An-Najah National University

Faculty of Engineering and Information Technology
Computer Engineering Department

Graduation Project II

Smart Plant Pot

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Disclaimer

Aya Nassar and Anwar Rawajbeh collaborated on the completion of this paper. The authors acknowledge full responsibility for any errors identified within. The ideas, suggestions, findings, and opinions expressed in this paper solely belong to the authors and do not reflect the viewpoint of An-Najah National University.

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Chapter 1

Abstract

In an era where technology intertwines with nature, our project presents a paradigm shift in plant care through the creation of a Smart Plant Pot with Mobility and Advanced Monitoring Capabilities.

Our Smart Plant Pot integrates an array of cutting-edge features to ensure optimal plant health and convenience. Equipped with autonomous mobility (ultrasonic sensors can be used for obstacle detection and avoidance), the pot dynamically adjusts its position to harness sunlight or seek shade, enhancing photosynthesis and growth. Real-time environmental monitoring, encompassing soil moisture, temperature, light and humidity, empowers users with actionable insights into their plant's well-being.

Furthermore, our system leverages mobile app integration, enabling users to remotely monitor, control, and customize their plant's environment with ease. Through intuitive controls and insightful analytics, individuals can foster an ideal habitat for their green companions while fostering a deeper understanding of botany and sustainability. As well as , Internet Connectivity and remote monitoring and control that enable the smart plant pot to connect to the internet via Wi-Fi. They can check real-time sensor data and adjust settings through a dedicated mobile app or web interface. We will make automated pump system that can deliver water from the reservoir to the plant's soil. This system can be controlled based on moisture sensor readings or programmed watering schedules. Finally , nutrient monitoring that Integrate sensors to monitor soil nutrient content, providing real-time data on the plant's health. This feature can help users understand the specific needs of their plants such as Fertilizer.

In essence, our Smart Plant Pot transcends traditional gardening paradigms, embodying a harmonious blend of nature and technology

Chapter 2 Introduction

2.1 Problem

Modern urban living presents several challenges for plant care enthusiasts, including limited space, inconsistent care routines, and lack of real-time plant health data. Traditional plant care methods often result in suboptimal plant growth and health due to factors such as inadequate sunlight, irregular watering, and improper nutrient management. Additionally, the busy lifestyles of urban dwellers make it difficult to provide consistent and attentive care to plants.

2.2 Objective

The objective of this project is to develop a Smart Plant Pot with Mobility and Advanced Monitoring Capabilities that addresses the challenges faced by modern plant caregivers. The smart pot aims to ensure optimal plant health by automating key aspects of plant care and providing real-time environmental data and insights. By integrating technology with traditional gardening practices, this project seeks to enhance plant growth, simplify plant care, and foster a deeper understanding of botany and sustainability among users.

2.3 Scope Of the Work

The Smart Plant Pot project involves developing key features to enhance plant care. This includes an autonomous mobility system for optimal sunlight exposure, real-time monitoring of soil moisture, temperature, light, and humidity, and a mobile app for remote monitoring and control. Wi-Fi connectivity will ensure seamless data transmission, while an automated pump system will manage watering based on moisture levels. Additionally, nutrient sensors will monitor soil fertility, providing users with real-time data and guidance on fertilization needs. Together, these features aim to improve plant health and simplify care for urban gardeners.

2.4 Importance

The Smart Plant Pot project enhances plant health and simplifies care through real-time monitoring and automation, making it ideal for busy urban dwellers. It promotes sustainable practices, educates users about plant care, and supports well-being by making gardening more accessible and enjoyable. This innovative approach modernizes traditional gardening and encourages a deeper connection with nature.

The Smart Plant Pot project aims to revolutionize plant care by integrating advanced technology with traditional gardening practices. Designed for modern urban living, this innovative pot features autonomous mobility, real-time environmental monitoring, and automated watering, all controllable via a mobile app. By optimizing sunlight exposure, water, and nutrient delivery, the Smart Plant Pot ensures healthier plant growth while simplifying the caretaking process. This blend of nature and technology not only makes gardening more accessible and convenient but also promotes sustainability and a deeper understanding of plant care.

