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APPLICATION OF AUTOMATIC WATERING SYSTEM BASED ON SOIL MOISTURE SENSOR FOR BONSAI PLANTS

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ABSTRACT

Bonsai plants, with their distinctive beauty and aesthetic value, have become an attraction for plant lovers in Indonesia. However, proper maintenance, especially watering, can be a challenge for many bonsai owners. In an effort to facilitate more efficient and effective maintenance, this research aims to develop an affordable and accessible soil moisture sensor-based automatic watering system. The research method includes an in-depth literature review of existing soil moisture sensor technologies and the growth characteristics of bonsai plants. Next, we designed and built a prototype watering system that can monitor soil moisture levels and automatically water bonsai plants according to their needs. Initial test results show that the system is able to maintain optimal soil conditions for bonsai plant growth. The system is also equipped with programming capabilities that allow users to customize the watering schedule according to their personal preferences. This research aims to provide a practical solution for bonsai plant lovers in Indonesia who want to maintain proper soil conditions for the growth of their plants, while minimizing the costs required for an automated watering system. This paper is expected to make a positive contribution to the maintenance of bonsai plants and serve as a guide for those interested in developing similar systems in the context of urban agriculture in Indonesia.

Keywords: arduino uno, Bonsai plants, IOT, Soil motsure sensor.

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INTRODUCTION

Amidst the daily grind, many bonsai owners face the challenge of maintaining a consistent watering schedule. The absence of constant supervision can result in bonsai plants experiencing drought stress or excessive humidity. That is why, in an effort to support more efficient and effective maintenance for bonsai plant lovers, Lack of water will cause plant growth to be severely disrupted and can even cause death (Setiawan & Anggraeni, 2019). This research aims to develop an affordable and easily accessible soil moisture sensor-based automatic watering system. Optimal soil moisture conditions can support plant growth and prevent potential problems such as drought or excessive waterlogging (Syarifatul Izza et al., 2023).

In the era of ever-evolving technology, sensor technology applications have permeated various aspects of our lives. In recent years, the Internet of Things (IoT) has become a fast-growing technology trend (Azam et al., 2023). Soil moisture sensors measure the moisture content of the soil. The soil moisture probe consists of several soil moisture sensors. neutron moisture meter (Mardika & Ardeana Kartadie, 2019), utilizing the moderator properties of water for neutrons. Data can be directly processed using computerized or digital data and provide outputs that can be used as a basis for consideration in decision-making (Paduloh & Muhendra, 2022). In the context of agriculture and crop care, the use of soil moisture sensors is becoming increasingly interesting and relevant. soil moisture of each sensor to depth, which is read and processed by the Arduino Nano (Merbawani et al., 2021).

This system will allow bonsai plant owners to monitor and control soil moisture levels automatically. Knowing the soil moisture value will be very useful to be able to determine steps or handling of the soil (Husdi, 2018), thus minimizing the risk of lack or excess water. Through this research, we aim to provide a practical solution for bonsai plant maintenance in Indonesia and design a system that is affordable, efficient, and customizable to the owner's preferences.

Bonsai plants, with their distinctive aesthetics and beauty, have long been a symbol of subtlety and care in the art of agriculture. However, for bonsai plant lovers, caring for and keeping these plants in proper condition often demands a great deal of time and attention. One of the crucial aspects of bonsai care is proper and consistent watering; hence, bonsai planting and maintenance are quite complicated, and how to care for bonsai plants from fertilization to shaping must be very careful and meticulous (Dwilestari & Nurmiati, 2018). Excess or lack of water can have a significant impact on the health and growth of these characterful bonsai plants.

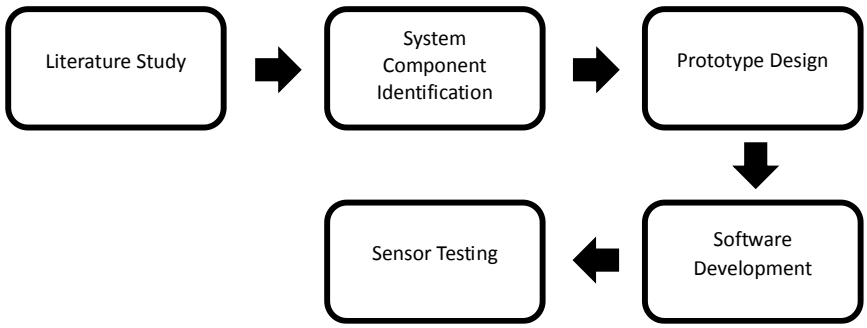
By utilizing soil moisture sensors, soil moisture monitoring activities can be automated, resulting in significant time and effort savings for ornamental plant hobbyists (Ramadhan et al., 2022). Not only does this research allow bonsai plant owners to approach maintenance more practically, but it also carries the potential to improve the overall health and aesthetics of bonsai plants. Therefore, we hope that our

