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IoT-based Smart Gardening System

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Abstract. Through this project, an IoT based smart garden system has been built which allows the user to monitor various parameters related to the plant including moisture-level, temperature, humidity and light condition. The soil moisture can be regulated with the help of the watering system which can be controlled by the user or operated on automatic mode. The automatic watering system that is provided besides manual mode regulated soil moisture without the needof human intervention. Fertilizer dispenser has been incorporated in the system. This ensures that the plant will get all the required nutrients. The system is Wi-Fi-based and it is supported bya smartphone application and a web dashboard. This makes the monitoring and controlling functions easy and convenient. Since the data is transferred to online database via internet, the data can be retrieved from any location. Thus, there is no limitation of range and it is especially useful if the user is travelling.

1. Introduction

In today's busy life, garden maintenance has become a difficult task. Plants need to be monitored and taken care of by providing adequate watering, fertilizers, etc. Also, for efficient growth, the plants need optimum conditions such as adequate light, proper temperature and moisture content in the soil as well as air. However, a lot of people are unable to take care of their gardens due to busy and hectic schedules. Also, some of these parameters are difficult to monitor without devices. All these factors result in detriment to the plant health and damage to the overall garden. IoT can provide a solution for this problem. With the help of network infrastructure, IoT enables remote sensing and controlling of objects. Thus, an IoT based smart gardening system can provide a convenient and easy means for plant monitoring and garden maintenance [1,2]. This smart gardening system will assist users in automatically tracking various plant-related parameters and controlling operations remotely from any location. This will ensure garden upkeep and maintenance without the need of human intervention at the actual location of the plant. This smart garden system will allow the user to monitor various parameters related to the plant such as moisture-level, temperature, light condition, etc. and also aid plant growth by regulating water content. The monitoring and controlling functions can be made easy and convenient with the help of wireless communication with an application or web interface. This enables the user to monitor the plant as well as control the functions from any location. [3-6] Patel et al. built a Smart Garden system consisting of TelosB and IRIS wireless sensor networks along with irrigation system. This system is monitored with a Java application [1]. Song built a smart garden based on the Internet of Things which allows the user to monitor the Plant Growth in real time. This system monitors temperature, moisture and humidity and also includes a gas sensor to detect smoke and harmful gases. The software consists of Rasberry Pi, Firebase as Database and a push notification host. [2]. Rahim et al. built an application along with system which is based on IoT for monitoring of gardens. This system is Arduino based and also incorporates ESP8266 for Wifi. It is connected to ThingSpeak platform for monitoring. A UV LED lamp has been incorporated for low light condition but it is not automatic [3]. Paravthi et al. developed smart garden system that is linked to the Ubidots platform. The technology also predicts whether rainfall is going to occur on the bases of measured humidity level. Accordingly, it takes decision for plant irrigation [4]. Sambath et al. made use of Arduino as microcontroller for their system. The system gives alerts of the plant and also has a lamp for night-time monitoring. [5]. Kolhe at al. built a smart garden with irrigation system. The android-based application can automate the process of irrigation in the garden by turning the motor ON/OFF based on the conditions [6]. Pendyala et al. developed an IoT System for agriculture which allows the user to monitor the crops and also includes an autonomous irrigation system [7]. Ahmad and Zaman built a crop-tracking system for agriculture with a PHP-based web interface along with Smartphone application. A microcontroller along with GSM module, Bluetooth technology and a number of sensors make up the monitoring device which makes use of these components to collect data from the field and send it to server by GSM [8]. Kumar et al. made us of sensor technology to build monitoring system for their smart garden which consisted of sensors along with pump, cooling fan and lighting system for controlling the conditions. [9]. Hadi et al. developed an irrigation system for gardening which is based on ESP8266 with DC motor pump [10]. Arbain et al. built a Weather Station in their garden. The sensors which have been incorporated into the weather station are capable of measuring light index, air pressure, dew point and so on. Blynk app is developed to show barometric pressure and sensor data reading [11]. Tingzona and Aborde built an Arduino-based Digital Garden System supported by Web and Mobile application. [12]. Swaraj C M has developed an IOT based Smart Agriculture Monitoring and Irrigation System. In this system, based on the behaviour of sensors arduino transfer the data to the cloud server called ThingSpeak server [13]. Obaideen et al. built a system which consist an overview of smart irrigation systems using IoT. Soil and weather monitoring system and irrigation are developed. Wifi and Global System Mobile communication (GSM) are used for communication purpose. Cloud technology is used for storage [14].Olawepo et al. built a system which consist an overview of smart garden automation. Sensors (Moisture, Temperature, Humidity, Ultrasonic), NodeMCU, Arduino and micro-controller are used to develop this system [15]. Sindhu P et al. developed a Smart Gardening System. LDR, Temperature Sensor is used to water the plants. An automatic water pump is used in the system. The Arduino Measures the real time data [16]. Ali et al. built an IoT based smart garden monitoring system using NodeMCU microcontroller. It provides real-time statistics of garden environmental factors, so the local users and gardeners are able to treat their plants in a well manner [17]. Singla et al. have done a study on smart irrigation system using IoT. Temperature Sensor, Node MCU, Arduino, Moisture Sensor are used in the system. The motor starts when the sensor senses a rise in temperature or low moisture and the plants get watered [18]. A. Anita et al. used ThingSpeak and IOT to monitor dampness of soil and plant is watered automatically based on these values [19]. Ashwini built an automated irrigation system using WSN and GPRS module. A data mining algorithm has been used for irrigation controlling. [20].

