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Smart Irrigation and Monitoring System for Pot Plant

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Abstract: In light of the rapid advancements in modern technologies, people who are busy with work schedules sometimes result in neglecting the needs of their potted plants, such as watering and fertilizing. The main goal of this project is to develop a Smart Irrigation and Monitoring System that minimizes the effort to manage plants amidst busy schedules. This system enables users to monitor their plants' health and make informed decisions regarding fertilization when nutrient deficiencies are detected. The project utilizes an Arduino Uno microcontroller to manage various sensors, including humidity, ultrasonic, and pH value sensors. An ESP-8266 Wi-Fi module is integrated into the system to provide Wi-Fi connectivity to the Arduino Uno, allowing it to connect to Wi-Fi networks and interface with the Blynk application, serving as the Internet of Things (IoT) platform. The implemented system automates irrigation, ensures an optimal water supply, and enables remote plant monitoring. Users receive warning notifications for pH value deviations based on the monitoring data, and the Blynk application facilitates convenient fertilization of plants. The system acts as an irrigation system while also providing real-time plant data monitoring for users.

Keywords: Irrigation System, Monitoring System, Blynk Application, Arduino Uno, IoT.

1. Introduction

Recently, gardening has become a popular activity and hobby, providing individuals with a wide range of benefits and enjoyment. In rural areas, people take pleasure in growing their vegetables and fruits in their gardens. This allows them to enjoy the nutritious and pesticide-free produce of organic farming. In metropolitan areas, individuals prefer to keep small potted plants in their homes and offices, not only for their decorative purposes but also for their ability to purify the air, enhance memory, reduce anxiety, and promote a positive attitude in the workplace. Gardening has evolved into a fulfilling pursuit that brings both aesthetic and health advantages to people's lives.

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Watering plants is usually considered to be one of the most important cultural activities as well as the most labor-intensive chore when it comes to the efficient preservation of plant life. However, people's busy schedules restrict them from tending to their plants as much as they would want [1].

As a result, the daily task of gardening can be simplified with the assistance of smart irrigation and monitoring systems developed. The pot plant's soil humidity will be monitored, and if the humidity level falls below a certain threshold, the system will water the plant automatically. In addition, the system contains the function of monitoring the pH value of the soil. According to Garden Express, extreme pH values can bring harm to plants in which the soil contains high concentrations of minerals. The best pH value for the plant to grow is a neutral pH value which is around 7 [2].

In the context of the present study, insights from the "Design of Automatic Watering System Based on Arduino" highlight the significance of incorporating the operational framework of the humidity sensor [11]. Furthermore, building upon the principles elucidated in the "GSM Based Agriculture Monitoring System", the project's architecture embraces the transmission of sensor-derived information to end-users via SMS communication [12]. Extending the capabilities of this endeavor, the integration of a notification mechanism through the Blynk application becomes evident, enhancing the project's usability by promptly alerting users to pertinent developments.

The research findings from the "IoT- based Smart Irrigation System using Soil Moisture Sensor and ESP8266 NodeMCU" underscore the use of ThingSpeak as a robust platform for real-time data monitoring [15]. Nonetheless, within the scope of this study, the preference leans towards Blynk as the chosen IoT framework. This preference is rooted in the mobile-oriented nature of the Blynk application, offering unparalleled convenience to users in contrast to the website-based interface necessitated by ThingSpeak. This strategic choice aligns with the project's commitment to user-friendly accessibility and seamless interaction.

The developed smart irrigation and monitoring system operates autonomously, watering plants when soil humidity drops below 30%, as detected by the humidity sensor. Additionally, it alerts users if the soil's pH level is beyond 6.5 to 7.5, crucial for optimal plant growth. Next, when the water level of the tank is detected below 30%, the water refilling process will be activated to ensure an optimum water level for the next irrigation process. An IoT interface via the Blynk Application was established to monitor plants and notify users of pH level deviations. The project's core focus is enhancing gardening convenience. It aims to automate watering and fertilizing, provide real-time health data through sensors, and use Blynk to inform users of pH changes. This ensures plants thrive in the best conditions for growth.

2. Materials and Methods

The methodology as well as the components used in this study are explained in this section.