findings can make a positive contribution to the community of bonsai plant lovers and encourage interest in this merging of technology and agricultural art.

METHODS

Developing and Implementing an Automatic Watering System Based on Soil Moisture Sensors for Plants in order to facilitate the application and can run systematically and refer to the desired objectives, steps are made in the research stages to be carried out as follows :

Figure 2. 1 Methods



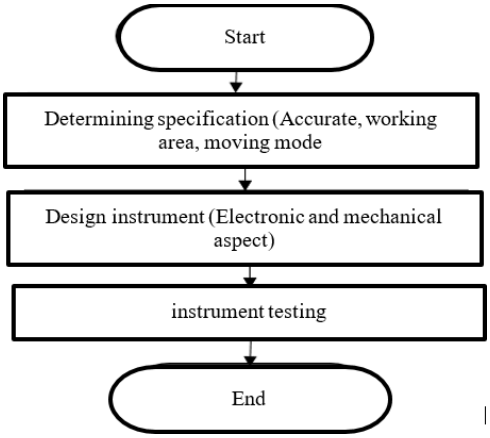
In this research, the literature study method is used which is applied in the planning and design stages of the soil moisture sensor integrated with software to regulate the watering system based on soil moisture sensor data. This research methodology includes the following stages:

1. Literature study aims to provide a strong knowledge base and thoroughly understand the existing literature on automatic watering systems and relevant soil moisture sensor technology.
2. Identification of system components aims to identify key components required in the construction of the system including the selection of appropriate soil moisture sensors, suitable microcontrollers, efficient water pumps, and other elements.
3. Prototype design aims at how all components will interact in the automatic watering system.
4. Software development focuses on the development of software that will control the operation of the system that will enable the processing of data from the sensors and the control of the water pump according to the needs of the bonsai plants.
5. Calibration sensor testing which aims as a test to ensure our soil moisture sensor functions accurately and consistently.

In this methodology chapter, our research has involved a series of critical steps to develop a relevant and efficient soil moisture sensor-based automatic watering system. An in-depth literature study provided a solid foundation of knowledge, enabling

an in-depth understanding of soil moisture sensor technology and existing automatic watering systems. Next, we identified the key components required, including the selection of an appropriate soil moisture sensor, a suitable microcontroller, an efficient water pump, and other elements. In the prototype design stage, we considered how all the components would interact synergistically in the system. The software development we have completed allows controlling the operation of the system with sensor data processing capabilities and controlling the water pump according to the needs of the bonsai plants. We also underwent calibration sensor tests to ensure the accuracy and consistency of the soil moisture sensors used in the system. All these steps are an integral part of our efforts to create practical solutions for bonsai plant lovers in Indonesia. Thus, this research makes a valuable contribution to the maintenance of bonsai plants and provides guidance for future researchers in developing similar systems in the context of urban farming in Indonesia.

Figure 2. 2 Flowchart



RESULT AND DISCUSSION

Literature Study

Bonsai is a highly valued ornamental plant in the world, and Indonesia is a great place for bonsai lovers. In essence, the art of bonsai is to imitate or make imitations of the shape of plants that exist in the wild whose growth is languishing due to the ferocity of nature. The art of bonsai in Indonesia has developed quite well. This is because it is supported by natural fertility and the richness of tropical flora species (Ipnuwati & Aditama, 2020).

Bonsai plants need sufficient water to grow well. Watering is done regularly, depending on the type of plant and environmental conditions. Bonsai plants should not be too dry or too wet (Hidayat et al., 2022), Soil moisture sensors have become a key component in monitoring and controlling soil moisture in various agricultural applications. (Febrina et al., 2021). Soil moisture sensors can be used in automatic plant watering systems to monitor soil moisture and set watering schedules automatically (Effendi et al., 2022).