2. Proposed System

After studying literature survey, it was seen that mainly the focus is on monitoring and automatic water supply systems. Also, some applications are Wifi-protocol based and not internet based. This gives the problem of range as the user has to be within the range of Wifi in order to monitor the plant. Through this project, a smart gardening system based on the Internet of Things has been built consisting of various sensors that will be utilized for the tracking and monitoring of soil moisture, air temperature, the light condition and percentage of humidity in air.

Till date, a lot of research has been carried out for developing plant watering systems. Various sensors have been incorporated in order to monitor parameters such as soil humidity, air temperature and humidity. However, there has been no development in fertilizer systems. This project incorporates a fertilizer dispenser which can be easily operated by the user from anywhere using the mobile application or web dashboard. Further, extensive survey has been carried out for choice of components in order to reduce the system cost, size and power-consumption as much as possible. The system has been developed such that it is effective, economical, sustainable and user-friendly.

The system has two modes: Manual and Automatic for water supply and consists of automatic watering system which is operated based on sensor readings. Further fertilizer dispenser has been incorporated into the system. The entire system can be monitored and controlled easily with the help of a Smartphone Application and Web Dashboard based on Blynk Platform.

3. Methodology

3.1. Components

Following components were procured and utilized in this project:

Electronic Components:

- NodeMCU microcontroller
- DHT11 sensor
- Soil moisture sensor
- Water pump
- Servo motor
- LDR sensor
- Connecting Wires
- Breadboard
- Batteries
- Miscellaneous components (pipe, funnel, etc.)

Software Components:

- Embedded C language
- Blynk IoT Platform
- Arduino IDE

Following are the requirements for operating the smart gardening system:

- Wi-Fi
- Smartphone/Internet-enabled Computer
- Water Supply
- Batteries/Power Source

3.2. System Architecture Design

The design for system architecture of the smart gardening system was built. The procured components were assembled accordingly. Fig. 1 depicts the design of system architecture of the smart gardening system.

The main component of the system is the NodeMCU microcontroller which communicates with the peripheral input/output devices. It is connected to three sensors namely Soil moisture sensor, LDR sensor and DHT11 sensor which measure the parameters ambient light, soil moisture content and air temperature-humidity respectively. The watering system consists of a relay which is connected to the microcontroller, water pump, water supply and a separate power supply. The fertilizer dispenser has a lid at the bottom which is controlled by a servo motor in turn connected to the microcontroller. All these components are powered by a DC power supply. NodeMCU has an inbuilt Wifi module for wireless communication. It communicates with the smartphone application and web dashboard via internet.

