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IoT Based Watering System Activation on Smart Garden

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ABSTRACT: Watering and maintaining garden plants are essential daily activities for garden owners. However, for busy individuals, this task is often neglected, causing the plants to dry out and eventually die. This study proposes an IoT-based automatic watering system designed to activate irrigation based on soil moisture readings. The system employs soil moisture sensors and the Blynk IoT platform for real-time monitoring and control. The experience results show that the automatic watering mechanism performs more effectively than manual watering, maintaining optimal soil conditions and ensuring plant health. Additionally, user can monitor system status remotely through a smartphone. The proposed system transforms an ordinary garden into a smart garden that support autonomous, efficient, and sustainable plant care.

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1- Introduction

In the modern city, some people have tight schedule on their work since in the morning till night sometime so that they have no time to watering and maintaining their gardens. To overcome this issue, there are many technologies that can be implemented, however some technologies still need some helps to operate the machine. The autonomous activation of watering system will be very important to implement especially for busy people.

Some researchers have discussed regarding smart garden or smart farming, as in [1] which explained smart irrigation system using IoT controlling for mini garden. In this research, the watering proses was based on soil moisture sensor and raspberry pi as controller. The similar article[2] said the smart farming using wireless sensor network for data acquisition and power distribution controlling. Talking about smart farming is also studied in[3] using ZigBee as a communication device. In 2019, research was conducted on a prototype of smart farming for monitoring using the telegram application as in[4]. Thus in 2021, the research was continued for monitoring smart garden using Wemos D1 and website for displaying condition of plant[5]. Furthermore, in 2023, the system was implemented on tomato plantation using android application such as app inventor[6]. The recent update study of monitoring system was designed in 2024 for controlling mint plant based on IoT and integrated with Fuzzy logic[7].

In this study, we propose a watering activation system that will be implemented in an IoT-based smart garden. Using environmental sensing areas, especially soil moisture sensing levels, to control the watering of plants in the garden. What differentiates this work from previous studies is its focus on developing a fully integrated, real-time IoT-based watering system that combines multi-sensor data fusion (soil moisture, soil temperature, and air humidity) with an automatic control mechanism implemented on a low-cost ESP32 microcontroller and monitored through the Blynk platform. While earlier research often relied on single-sensor control systems or more expensive platforms such as Raspberry Pi or ZigBee, this study emphasizes efficiency, affordability, and scalability for small-scale home gardens. The proposed system introduces a practical and energy-efficient automation model, capable of making intelligent decisions based on environmental feedback while allowing users to monitor and control the garden remotely in real time. Therefore, the main contribution of this work lies in its ability to bridge the gap between academic smart farming systems and real-world home applications, offering a reliable and user-friendly IoT solution that supports sustainability, resource efficiency, and autonomous garden management. Some examinations will be used for measuring the effectiveness system by comparing the proposed design and the manual system. The following part of this paper will explain the design of the proposed

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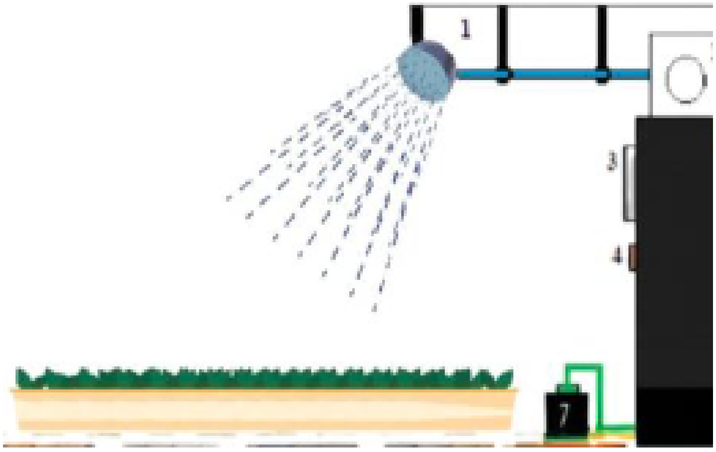

Fig. 1. Proposed Watering System for Smart Garden.

