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Controlled sprinkler irrigation system for agricultural plant cultivation

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Abstract. In recent decades, precision agriculture and smart farming have become promising issues particularly in the industrial revolution era 4.0. The main objective of this presented paper is to apply the optimized controlling system developed by means of Internet of things for controlling sprinkler irrigation systems used for agricultural product cultivation where in this study, we used shallot plants. The controlling systems were established by designing hardware and software used to monitor water distribution in sprinkler irrigation for onion plants during five initial days of cultivation. The result showed that controlled irrigation can optimize and monitor all plant growth indicators namely soil moisture, temperature, air humidity and water discharge and be able to carry out watering according to the desired level of soil moisture. It may conclude that a controlled sprinkler irrigation system can be applied as a part of precision agriculture practice in order to enhance production and sustainable agriculture.

1. Introduction

Shallots are annual plants that are widely needed in everyday life. The need for shallots is increasing because almost all dishes require this spice commodity. Shallots have good market prospects so that they are included in the national superior commodity [1]. The success of shallot agricultural activities is closely related to various factors, including climate change, which greatly affects the risk of horticultural production [2].

In general, farmers provide crop water using conventional irrigation methods. Conventional irrigation methods are less able to provide proper, fast and uniform water supply [3]. Farmers have to water the plants one by one manually. At the time of watering, the soil also has the ability to store water differently so it is necessary to pay attention to moisture [4]. But farmers find it difficult to pay attention to soil moisture conditions because it takes longer and is less accurate. This increases the possibility of plants not being able to grow optimally and will lead to reduced yields [5].

Entering the era of the Industrial revolution 4.0, the use of technology is growing rapidly in all aspects, including agriculture [6]. This is indicated by the use of automated machines that are integrated and integrated into the internet. The agricultural sector is also expected to be able to adapt to the industrial revolution 4.0 to answer future challenges so that the farming process is more efficient and can increase productivity as well as product competitiveness [7]. The industrial revolution 4.0 is expected to make it easier for farmers to carry out agricultural activities such as processing planting land, distributing plant water and harvesting which will only be carried out using remote control and monitored anywhere [8–10].

This presented study refers to a system controlling the distribution of water to plants with a bulk irrigation system (sprinkler) which can be done remotely and is also time efficient by using an Arduino based internet of things connected to a Smartphone. Internet of things (IoT) is a concept



where certain objects have the ability to transfer data over a network without requiring any interaction between humans and computer/smartphone devices or humans with other humans.

2. Materials and methods

2.1. Bulk irrigation system design and parameters (sprinkler)

The initial step of this research is to design a bulk irrigation system (Sprinkle) by preparing tools and materials that are installed into a series, the tools used consist of hardware and software shown in Tables 1 and 2. Materials used Pipes Inch PVC, pipe joints, onion plants, soil and water. Next determine the main pipe diameter, manifold pipe diameter, lateral pipe diameter, and design the layout of the system that is best suited to tools and materials. In order to support the computerization process, Arduino Uno hardware design was carried out on several electronic components including the capacitive soil moisture sensor type v1.2, sensor and air humidity Type DHT22, relay and water pump, and NodeMCU ESP8266 Type12E. In order to run the program, the Arduino Uno software was used which functions to create, edit, validate and upload program code where the features used are program editor, verify/compiler and uploader which are then controlled by the Blynk platform.

Table 1. Hardware used in the study.

No	Hardware	Description
1	Arduino Uno	2 units
2	Capacitive soil moisture sensor type V1.2	1 units
3	NodeMCU ESP8266 Type12E	1 units
4	Sensor water flow meter	1 units
5	Module relay	1 units
6	Nrf24l01	2 units
7	Nozzle head sprinkler	1 units
8	Water pump	1 units
9	Pipe saw	1 units
10	12V adapter	2 units
11	PCB	2 units
12	Jumper cable	1 package
13	Power cable	15 meters
14	Solder and tin solder	1 package
15	Electric socket	2 units
16	Laptop and stationery	1 package

2.2. Controlling

The control system on this device begins by opening the application and checking whether the network is connected to the device and system, then the user can check the status of conditions in the field. After the user knows the temperature and humidity conditions on the land, the user can turn on (on) or off (off) the watering of plants through the system interface connected to the controller. This process runs when the data received by the controller is forwarded to the relay, assuming if the value received is equal to on/1 then the pump is on, whereas if the data received is equal to off/0 then the pump is off. The Controlling block diagram is shown in figure 1.