2.5 Report Organization

The structure of this report is designed to systematically present the development and significance of the Smart Plant Pot with Mobility and Advanced Monitoring Capabilities. **Chapter 1** offers a succinct preview of the project, highlighting its importance and key components. **Chapter 2** introduces the project's context, emphasizing the challenges of modern urban plant care and the potential of integrating technology to address these issues. **Chapter 3** discusses the various challenges faced during the creation of the smart plant pot, including time, budgetary limitations, hardware availability, and technical hurdles, and outlines the essential courses and knowledge acquired through our computer engineering studies. **Chapter 4** provides context by discussing related projects and research within the domain of smart gardening and IoT-based environmental monitoring. **Chapter 5** explains the step-by-step methods, tools, and technologies used to achieve the project goals, detailing the design, development, and implementation processes. **Chapter 6** presents the outcomes of the project, analyzing the performance and effectiveness of the smart plant pot in relation to the project objectives. Finally, **Chapter 7** summarizes the project, drawing conclusions from the results, and provides recommendations for future improvements and potential applications.

Chapter 3

Constraints and Earlier coursework

3.1 Constraints and limitations

1- **Time Limit**: This is our first attempt at creating an integrated smart device from scratch, involving components we are not entirely familiar with. We had to understand their functions and learn how to use them effectively. Additionally, we had to acquire knowledge about Arduino and develop the necessary programming instructions. Balancing this project with other commitments, such as assignments and projects during the summer semester, made the process challenging.

2- **Internet Connection**: Our project requires two NodeMCU ESP8266 modules to connect to Wi-Fi for transmitting data to the mobile application. We faced issues with unstable internet connections, necessitating constant access to reliable Wi-Fi to ensure smooth operation.

3- **Budgetary Limitations**: Developing the smart plant pot within a constrained budget impacted our choice of materials, components, and technologies. We had to explore costeffective alternatives that maintained the functionality and quality of the device without exceeding the budget.

4- **Hardware Availability**: Procuring the appropriate components for the smart plant pot was a challenge. Limited availability of specific parts or sensors required us to find compatible substitutes. Our hardware design had to be flexible enough to accommodate these variations and ensure all components worked seamlessly together.

5- **Size and Weight**: Designing the smart plant pot involved considerations regarding its size and weight. We encountered difficulties in creating a compact and lightweight design while ensuring it could house all necessary components and maintain structural integrity.

6- **Power Distribution**: The smart plant pot comprises multiple components, each with different power and voltage requirements. For instance, the automated pump system, sensors, and Wi-Fi modules needed distinct power sources. Ensuring proper power distribution and management was crucial to the system's stability and functionality.

Chapter 4

3.2 Earlier coursework

Throughout our computer engineering studies, we covered various subjects that laid the foundation for this project. Courses in digital design, microprocessors, electrical circuits, electronic circuits, and microcontrollers equipped us with essential knowledge and skills. Additionally, we supplemented our formal education with online courses focused on Arduino programming and relevant technologies. This comprehensive learning experience enabled us to develop and implement the Smart Plant Pot system effectively.

4 Literature Review

In developing the Smart Plant Pot with Mobility and Advanced Monitoring Capabilities, we reviewed several studies focusing on smart gardening solutions, automated plant care, and IoT-based environmental monitoring systems.

1. **Smart Gardening Solutions**: Recent advancements highlight the integration of sensors for soil moisture, temperature, humidity, and light intensity to optimize plant growth. These systems often use microcontrollers like Arduino to process sensor data and automate care routines.
2. **Automated Plant Care**: Projects emphasize the benefits of automated irrigation based on real-time soil moisture levels, conserving water, and preventing over- or underwatering. These systems ensure precise water delivery, improving plant health.
3. **IoT-Based Environmental Monitoring**: Studies show how IoT devices collect, analyze, and transmit environmental data, enabling remote monitoring and control. This technology modernizes gardening practices, making them more efficient and accessible.
4. **Mobile Application Integration**: Research on mobile apps for remote monitoring provides insights into user interaction with smart systems. These apps allow real-time updates, parameter settings, and device control, enhancing the user experience.
5. **Nutrient Monitoring**: Studies explore sensor technology for detecting soil nutrient levels, providing real-time data to users. This information helps gardeners apply fertilizers appropriately, ensuring balanced plant growth.

