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Design and Development of an IOT based Plant Growth Monitoring and Management System for Indoor Farming

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ABSTRACT

Currently, the indoor plants are watered and fertilized manually every day. However, incorrect watering and fertilizing may result in plants perishing, not flowering, or not thriving. Moreover, users also need knowledge in temperature and humidity to take care of specialized plants and have a longer life. The current lifestyle also limits the ability of the user to maintain their indoor plants. Therefore, this study aims to develop an IoT-based plant monitoring and watering system. This system seeks to water the plants based on schedule and user input automatically. The single, smart pot system comprises controllers and sensors to monitor plant growth and automatic watering and fertilizer. The sensors include temperature, humidity, and soil moisture sensors. The data is transferred through Wi-Fi to a smartphone application where all the data can be viewed. Additionally, the system will have a Graphical User Interface (GUI) that shows the plant's current conditions. The plant status in the GUI includes information such as temperature, humidity, and whether the light is on or not. Information like when the plant will be watered and fertilized is also displayed. Finally, the time when the light will be toggled on or off is shown as well. The data is also used to manage the plant watering and fertilization processes.

1. INTRODUCTION

Nowadays, the plant is watered and fertilized manually. However, human beings are prone to forgetting to perform things. Home gardening requires the user to remember to water and fertilize the plants as a lack of this will result in the plants dying. Human beings are also prone to doing something incorrectly, such as watering or fertilizing the plant too much. The watering and fertilization of a plant to be forgone or done incorrectly could result in the plant dying or not thriving to its full potential. Also, to take care of plants with specialized requirements and allow for their flowering and blooming, the user needs to know specific plants' information. Therefore, an automatic plant watering system is necessary to optimally water and fertilizing the plants.

There have been many researchers has worked in automatic plant watering system. For example, Amani Che Rus et al. have developed a Smart Plant Management System to control the plant's watering and fertilization based on their optimal growth conditions ranging from temperature to soil moisture [1]. Moreover, Mitesh Sarode et al. have developed a wifi-based automatic plant watering system for house lawns [2]. Pramod Kumar Marya et al. have designed an intelligent irrigation system that can detect soil moisture content and facilitate automatic watering to the plants along with a buzzer system [3]. Meanwhile, Afu Ichsan Pradana et al. conducted work in developing a watering system that can be controlled using a smartphone application [4]. Furthermore, Rossy Nurhasanah et al. implemented an IoT-based agricultural technology innovation to address the problem of a precise watering system based on soil moisture and air temperature

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rate, which can be controlled remotely via an internet connection [5]. Hicham Megnafi et al. developed a solar-powered watering system that measures soil humidity and ambient temperature to determine optimal watering conditions [6].

This study aims to develop an automated system for taking care of plants, including automatic watering, fertilization, and light providing. The system allows plants to be taken care of entirely automatically and removes human interaction from the equation. Information such as temperature and humidity are also measured, and all the information is displayed in a mobile application that can be viewed remotely by the user. The scope of the study focuses on the plant growth monitoring and management system for indoor farming. The analysis constantly monitors the temperature and humidity of the plant. The study also records the last and next time that the plant will be watered or fertilized. This information is all viewable from a mobile application. The study also waters and fertilizes the plant at regular intervals. The system also includes GUI that allows the user to schedule the watering, fertilization, or lighting of the system. This would be useful for specialized plants with specific requirements.

The rest of the paper is structured as follows: Section 2 presents the methodology that includes details such as block diagram, flow chart, and system components. Section 3 presents the results, such as the performance of the system in a real-life environment. Finally, Section 4 summarizes the findings of this work.

2. METHODOLOGY

2.1 Components

The development of the IoT solution for plant growth monitoring and management system for indoor farming requires specific components such as a moisture sensor, RTC module, and a temperature and humidity sensor. In this study, the materials used are Arduino UNO Board, REMOTEXY Software, Water Pump, ESP8266 WIFI Module, Relay, Silicon Tubing, Humidity Sensor, Temperature Sensor, Moisture Sensor, Variable DC Voltage Source, RTC Module, and LED. Other components used include an LED, WIFI module, relays, and servo pumps.

2.2 Methodology

The block diagram of the proposed system is shown in Figure 1. The system comprises of inputs from several sensors such as moisture, temperature, and humidity. The outputs include LED, relays, and pumps. The RTC module is to provides date and time inputs. Meanwhile, the Wi-Fi module is used for wireless data transmission.