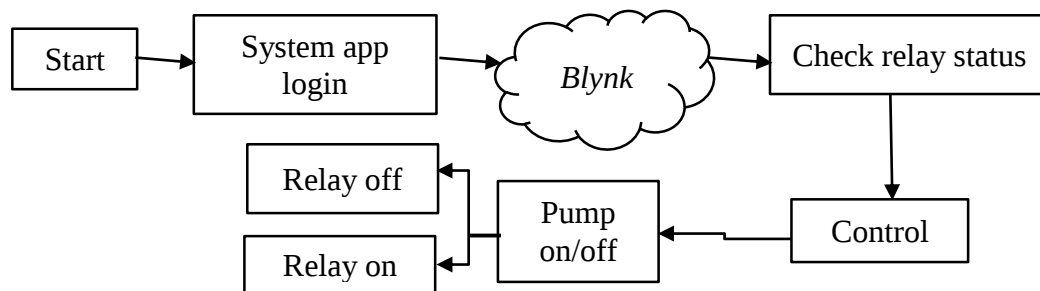


Figure 1. Block diagram controlling.

2.3. Flowchart based on internet of things (IoT)

Starting with the design of a bulk irrigation system (sprinkler), hardware and sensors are designed to make a series of automatic sprinklers. Programming software (Arduino IDE) is designed to be able to give orders to sensors and send sensor readings data to Blynk. Hardware (NodeMCU ESP8266 type12E) that has been connected to the Arduino Uno is connected to Wi-Fi and the internet via programming software (Arduino IDE). If the connection process between the NodeMCU ESP8266 type12E and Wi-Fi has been connected, the sensor input (V1.2 and DHT22) that has been read will be sent to Blynk and then display the data in the form of a chart. If the connection between the NodeMCU ESP8266 type12E and Wi-Fi fails, it will be restarted to connect. If the V1.2 sensor reading data shows the soil moisture level < 50%, the pump will be turned on and if the soil moisture level is > 70% then the pump will be turned off. The pump is turned on/off by the user through the Blynk application on the Smartphone.

3. Results and discussion

3.1. System implementation

The implementation of the system here includes the implementation of the main construction, implementation of hardware (hardware) and implementation of software (software). The implementation of the main construction is a sprinkler irrigation network made using components such as pumps, reservoirs (wells), main pipes, lateral pipes, and sprinklers. The hardware implementation, namely a series of bulk irrigation control devices, is assembled on a breadboard that is connected to the Arduino Uno board. The task of this series of irrigation control devices is to receive data and then send it back to the application that is used to be displayed on a smartphone. The results displayed become a reference in the controlling process for the bulk irrigation. The schematic of data sender and data receiver is shown in figure 2.

The Arduino Uno board is also in charge of giving orders to turn on and off the relay connected to the water pump, as well as display monitoring results on the PC. Implementation of the NRF24L01+ radio frequency which functions as a communication module between the sender and receiver of data. The rate of data transmission speed is 250 kbps to 2 Mbps. Delivery range is 800m in the open. In this study, the distance between the sender and the recipient of the data is about 20 m, so the received data is sent properly without any problems. The NRF24L01+ wireless module utilizes the 2.4GHz ISM (industrial, scientific and medical) RF band. Implementation of the NodeMCU ESP8266 Type12E which functions as the brain of the irrigation control system that will read input data from the DHT22 sensor, V1.2 sensor and water flow meter sent by the transmitter to the receiver. This ESP8266 NodeMCU will also connect with Blynk services so that users can monitor and manage the system remotely through the Blynk application remotely.