2.1 Materials

The primary goal is to simplify the daily task of watering potted plants and receive timely notifications in case of any health issues. The system's working mechanism is depicted in Figure 1, which illustrates the flow of operations. Various hardware components play essential roles in the system including the Arduino Uno responsible for coordinating all functions, along with a soil humidity sensor to monitor moisture levels in the soil. Additionally, an ultrasonic sensor is employed to measure the distance of the water level in the reservoir. The system also incorporates an analog pH value sensor to ensure the pH of the soil remains within the optimal range. To establish the necessary connections, a breadboard and jumper wires are utilized. The water pump and solenoid valve act in tandem to regulate water flow and distribution. Moreover, a single-channel relay is integrated into the system to manage power to the water pump. To enable wireless communication and control, the ESP8266 Wi-Fi module is used. By combining these hardware components, the project aims to create an efficient and automated irrigation system that simplifies plant care while offering real-time monitoring and timely alerts to maintain the plant’s health and growth.

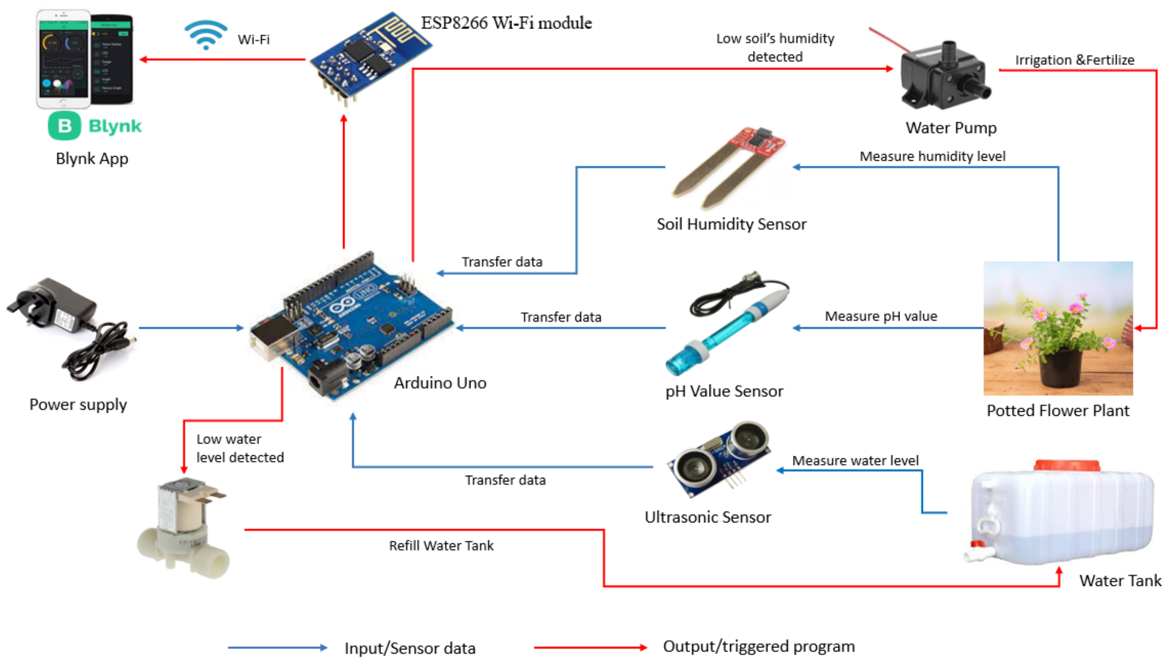

Figure 1: Block diagram of the system working mechanism.

2.2 Methods

The system is controlled by Arduino Uno to control the various processes such as the irrigation process, and sensed data is transmitted to the Blynk application and stored in the Blynk cloud server. The system will alert the user that the plant may have health problems if the pH value sensor determines that the soil is not between 6.5 and 7.5. This is because a plant needs a pH level of roughly 7(neutral pH) to flourish. Whenever a pH value outside of the 6.5 to 7.5 range was detected, it indicated that the plant is suffering from insufficient nutrients and hence can be solved by the fertilization process. A user interface developed in the Blynk application has been created to monitor the plant and give alerts when the pH or water values are outside of the appropriate range by using the Blynk Application. When the pH value is not in the ideal range of 6.5 to 7.5, users can fertilize the plant through the Blynk application. The virtual switch on the Blynk application design allows users to fertilize the plant. Liquid fertilizer was used in the system due to its advantage of a faster absorption rate. Figure 2 illustrates the flowchart of the system, and it explains each process criteria. The simplicity of modern gardening is the focus of this design.

