



Design of Automatic Watering System Prototype with Arduino-Based Soil Moisture Sensor for Strawberry Plants (*Fragaria Ananassa*)

Ratika Sekar Ajeng Ananangtyas⁽¹⁾, Ragil Ellang Sakti⁽²⁾, Muhammad Helmi Hakim⁽³⁾, Rizka Rizqi Robby⁽⁴⁾, Rachmadania Akbarita⁽⁵⁾

^{1,3,4,5}Universitas Nahdlatul Ulama Blitar, ²Badan Meteorologi, Klimatologi, dan Geofisika

E-mail: : ratikasekar@gmail.com

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Abstract

Automatic water management using an Arduino-based humidity sensor as a microcontroller provides practicality in strawberry cultivation, especially in high temperature areas such as in Blitar City. The purpose of this research is to design and test a automatic watering system prototype with an arduino-based soil moisture sensor for strawberry plants (*fragaria ananassa*). In this study, the method used was designing a prototype automatic watering system with an arduino-based soil moisture sensor for strawberry plants (*fragaria ananassa*) according to the design so that the prototype could work properly and testing the prototype for strawberry plants (*fragaria ananassa*) to get moisture data and the right time for giving water every certain period of time. The research activities were carried out in 4 stages including the needs analysis stage, the prototype design stage, the test and evaluation stage, and the final product stage. From the results of product design and development, it was found that the soil moisture sensor, arduino and water pump work according to the input or command.

Keywords: arduino, soil moisture sensor, watering system

Introduction

Indonesia is an agricultural country and has fertile soil conditions where many types of plants can grow well, one of which is strawberry plants (*fragaria ananassa*). But not all areas can be planted with strawberries because they need lighting (Suparlin, Akbar, & Syauqy, 2018), air temperature and soil moisture (Sandi & Arrofiq, 2018) the right one so that it can grow to the maximum. Lighting, air temperature and humidity depend on the weather as well as the surrounding climate. Strawberry plants can grow at temperatures around 17 – 20 C, air humidity around 80 – 90%, solar irradiation 8 – 9 hours/day, and rainfall between 600 - 700 mm/year (BBPP Lembang, 2007).

Irrigation management is one of the determining factors for strawberry plant growth. Managing water use in response to changes in air temperature and soil moisture is important to be done appropriately to suit your needs. One way to manage water use is to use a SOIL MOISTURE SENSOR that can provide infor-

mation on the state of the deficit or excess water in the soil (Goodchild & Jenkins, 2018). In the presence of a humidity sensor, the feeding of water with a certain frequency (Abdelkerim, Eusuf, Salami, Aibinu, & Eusuf, 2013) can be done practically and automatically.

As per the development of science and technology in the present, a wide variety of moisture sensors have been created from different materials. Some types of materials for making moisture sensors are optical fiber (Ascorbe, Corres, Arregui, & Matias, 2017), polyimide sensing material (Boudaden et al., 2018), graphene-based materials (Lv et al., 2019) (Liang et al., 2020), coffee ground biochar (CGB) (Jagdale, Ziegler, Rovere, Tulliani, & Tagliaferro, 2019), transparent and flexible cellulose/KOH composite ionic film (CKF) (Wang, Zhang, Zhou, & Lu, 2020), and so forth. Developing an easy, cost-effective and environmentally friendly method to create a multifunctional moisture sensor is important to expand its practical applications (Duan et al., 2019). Besides being able to be used to measure soil moisture, moisture sen-

sors can be applied in various fields, such as health, food processing and storage, and electronic manufacturing which requires fast and accurate moisture measurement (Ascorbe et al., 2017).

Water management automatically using Arduino-based humidity sensors as microcontrollers provides practicality in the cultivation of strawberry plants, especially in high temperature areas such as in Blitar City. The design of an automatic watering system prototype with an Arduino-based soil moisture sensor for strawberry plants (*fragaria ananassa*) is expected to provide solutions to the community, especially in high temperature areas who want to cultivate strawberry plants practically and effectively.