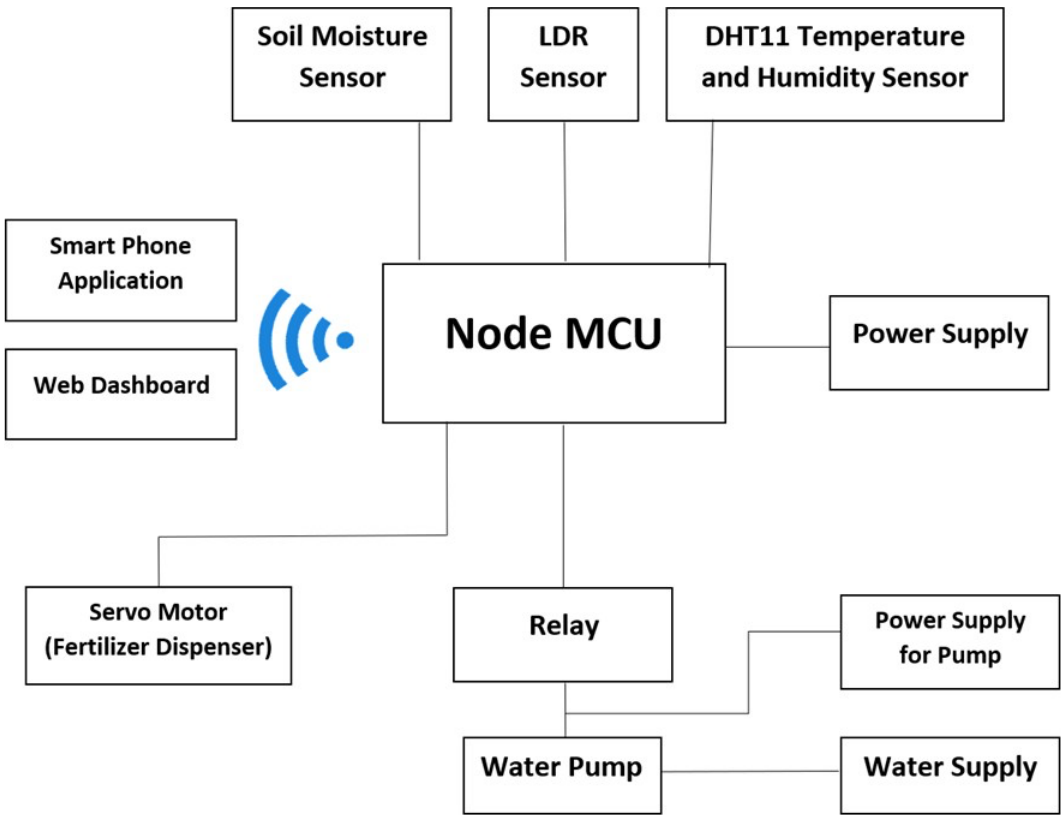

Figure 1. Smart Gardening System Architecture Design.

3.3. Working

The system consists of sensors which monitor parameters including temperature, moisture, humidity. The NodeMCU microcontroller consists of an inbuilt Wifi module which connects to the internet and transmits this data to the Blynk Platform. The user can keep track of parameters and control functions by using the smartphone application or the web dashboard available on Blynk. Since the monitoring and controlling is done via internet, there is no limitation of range and the user need not be near the system. This system consists of sensors, relay, servo motor, Node MCU, Web dashboard and Mobile Application.

Sensors include soil moisture sensor, LDR sensor, DHT11 temperature and humidity sensor. A soil moisture sensor is used to measure moisture of soil. A soil moisture sensor indirectly measures the volumetric water content using some other properties of the soil, such as dielectric constant or interaction with neutrons and electrical resistance. DHT11 sensor is used to measure the temperature and humidity in around the plant. Temperature and humidity sensor that comes with a NTC (Negative Temperature Coefficient). An NTC is used to measure temperature while an 8-bit microcontroller is used to provide temperature and humidity values. An LDR sensor can measure light intensity and indicate the presence or absence of light. Automatic water supply is carried out with the relay. If the relay is set to 1, the pump will start and automatically supply water to the plant. Setting the relay to 0 will turn off the pump and stop the water supply. A servo motor is used to dispense the fertilizer. After setting Fertilizer to 1 the motor will start and dispense the fertilizer. Once Fertilizer is set to 0 it stops dispensing fertilizer. All these components are connected with Node MCU using WiFi. Node MCU is connected with mobile application or web dashboard. Mobile application or web dashboard can control water level and fertilizer quantity. It shows soil moisture, light intensity, temperature and humidity.

3.4. Software Component

The code for the system was written in Embedded C language and uploaded onto the microcontroller via Arduino IDE. The system requires the libraries ESP8266WiFi, DHT, Servo, BlynkSimpleEsp8266. The code provides various functionalities for connecting to the Wi-Fi network, measuring the parameters, controlling the water supply as well as the fertilizer dispenser.

Data streams were created for communication of data between the system and Blynk IoT platform. The Web Dashboard and Smartphone Application were designed and the control and monitoring functions were set up on the platform with the help of these data streams. The data streams are represented by virtual pins which enable communication between hardware and the platform (denoted by V_n).

Fig. 2 shows the application design. The application depicts the various monitored parameters organized into blocks. Temperature and Light readings are in text form while Soil Moisture and humidity readings are represented by gauges. The application provides control over water supply and fertilizer with the help of buttons which can be toggled ON or OFF. Similarly, a button is used to toggle the automatic mode and manual mode. Fig. 3 shows the web dashboard design. It is similar to the application and consists of the data stream blocks arranged onto the dashboard.