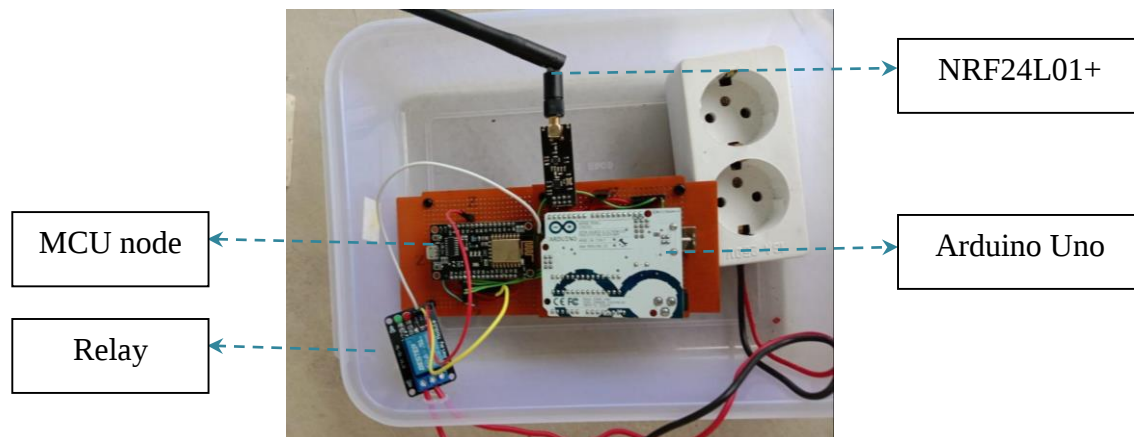


Figure 2. Controlling tools in sprinkler irrigation.

Implementation of Arduino IDE programming by entering program code to run commands to a series of irrigation control devices and sending sensor data to Blynk. There are 2 programming sketches that have been made in the Arduino IDE software, namely a sketch for retrieving data from the transmitter and a sketch for sending data from Arduino Uno to Blynk using the NodeMCU ESP-12E. Implementation on smartphones using the Blynk application, the benefits of the Blynk application in this design are to see the current development conditions in the Bawang Merah field and to control the water pump in the water supply system to the land [11]. The data displayed on the monitor screen is successfully sent to Smartphone users using the Blynk application. The display of the Blynk application can be seen in figure 3.



Figure 3. Blynk application view.

3.2. System parameter test

System testing is carried out on relay parameters, differences in data displayed on the monitor screen and in the Blynk application and testing on the Blynk application system that is run with program code (sketch). System testing on the relay aims to determine whether the relay module is running well or not. The relay works according to the relay specifications, which requires a voltage of 3.3V to activate

the coil. When the relay gets a HIGH signal from the Arduino, the relay contact will move from the previous NC to NO so it will activate the pump. Meanwhile, when the relay gets a LOW input signal, the relay contact will move from NO to NC and will turn off the pump, this indicates the water pump is working as needed. Table 2 shows the results of relay testing in 3 days.

Table 2. Relay test results.

Date	Time	T (°C)	Humidity (%)	Debit (L/time)	Soil moisture	Relay	Description
05/09/2020	08:00	27	83	653	534	ON	Functioned
	10:00	30	69	0	496	OFF	Functioned
	12:00	32	71	0	527	OFF	Functioned
	16:00	30	70	625	575	ON	Functioned
	18:00	26	86	0	462	OFF	Functioned
06/09/2020	08:00	26	86	617	553	ON	Functioned
	10:00	30	70	0	487	OFF	Functioned
	12:00	31	73	0	520	OFF	Functioned
	16:00	29	77	604	562	ON	Functioned
	18:00	28	84	0	478	OFF	Functioned
07/09/2020	08:00	27	86	569	557	ON	Functioned
	10:00	31	70	0	469	OFF	Functioned
	12:00	33	67	0	515	OFF	Functioned
	16:00	29	78	604	571	ON	Functioned
	18:00	28	84	0	442	OFF	Functioned

The test results of the relay are functioning properly. This is part of controlling the Blynk application by users. If the user presses the ON button, the relay will activate and run the pump, and vice versa. The relay is activated based on the results displayed on the Blynk monitor screen, if the soil moisture reads 501-600 which means the soil moisture level reaches <50% then the user can activate the relay (figure 4). If the relay is active, it will be indicated by the LED indicator light up. And if the soil moisture data displayed is 400-500 which means the soil moisture level has reached >50%, the user can press the OFF button to turn off the pump (figure 5) and the LED indicator light on the relay will turn off.

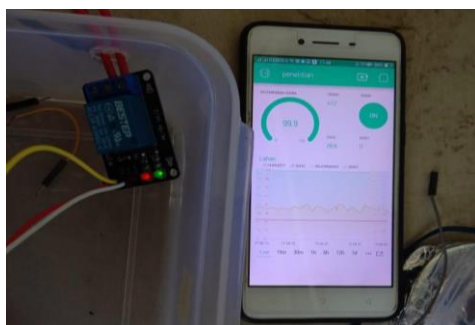


Figure 4. Relay in ON position.

