Smart Greenhouse Monitoring and Controlling based on NodeMCU

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***Abstract*—Food security is one of the major rising issues as the human population is larger and the land available for cultivation is smaller, as well unassured affairs happened often in society especially in the current CoVID-19 rapidly spread days. To mitigate this condition, further improve the yields and quality of food, this paper proposed a smart and low-cost greenhouse monitoring and control system, which mainly consists of sensors, actuators, LCD display and microcontrollers. DHT22 sensor is used to get the surrounding temperature and humidity in the greenhouse, and NodeMCU is used as the main microcontroller. Some other facilities such as fan and heater are used to adjust the inside environment. The system could monitor the growth environment continuously with Internet-connected, the monitoring data is transmitted and stored in the ThingSpeak cloud, the users can visualize the live data through a webpage or phone APP in real-time. If the environment condition is out of the predefined level, the environment is monitored continuously, and the system can be adjusted automatically. This system can be deployed in the greenhouse simply and maintain the greenhouse environment in a normal range dynamically and continuously.**

Keywords*—*Smart greenhouse; ThingSpeak cloud; NodeMCU

I. Introduction

As urbanization is continuously expanding, resulting in a huge decrease in arable land, the rapid growth of human population has increased the demand for food as well. The traditional agriculture method is not satisfied with current demands [1]. The problem of food for humans is becoming more and more serious. Food security is still a main issue in current days, it is an integrated and long-term task to deal with not only for agriculture but also for political will [2]. Climate change has resulted in severely damaging agroecosystems of the Loess Plateau in China, further aggravating the loss of soil and crop yields [3]. The living standards of people are greatly affected. The traditional farming model requires more land and manpower to manage, so traditional farming along could not be sufficient and resolve food security problems, it requires to apply of modern technology especially the Internet of Things (IoT) to improve it in this digital age.

In nowadays, the greenhouse is applied widely in the countryside to plant crops or vegetables for the whole year regardless of the seasons. It has heat-keeping, anti-coldness, and transparency characteristics. The main significance of greenhouse is the climate inside can be controlled at a suitable level constantly of the specific plant favorable. Some important nursery factors such as temperature, humidity, soil moisture, pH, light intensity et al [4]. Along with the yield prediction character, the most efficient production of the greenhouse could be possible with the help of advanced technology. Researchers and Engineers use Internet of Things (IoT) and other modern technologies to make it realize. With the popularity of smartphones, farmers could use phone to monitor and control the greenhouse in real-time without extra human intervention [5]. IoT technology applied in agriculture is a developing trend, the potential benefits not only expand the yields and quality of the planting crops but also reduce farmers' burden and improve income.

It is important to apply smart greenhouse technology in urban areas. An Arduino uno based smart greenhouse prototype was designed and implemented, the greenhouse environment is monitored in real-time and can be accessed through an Android application. The user also could use the Android phone to manually control the inside environment remotely. The prototype was examined and highlighted that it could improve the yields of plants [6]. An STM32-based temperature monitoring and control system was developed; this development proved that smart agriculture could ease the management burden and increase the yields of crops [7]. Artificial intelligence (AI) technology is playing an important role in the smart greenhouse as well. An improved fuzzy neural network algorithm was designed to fit the intelligent greenhouse development. It is a trend that different technologies such as 5G, AI, NB-IoT, and Cloud should be applied to make the greenhouse more sustainable and smarter [8]. The greenhouse can be designed and implemented in a modern way by using different kinds of technologies.

The rest of this paper is divided into sections mentioned below: Section II is about the literature review, it summarizes the corresponding works of the smart greenhouse. In Section III, the proposed system and experimental setup are presented in detail. In Section IV, the results of this research project are described. Finally, the conclusion is summarized in Section V.

II. Literature Review

Though IoT technology is widely used in different fields, such as smart parking systems, smart healthcare and so on, it still does not apply in large-scale agriculture in many countries especially developing countries. A Lora-based small-scale smart greenhouse was developed; the system could monitor soil moisture, light strength and temperature; the data was transmitted to the Tata server; and the data could be retrieved from Microsoft Azure Cloud and displayed on the developed webpage through the network [9]. In order to further efficient management of farming, a camera was deployed not only to monitor the growth conditions of plants, but also to check which disease the crops have by using image processing technology [10]. An Esp8266-based smart and automated controlling agriculture system was designed, four parameters: temperature, humidity, light and soil moisture were monitored in real-time, the data was transferred to the customized webpage through a wireless network, the system also could adjust its environment conditions automatically if one factor was out of the predefined threshold so that it could maintain the optimum environment for the crops to grow rapidly [11]. A data analysis platform based on docker technology was designed and implemented; this platform was deployed simply regardless of the underlying operating system [12]. Data analysis is an important process after data gathering in IoT technology.