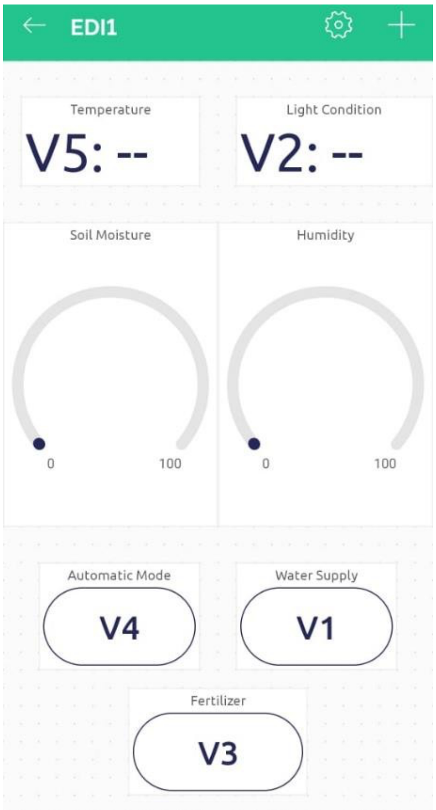

Figure 2. Application Design made on Blynk IoT Platform containing the blocks for monitoring the plant-related parameters and buttons for controlling the operations.

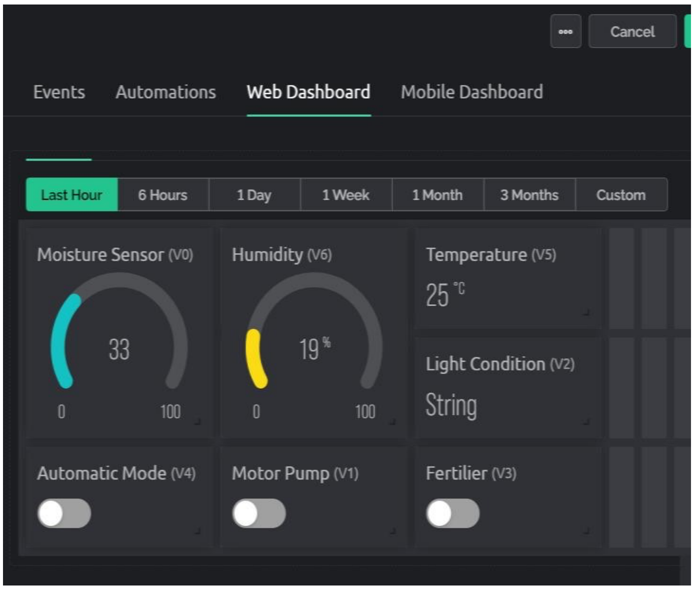

Figure 3. Web Dashboard Design made on Blynk IoT Platform containing the blocks for monitoring the plant-related parameters and buttons for controlling the operations.

4. Results and Discussion

The smart gardening system was built and tested successfully. The NodeMCU microcontroller connects to the configured WiFi and transmits data to Blynk Platform. Fig. 4 shows the completed prototype of the smart gardening system. The sensors monitor the soil moisture, temperature and humidity, along with light condition. These parameters can be monitored on the Application as well as the Web Dashboard. Fig. 5 shows the Smartphone Application showing the monitored parameters as well as the controlling functions available in the system. The system has been programmed in two modes: Manual and Automatic. The mode can be changed with the help of a toggle switch available on the platform. In Manual mode, the user may control the watering system by turning the motor ON or OFF. In the Automatic Mode, the system is automatically operated according to the soil moisture readings of the sensor. If the soil moisture content goes below the preprogrammed limit, the water supply is turned on automatically without the need of human intervention. A fertilizer dispenser has also been incorporated in the system. The dispenser has a lid at the bottom, which is attached to a servo motor. The lid can be opened or closed with the help of the motor. The control for this is also provided in the application in the form of a button.