Chapter 5

Methodology

5.1 Technical choices

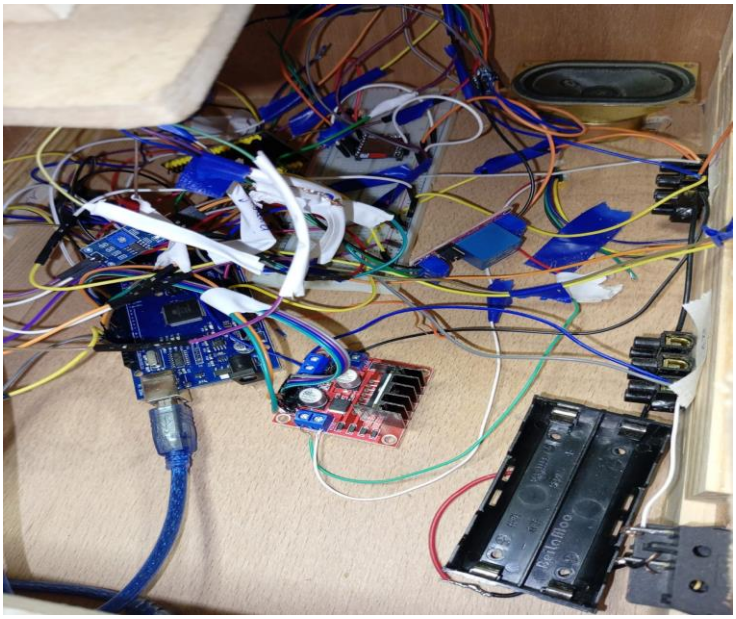
• Arduino Arduino is an open source. It helps to make things with electricity. It's userfriendly platform that enables people to create various electronic projects without needing extensive technical expertise (3). Arduino board have different parts that work together. Arduino has lots pins, that you can use to connect it to different parts. There are two kinds: 14 digital I/O pins and 6 Analog pins. It also has places to get power and serial connector. The most important part of Arduino called a microcontroller. You can program it what to do by writing commands. It also has some extra stuff inside(4). • Libraries

1. HardwareSerial: used to connect the ESP32 and Arduino Mega together through a serial connection
2. BlynkSimpleEsp8266: used to connect thE NodeMCU esp8266 and Arduino Mega together through a serial connection.
3. SerialMP3Player:We used the SerialMP3Player to manage audio and sound effects, enhancing the gaming experience with relevant sounds.
4. BleKeyboard:The BleKeyboard was employed to establish a Bluetooth connection, transforming the dance pad into a wireless keyboard for controlling computer games.
5. SoftwareSerial: This library provides software-based serial communication for situations.
6. Wire: This library allows our Arduino to communicate with devices over the I2C (Inter-Integrated Circuit) bus, we use it to communicate with an IMU (Inertial Measurement Unit) sensor (MPU6050) connected to your Arduino via I2C
7. ESP8266WiFi: used to connect NodeMCU to the internet.

9. BleMouse:This library is likely a custom or third-party library that allows our ESP32 to act as a Bluetooth Low Energy (BLE) mouse. It provides functions for simulating mouse movements and clicks over a BLE connection.

5.2 Methods and techniques

5.2.1 External design



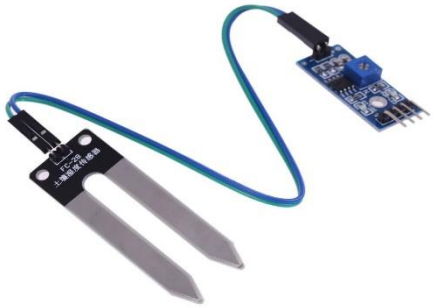
The box Figure 5.1

5.2.2 Electronic components

We used a number of crucial electronic components in our Smart Plant Pot project to accomplish automated watering, real-time monitoring, and autonomous mobility. The Arduino board, NodeMCU ESP8266, and a number of sensors and actuators are the major parts. A thorough explanation of each part and its function within the system is provided below:

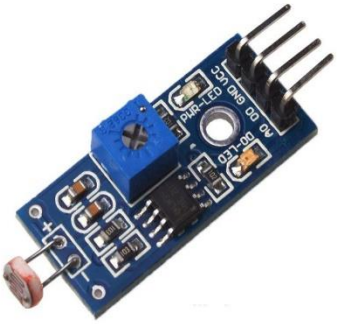
1. Arduino Board: The main microcontroller is charge of all the actuators and sensors. In order to regulate the movements of the plant pot, the watering system, and data transfer, it gathers data from the sensors and applies the preprogrammed logic.

