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SMART WATER PUMP DESIGN USING DECISION TREE FOR IOT-BASED AUTOMATIC FRUIT PLANT IRRIGATION

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Abstract

The continuous growth of the population each year increases the demand for adequate food supplies, while land for cultivation is becoming more limited. One solution to this issue is the technique of growing fruit in pots (tabulampot). Irrigating potted plants is a crucial maintenance stage, where deficit irrigation can help manage fruit quality. However, manual watering by farmers is time-consuming and labor-intensive, necessitating an automation system. This research aims to design and build a smart water pump system based on the Internet of Things (IoT) using a Decision Tree algorithm to monitor and irrigate potted fruit plants. The designed system can irrigate plants based on predetermined times and soil moisture conditions. Utilizing IoT technology, this system can be accessed and controlled via smartphone. The research results indicate that the system operates automatically, with the ability to monitor soil moisture and irrigate based on real-time sensor data. The implementation of this system is expected to enhance the efficiency of potted plant care and reduce farmers' workload.

Keywords: Potted Fruit Plants; Decision Tree, Soil Moisture, Internet of Things, Smart Irrigation System.



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1. INTRODUCTION

The continuous growth of the population increases every year [1], demanding sufficient food supply [2]. Additionally, it causes home garden areas to become limited, making it difficult for communities to grow fruit plants [3]. One new trend in planting is the technique of growing fruit in pots (tabulampot) [4]. Tabulampot is a solution to the problem of limited land [5]. One maintenance stage for tabulampot is irrigation. The application of deficit irrigation in fruit production is a strategy to manage fruit quality [6]. The water needs of tabulampot must be carefully monitored due to the limited volume of the growing medium, as roots can quickly become stressed if water is insufficient. Water must always be monitored, especially during the dry season or if the plants have a canopy [7]. Water loss causes wilting, shrinkage, browning, loss of fruit texture, taste, and weight, which can affect marketability and accelerate aging

[8]. Irrigation should ideally be done daily [9], while during the dry season, it should be done every two to three days according to soil moisture. Avoid overwatering, as prolonged soggy can lead to root rot and yellowing leaves [10]. This process can consume time and energy since farmers must constantly check soil moisture and water daily [11].

Research and development on smart farming focusing on irrigation processes have been widely conducted. For instance, a study by Anwar Fu'adi and Agus Priangono in 2020 titled "Automatic Irrigation System for Potted Fruit Plants Based on Arduino" simulated an automatic irrigation system based on decision-making, resulting in a functioning prototype according to predetermined decisions. The prototype was developed using four decisions within the SDLC [12]. Another study by Tri Waiingsih, Yohana Nursuwening, and Reni Sulistyowati AM successfully created a timer controller for irrigation in tabulampot using a scheduling method. The automatic irrigation

based on plant needs proved to be more effective and efficient compared to other irrigation methods [13]. Furthermore, research conducted by Effendy Candra Sisworo and Devi Yunita in 2023 developed an Automatic Irrigation System for Potted Fruit Plants based on the Internet of Things, utilizing Wemos D1, soil moisture sensors, relay modules, and water pumps [14].

The novelty of this research, which distinguishes it from previous studies, is the application of the Decision Tree algorithm to determine the decisions made by the system based on the moisture values read by the sensor, thus allowing for more accurate decision-making. The system will irrigate based on two conditions: predetermined times and soil moisture conditions, maximizing irrigation efficiency. The system will be controlled via smartphone, enabling mobile access anytime and anywhere. This system leverages Internet of Things technology, ensuring control is unlimited as long as the system and user are connected to the internet.

The main reason for conducting this research is that irrigation and monitoring of tabulampot are still done manually by farmers, whereas proper irrigation is crucial; otherwise, it leads to wasted time and effort.

Based on the explanation above, the goal of this research is to design and build a smart water pump system using the Decision Tree algorithm as a monitoring and automatic irrigation tool for potted fruit plants based on Internet of Things technology.

2. RESEARCH METHODS

2.1 Research Stages

The stages, activities, descriptions, and achievement indicators can be seen in Table 1.

Table 1. Research Stages

Stages	Activity Description	Achievement Indicators
Identification of Research Problem	Process of determining the research topic or problem to be studied	- Understanding the research topic
Needs Analysis	Conducting a needs analysis regarding the problems to be solved	- Knowledge of the system requirements to be developed
Development of Research Methods	Creating a report on the research methods	- Understanding the components and explanations of the research roadmap and flowchart
Procurement of Research Materials and Equipment	Preparing tools and materials	- Tools and materials for system development have been prepared. - Tools and materials for cultivation have been prepared.

