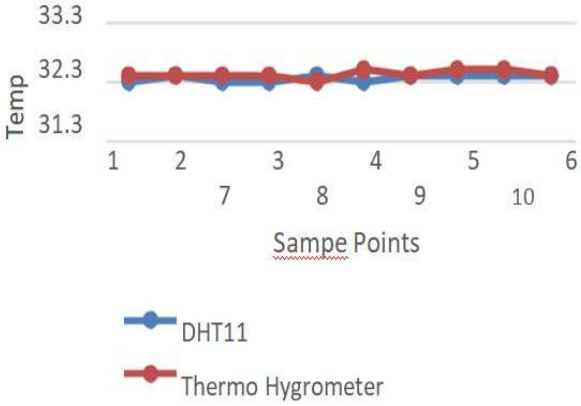

Fig. 6. Graph of air temperature measurement DHT11 sensor and thermo hygrometer

Result of the DHT11 sensor air humidity tested with Weather meter can be seen in Table 4.

Table 4. Humidity measurement DHT11 and thermo hygrometer

No.	Humidity Udara DHT11 (%)	Weather meter (%)	Difference (Absolut)	Akccuracy (%)
1.	61,00%	63.4 %	2,4	96,21%
2.	62,00 %	62,3%	0,3	99,51%
3.	61,00%	62,3%	1,3	97,91%
4.	62,00%	62,3%	0,3	99,51%
5.	63,00%	63,5%	0,5	99,21%
Average			0,96	98,47%

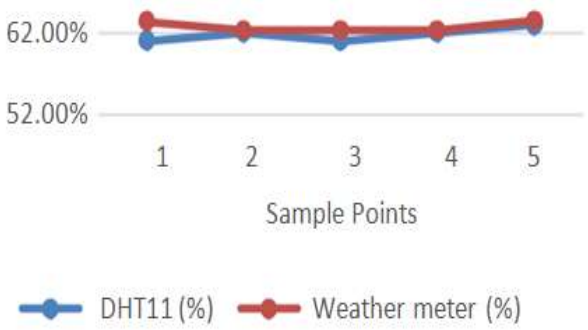

Fig. 7. Graph of humidity measurement DHT11 sensor and weathermeter

Sensor testing shows the difference and accuracy between the DHT11 and the weather meter are accurate. The average difference or deviation of the temperature values obtained is 0.96% and the sensor accuracy value is 98.47%. Graphically the temperature comparison between the DHT11 and the weather meter is shown in **Fig. 7**.

Result of the DHT11 sensor air humidity test with Thermo Hygrometer can be seen in Table 5.

Table 5. Air humidity DHT11 and thermo hygrometer

No.	Air Humidity DHT11 (%)	Thermo Hygrometer (%)	Difference (Absolut)	Accuracy (%)
1.	77%	77%	0	100%
2.	78%	78%	0	100%
3.	77%	78%	1	98,71%
4.	78%	78%	0	100%
5.	78%	79%	1	98,73%
6.	77%	80%	3	96,25%
7.	78%	80%	2	97,50%
8.	77%	81%	4	95,06%
9.	77%	81%	4	95,06%
10	77%	79%	2	97,46%
Average			1,7	98%

Air humidity test results, The average difference in values obtained is 1.7 and the average percentage accuracy of DHT11 with the thermo hygrometer is 98%. Graphically the comparison of DHT11 air humidity with the thermo hygrometer is shown in **Fig. 8**.

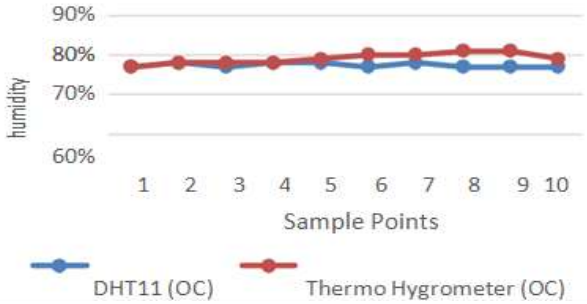

Fig. 8. Air humidity DHT11 and weather meter

4.2 PH Sensor Test Results

Table 6 shows the difference in measurement results and accuracy (%) between the soil pH sensor and the Soilmeter measuring instrument. From the calculation, the average difference or deviation that occurs is 0.33 with a sensor accuracy level of 95.85%.

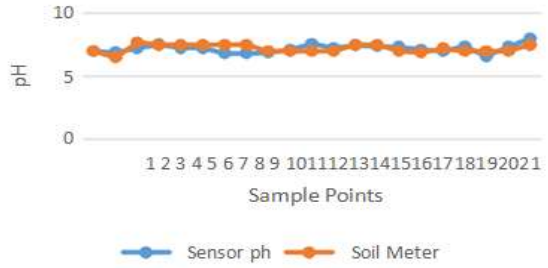

Fig 9. PH sensor testing

Table 6. PH sensor testing

No.	pH Sensor	Soil Meter	Difference (Absolut)	Accuracy (%)
1.	7,02	7	0,02	99,71%
2.	6,91	6,5	0,4	93,69%
3.	7,24	7,7	0,5	93,64%
4.	7,52	7,5	0,02	99,73%
5.	7,27	7,5	0,3	96,93%
6.	7,21	7,5	0,3	96,13%
7.	6,83	7,5	0,7	91,06%
8.	6,83	7.5	0,7	91,06%
9.	6,86	7	0,2	98%
10.	7,13	7	0,13	98,14%
11.	7,6	7	0,4	91,42%
12.	7,27	7	0,5	96,14%
13.	7,49	7,5	0,01	99,86%
14.	7,41	7,5	0,09	98,80%
15.	7,32	7	0,7	95,42%
16.	7,13	6,9	0,04	98,14%
17.	7,02	7,2	0,12	97,50%
18.	7,38	7	0,38	94,57%
19.	6,61	7	0,4	94,42%
20.	7,32	7	0,7	95,42%
21.	8,01	7,5	0,5	93,20%
Average			0,33857143	95,8561905 %

4. Conclusion

1. Automatic watering based on the command of the microcontroller when the soil moisture reaches less than 40%. Watering will die when the soil moisture reaches 70%, so that soil moisture is stable, never less than the minimum limit of 40% soil moisture for potato plants.

2. Soil moisture, acidity (pH), and temperature data can be monitored via the Android application. The sensor used to measure humidity is a capacitive sensor with an accuracy of 96.6%. While the sensor used to measure the degree of soil acidity has an accuracy of 95.85% compared to Soil Meters. Measurement of temperature and humidity is used by DHT11 sensor with an accuracy of 99.75% compared to the thermo hygrometer and weather meter.

3. Watering can also be done manually by pressing a button on the Android application, so that watering can still be done even though the humidity is still above 40%.

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