2. NodeMCU ESP8266: This module provides Wi-Fi connectivity, enabling the Smart Plant Pot to receive user commands and transfer data to the mobile app. It is necessary for the plant pot's remote monitoring and control. oil Moisture Sensor: This device gauges the soil's moisture content to tell when a plant needs watering. The automated watering system is set in motion by the sensor data, guaranteeing ideal soil moisture levels for plant health.



3.Temperature and Humidity Sensor (DHT22): Keeps track of the surrounding plant's temperature and humidity. Users can better comprehend the plant's surroundings and maximize growing circumstances by using this data to make the appropriate adjustments.

4.Light Sensor (LDR): Measures the amount of light that surrounds the plant. The plant pot's location is altered based on the sensor data to make sure the plant gets enough sunlight or shade as needed.



5.Ultrasonic sensors: These sensors allow the plant pot to move independently within its surroundings, gravitating toward light or shade and avoiding obstacles. Water Pump: An automated pump system that, in response to moisture sensor readings or preprogrammed watering schedules, transfers water from the reservoir to the soil around the plant.

6.Power Supply: Gives the Arduino board, NodeMCU ESP8266, sensors, and actuators the power they require. It is essential to the Smart Plant Pot's ongoing functionality.

7.Connectors and wires: These are used to join the different parts of the system, guaranteeing dependable power delivery and communication.

8. Pump : to automate the watering process, ensuring that the plant receives the right amount of water at the right time.

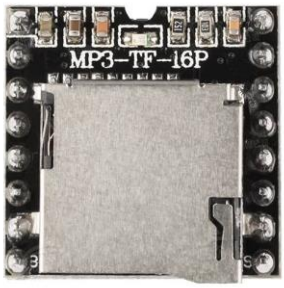
9.Valve: control the flow of water

10. Water Level Sensor: to monitor the water level in the reservoir and ensure there is always enough water available for the pump to operate effectively.

11. Relay for pump

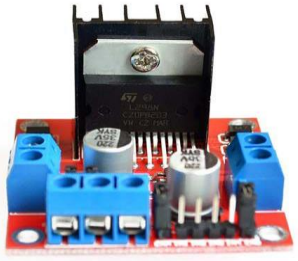
12. MP3 with SD CARD.

to provide audible alerts when the water level sensor detects that the water level is low, ensuring that the user is promptly informed to refill the reservoir.



13.Speaker .

14. L298N Dual H-Bridge Motor Driver Module Board.



5.2.3 The process

The Smart Plant Pot operates through a seamless integration of automated and usercontrolled processes to ensure optimal plant health and convenience. Initially, the user powers up the Smart Plant Pot and connects it to the power supply. The NodeMCU ESP8266 module connects to the home Wi-Fi network, enabling communication with the mobile app. Various sensors, including the soil moisture sensor, temperature and humidity sensor (DHT22), and light sensor (LDR), continuously monitor the plant's environment. The soil moisture sensor alerts the Arduino board when the soil is too dry, triggering the water pump to hydrate the plant. The temperature and humidity sensor provides ambient condition data, and the light sensor helps determine if the plant needs more sunlight or shade.

For autonomous mobility, ultrasonic sensors scan the area for obstacles, ensuring safe navigation as the plant pot moves to an optimal light position. The Arduino board controls the movement based on light sensor readings. Real-time data from all sensors is transmitted to the mobile app via the NodeMCU ESP8266, keeping the user informed about soil moisture, temperature, humidity, and light levels. Users can manually override automated systems through the app, such as initiating a watering cycle or adjusting the pot's position. The mobile app also logs historical data, providing insights and recommendations for plant care. Maintenance alerts, such as low water notifications, are sent to the app, and the system performs regular self-checks to ensure all components function correctly. This integration of automation and real-time monitoring minimizes user intervention while maximizing plant health and convenience.