Data Collection	Collecting the Necessary Data to Develop the System	Knowledge of care data for potted fruit plants, specifically during the irrigation stage.
Analysis of Hardware and Software Design	Analyzing and Designing the Hardware and Software for the System to be Created	Understanding the design of the hardware and software for the smart water pump system.
Selection of IoT Platform	Selecting the Internet of Things Platform to be Applied to the System	Knowledge of the IoT platform to be used.
Design and Development of the User Interface (UI) for the Monitoring Application	Designing and Building the UI for the Application Used to Monitor System Devices via Android	The application used for monitoring the system devices has been completed.
Process of Creating the Hardware for the Smart Water Pump System Based on the Internet of Things	Creating the Hardware for the Smart Water Pump System	- The hardware for the smart water pump system using the Decision Tree algorithm and IoT has been completed
Design and Construction of Potted Fruit Cultivation	Building a simple potted fruit plant cultivation area as a place for system application	- The simple potted fruit cultivation has been completed
Analysis and Interpretation of Results	Analyzing and interpreting the smart water pump system	- Understanding the accuracy level of the system in performing automatic irrigation and monitoring
Implementation of Outcomes	Publishing a scientific journal accredited by Sinta 4	- Link to the published journal in Sinta 4

2.2 System Diagram

The system diagram for the system to be created can be seen in Figure 1. This diagram illustrates how each potted fruit plant (tabulampot) system consists of a soil moisture sensor, relay, and water pump connected to the NodeMCU ESP8266. Each tabulampot system sends data to Blynk Cloud via the internet, allowing the data to be accessed in real-time through a monitoring application available on smartphones.

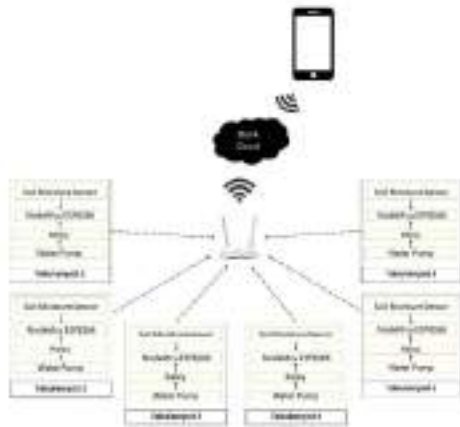


Figure 1. System Diagram

2.3 Design of the Decision Tree Algorithm in the System

A decision tree is a type of tree structure where testing attributes are represented by each node, test outcomes by each branch, and specific class groups by each leaf node [15]. The decision tree algorithm is used to determine the decisions made by the system based on the moisture values provided by the sensor [16]. The design results of the algorithm to be applied to the system can be seen in Figure 2.



Figure 2. Design of the Decision Tree Algorithm

The application of the decision tree algorithm is used to determine the irrigation decisions for potted fruit plants based on the scheduled time and soil moisture values. Initially, the system checks the time set in the monitoring application. If the scheduled time matches the current time, the system will perform irrigation. If not, the system will proceed to check the soil moisture value. If the detected moisture value is below the predefined moist soil level, the system will not irrigate. However, if the detected sensor value is above the specified moist and dry soil levels, the system will carry out irrigation.

3. RESULTS AND DISCUSSION

This research has successfully developed a smart water pump system using a decision tree algorithm as a monitoring and automatic watering tool for potted plants based on the Internet of Things.

3.1 Design of Hardware

The results of the hardware design for the system can be seen in Figure 3.



Figure 3. Design of Hardware

3.2 Design of Software

The results of the software design to be implemented in the system can be seen in Figure 4.

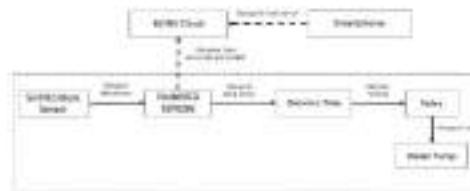


Figure 4. Software Design of the System

3.3 System Implementation

System implementation is a phase of system development carried out in stages to form a cohesive system. This process begins with design and culminates in the creation of a smart water pump system that functions as an automatic irrigation and monitoring tool for potted fruit plants (tabulampot) using Internet of Things technology, the decision tree algorithm, and a monitoring application developed on the Blynk platform.

3.3.1 System Hardware

The hardware used in the creation of the Sensor Node circuit includes the Soil Moisture Sensor V 2.0, which functions to detect soil moisture; the NodeMCU ESP8266, which processes the data read by the sensor; a relay that activates the water pump; and the water pump itself, which delivers water to the potted fruit plants (tabulampot). The system hardware can be seen in Figure 5.



