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by Rina Mardiati

Growth Monitoring System and Automatic Watering for Chili Plants Based on Internet of Things

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***Abstract*—The development of Internet of Things (IoT) technology in this all-digital era is increasingly advanced. The need in the form of automatic plant watering equipment in the community is starting to be needed given the increasingly sophisticated technology. Fulfillment of this increasing need must be accompanied by an increase in the productivity of chili cultivation. In this study, a monitoring system has been developed to observe the growth of chili plants integrated with the Internet of Things (IoT) with a power source from solar panels. In this system, a soil moisture sensor is added which functions as a sensor for detecting soil moisture, whose data will be used as a variable for the automatic watering system. Chili growth monitoring is carried out using a height sensor that is stored above the chili plant. Based on the test results, the results obtained for the growth of plants are very good and the soil moisture is below 60% which causes the water pump to turn on and then the data is sent to the Blynk application. And the voltage obtained from the solar cell is 12.95 volts.**

***Keywords*— Watering automation, IoT, ultrasonic sensors, humidity sensors, solar cell.**

I. INTRODUCTION

Increased development in the technology sector affects the increasing use of tools and machines, especially in the agricultural system in Indonesia [1]. In the current industrial era 4.0, the use of appropriate technology to increase agricultural productivity in Indonesia so that high economic value is possible to realize. This is in line with the agricultural development priority agenda in the future, namely to achieve food sovereignty. One of the crops which is the main national food commodity [2] and which has a high economic value in agriculture is the chili crop [3]. Along with the increasing population, the need for chili in Indonesia is also increasing [4].

Currently there are alternative energy sources that have been applied in the agricultural sector, namely solar (solar cell / PhotoVoltaic / PV)[5]. Many of them are used as a source of electrical energy to drive water pumps in agricultural irrigation [6]. Solar cells are devices that convert light energy into electrical energy. Solar cells are included in environmentally friendly new and renewable energy sources (EBT). Considering the potential of Indonesia's territory which is located in tropical areas, the use of electricity has a considerable advantage, namely receiving continuous sunlight throughout the year [7]. Furthermore, the application of solar can be used for the need for electrical energy in a green house and its automation [8].

The control system that can be used for environmental conditioning of planting media and monitoring plant growth is the Raspberry Pi. Raspberry Pi is a small computer that can be used like a Personal Computer (PC) [9]. In the current 4.0 industrial revolution, Raspberry devices have been integrated with the IoT system. IoT allows every item (things) that is owned to be connected to the internet so that it can be controlled from a far distance with a smartphone or change with voice commands [10]. The development of this IoT system makes the use of the Raspberry device much more leverage because it can be monitored in real time from a remote location or location [11].

II. DESIGN AND IMPLEMENTATION

A. Block Diagram System

The design is the stage of this research process. System design is used to determine the composing components of a tool to be made, so that the final result is as desired. After collecting some references and analyzing the needs for making tools, this system block diagram includes Hardware and Software design.

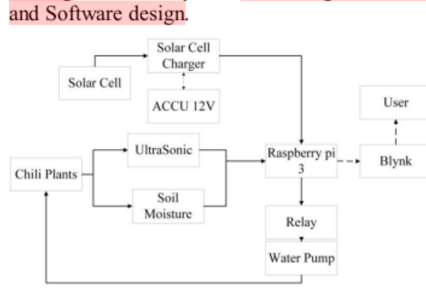

Fig. 1. Block diagram system.

B. Hardware Design

The design of growth monitoring system hardware has several tools and materials needed to fulfill this process. The design of an automatic watering system for chili plants uses a

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soil moisture sensor, the relay module functions as a mechanical switch to turn on the pump automatically and automatically. Raspberrypi3 will carry out the process of measuring soil moisture using a soil moisture sensor and will measure it in Rh units. Raspberry pi as the brain of the control system in the process of reading the sensor data that is present during the use of the device. Then the relay is used to control the system input and output in the form of a water pump with a soil moisture setpoint value of 60-70% Rh [29]. This is done to maintain the desired soil moisture parameters. The design of the solar cell voltage received by the solar cell is forwarded to the solar charger and stored in the battery, so that the input current to the raspberry is contained in the battery.

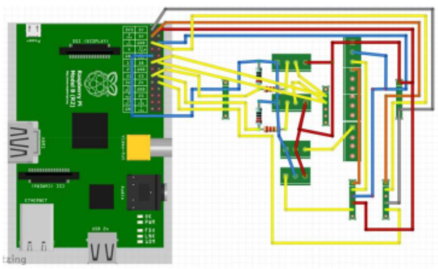


Fig. 2. Monitoring and watering circuit scheme.