The yields of outside crops are mostly influenced by severe weather such as rain, and storm. The change of temperature and humidity could result in different diseases for the crops. An Arduino Nano-based smart agriculture system was developed to realize monitoring and controlling of the greenhouse in real time, in this study, compared with traditional monitored parameters: temperature, soil moisture and light intensity, one more rain sensor was used to detect the weather conditions, and to trigger the top of the greenhouse open or close automatically to irrigate the crops. Users not only could see the monitoring environment values on a 16X2 LCD display, but also access the data through the designed phone application remotely [13]. An intelligent supervisory fuzzy controller (ISFC) was developed to control and adjust the greenhouse environment remotely [14]. Soil is the base for plants to grow, so an intelligent soil management system is designed and developed, it is more convenient for farmers to manage and maintain their crops in the greenhouse [15]. Farmers could observe the monitoring data through a blynk application. In order to quickly identify the vegetable disease, deep learning algorithms were integrated into the smart greenhouse monitoring system to avoid loss in the early stage [16]. With the help of machine learning technology can make the whole smart greenhouse system more intelligent [17]. Solar power could be used as a renewable resource to provide electricity for the whole smart greenhouse monitoring system. It not only reduces the cost, but also no pollution to the environment. And the extra power was stored in the rechargeable battery to save cost [18]. A smart greenhouse system can be integrated with hydroponics planting, the soil is saved in this way, and it could provide rich nutrients to make the vegetables grow freely and rapidly [19]. With the help of advanced technology, the smart greenhouse is executable and efficient.

III. PROPOSED SYSTEM

Internet of things (IoT)-based technology applications are a tendency to make everything intelligent and facilitate. In this project, a low-cost and sustainable smart greenhouse monitoring and controlling system for agriculture is designed and developed. The architecture and experimental prototype setup of this research project are presented in this section.

A. System Architecture

In this project, the greenhouse environment not only can be monitored in real-time, but also it can adjust the environment conditions: temperature and humidity at a suitable level automatically and continually. If the temperature is lower than the predefined threshold, the heater would turn on, if the temperature is higher than the preset temperature or the humidity is outside the threshold, the fan would turn on, otherwise, the fan and heater are turned off. Users can remotely access the monitoring data by phone or webpage through the network wherever the users are. The proposed architecture of the smart greenhouse system is illustrated in Fig. 1.

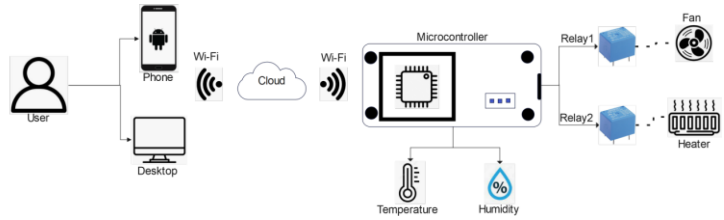

Fig. 1. System Architecture.

B. Experimental Setup

This project is developed based on a NodeMCU microcontroller coupled with other electric devices. NodeMCU is a low-cost and open-source Internet of Things developing platform. Arduino IDE is used as the programming tool; the firmware development is based on the ESP8266 environment. The NodeMCU diagram is shown in Fig. 2.

Fig. 2. NodeMCU Microcontroller.

HT22 sensor is used as the humidity and temperature detecting node. It has 4 pins: VCC, DATA, NC, and GND. The normal voltage range of VCC is from 3v to 5v. The working principle of DHT22 is through a built-in capacitive humidity sensor and thermistor to measure. The data is transmitted to the controller through the DATA pin. The maximum working current is 2.5mA [20]. The picture of the DHT22 sensor is shown as Fig. 3.

Fig. 3. DHT22 Sensor.

According to the proposed system architecture, a small-scale and easy-installed smart greenhouse monitoring and controlling system prototype is designed and implemented. In this system NodeMCU is applied as the main microcontroller to collect and transfer the monitoring data, a DHT22 sensor is used to get the temperature and humidity of the environment, the collected data is stored in the ThingSpeak cloud, the data can be visualized through a mobile application or ThingSpeak website through specific channel ID. A two-channel relay is used as the actuator to connect the heater and fan. The diagram of the relay is shown as Fig. 4.

Fig. 4. 2-Channel Relay.

A 16x2 LCD is used to display the current monitoring environment values. The connection of the hardware modules is shown as Fig. 5.

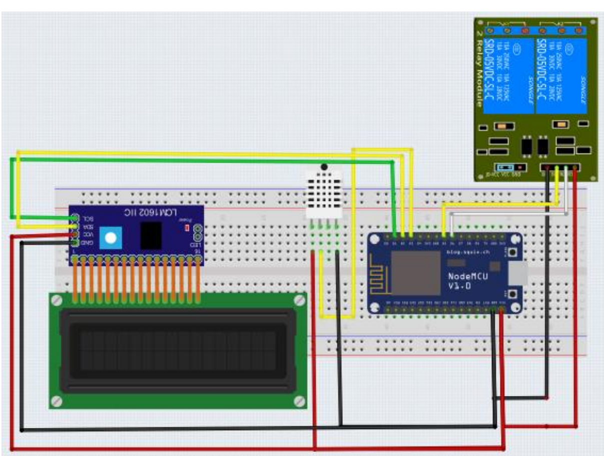

Fig. 5. Connection of Hardware Modules.