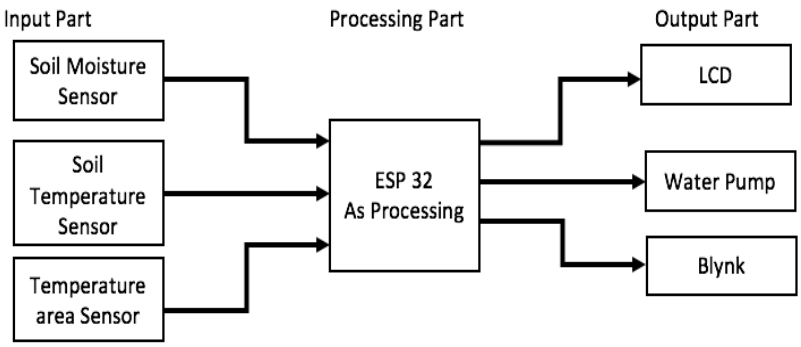

Fig. 2. Block Diagram of Watering System for Smart Garden.

watering system which contained the design of the hardware and software as well as the design of IoT in this case it`s using Blynk. The next after that, the result and discussion of the experience will be declared. The end of section will be closed by conclusion of this proposed design.

2- Design of The Proposed Watering System

In this section, the discussion will focus on the plan of the watering system design including hardware and software design. Furthermore, the examination will be done for testing the system and making sure all of design will be run as the planning.

2- 1- The Proposed Block Diagram of Watering System

The proposed design of watering system for smart garden was shown in Fig. 1. In Fig. 1, the design contains some components such as ESP32 as the processor for controlling the output parts based on input parts.

The input parts of this system are soil moisture sensor and two temperature sensors where the data of all sensors will be sent to LCD and Blynk for monitoring. In the meantime, the output parts are LCD for monitoring in the location, water pump for watering the plantation and Blynk application as an android app for monitoring from everywhere. The detail block diagram of watering system can be seen on Fig. 2.

2- 2- Watering System Hardware Design

In Fig. 3, it can be seen the watering system hardware design which there will need router to connect communication between android mobile and ESP32, the detail explanation as follow.

2- 2- 1- ESP32

The automatic watering system developed using the ESP32 microcontroller as the main processing unit. ESP32 has significant advantages compared to other conventional microcontrollers, including dual-core computing capabilities, integrated WiFi and Bluetooth connectivity, and larger

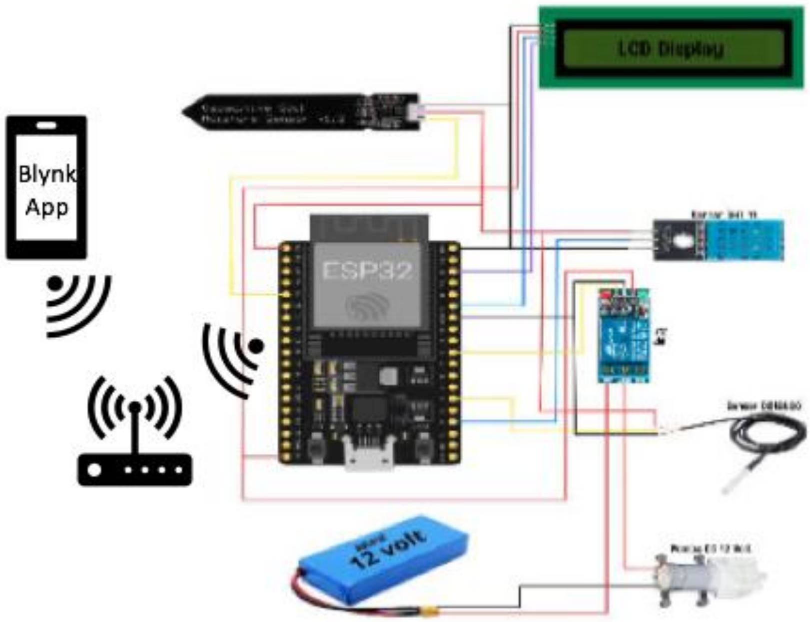

Fig. 3. Watering System Hardware Design.

Fig. 4. The Construction of ESP32.

Fig. 5. Soil Moisture Sensor FC-28.

memory. These characteristics enable more efficient sensor data processing and more stable communication with IoT platforms [8]. Fig. 4 shows the ESP32 with some feature as follow[9].

- WiFi
- Bluetooth
- CPU and Memory
- Clock and Timer
- Advance Peripheral Interface
- Power Management
- Security

2- 2- 2- Soil Moisture Sensor

The implementation of sensors in the system involves several key components. Soil moisture sensor is a humidity sensor that can detect embedded moisture; this tool functions as a detector of soil moisture levels in the plants[10]. Fig. 5 shown the Soil Moisture Sensor FC-28 which has specification as follow[11],

- input voltage specification of 3.3V or 5V
- output voltage of 0 – 4.2V
- current of 35 mA
- ADC value range of 1024 bits ranging from 0 to 1023 bits

2- 2- 3- Soil Temperature Sensor

For monitoring soil temperature using the DS18B20 sensor. The DS18B20 sensor has the ability to measure temperature with an accuracy of ±0.5°C through the one-wire communication protocol[12] as seen on Fig. 6.