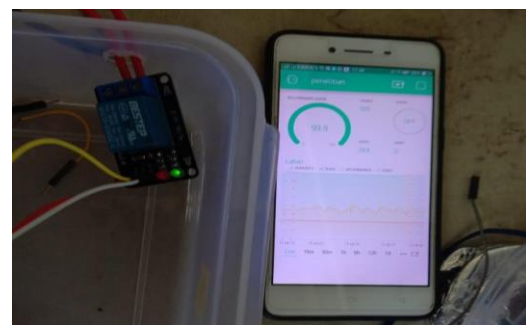


Figure 5. Relay in the OFF position.

The soil moisture level reference used for relay testing was obtained after testing the soil moisture sensor v1.2 on dry and wet soil conditions with five soil samples taken randomly at the research location. The range of values obtained on dry soil conditions (510-579) and ranges of values on wet soil conditions (460-500). Referring to the basic value read by the soil moisture sensor v1.2 when the humidity value in the air 600 is equal to 0%, and when the sensor is in water 400 is equal to 100%. The range of dry soil moisture values obtained this if the results are in the range of 49% to 10% and the range of wet soil moisture values is from 70% to 50%.

4. Conclusions

Controlling the sprinkler irrigation system on shallots plants (*Allium cepa* L.) using the Internet of things (IoT) based on *Blynk* Platform can run well according to its function. The *Blynk* application is able to read the value of soil moisture, temperature, air humidity and water discharge, and is able to carry out watering according to the desired soil moisture level. Therefore, the sprinkler irrigation control system using the MCU Node ESP8266 module can run properly. Watering based on the soil moisture value read by the capacitive sensor v1.2 was successfully carried out with the help of a relay as a switch to turn the pump on and off.

References

- [1] Saptana, Gunawan E, Perwita A D, Sukmaya S G, Darwis V, Ariningsih E and Ashari 2021 The competitiveness analysis of shallot in Indonesia: A Policy Analysis Matrix *PLoS One* **16** e0256832
- [2] Suswadi, Prasetyowati K, Kartikasari R D and Prasetyo A 2021 A feasibility study on cultivating shallots (*Allium ascalonicum* L) in Selo District, Boyolali Regency, Indonesia *IOP Conf. Ser. Earth Environ. Sci.* **824**
- [3] Tabatabaei S-H, Fatahi Nafchi R, Najafi P, Karizan M M and Nazem Z 2017 Comparison of traditional and modern deficit irrigation techniques in corn cultivation using treated municipal wastewater *Int. J. Recycl. Org. Waste Agric.* **2017** *61* **6** 47–55
- [4] Cepuder P and Nolz R 2007 Irrigation management by means of soil moisture sensor technologies *J. Water L. Dev.* **11** 79–90
- [5] Shareef T M E, Ma Z, Zhao B, Shareef T M E, Ma Z and Zhao B 2019 Essentials of Drip Irrigation System for Saving Water and Nutrients to Plant Roots: As a Guide for Growers *J. Water Resour. Prot.* **11** 1129–45
- [6] Zambon I, Cecchini M, Egidi G, Saporito M G and Colantoni A 2019 Revolution 4.0: Industry vs. agriculture in a future development for SMEs *Processes* **7** 1–16
- [7] Madushanki A A R, Halgamuge M N, Wirasagoda W A H S and Syed A 2019 Adoption of the Internet of Things (IoT) in agriculture and smart farming towards urban greening: A review *Int. J. Adv. Comput. Sci. Appl.* **10** 11–28
- [8] Placidi P, Morbidelli R, Fortunati D, Papini N, Gobbi F and Scorzoni A 2021 Monitoring soil and ambient parameters in the iot precision agriculture scenario: An original modeling approach dedicated to low-cost soil water content sensors *Sensors* **21**
- [9] Nasution I S, Iskandar M R and Jayanti D S 2020 Internet of things: automatic sprinklers in prototyping greenhouse using smartphone based android *IOP Conf. Ser. Earth Environ. Sci.* **425** 012069
- [10] Nasution I S, Munawar A A, Devianti, Satriyo P, Gunawan H G and Yunus Y 2021 Precision agriculture: automated irrigation system in tandem with solar panels for melon farming cultivation *IOP Conference Series: Earth and Environmental Science*
- [11] Darusman D, Juwita I R, Munawar A A, Zainabun Z and Zulfahrizal Z 2021 Rapid determination of mixed soil and biochar properties using a shortwave near infrared spectroscopy approach *IOP Conf. Ser. Earth Environ. Sci.* **667**