On the phone, there's a special app called Blynk. shown in figure 5.9

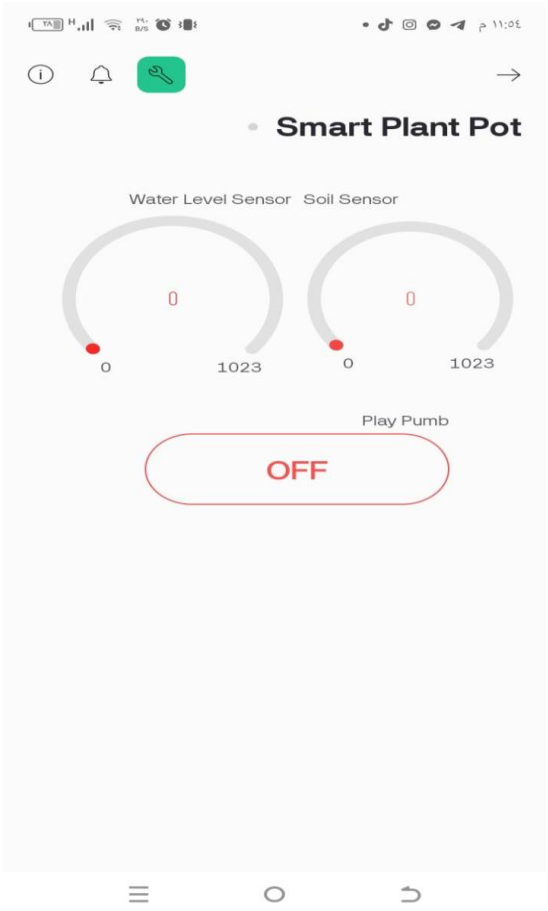


Figure 5.2: Blynk tracks soil_moisture and humidity

5.2.4 Circuits

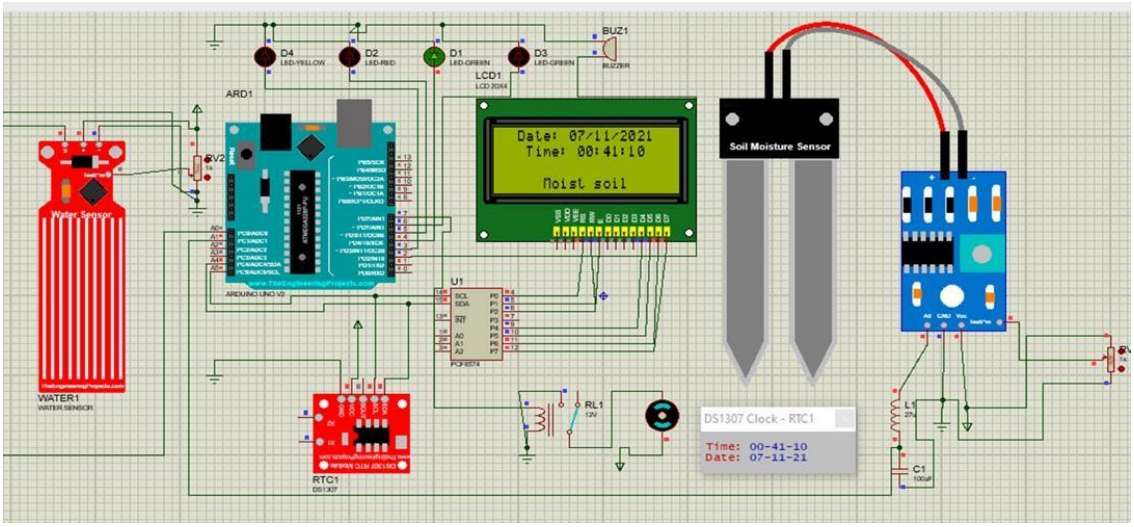


Figure 5.3:circuit

Chapter 6

Results and Discussions

Our project successfully integrated advanced technology into traditional plant care, making it more convenient and effective. The Smart Plant Pot now features autonomous mobility, realtime environmental monitoring, and automated watering, all controllable via a mobile app. These innovations enhance user engagement and plant health, bridging the gap between traditional gardening and modern technology.