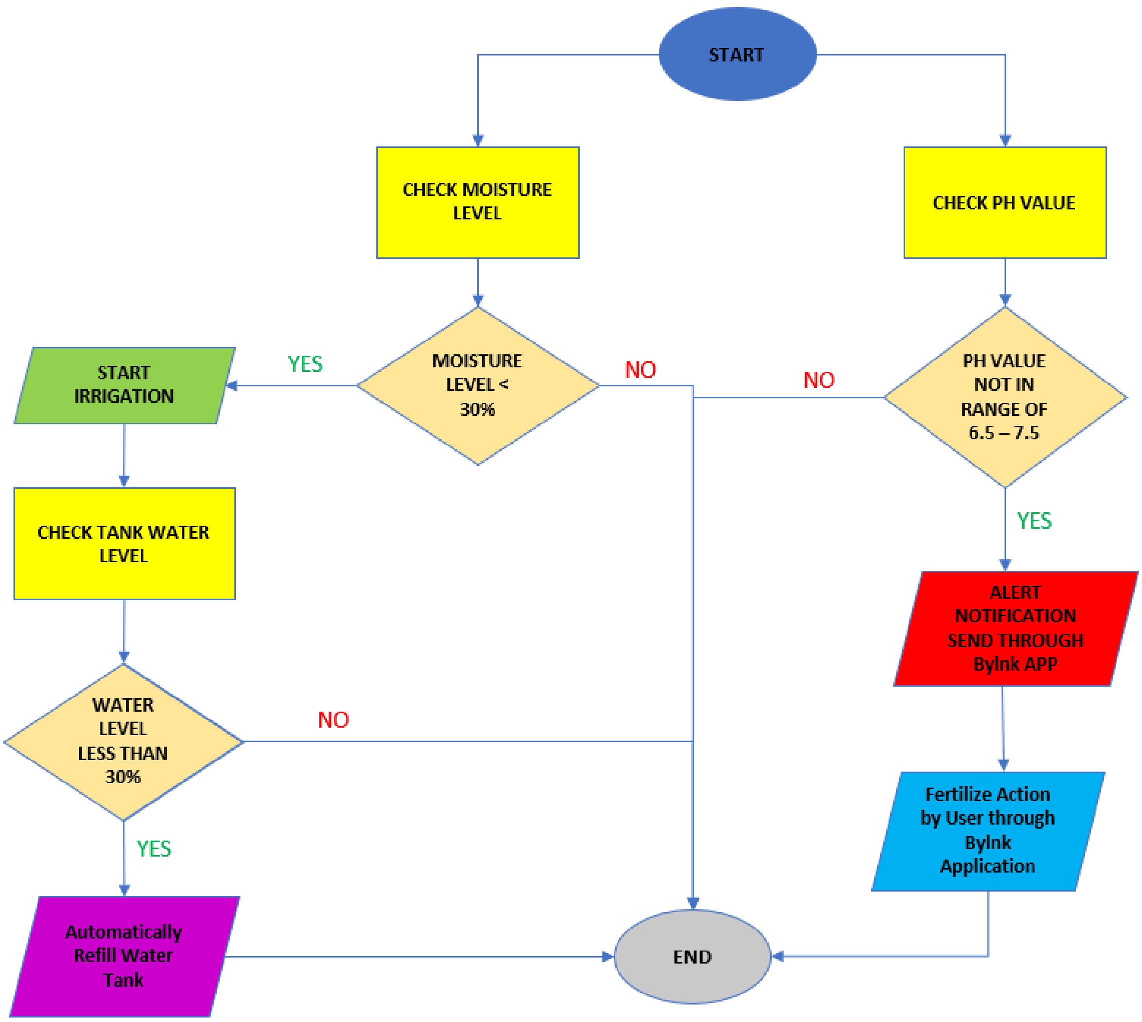

Figure 2: Flowchart of the irrigation system working mechanism.

2.3 Ultrasonic Sensor Equations

Based on the theory and operating principle of ultrasonic sensor, its formula was derived as in Eq.1 to measure the water level. The process of ultrasonic sensor involves determining the distance travelled by the sound wave. This distance can be obtained by dividing the speed of sound by the time it takes for the sound wave to complete its round trip. Given that the duration recorded by the pulseIn() function is in microseconds, it's necessary to convert this value to seconds by dividing it by 1,000,000 (1 million).

$$Distance = \frac{Duration}{2} \times \frac{Speed\ of\ sound}{1000000} \qquad Eq.1$$

$$= \frac{(Duration \times Speed\ of\ sound)}{2 \times 1000000} \qquad Eq.2$$

Since speed of sound in air is approximately 34300 centimetres per second,

$$Distance = \frac{(Duration \times 34300)}{2000000} = \frac{Duration}{58.2} \qquad Eq.3$$

The formula to calculate the distance travelled by the ultrasonic sensor wave is given as in $Eq.1$. The formula is then simplified into $Eq.2$. Next, the speed of sound is substituted into$Eq.2$ to obtain the final formula used to calculate the ultrasonic sensor wave distance traveled as shown in $Eq.3$.