C. Software Design

The use cases used in the design of the growth monitoring system and watering the chili consist of users, use cases and relationships. The user plays a role in running a growth monitoring system and watering the chilies. The user logs in first and then enters the main view of the chili growth monitoring and watering platform. Users can see the results of monitoring the value of chili growth (Cm), the value of soil moisture (Rh), manual and automatic watering push buttons. In order to enter the growth monitoring and chili watering system, users must first log in. Furthermore, if the user's email and password match, the user will enter the growth monitoring system and automatic chili watering.

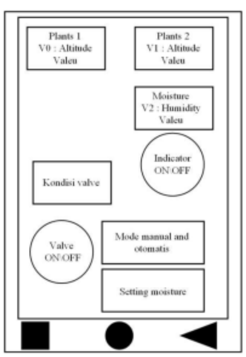


Fig. 3. GUI Design

D. Implementation

The ultrasonic sensor in this prototype functions as a measuring tool for the height of the plant in the form of a centimeter. Two pairs of ultrasonic sensors were used with the detection of 2 chili plant objects.

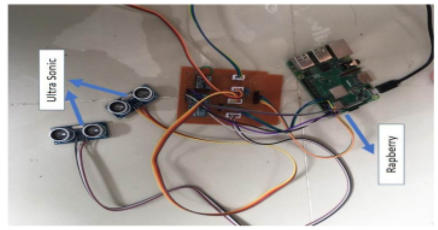


Fig. 4. Implementation raspberry and ultrasonic.

Sensorsoilmoisture (soil moisture) on this prototype functions as a measure of soil moisture related to the growth and watering process of chilies. Soil moisture sensor has a moisture value with a unit of value in the form of Rh (Relative Humadity).

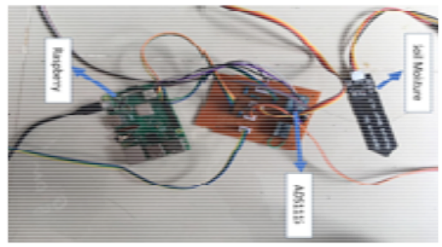
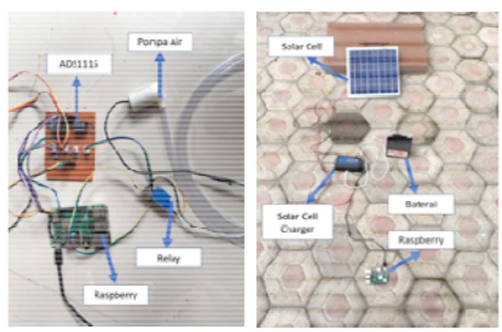


Fig. 5. Implementation raspberry and ultrasonic.

The water pump actuator in this prototype functions as a manual and automatic watering tool for watering chilies based on a predetermined soil moisture value. Automatic and manual water pump indicators can be done on the Blynk platform by pressing the water pump push button and can adjust the humidity value that the user wants. The water pump can be connected to the raspberry via a 1 channel relay module as a breaker. The solar cell in this prototype functions as power input to the growth monitoring system and watering the chilies. The power input in this system has the concept of a battery charge with a solar charge controller module with an output in the form of a 12 V ACCU which will be connected to the power raspberry pi 3.



(a) (b)

Fig. 6. Implementatiom of : (a) raspberry pi 3 and waterpump; (b) Raspberry pi 3 and solar cell.

After all are strung together, the series is put together as the final presentation of the series.

Fig. 7. Hardware implementation.

After assembling the hardware, the software used is ready to be combined with the hardware. The software that has been previously described is designed for software, then implemented in hardware. Like uploading source code in Python and opening the Blynk Platform to display the monitoring system.

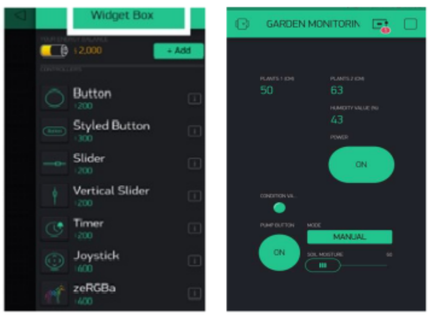


Fig. 8. Application.