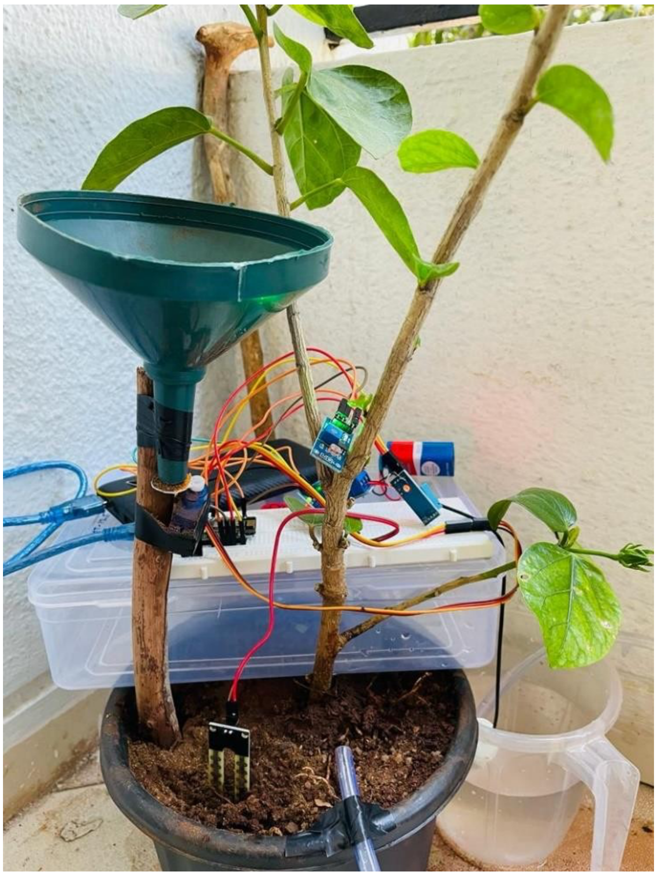

Figure 4. Completed Prototype of Smart Gardening System.

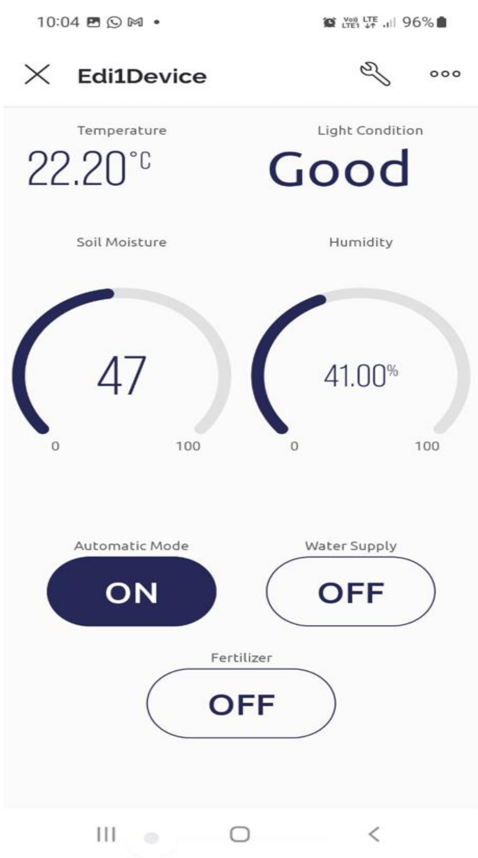

Figure 5. Smartphone Application showing monitored parameters and controlling functions.

The NodeMCU microcontroller used in this system has an inbuilt Wifi module and is cost-efficient as well. The sensors and actuators incorporated are also low-cost and effective. Further, the system sends the data over internet to the cloud and thus this system may be monitored and controller from anywhere. There is no limitation of range. The dashboards have been designed such that they are easy to understand and operate. Thus, this smart gardening system provides an easy, convenient and user-friendly solution to garden maintenance. The system has a compact design and can be operated remotely over the internet. Further, the system is scalable and also economical.

5. Conclusion and Future Scope

Gardening is an activity that requires a lot of monitoring and control. This system has been designed to track the soil moisture, air temperature and percentage of humidity along with light conditions around the plant in real time and water the plant based on these observations or add fertilizer. This project has given us a chance to study advantages and disadvantages of the existing systems. The system built through this project includes a water pump which can be switched (on/off) based on sensor values. This helps to automate the process of watering of the plant. This technique keeps the plant from being over-watered or under-watered, maintaining the health of the plant. Fertilizer dispenser has been implemented which can be turned ON/OFF via the mobile application or web dashboard. The garden owner is able to track the entire system online through the Blynk IOT Application. This work can reduce water wastage and electricity consumption of the motor and thus sustain them for use in future. The dashboards have been designed such that they are easy to understand and operate. Thus, this smart gardening system is economic, convenient and user-friendly.

To improve this system, a camera can be placed in the vicinity of the plant which can capture images and images can be transmitted to the owner via internet on the app, The project design can be made more compact so that it can be fitted anywhere. Further, AI can be incorporated to check whether plant is in good condition. Solar cells can be incorporated to make the design more sustainable.

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