3. Results and Discussion

This chapter discusses the findings that are important to accomplishing the aim of the research. The results of the study had been discussed and analyzed to do improvements to the irrigation system and its monitoring IoT interface.

3.1 Results

The prototype of the system was successfully built with the use of Arduino Uno as the microcontroller. Figure 3 shows the prototype of the system after installing all the components to the system. The system had undergone calibration, testing, troubleshooting and debug phases to ensure the prototype is functioning normally.

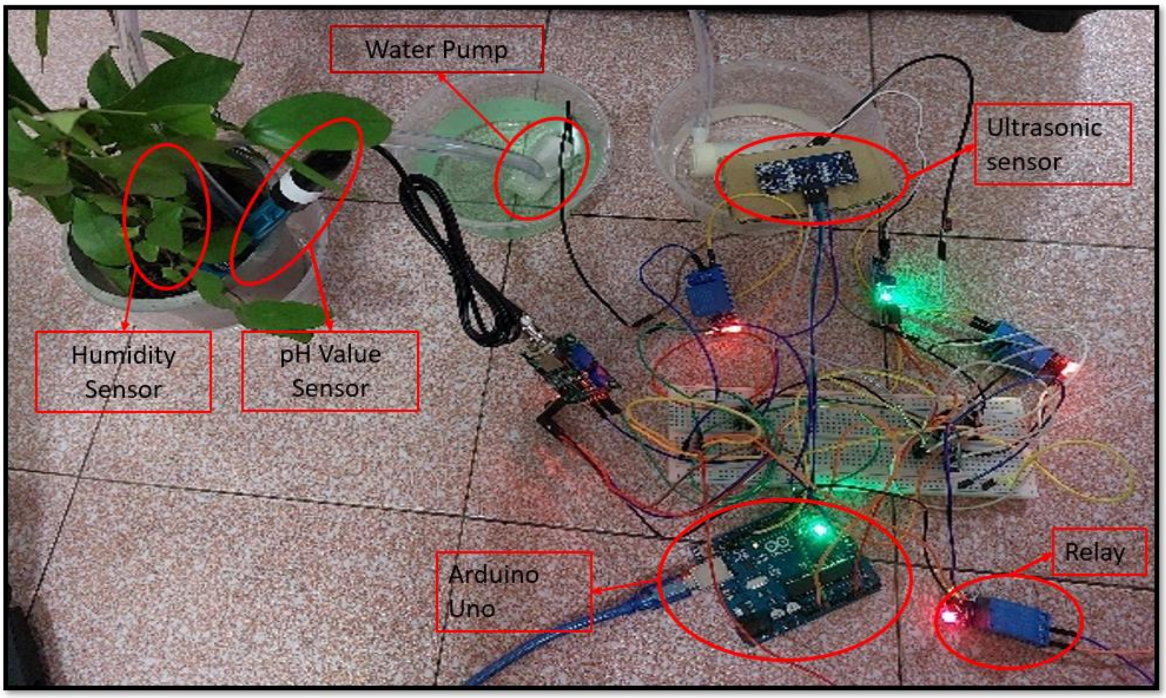

Figure 3: Prototype of the Smart Irrigation and Monitoring System for Pot Plant.

The monitoring system interface on the Blynk application consists of 3 parameters which are pH value, water level of the tank, and humidity value of the plant's soil. Figure 4 illustrates the user interface of the system on the Blynk application. Users can monitor their plants' status by using the monitoring application through a Wi-Fi connection. Whenever the system detected that the soil's pH value is in not the range of 6.5 to 7.5, the system will send a notification to the users, and hence the user can fertilize the plant through the Blynk application switch button(V5) to prevent insufficient or excess nutrient required by the pot plant. Next, the system will also send notifications to the users to remind them whenever the water level of the tank is low.

Figure 4: User interface design of the monitoring system in the Blynk application.