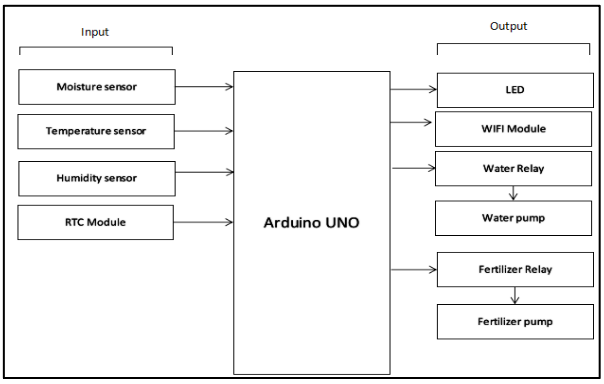

Fig. 1. Block Diagram.

The flow chart of the system is illustrated in Figure 2. The Arduino uses the RTC module to calculate the times it will turn on the water relay or the fertilizer relay connected to the water and fertilizer pumps, respectively. The Arduino also uses the RTC module to calculate when the LED light should be on or off. When it is time to turn on the water relay, the Arduino will first check with the moisture sensor to see if the environment is ideal or not. If the environment is not perfect, then the relay will be turned on. The WIFI module sends the temperature and humidity information from the temperature and humidity sensors to the mobile application. Other information such as when the device will be watered and fertilized next and when the light will be toggled are also sent.

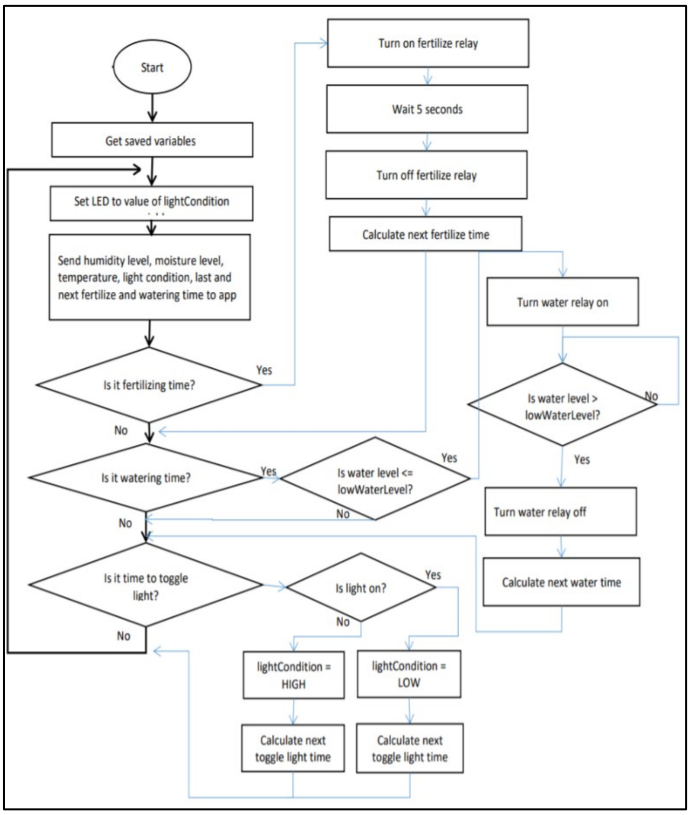

Fig. 2. Flow Chart

The prototype design is shown in Figure 3. The components will be placed in a water-sealed box with two-cylinder bottle been used for water storage.

The IoT functionality includes allowing the user to view the application of humidity, light condition, and what times the device has and will be watered from any location. The variables are detected using the moisture sensor, humidity sensor, and RTC module. The information is then sent to the mobile phone application using the WIFI module connected to the device. This information can be viewed at any time. The class import used to allow this to be conducted quickly through the Arduino is the REMOTEXY class. The REMOEXY class also provides for a UI to be created for the user. The system prototype was also designed in the GIMP image processing and editing software, allowing proper proportion components to symbolize the physical device.