Fig. 6. The DS18B20 of Soil Temperature Sensor.

Fig. 8. The Display of LCD.

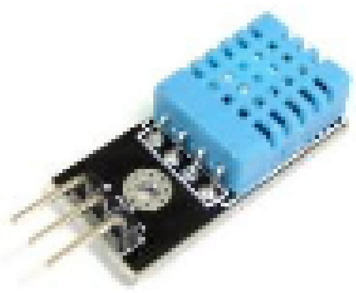

Fig. 7. The DHT11 Temperature Area Sensor.

Fig. 9. The Construction of Relay.

2- 2- 4- Temperature Area Sensor

To monitor the ambient temperature parameters using the DHT11 temperature sensor, which provides simultaneous readings for temperature and air humidity. The integration between the Ds18B20 sensor and the DHT11 provides comprehensive monitoring of the microclimate conditions affecting the growth of the plants[13]. The DHT11 temperature sensor has been shown as Fig. 7

2- 2- 5- LCD

The LCD display is implemented as the local system interface, following the recommendation to provide direct monitoring of parameters at the planting location. This interface allows for quick verification of system conditions and environmental parameters without the need for access to the IoT platform[14]. Fig. 8 shown the construction of LCD.

2- 2- 6- Relay

The integration of the relay as a system actuator adopts the principles described by[10], where the relay functions as an electromechanical switch that controls the irrigation system based on input from sensors and control algorithms. This system is equipped with optical isolation for long-term operational safety and reliability. The construction of Relay can be seen on Fig. 9.

Fig. 10. The Blynk App Logo.

2- 2- 7- Blynk Application

The Blynk IoT platform was chosen as the infrastructure for remote monitoring and control. [15] demonstrates that Blynk provides a customizable interface, data storage capabilities, and an integrated notification system. This platform consists of three main components: the Blynk app for the user interface, the Blynk server for communication management, and the Blynk library for hardware integration and the Blynk App Logo can be seen on Fig. 10.

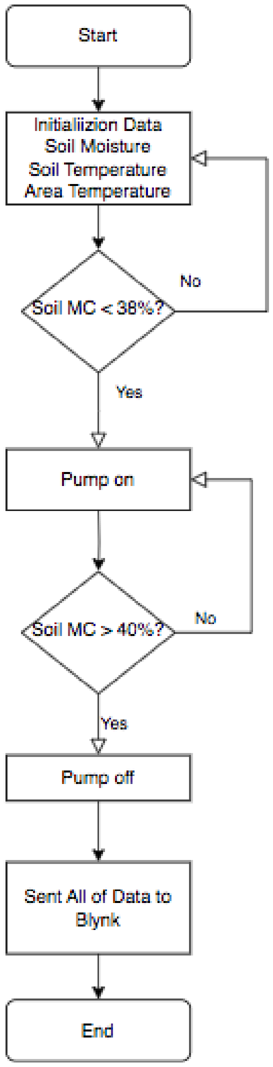

Fig. 11. Flowchart of Watering System.

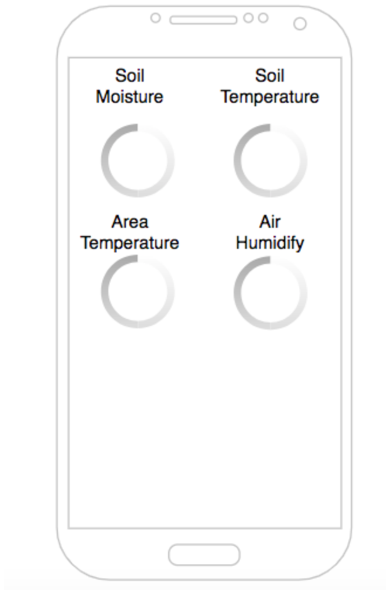

Fig. 12. Design of Blynk Watering System.

2- 3- Watering System Software Design

Watering system software design was made as the algorithm and illustrating in Fig. 11. As seen on Fig. 11, the system was started by initializing the data or take the data from sensing device such as soil moisture, soil temperature and area temperature data. After that, the system will check whether the data of soil moisture below than 38%, if so then the water pump will be on. The system will be back to sensing data and check the soil moisture. The water pump will be off when the soil moisture reach until 40%.

