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Internet of Things (IoT)-based Smart Irrigation System for Sustainable Agriculture

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Abstract

A collection of networked devices having self-configuring capabilities is called the In-ternet of Things (IoT). The Internet of Things (IoT) has revolutionized every element of the typical person's everyday existence by making everything intelligent and smart. In order to monitor and regulate the field's environment in real time, this study suggests an Internet of Things (IoT)-based smart irrigation system that makes use of cloud computing, a variety of sensors, and a microcontroller. The system aims to reduce the time and energy of farmers by automating the process of monitoring field conditions and show the real-time measurement on mobile application and web application. To enable automation using IoT devices, the gathered data is processed and kept on the cloud. Temperature (DHT-11), humidity (DHT-11), soil moisture, water pump, fertilizer management (pH meter), and raindrop monitor are among the experiment's outcomes. The technology interacts with farmers to conduct decision-making analysis, and it has the ability to boost crop output and cut down on resource waste in the agriculture industry.

Keywords

Irrigation, Internet of Things, NodeMCU, Sensors, Sustainable Agriculture

1. Introduction

Since the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, sustainable development has been the cornerstone for all spheres of the political and economic spheres. Additionally, it is widely acknowledged that sustainable agriculture is a key objective for the industry, and that sustainable development on a world-wide scale depends on it [1]. There is general agreement that creating sustainable agricultural production systems is urgently necessary [2]. For most of the South Asian countries, including Bangladesh, agriculture is the main driver of economic growth and development [3]. The overuse of hazardous pesticides and the deterioration of land and water resources are to blame for Bangladesh's declining agricultural [4].

Smart irrigation systems powered by the Internet of Things (IoT) and equipped with a range of sensors have shown promise in redefining conventional farming methods. The Internet of Things (IoT) has garnered a lot of attention lately because of its potential for a number of uses, including irrigation systems. Farmers may maximize crop productivity by monitoring environmental conditions in real-time and making data-driven choices by utilizing a variety of sensors, microcontrollers, and wireless communication technologies. The need to increase yields and decrease resource waste is continual in the agriculture industry due to the growing global population and the need to produce more food in a sustainable manner. Our study has produced an Internet of Things (IoT)-based smart agricultural system that enhances crop quality and quantity while saving labor and energy expenses and water resources. This system offers a workable solution to these problems.

With the use of a variety of sensors, the project seeks to advance the development of an innovative Internet of Things (IoT)-based smart real-time irrigation system that would enable farmers to boost output while lessening their environmental effect. On the other hand, our Internet of Things (IoT)-based irrigation technology has the potential to completely transform the agricultural industry.

2. Related Works

New horizons have been opened in the field of agriculture through research in keeping with modern technology to revolutionize the field of agriculture. But we know that there is no end to innovation, but by analyzing those published research papers, we want to open a new horizon by working on the issues that need to be worked on or the opportunities that exist so that farmers can easily produce the best crops with the help of technology. In this part of the research paper, the topic of the published research paper is highlighted. Here describe various research papers related to the use of modern technology in agriculture to increase crop yield and efficiency.

Sekaran et al. [5] work with farmers to make decisions by analyzing data on temperature, humidity, soil moisture, and water consumption in the field. Priya et al. [6], focused on integrating IoT technology, including temperature, moisture, and pH sensors, with wireless networks to create a remote monitoring system for agriculture production.

Patil et al. [7], proposed a similar system, but also includes alerts through SMS and advice on weather patterns and crops. According to Dhanaraju et al. [8], there are obstacles involved in fusing technology and traditional farming, as well as instruments and apparatus utilized in wireless sensor applications in IoT agriculture.

Srivastava et al. [9], focuses on smart agriculture, which uses IoT sensors to provide information about agriculture fields and automate certain tasks. According to Nagaraja et al. [10], a smart agricultural management system measures environmental parameters and minimizes resource waste through precision agriculture by using sensors to collect data.

Dholu et al. [11], proposed a sensor node capable of measuring various agricultural parameters and creating actuation signals for actuators, with an Android application for accessing the data. Marcu's et al. [12], proposed an IoT-based system for monitoring parameters that affect plant growth, crop diseases, and soil properties to improve crop health.

3. Proposed Methodology

This paper presents the creation of a smart irrigation system that incorporates sensors and microcontrollers within an Internet of Things (IoT) framework. By using continuous monitoring of the field's environmental conditions to inform plant choices, the main goal of this research is to demonstrate the sophisticated capabilities of the microcontrollers. The aim is to demonstrate the system’s smart and intelligent features.