Materials and Method

The research carried out is development research (R&D) which begins with analyzing needs, designing prototype of automatic watering systems with Arduino-based soil moisture sensors, testing and evaluating, and producing the final product). As shown in Fig 1., the components used are arduino uno R3, relay, LCD 16x2, soil moisture sensor, I2C, transformer 12 V, cable, water pump, and switch that are assembled according to the diagram and programmed using Arduino IDE. To see if the system can work properly, a working test of the

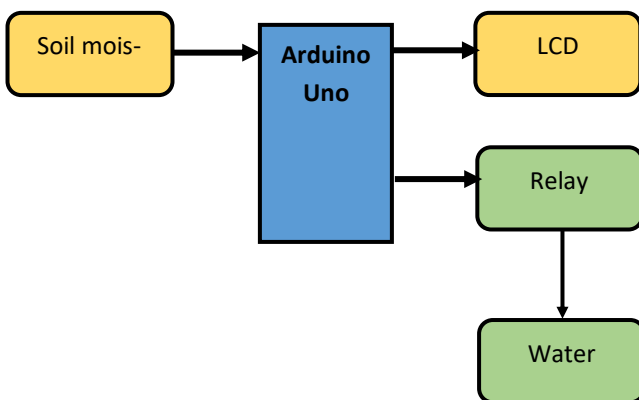


Figure 1. Diagram of prototype

Results and Discussion

This research was conducted in four steps which are described as follows.

1. Needs Analysis

The first stage in the development of an automatic watering system prototype with an Arduino-based soil moisture sensor on strawberry plants (*fragaria ananassa*) is a needs analysis. In the needs analysis, conventional strawberry planting trials were carried out and periodic temperature data collection in the Blitar City environment

soil moisture sensor and arduino is carried out in turning on the water pump according to the command, if the soil moisture is less than 40%.

during October 2022. From conventional strawberry planting, strawberries can grow and bear fruit, but not too dense as per Figure 4.1. While during October 2022 the highest average air temperature is 32.7 °C and the lowest average air temperature is 24.9 °C.

Strawberry plant growing requirements must meet the optimum temperature conditions of 17-20 °C, air humidity around 80-90%, solar irradiation 8-9 hours/day, and rainfall between 600 -700 mm/year, as well as the state of garden soil or polybags. However, from the needs analysis carried out, the air temperature in Blitar City is too high for more optimal strawberry planting so that tools are needed that can support it.

2. Designing Prototype

The design of the prototype began with the preparation of tools and materials, which were arduino uno R3; soil moisture sensor, then circuit design, and coding through arduino IDE. In the design step, a circuit diagram was made first to make it easier to assemble the components.

In the coding step through arduino IDE, there was a trial and error that determines the output of the system. The first thing to do in this step was to determine the limit of soil moisture needed to turn on the water pump. Soil moisture measured using sensors was used as a reference in turning on the water pump, so that the soil remains moist and strawberries can still grow well. The soil moisture limit used is 40%, if the sensor detects soil moisture below that limit, then the water pump turns on to the soil moisture limit of 40%.

The next step was to determine the magnitudes displayed on the LCD screen. Because it takes one quantity as a parameter to turn on the water pump, only the soil moisture value is displayed on the LCD screen. The soil moisture value is displayed in real time and shows the value corresponding to the state of the soil.

3. Testing and Evaluating

At the test stage, a system test was carried out by seeing whether the system can work according to the command (input). The first test on the soil moisture sensor was done by comparing the sensor readings when tested on dry soil, moist soil, and wet soil. Moisture measurements were carried out five times for each soil condition, then the average soil moisture value that appears on the LCD screen and its standard deviation were calculated.

From the test results of soil moisture sensors on various types of soil conditions obtained values for which dry soil moisture was $31.2 \pm 0.7\%$, in moist soil it was $60.4 \pm 0.5\%$, and on wet soil it was $97.6 \pm 0.5\%$. Based on the comparison of the real form of the soil state and the soil moisture value tested with the sensor, it was shown that the sensor can work according to the state of the soil and produce the corresponding value readings, so the sensor is declared to work properly.