Arduino can be used as a base to create an automatic plant watering tool with a soil moisture sensor. This tool can help organize automatic plant watering based on soil moisture, so as to save water usage and facilitate plant care (Setiobudio & Suharyanto, 2019).

It can be concluded that bonsai is an ornamental plant that has high aesthetic value, but caring for it requires a fairly high level of accuracy, especially in terms of watering. Special attention is needed because the condition of the bonsai plant must be maintained so that it is not too humid or too dry. In an effort to simplify this maintenance, this research utilizes soil moisture sensor technology connected to the Arduino programming platform. The soil moisture sensor helps monitor soil moisture levels accurately, and based on the data obtained, the Arduino will automatically adjust watering according to the needs of the bonsai plants. Thus, this technology can provide an efficient and effective solution to maintain proper soil conditions, making bonsai maintenance easier and more controlled.

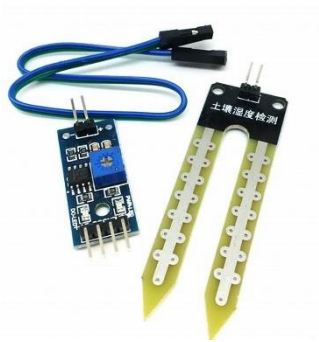
Plantation commodities are the mainstay of national income and foreign exchange This is reflected in the value of national exports in 2015 (Paduloh et al., 2020).(Paduloh et al., 2020)

Identification of system components

In the initial stages of this research, an important step is to identify the key components that will make up an effective automatic watering system for bonsai plant care. The identification of these components will form the foundation of adequate system design and development. Here are the key components that we have identified:

1. Soil Moisture Sensor: The soil moisture sensor is the core element in this system. We will choose a reliable and accurate sensor to measure the soil moisture level

figure 3 1 Soil motsure sensor



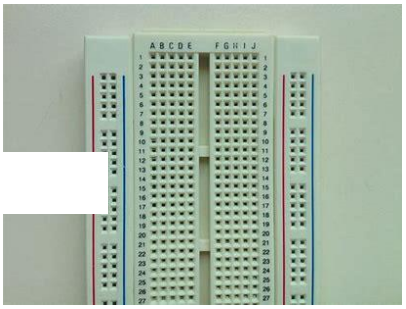
around the roots of the bonsai plant. This sensor will be the 'eye' of the system that provides vital information about the plant's water requirements.

2. A breadboard is a rectangular board with many small holes arranged in rows and

figure 3 2 Beardboard

columns. Inside the board, there are metal strips that connect the holes in each row or column.

figure 3 3 Arduino UNO



3. Microcontroller Control: The microcontroller control device will serve as the brain of the system. We will choose a microcontroller that has sufficient processing capabilities and is compatible with the sensors and pumps we choose. It will be used to retrieve data from the sensors, make watering decisions, and control the overall system operation.

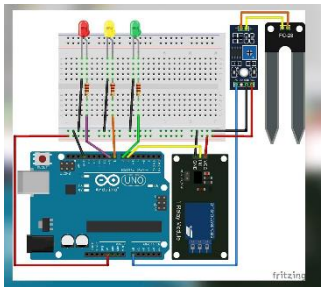
4. Additional Hardware: In addition to the main components, we will consider additional hardware requirements such as pipes, valves, water containers, and watering cans. These hardware will form the physical infrastructure of the watering system.

The identification of these components is a key step in the development of an efficient and reliable automatic watering system for bonsai plants. We will ensure that each component is carefully selected to meet the diverse needs of bonsai plants and to ensure the success of this research.

Prototype design

At this stage we visualize the circuit schematics of the components in Figure 2 showing the circuit diagram of the Arduino UNO microcontroller board connected to the soil moisture sensor and relay module. The Arduino UNO board is a blue electronic board that has a USB port, power jack, and several pins for connecting external components. This board uses an 8-bit ATmega328P microcontroller that can be programmed through the Arduino IDE. The soil moisture sensor is a blue rectangular module with two probes that can measure the change in capacitance between the two probes due to the presence of water in the soil. This sensor is connected to analog pin A0 on the Arduino UNO board with a red wire. The relay module is a black rectangular module with three pins that can turn on or off the flow of electricity to other

Figure 3. 1 Prototype Design



components, such as LED lights, based on digital signals from the Arduino UNO board. This module is connected to digital pin 7 on the Arduino UNO board with a green wire. This image also shows a breadboard with several LED lights and resistors connected to the Arduino UNO board with yellow, red, and green wires. The LED lights are used to visually indicate the soil moisture level, for example, the red LED lights up if the soil is too dry, the green LED lights up if the soil has enough moisture, and the yellow LED lights up if the soil is too wet. A breadboard is a plastic board with holes that can be used to connect electronic components without soldering.