The objective of this project is to create a battery-operated smart irrigation system that uses a network of wireless sensors to track temperature, water pump performance, fertilizer management, soil moisture, and raindrop monitoring. In addition, the system features a NodeMCU ESP8266 that serves as an Internet of Things gateway and is outfitted with Wi-Fi modules for data transfer and wireless communication. Sensor data is sent to the cloud so that users may utilize an application to remotely view and monitor the parameters. By uploading the data to the cloud, it enables the user to access and monitor the parameters continuously and conveniently.

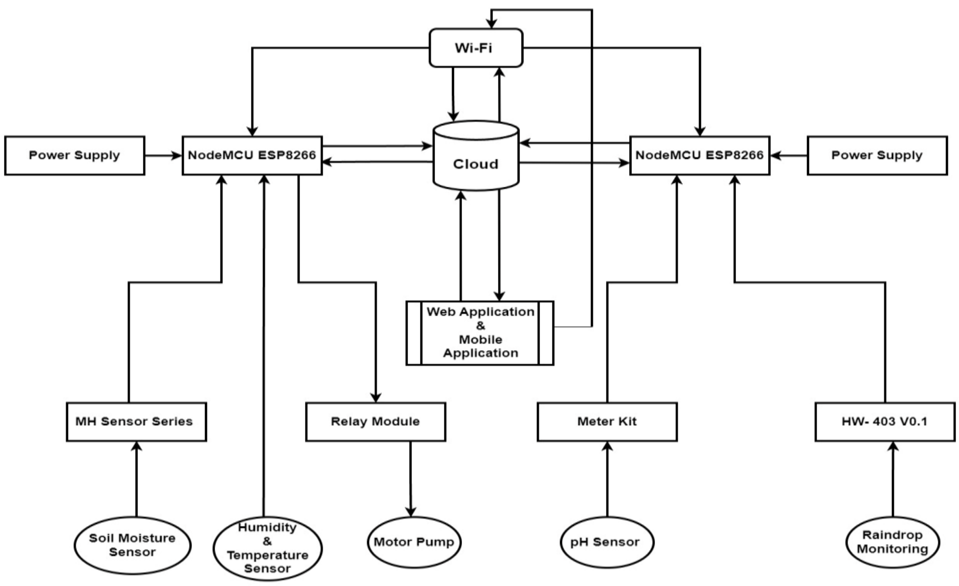

Figure 1. Block Diagram of Internet of Things (IoT)-based Smart Irrigation System

The block diagram of the suggested system is displayed in Fig. 1. Two NodeMCU ESP8266s make up the system. The water pump, soil moisture sensor, and DHT-11 temperature and humidity sensor all require one NodeMCU ESP8266. Rain and pH sensors are operated by the other NodeMCU ESP8266. The NodeMCU ESP8266 functions as both the IoT gateway and the central command center for all board activities. Sensors are in charge of identifying different physical parameters and translating analog to digital signals. The field's temperature and humidity are measured by the temperature and humidity sensors, respectively. To find out how much moisture is in the soil, sensors that use a capacitive sensing method are called soil moisture sensors. A water pump is available that can be turned ON or OFF based on the farmer’s decision. When the farmer sends a signal to the cloud, it is forwarded to the gateway, which then activates the relay and turns ON the water pump. Additionally, a rain sensor is utilized to detect rainfall. If rain is detected, a signal is sent to the cloud, which in turn sends a signal to the application via the gateway. A pH sensor cannot directly measure fertilizer in the field. However, it can be used to indirectly monitor the effectiveness of fertilizer by measuring the pH level of the soil. When fertilizer is applied to the soil, it can affect the pH level of the soil. Some fertilizers, such as those containing ammonium, can cause the soil to become more acidic, while others, such as those containing lime, can make the soil more alkaline. By using a pH sensor to measure the pH level of the soil, farmers can monitor the impact of fertilizer on the soil acidity and adjust their fertilizer application practices accordingly. In general, farmers may make better judgments about how to apply fertilizer by combining IoT technology with a pH sensor. This can lead to more effective resource utilization and possibly higher crop yields. The data management during the processing stage is done by the cloud. This consists of a Web server, a database that houses the gathered information, and an algorithm that makes choices based on the information. The Android application receives the decision-making algorithm's result during the information distribution phase.

4. Result and Discussion

Making decisions instantly based on real-time data is made easier by the use of the Internet of Things (IoT) in smart agriculture systems. After giving the farmer access to the Android or web application, the system is implemented in three stages: sensing, processing, and distribution of information. Sensors attached to the NodeMCU ESP8266, the IoT gateway, enable the detection of physical parameters including temperature, humidity, moisture, fertilizer, water pump, and raindrop monitoring during the sensing phase.