The second test was the test of the water pump connected to the system. In the coding, it is determined that the water pump turns on when the humidity is $<40\%$, so to test it, three kinds of soil that had differences in moisture were used, which were dry soil, moist soil, and wet soil. Based on the results, it was obtained that the pump turns on at a soil moisture below 40% , and if the soil moisture was above 40% then the water pump did not turn on. This is in accordance with the coding command on arduino so it can be stated that arduino can work properly according to the input.

From the results of the system test, evaluation needs to be carried out in order to obtain an appropriate and useful product as needed. The evaluation was to make the product as neat as possible, display the output on the LCD screen as needed, and the water pump can work properly.

4. Producing Final Product

From the test and evaluation results obtained product specifications that provide information about the range of soil moisture values that can be displayed in the LCD; arduino response speed; product dimensions; and so forth. The product specifications developed in detail are described in Table 1.

Product Specification	Information
Range of soil moisture values	10-100%
Response speed	<5 second
Operational temperature	$28-34^{\circ}\text{C}$
LCD size	16×2
Dimention of prototype	$10 \times 8 \times 15$ cm
Power Input	220 V AC
Voltage	12 V
Arduino	Uno R3 (Atmega 328p)

Tabel Pro-

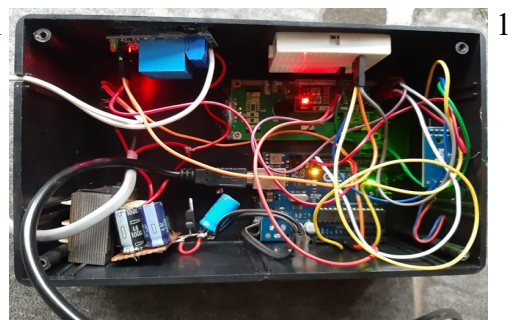


Figure 2. Circuits tested and evaluated

prototype of automatic watering system specification with Arduino-based soil moisture sensor



Figure 3. Final product of prototype

The results of diagram design, assembly, coding, testing, and evaluation, resulted in the final product in the form of an automatic watering system prototype with an Arduino-based soil moisture sensor. The developed product is ready to be implemented on strawberry plants in high-temperature environments such as in Blitar City. This product is expected to be able to help in the cultivation of strawberry plants that are more practical and efficient.

developments need to be carried out to improve the product so that it is useful and appropriate according to the needs of the community.

The advantage of the product developed is the presence of efficiency and real-time data that makes it easier to control the quality of the soil as a strawberry growth medium. Farmers can save time in the maintenance of strawberry crops especially at the step of watering with this product. In addition, this product is made from components that are easy to find in the market as well as affordable prices and specifications that are easy to adjust. The use of technology, especially in the era of the industrial revolution 4.0, should be intensively used so that the production of cultivated plants and food can be more optimal (Cormier et al., 2020; Goodchild, K. D. Kühn, Jenkins, Burek, & Dutton, 2015; Létourneau & Caron, 2019; Moritani, Nanjo, Itou, & Imai, 2018). So that the presence of the technology can balance the productivity and efficiency of human work (Ananangtyas, Sakti, Hakim, & Lestari, 2022).

Conclusion

The design of an automatic watering system prototype with an Arduino-based soil moisture sensor for strawberry plants (*fragaria ananassa*) was carried out with a needs analysis step seen from the air temperature of the planting environment, designing a prototype using Arduino; humidity sensors; and water pumps, test and evaluate the product until the final product is obtained. Testing of the automatic watering system prototype with an Arduino-based soil moisture sensor on strawberry plants (*fragaria ananassa*) was carried out by testing the soil moisture sensor and the flame of the water pump, from the test results it was obtained that the designed prototype could work properly.

Suggestion

From the results of the design of an automatic watering system prototype with an Arduino-based soil moisture sensor for strawberry plants (*fragaria ananassa*), the suggestion that can be proposed is that it is necessary to equip a soil pH (acidity degree) sensor so that soil quality is better maintained because pH is also one of the parameters determining the fertilization of strawberry plants and it is also necessary to add new renewable energy sources such as solar cells as a source of electricity.

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