The 2% buffer between the activation (38%) and deactivation (40%) thresholds serves as a hysteresis margin to prevent rapid switching of the water pump when soil moisture fluctuates around the threshold. This range ensures system stability, reduces relay wear, and minimizes power consumption. In real soil conditions, minor fluctuations (±1–2%) are common due to sensor sensitivity and evaporation. Therefore, this small buffer allows smoother transitions and prevents the pump from continuously turning on and off, which could damage the hardware and waste energy. The system will continue to send the all of data to the Blynk server for monitoring system in android application. The design of displaying monitoring system using Blynk application will explain in the following sub part.

2- 4- Blynk Application Interface Design

The Blynk display design for the monitoring system can be seen in Fig. 12. The monitoring system will display soil moisture, soil temperature, and area temperature. On the area temperature sensor, it not only detects temperature but also air humidity. Thus, the monitoring system display shows four data images as in Fig. 12

2- 5- Testing System

The testing of watering system is started by examination each input parts system such as soil moisture, soil temperature and both area temperature and air humidity. In order to have the complete data from morning to afternoon then the data will take randomly as five data of each input parts. From these data system will check and give some responses by turning on or off for water pump to watering the plant.

The other testing is water pump, as mentioned that when the soil moisture is below than 38% then the water pump will be on. This water pump will off when the soil moisture shows equal to or greater than 40%. The testing will be done from in the morning until afternoon so it can be shown when the water pump is on and off.

The last testing is output display monitoring system which it will display on LCD as well as Blynk android application.

Fig. 13. The Prototype of Watering System.

Both medias will display the same value of sensing result.

3- Experimental Results and Analysis

3- 1- Prototype of Watering System Result

After assembling input part and output part also processing part then the prototype of watering system is ready to fill the program as the algorithm. The prototype of watering system can be seen on Fig. 13.

3- 2- Hardware Testing Result

In order to make sure the sensing device can work properly then it need to have some testing. The test has been done in whole day from 06.00 AM to 05.00 PM. The data which presented in the table were an average of multiple measurement recorded over one-hour intervals such as 09.00-10.00 not a single measurement. The first testing is Soil Moisture and Soil Temperature testing and the result can be seen on the Table 1.

In Table 1, it tells that the soil moisture tends to be moist and it reached 78%. As the day change to noon then the soil will be dry and the dry peaks is 32% when the timing on 12.00-01.00 PM. The value of soil moisture is getting up while the soil temperature is getting down.

The second testing is area temperature and air humidity testing. Same as pervious test, it also has been done from 06.00 AM to 05.00 PM. The result of these testing as seen in Table 2.

Similar to the first test, the higher the temperature, the lower the percentage of air humidity, as shown in Table 2. The lowest air humidity was 34% between 12:00-01:00 PM and the highest temperature was 38.3°C between 12:00-01:00 PM.

The next test is the reaction when the soil moisture is below 38%. This test is called the water pump test, which involves sensing the soil moisture level. The results of the water pump test are as follows.

The data, in the Table 3, shows the data that was taken from in the morning until afternoon. The pump indicator is

Table 1. Soil Moisture and Soil Temperature Testing.

Time	Soil MC (%)	Soil Temp (ºC)
06.00-07.00 AM	78	28.2
09.00-10.00 AM	65	32.5
12.00 - 01.00 PM	32	38.8
02.00-03.00 PM	38	34.8
04.00-05.00 PM	68	32.1

Table 2. Temperature Area and Air Humidity Testing.

Time	Air Humidity (%)	Area Temp (ºC)
06.00-07.00 AM	86	29.3
09.00-10.00 AM	58	32
12.00 - 01.00 PM	34	38.3
02.00-03.00 PM	59	34
04.00-05.00 PM	66.3	32.3

Table 3. The Water Pump Testing.

Soil MC (%)	Pump Indicator	Note
78	Off	No watering plant
65	Off	No watering plant
32	On	Watering plant
38	Off	Watering plant
68	Off	No Watering plant

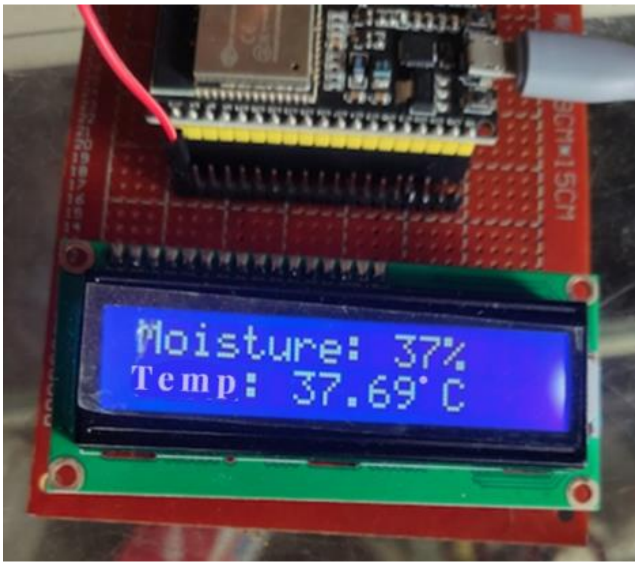

Fig. 14. The LCD Display of Monitoring System.