3.3 Discussions

The system can connect to the Blynk server and transmit data through a specific Blynk authentication token. The Blynk authentication token is a unique identifier associated with your Blynk account and projects. It serves as a security measure to ensure that only authorized devices and applications can communicate with your Blynk projects. Figure 5 illustrates the data monitoring in the Blynk application. The Blynk application user interface consists of the humidity and pH value of the soil, the water level of the water tank, the humidity graph, and the virtual switch for fertilization. At the Blynk application, user can monitor their plant health situation based on the pH value and humidity graph. In the graph, the past data of the plant can be observed and hence users can make informed decisions to fertilize the plant through the virtual switch to fertilize the plant during abnormal pH value is detected.

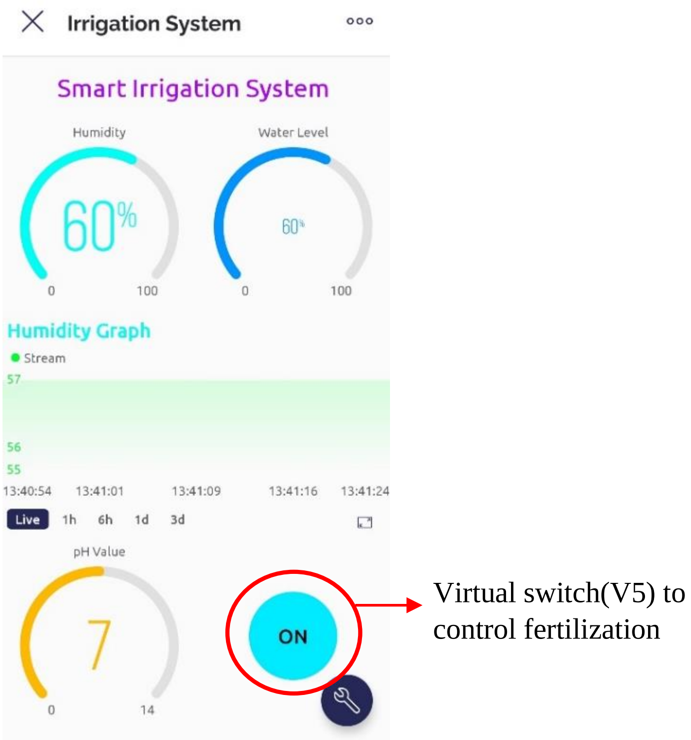

Figure 5: Data Monitoring Interface in Blynk Application.

In the Blynk application, the warning notification had been turned on for both water level and pH value. When the water level is fall below 30%, Blynk will send a notification to the user's phone to notify the user. Similarly, if the pH values are outside the desired range of 6.5 to 7.5, the user will also receive a warning notification from the Blynk application. The warning notification pops out on the mobile phone when the pH value and water level are not in the desired range as shown in Figure 6. This notification serves as proactive reminder to ensure that users are promptly informed about conditions related to their water level and pH levels. Users can take appropriate actions to maintain the optimal conditions of their plant, such as turning on the fertilizer virtual switch to fertilize the plant by staying updated through these notifications.

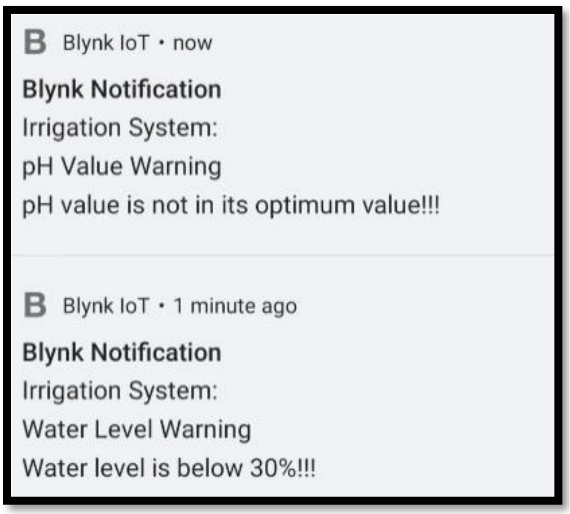

Figure 6: Warning Notification Pop Out

Furthermore, the timeline function of the Blynk program allows us to view previous notifications as shown in Figure 7. This function enables users to review and analyse the history of notifications received regarding our plant. Some useful insights such as patterns and trends of water level and pH values able to obtain by referring to the timeline. This data allows us to have a deeper understanding of our plant's behaviours and make correct and well-informed decisions to optimize its maintenance. The timeline function is a useful tool for tracking our plant's growth and general health.