III. Result and Analysis

In research, the growth monitoring system and chili watering were carried out by several tests including height testing with an ultrasonic sensor which has a set point value of 60 cm of chili growth, then when the height of the chili plants reaches a height of 30 cm the set point is changed to 100 cm, then the data results will be compared with ruler gauge, humidity test uses a soil moisture sensor with Rh (relative humadity) unit which has a set point value of 60% and when the soil moisture value is below the predetermined set point value, the actuator in the form of a water pump will turn on. The monitoring system is carried out through the Blynk platform with an interface in the form of data values for height, soil humidity and manual and automatic pump indicator buttons.

TABLE I. Growth Monitoring Result

No	Chili Plants 1			Chili Plants 2		
	Ultrasonic 1 (cm)	Ruler 1 (cm)	Error (%)	Ultrasonic 2 (cm)	Ruler 2 (cm)	Error (%)
1	5	4.9	2	4	3.8	5
2	11	10.2	7.2	7	6.5	7.1
3	17	16.2	4.7	10	9.2	8
4	21	20.3	3.8	15	14.9	0.6
5	26	25	3.8	16	15.9	0.6
6	34	33.5	1.4	19	18.2	4.2
7	39	38.7	0.7	22	21.2	3.6
8	43	42.8	0.4	26	25.3	2.6
9	48	47.5	1.04	29	28.2	2.7
10	52	51.8	0.38	36	35.4	1.6
Avarage			2.54	Avarage		3.6

In testing the height of chili growth, it was carried out with 10 tests for 28 days with a set point value of chili growth of 52 cm and 36 cm using 2 ultrasonic sensors which were then compared with the measurement results with a measuring instrument in the form of a ruler. The results of the comparison of the ultrasonic sensor 1 obtained an average error value (%) of 2.54% while the ultrasonic sensor 2 resulted in an average error value (%) of 3.6%. The factor that causes the difference between the ultrasonic and the ruler measuring instrument is because the ultrasonic sensor has an accuracy value of 3mm while the ruler gauge is 0.5 mm and the factors that cause good chili growth are precisely watering the chilies based on the soil moisture value on the planting medium and applying fertilizers and enough sunlight.

While the soil moisture test was carried out with 10 tests with a humidity set point value of 60% (relative Humadity) with an actuator in the form of a watering pump. When the soil humidity is less than 60%, the actuator in the form of a water pump will automatically flush and when the soil humidity is more than 60%, the actuator will not run.

TABLE II. Testing of Watering Automatic System

No	Sensor Soil Moisture (%)	Soil Condition	Water Pump	Watering Status
1	79	Wet	Off	No Successfull
2	75	Wet	Off	No Successful
3	70	Wet	Off	No Successfull
4	69	Wet	Off	No Successful
5	65	Wet	Off	No Successfull
6	59	Dry	On	Success
7	57	Dry	On	Success
8	54	Dry	On	Success
9	49	Dry	On	Success
10	45	Dry	On	Success

The open circuit voltage of this sollar cell is cloudy, cloudy, sunny and hot. From the above test, it is found that the average output voltage of the sollar cell is 12.95 V. As well as from the open circuit voltage measurement table it is known that the output of the open circuit sollar cell voltage is strongly influenced by the intensity of sunlight and when there is no sunlight the system can running due to charging at ACCU 12V and the raspberry pi microcontroller only requires a voltage of 5 Vdc.

TABLE III. Result of Solar Cell Voltage

No	Hour	Voltage (Volt)	Weather
1	10.00	12.59	Cloudy
2	10.30	12.66	Cloudy
3	11.00	12.71	Bright Cloudy
4	11.30	12.90	Hot
5	12.00	13.45	Hot
6	12.30	13.45	Hot
7	13.00	13.20	Hot
8	13.30	13.00	Bright
9	14.00	12.87	Bright Cloudy
10	14.30	12.70	Bright Cloudy
Average		12.96	

The response time for data retrieval was carried out by 10 tests with network connectivity using a Telkomsel provider. Then the results showed that the average delay time for sending data (second) to the Blynk platform was 1.9 seconds. The factor that causes delay in sending data to the Blynk platform is due to network connectivity during busy hours so that the value of the delivery time delay is getting bigger.

IV. CONCLUSION

The installed monitoring and automation design standard has a good enough to be applied. The overall test shows that the chili plants monitored in open land have an increase in plant height of 1-7 cm per three days. In addition, a soil moisture test was conducted for an automatic watering system with a percentage of humidity that fluctuates in accordance with environmental conditions with a set point value below 60%, the water pump will turn on, and the input voltage power to the solar cell with an average value of 12.95.

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