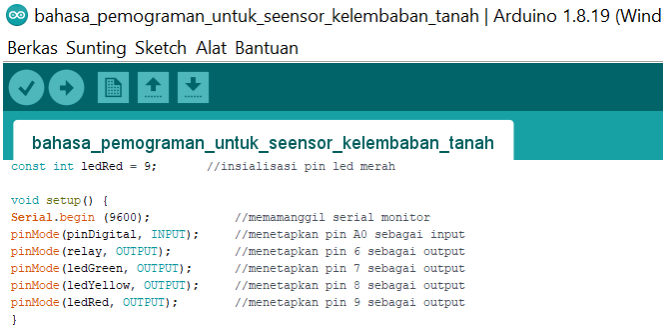
Software development

The automatic watering system that has been developed focuses on maintaining proper soil moisture conditions for bonsai plants. The program is designed to operate on top of the Arduino platform with the use of a soil moisture sensor as its essential component. Here are the details :

1. Pin Initialization and Serial Communication

   The program starts with the initialization of the pins that will be used in the system. Pin A0 is used to read the value from the soil moisture sensor. Other pins include a relay and three LEDs (green, yellow, and red) that will be used to indicate soil conditions and control the watering action.

   Gambar 3. 2 Pin Initialization and Serial Communication



2. *Loop* utama

In the "Main Loop" section of this program, there are two main stages that play an important role in maintaining optimal soil conditions for bonsai plant growth.

The first stage is the reading of the value from the soil moisture sensor connected to pin A0. This sensor provides information on the extent to which the soil has dried out, which is very important for the maintenance of bonsai plants. The value obtained from this sensor is then used in the evaluation stage.

The second stage is soil condition evaluation. The program processes the sensor values and decides the current condition of the soil based on a certain threshold. There are three possible conditions that can occur.

1) If the soil moisture value is less than 500, the system considers that the "Media is Still Wet." In this condition, the system will turn on the green LED, turn off the

Gambar 3. 2 Media is Still Wet

```
//tetapi jika analog A0 kurang dari 500, print kata serta nyalakan led hijau dan matikan led kuning,merah dan juga relay
if (dataAnalog < 500) {
Serial.println(". Media Masih Basah");
digitalWrite (ledGreen, HIGH);
digitalWrite (ledYellow, LOW);
digitalWrite (ledRed, LOW);
digitalWrite (relay, HIGH);
}
```

yellow, red LEDs, and relays as a precautionary measure.

2) If the soil moisture value is between 500 and 800, the system considers that "Soil Moisture Is Still Adequate." The system will turn on the yellow LED and relay, and turn off the green and red LEDs.can be seen in Figure 5, with the information that if the A0 value is less than 900, then turn on the yellow LED and relay and turn off all remaining LEDs.

Figure 3. 3 Soil Moisture Is Still Adequate

```
,
// selain dari itu, hanya nyalakan led merah dan juga relay
else {
  Serial.println(". Perlu Tambahan Air");
digitalWrite (ledGreen, LOW);
digitalWrite (ledYellow, LOW);
digitalWrite (ledRed, HIGH);
digitalWrite (relay, HIGH);
}
```

3) If the soil moisture value is more than 800, the system considers that "Additional Water is Required." In this condition, the system will turn on the red LED and relay, while turning off the green and yellow LEDs..