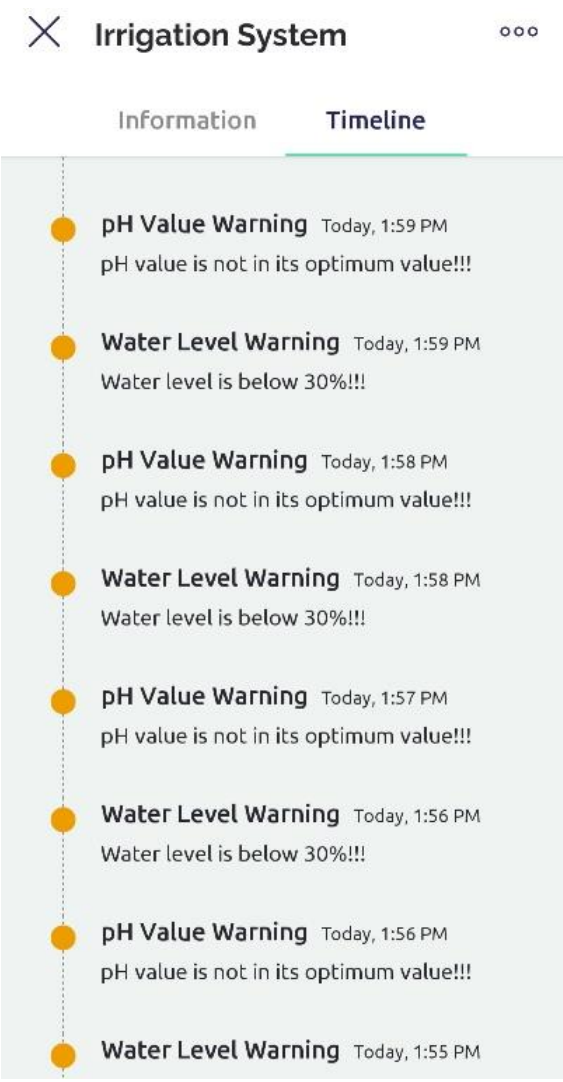

Figure 7: Timeline of Notification

3.3 Summary of Results

Whenever the system detected a low humidity (below 30%), the irrigation process will start and the sensed data will be sent to the Blynk application. From there, the user can monitor the real-time history of the humidity level in the humidity graph. Next, whenever an undesired pH value (not in the range of 6.5-7.5) was measured by the pH sensor, the data will be sent to the Blynk application and a warning notification will pop out in the user’s mobile phone. The same situation goes for the ultrasonic sensor, whenever it detected a low water level (below 30%), the data will be sent to the Blynk application and a warning notification will pop out. In addition, a solenoid valve was used to achieve an autonomous refill of the water tank. Next, a virtual control switch in the Blynk application can control the fertilizer pump. Users can fertilize the plant whenever the pH value of the soil is not in the optimum value which indicates insufficient nutrients in the soil. Lastly, the warning notification also can be observed in the timeline function in the Blynk application. Table 1 shows the summary result of the components used and their function in the system.

Table 1: Summary of results

Components	Function	Result
Humidity sensor	Measure the humidity level in the soil.	The measured data was sent to the Blynk application and started the irrigation process when the humidity level is below 30%.
Ultrasonic sensor	Measure the water level in the tank.	The measured data was sent to the Blynk application and whenever the water level is low, the solenoid valve will be opened thus the water tank can be refilled.
pH value sensor	Measure the pH value of the plant's soil.	The measured data was sent to the Blynk application and whenever the value is not in the optimum range, a warning notification will be sent to the user's phone.
Solenoid valve	Control the flow of water.	If the user received a warning notification of pH value, it indicated insufficient nutrients in the soil. Hence the user can fertilize the plant through the virtual switch on the Blynk application.
Blynk Application	IoT interface to monitor the plant.	Users can monitor the sensed data with Wi-Fi access. It also can alert users about the abnormal situation of the plant.

4. Conclusion

A smart irrigation and monitoring system with IoT applications has been successfully developed. Inside the Blynk application, users can monitor their plant's real-time data including humidity level, pH value, and water level. Whenever the pH value is not in the desirable range, which is out of 6.5 to 7.5, users can decide to fertilize the plant through the Blynk application's virtual switch. This will turn on the fertilizer's pump and hence able to solve the issue of plants' lack of nutrients. For future recommendations, some improvements can be made to the system to become an AIoT application such as adding some AI application to the system so that it can differentiate various plants and provide the data of the plant's behavior. For example, when the system takes a photo of a Durian plant, it should be able to detect that it is a durian plant and will automatically adjust the humidity level and pH value setting that is suitable for the specific plant to grow. The implementation of AIoT in the system can increase its efficiency and improve data management.

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