The prototype of the proposed system is designed and implemented, and is shown as Fig. 6. LCD display, DHT22 sensor, 2-channel relay, switch and NodeMCU microcontroller are deployed on the top of the printed circuit board (PCB) board. Two 18650 batteries are used to support power for this system and put on the back of the PCB board. The relays connect to the fan and heater. The LCD display screen is connected to the microcontroller via an I2C interface. The real-time monitoring data can not only be displayed on the LCD display screen but also can be visualized by phone APP and webpage through network.

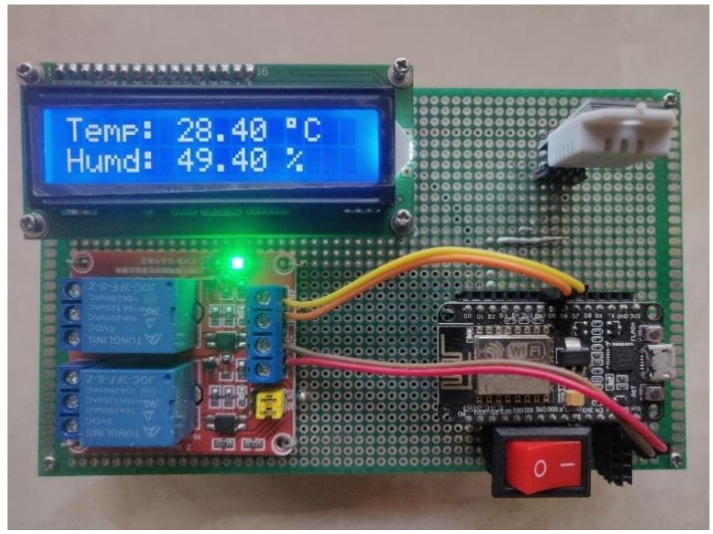

Fig. 6. Implementation of Proposed System.

IV. Results

The data also can be assessed through a mobile application called ThingView or ThingSpeak website remotely with an Internet connection. The monitoring data from the ThingSpeak webpage is shown as Fig. 7. From the platform, users can monitor the greenhouse environment in real-time. The live data is accessed through the smartphone application with a specific channel ID and is shown as Fig. 8. The data is updated every 15 seconds. The greenhouse environment is adjusted at a predefined suitable level dynamically.

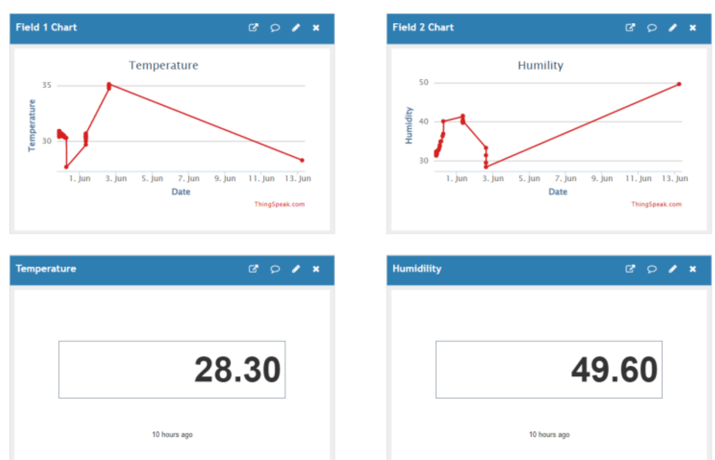

Fig. 7. Real-Time Monitoring Data through Webpage.

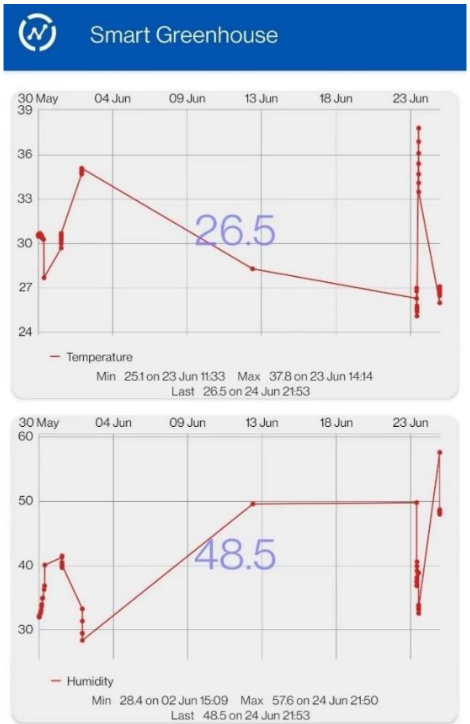

Fig. 8. Real-Time Monitoring Data through Phone APP.

V. Conclusion

Based on the research question, data analysis is a useful way; from the simple test demonstration we can conclude that there is a negative relationship between temperature and humidity. In the future, machine learning technologies such as clustering and classification algorithms can be applied in this system, based on the big data and machine learning technology the expected model could be constructed accurately, and the model can decide whether to activate the specific instrument to predict and adjust current condition for the whole greenhouse system. It adjusts the environment in a normal range dynamically and automatically, to avoid big losses and reduce human intervention.

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