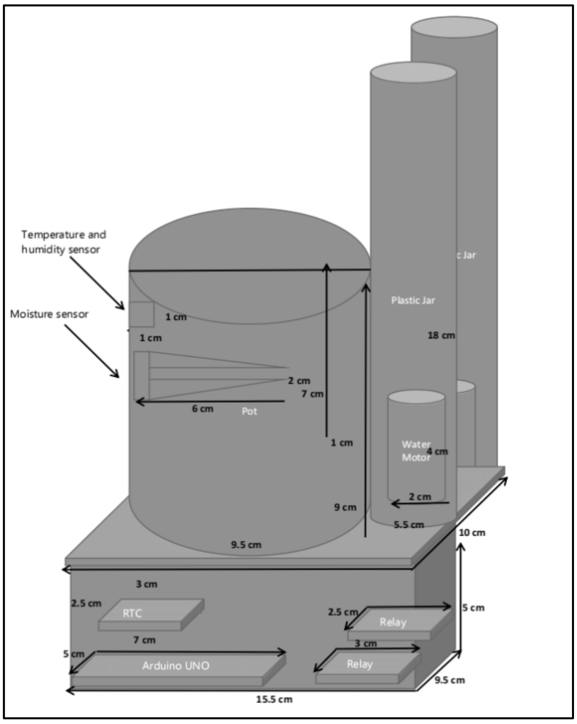

Fig. 3. Prototype design.

The connection and wiring between all the sensors to Arduino module were shown in the system schematic shown in Figure 4.

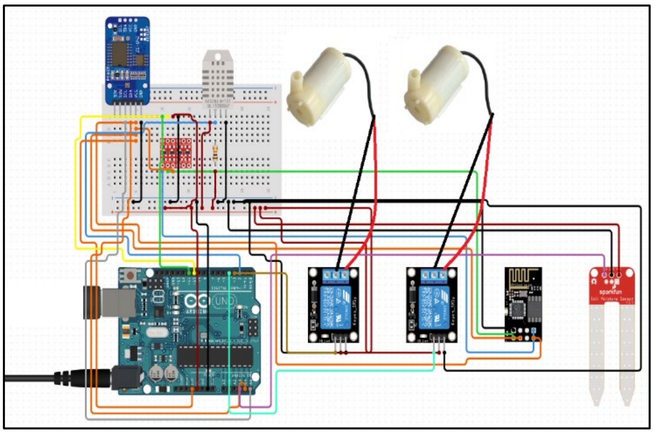

Fig. 4. Schematic.

3. Results And Analysis

The objectives of the proposed system are as follows: Develop air device that can automatically fertilize a plant regularly; develop a system that can maintain the moisture level of a plant at a desired level. and develop a mobile application that can allow the user to monitor the plant.

The first objective of the proposed system is to develop a system to allow the plant to receive fertilization automatically. The fertilization liquid is stored in a plastic container that acts as a reservoir. Inside the fertilization, the liquid reservoir is the fertilization liquid. Inside the container is also a small water pump. The water pump is connected to the pot via silicon tubing. This allows the fertilization fluid to be transferred to the pot to permit the plant's fertilization. The pump is powered through a relay which is connected to the Arduino and the external DC voltage source. The voltage source coming from the adapter is 12V. Therefore, a module is connected to the adapter's output, creating 3.3V, 5V, and 12V pins. The 5V pins are used to power the fertilizer relay and, therefore the pump.

The current time is received from the RTC module. This time is used to calculate when the fertilization will happen. It is found that the most optimal general frequency for fertilizing plants is every two weeks. If the EEPROM is empty, then this value is saved in the first slot in the EEPROM. Otherwise, the previous value will be recovered from the EEPROM. This allows the device to continue operating and fertilizing the plant at the appropriate times even if power is lost for any reason.

The fertilization process consists of the relay being turned on for five seconds. Afterward the relay is turned off. Then the current time is once again received from the RTC module. A new time for the subsequent fertilization is calculated. This time is used to overwrite the old time in the Arduino's EEPROM so that even if power is lost, fertilization will occur at the correct time. The final prototype of the system is shown in Figure 5.