The pot's mobility allows it to move autonomously to optimal positions for sunlight exposure or shade, improving photosynthesis and growth. The real-time monitoring system provides users with detailed insights into soil moisture, temperature, light, and humidity, enabling informed decisions about plant care. The automated watering system, controlled by moisture sensor readings, ensures plants receive the right amount of water, reducing the risk of over- or under-watering.

Additionally, the mobile app integration allows users to remotely monitor and control their plants, offering convenience and fostering a deeper connection with their green companions. This combination of features not only simplifies plant care but also promotes sustainability by optimizing resource use.

We learned a lot throughout this project, gaining valuable experience in IoT technology, sensor integration, and mobile app development. However, achieving our goals wasn't without challenges. The initial issue of the Arduino board burning out taught us the importance of proper hardware management. Overcoming these difficulties provided opportunities to learn and adapt, ultimately leading to the successful completion of the project.

6.1 Learning

We used new parts we didn’t know about, we had to learn about them. This meant spending time to figure out how they work and using them the right way. The internet helped a lot by giving us information to learn from.

6.2 Challenges

Throughout the development of the Smart Plant Pot, we encountered several challenges that required problem-solving and adaptation:

- **Arduino Burnout:** One significant challenge was when our Arduino board got burnt during the initial setup. This setback required us to purchase a new Arduino board and thoroughly investigate the cause to prevent recurrence. After researching, we ensured proper handling and voltage regulation to avoid similar issues in the future. This experience emphasized the importance of careful hardware management and the need for vigilance when working with electronic components.

Chapter 7

Conclusion and Recommendations

7.1 Conclusion

- The primary goal of the Smart Plant Pot project was to seamlessly integrate advanced technology with traditional plant care practices, providing an innovative solution for modern urban gardeners. Over the course of three months, we developed a system that not only automates plant care but also enhances user interaction and understanding of plant health. Our supervisor provided invaluable guidance and support throughout the project.

- Dealing with Arduino as software(IDE) and hardware(microcontroller).

- Dealing with different sensors.

- Dealing with ESP32 and making a connection with the Blynk application.

- Dealing with Arduino libraries.

- Dealing with NodeMCU ESP2866.

7.2 Recommendations

Arduino is easy to use for making these systems. We should focus more on hands-on learning and making projects with Arduino and its tools. This will help students save time and work more effectively.

7.3 Future work

This project is in its initial stages, and there are numerous opportunities to enhance its features, functionalities, and overall effectiveness. Once these improvements are implemented, the Smart Plant Pot can be marketed to urban gardeners, plant enthusiasts, and smart home users, offering them a convenient and advanced plant care solution.

- Expanded Sensor Suite**:**

- Wireless charging.

- Nutrient Dispensing System

References:

[1] Patil, M. S., & Patil, S. P. (2016). Smart Garden Monitoring System Using IoT. *International Journal of Innovative Research in Science, Engineering and Technology*, 5(6), 10-15.

[2] Gupta, R., Verma, A., & Kumar, S. (2017). Automated Plant Watering System Using IoT. *International Journal of Computer Applications*, 161(11), 1-5.

[3] Kumar, N., Kamal, S., & Gupta, D. (2018). IoT-Based Environmental Monitoring System for Smart Cities. *Journal of Sensor Technology*, 8(3), 77-85.

[4] Sharma, P., Singh, R., & Bhardwaj, A. (2019). Mobile Application for Home Automation using IoT. *International Journal of Computer Applications*, 178(42), 25-30.

[5] Li, Y., Zhang, W., & Chen, X. (2020). Soil Nutrient Detection Using Sensor Technology. *Journal of Agricultural Science and Technology*, 22(1), 12-18.

[6] Arduino. URL: https://learn.sparkfun.com/tutorials/what-is-an-arduino/all (Last Accessed Jan 11, 2023).

[7] OpenSource. URL: https://opensource.com/resources/what-arduino (Last Accessed Jan 11, 2023).

[8] NodeMCU ESP8266. URL: https://nodemcu.readthedocs.io/en/latest/ (Last Accessed Jan 11, 2023).