Figure 5. System Hardware

3.3.2 Results of Software Development

3.3.2.1 System Software

The implementation of the system software aims to test whether each hardware component functions as expected. This system software is developed using the Arduino IDE by writing lines of code, which are then uploaded to the NodeMCU ESP8266.

```

// Pin definitions
#define SOIL_MOISTURE_PIN 0 // Soil moisture sensor analog input pin
#define RELAY_PIN 5         // Relay module control pin

// Variables
int soilMoisture = 0;
bool relayOn = false;

// Setup function
void setup() {
  Serial.begin(9600); // Initialize serial communication
  pinMode(SOIL_MOISTURE_PIN, INPUT); // Set soil moisture pin as input
  pinMode(RELAY_PIN, OUTPUT);        // Set relay pin as output
}

// Main loop function
void loop() {
  soilMoisture = analogRead(SOIL_MOISTURE_PIN); // Read soil moisture value
  Serial.println(soilMoisture);                 // Print soil moisture value

  // Decision tree logic
  if (soilMoisture < 100) { // If soil is dry
    relayOn = true;         // Turn on relay
  } else {                  // If soil is moist
    relayOn = false;       // Turn off relay
  }

  digitalWrite(RELAY_PIN, relayOn); // Control relay
}
    
```

Figure 6. System Software

3.3.2.2 Monitoring Software

The testing of the monitoring software aims to ensure that the developed software can effectively display soil moisture sensor data. This software is created using the Blynk platform, as shown in Figure 7.



Figure 7. Monitoring Software

The values displayed in Figure 7 represent the soil moisture sensor readings converted into percentage form.

3.3.3 Installation of Hardware

The fully functional system will be installed on each potted fruit plant (tabulampot) to monitor and irrigate the plants automatically, as shown in Figure 8.



Figure 8. Installation of the System on Potted Fruit Plants

3.4 Testing Results of Each Component

Overall, the system operates by monitoring soil moisture and automatically irrigating the potted fruit media using Internet of Things (IoT) technology. The system consists of a soil moisture sensor that detects the moisture level of the potted fruit plants, which is then sent to the NodeMCU ESP8266 for processing using the decision tree algorithm to determine whether the planting media is dry or moist. If any planting media is detected as dry, the NodeMCU ESP8266 activates a relay to turn on the water pump for irrigation. Additionally, the NodeMCU ESP8266 also sends real-time data from the sensor to Blynk Cloud, which can be accessed through the monitoring application.

3.4.1 Sensor Testing Results

Sensor testing was conducted to determine the values from the soil moisture sensor and to establish the categories of dry and moist by comparing the moisture sensor readings with those from previously existing sensors. The data obtained from the sensor will then be processed by the NodeMCU ESP8266 using the decision tree algorithm. This testing was performed on all six devices that will be installed on each potted fruit plant (tabulampot).



Figure 9. Testing and measuring the soil moisture sensor readings for dry and moist soil.

The results of the sensor node testing can be seen in Table 2.

Table 2. Sensor Testing Results

Device	Sensor Value in Soil Condition	
	Dry	Moist
1	644	675
2	673	655
3	680	676
4	694	681
5	673	643
6	669	649

After obtaining the sensor values, the next step is to input these values into the program code, which will be processed automatically by the system using the decision tree algorithm to determine the maximum and minimum values for the wet and moist categories.

3.4.2 RTC (Real Time Clock) Testing Results

The RTC used is the one provided by the NodeMCU ESP8266, utilizing the server time from the NodeMCU itself. This RTC value will be compared with the scheduled irrigation time set in the monitoring application. If the time on the RTC matches the scheduled time in the monitoring application, the system will initiate irrigation. This testing was conducted by observing the alignment between the RTC time and the time set in the monitoring application. The results of the testing can be seen in Table 3.

Table 3. RTC Testing Results

Waktu RTC	Time Set in the Application	Watering
10.00	10.00	Watering
09.00	10.00	Not Watering

3.4.3 Overall System Testing Results

The overall testing of the system aims to assess its performance in detecting soil moisture levels, watering, and transmitting data to Blynk Cloud. The tests were conducted under two conditions: dry soil and moist soil.

Table 4. Results of System Testing on Dry Soil

Device	Sensor Value	Relay Condition	Water Pump Condition	Blynk Status
1	644	ON	ON	Sent
2	673	ON	ON	Sent
3	680	ON	ON	Sent
4	694	ON	ON	Sent
5	673	ON	ON	Sent
6	669	ON	ON	Sent

Table 5. Results of System Testing on Moist Soil

Device	Sensor Value	Relay Condition	Water Pump Condition	Blynk Status
1	625	OFF	OFF	Sent
2	655	OFF	OFF	Sent
3	676	OFF	OFF	Sent
4	681	OFF	OFF	Sent
5	643	OFF	OFF	Sent
6	649	OFF	OFF	Sent

4. KESIMPULAN

After undergoing a series of research phases, including the design, development, and testing of a monitoring and automatic watering system for potted plants using a decision tree algorithm based on the Internet of Things, it can be concluded that this research has produced a system capable of automatically watering and monitoring potted plants. The study involves six potted plant locations, each equipped with devices that read and transmit soil moisture data to Blynk Cloud in real-time using Internet of Things technology.

The test results indicate that the six systems developed successfully read soil moisture data in real-time and transmitted this information to Blynk Cloud. Furthermore, the algorithm implemented in this system, the decision tree, is effective in processing the readings from the soil moisture sensors, allowing the system to determine whether the plants need watering. The monitoring application developed is capable of displaying soil moisture data as a percentage (%), enabling farmers to know the moisture levels of the 6 potted plants.

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