Figure 3. 4 Additional Water is Required

```
//tetapi jika nilai A0 kurang dari 900, print kata serta nyalakan led kuning dan relay kemudian matikanled hijau dan led merah
else if (dataAnalog < 800) {
  Serial.println(". Kelembaban Tanah Masih Cukup");
  digitalWrite (ledGreen, LOW);
  digitalWrite (ledYellow, HIGH);
  digitalWrite (ledRed, LOW);
  digitalWrite (relay, HIGH);
}
```

This main loop serves as the brain of the system. It runs repeatedly, allowing the system to continuously monitor soil conditions in real-time and respond quickly to maintain soil conditions that match the needs of the bonsai plants. In this way, the automatic watering system provides efficient and effective care for bonsai plants, maintaining their beauty and health.

3. Serial Communication and Delay

Each sensor reading and action taken is recorded in the serial monitor for monitoring. The program also has a delay of 500 milliseconds between each sensor reading to avoid excessive readings.

The program efficiently combines Arduino programming to produce an automatic watering system that can monitor and respond well to soil moisture conditions. This provides a practical solution for bonsai plant lovers who want to maintain proper soil conditions for the growth of their plants.

Sensor Testing

Soil moisture sensor testing was conducted in three different soil types, namely Soil A, Soil B, and Soil C, to evaluate the sensor's response to soil moisture in each soil type. Testing was carried out 5 days by testing 2 times a day on 3 different types of soil, with moisture measurement. basically the sensor tool can determine the humidity with numerical numbers ranging from 0 to 1029 the higher the drier the soil, in this device we divide the numerical number into 4 parts, namely <500 (still wet then the green light is on), 500-800 (the media is still sufficient then the yellow light is on), >800 (the media is still wet then the green light is on). In this experiment, we conducted on 4 different types of soil, namely clay, humus soil, and clay soil which have different soil characteristics when viewed from the water content contained in them.

Soil Type:
Soil A: Sandy clay with low drainage.
Soil B: Humus soil with good drainage.
Soil C: Medium-drained loamy soil.

Daily Measurement Results (LED Color Indicator):

Soil A:
Tabel 4. 1 Test Results In Soil B

Trial To-	Indicator light	Description
1	Red	Dry
2	Red	Dry
3	Yellow	Medium
4	Yellow	Medium
5	Green	Wet
6	Green	Wet
7	Green	Wet
8	Green	Wet
9	Yellow	Medium
10	Yellow	Medium

Soil B:
Tabel 4. 2 Test Results In Soil B

Trial To-	Indicator light	Description
1	Red	Dry
2	Yellow	Medium
3	Yellow	Medium
4	Green	Wet
5	Green	Wet
6	Green	Wet
7	Green	Wet
8	Green	Wet
9	Yellow	Medium
10	Red	Dry

Soil C :

Trial To-	Indicator light	Description
1	Red	Dry
2	Red	Dry
3	Yellow	Medium
4	Yellow	Medium
5	Green	Wet
6	Green	Wet
7	Green	Wet
8	Green	Wet
9	Yellow	Medium
10	Yellow	Medium

Tabel 4. 3 Test Results In Soil C

In this experiment, we have tested a soil moisture sensor using LED light indicators to measure soil moisture levels in three different soil types. The test results show that using LED lights as color indicators provides a simple and intuitive solution for understanding soil moisture levels. Soils with different characteristics, such as Soil A, Soil B, and Soil C, are effectively reflected through the corresponding LED color indicators (dry, medium, wet). This shows that our sensors and systems can respond well to moisture changes and provide clear visual cues to users.

This LED color indicator approach can be a practical solution in automated watering systems aimed at bonsai plant maintenance, especially for those who may lack experience in understanding soil moisture percentage data. We believe that the use of this technology can provide convenience in caring for bonsai plants, maintaining optimal soil conditions, and ensuring healthy growth. In addition, the results of this study can serve as a basis for the development of similar systems in the context of urban agriculture and other applications in the future.

CONCLUSIONS

In order to improve the efficiency and effectiveness of bonsai plant care, this research successfully developed an affordable and accessible soil moisture sensor-based automatic watering system. Through a literature review approach, identification of system components, prototype design, software development, and calibration sensor testing, we succeeded in creating a practical solution that allows bonsai plant owners to monitor and control soil moisture levels automatically. By utilizing soil moisture sensor technology, the system provides significant time and effort savings for bonsai plant lovers, reducing the risk of under- or over-watering that can negatively affect plant health and growth. It is hoped that these findings can make a positive contribution to the community of bonsai plant lovers in Indonesia, combining

technology and the art of farming to create a more efficient and customized care environment.

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