Figure 2. Internet of Things (IoT)-based Smart Irrigation System

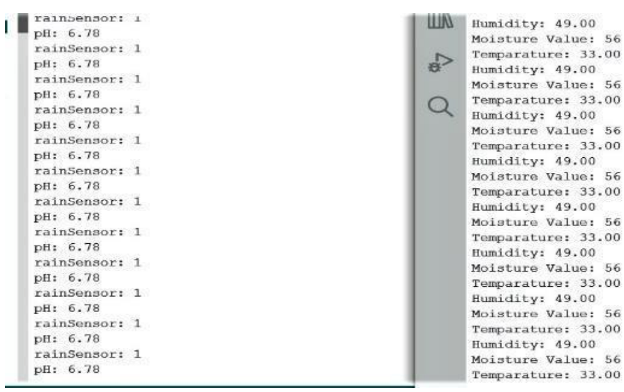

Figure 3. Serial Monitoring of the Proposed System

Figure 2 depicts the entire suggested system, a Smart Irrigation System based on the Internet of Things (IoT). The board uses the Wi-Fi ESP8266 module to send the gathered data to the cloud. A web server, a database for keeping track of the gathered data, and decision logic for choosing the right course of action in response to the sensed data make up the cloud architecture. The output of the decision logic is sent to the Android and web application at the information distribution stage. Every single measurement that is received, analyzed, and shown on the Serial Monitor window is depicted in figure 3. Temperature, humidity, soil moisture, raindrop monitor, and pH level are all monitored during the procedure.

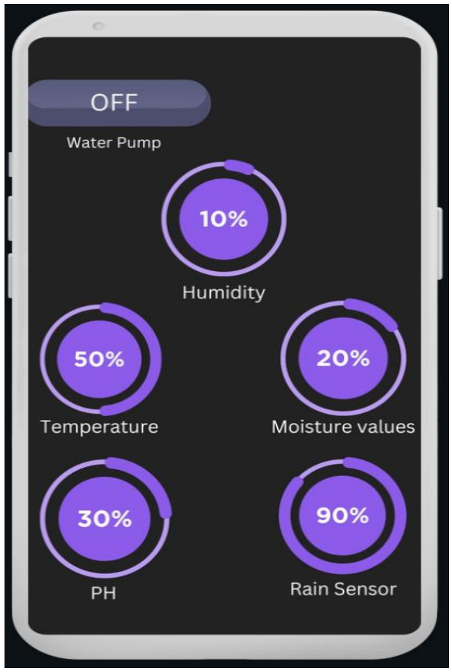

Figure 4. Real-Time Monitoring in Mobile Application

Figure 5. Real-Time Monitoring in Computer Application

Figure 4, showed the entire individual monitoring via mobile application. However, the disguising feature in this system is that the motor pump switch. The switch is manually programmed to turn ON or OFF based on the moisture level. The Figure 5, also show real-time data that collect from the sensors via computer interface. If we look all the part of data monitor at a time showing all the data are same that means our developed system works successfully.

5. Conclusion

For sustainable agriculture, the Smart Irrigation System, powered by the Internet of Things (IoT), is revolutionary. This system makes use of a number of sensors to keep an eye on and gather information on critical variables such as pH level in the field, soil moisture, water pump, temperature, and humidity. The data gathered by these sensors is processed and analyzed on the cloud with the aid of an IoT gateway, and the farmer receives the results through an Android application. This system not only helps farmers in making informed decisions regarding temperature and humidity, soil moisture, water pump, fertilization, and rain monitoring, but it also increases the efficiency and productivity of the farming process. With technological advancements, this system is poised to revolutionize the agriculture sector providing sustainable solutions for the ever growing demand for food production.

6. Future Work

While our research work has made substantial contributions to the understanding and implementation of IoT-based Smart Irrigation Systems, there remains a rich landscape for future exploration and development in this field. The following are some directions for future work:

- **Integration of AI and Machine Learning:** The predictive capabilities of an Internet of Things (IoT)-based smart irrigation system may be further improved by integrating cutting-edge AI and machine learning algorithms. These systems are able to predict the demand for irrigation, identify irregularities, and offer more accurate water consumption recommendations by examining past data.
- **Remote Sensing and Satellite Technology:** Future research can explore the integration of remote sensing and satellite technology to monitor larger agricultural areas. This could facilitate a more comprehensive and efficient approach to precision irrigation, especially in large-scale farming operations.
- **Scalability and Cost Reduction:** Research into scalable and cost-effective Internet of Things (IoT) components and systems is essential. Lowering the cost barriers will make this irrigation system more accessible to small and resource-constrained farmers, thereby increasing its adoption.

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