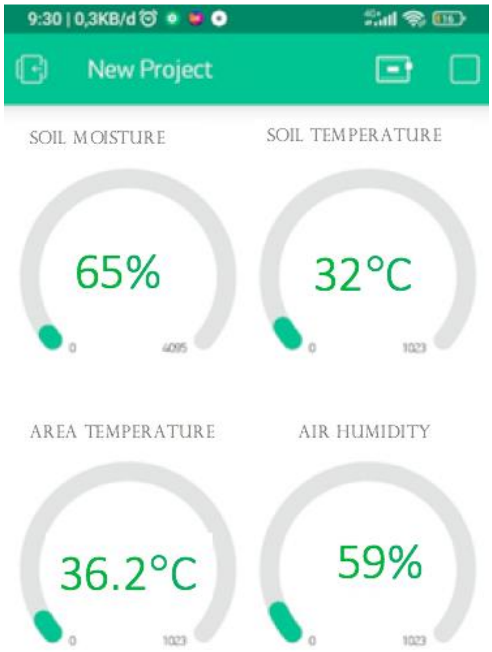

Fig. 15. The Blynk App of Monitoring System.

on as the soil moisture 32% and 38%. The others percentage show no watering plant in the note column.

3- 3- System Monitoring Result

The system monitoring result is the output testing which display the value of sensing result. There are two displays to monitor the sensing value. The first display is LCD as seen in Fig. 14.

The information displayed on the LCD is soil moisture and area temperature. Fig. 14 shows at 37% for soil moisture and 37.69 ºC for area temperature. As mentioned previously when the soil moisture below 38% thus the area temperature also is high and it was 37.69 ºC. This display was taken when the moisture was low and it was triggering watering.

The other display for monitoring system is Blynk App at android mobile. In this app, the information of all of sensing value will display as seen on Fig. 15. From the displayed application, the soil moisture shows a figure of 65% while the soil temperature shows a value of 32º C. Meanwhile, the area temperature shows 36.2º C when the air humidity is at 59%. This figure was taken after watering when the soil was sufficiently moist.

3- 4- Performance Metric of the Effectiveness System

The Effectiveness system can be performed by adding some measurement metric and the summary of them has presented in Table 4.

From Table 4, it shows that the system achieved an average response time of 1.8 seconds and maintained 97% accuracy in moisture detection, indicating stable real-time performance. Experimental results demonstrate that the proposed ESP32-based watering system improves water efficiency by 12% compared to manual irrigation and reduces latency by 44% compared to previous IoT prototypes, validating its effectiveness for small-scale smart gardens

4- Conclusion

Based on the research and discussion that have been conducted, the IoT-based Watering System Activation on Smart Garden has been successfully developed and implemented well. This system is capable of monitoring and controlling environmental parameters in real-time

Table 4. The Comparison of Performance Metric.

Parameter	Manual Watering	Previous IoT Model (Raspberry Pi)	Proposed System (ESP32+Blynk)
Response Time	-	3.2	1.8
Water Efficiency (%)	100	85	97
Cost (IDR)	-	800.000	80.000
Remote Access	None	Yes	Yes (via Blynk)

through the watering system by activating based on the soil moisture sensors, DS18B20, and DHT11 with the ESP32 microcontroller as processing. The test results show that the system can automatically regulate watering based on the predetermined soil moisture threshold, where the pump will activate when the soil moisture is below 38% and turn off when the moisture reaches above 40%. Monitoring environmental parameters can be accessed through the Blynk platform in real-time, which enables effective remote monitoring. However, this research has several limitations, including the absence of a power backup system to anticipate power outages and the lack of a long-term data storage system for plant growth analysis. For future development, it is recommended to integrate the system with machine learning for optimizing watering scheduling based on historical patterns, add soil nutrient sensors for more comprehensive monitoring, and develop a more advanced notification system for critical conditions. Further research can also focus on developing a system that can accommodate various types of plants with different watering needs.

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