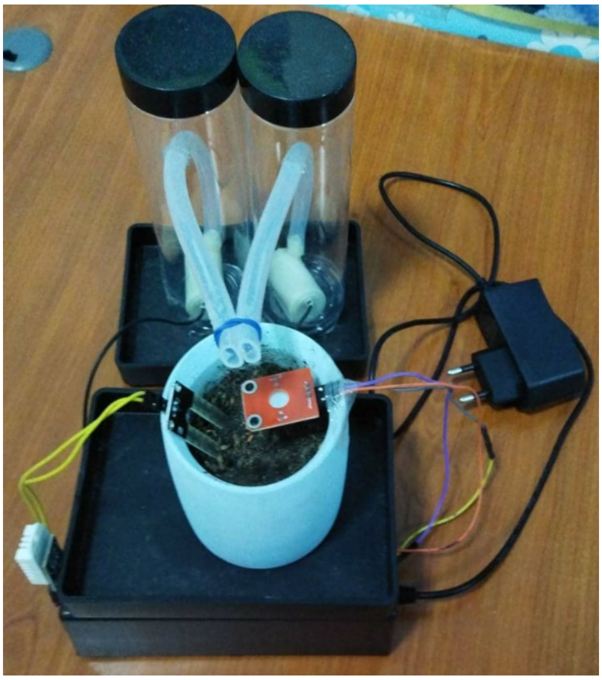

Fig. 5. IOT system for automated plant watering and fertilizing

The second objective of the proposed system is to develop a system to allow the plant to obtain watering automatically and maintain a water level at the desired point. The water is stored in a plastic container, acting as a reservoir. Inside the container is a small water pump to pump the liquid to the plant. The water pump is connected to the pot via a piece of silicone tubing. The pump is powered through a relay that is connected to the Arduino and the external 12V DC voltage source. A module is connected to the output of the adapter, creating 3.3V, 5V, and 12V pins. The 5V pins are used to power the water pump.

The current time is received from the RTC module. This time is used to calculate when the watering will happen next. If the EEPROM is empty, then this value is saved in the first slot in the EEPROM. Otherwise, the previous value will be recovered from the EEPROM. This allows for the device to continue to operate and water the plant at the appropriate times, even if power is lost for any reason.

To maintain the integrity of the moisture sensor module, it is recommended to have the module not running constantly. It is also recommended that plants should be watered twice a day [1]. Therefore, the system checks twice a day whether the water level is at the desired level or not. If it is at the desired level, then no action will be taken. If it is not at the desired level, then the water pump will be turned on until the desired water level has been achieved. After this is completed the next watering time will be calculated.

The mobile application is created using the REMOTELY software. The software allows for creating a mobile application by dragging elements onto a graphical screen and allowing functionality through Arduino code. REMOTELY pairs with a mobile application downloaded from the Google Play Store under the same name that enables the user to connect with any REMOTELY application nearby.

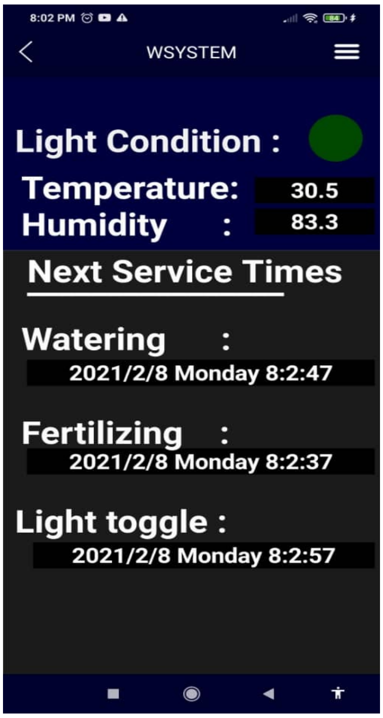

Fig. 6. Graphical User Interface

The light condition is being used to determine the status of an LED in the mobile application. The temperature and humidity are also being displayed. Finally, the next watering, fertilizing, and light toggle times are displayed to the user. The window for the application can be seen below in Figure 6.

4. Conclusion

In conclusion, an IOT based plant growth monitoring and management system for indoor farming have been developed. . information on how to buy cheap and reliable electrical The system will be improved further with the inclusion of a card reader instead of the Arduino EEPROM to save data. Moreover, GUI can also be improved by allowing the user to select several types of plants from the mobile application. Ways of a drop-down list can do this. Each plant name will hold variables for how often the plant should be fertilized and watered and how much light it requires. The user can also click on a button to create a custom plant environment. This will allow the user to choose how often they want their plant to be watered, fertilized and how much light it requires.

Acknowledgement

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