IoT based smart embedded system for greenhouse parameter monitoring and control

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Abstract: **- In the present work attempt has been made for technology assisted greenhouse parameter monitoring and parameter control system based on the Internet of things (IOT). The four important parameters inside the greenhouse are considered that are temperature, relative humidity, soil moisture and light. Commercially available sensors are used for sensing parameters and Arduino core microcontroller is used for overall data acquisition, processing and communicating data on to an internet channel via ESP8266 Wi-Fi module. Think speak server service is used for IoT perspective use of acquired data. The developed greenhouse module have ability to show sensed parameter on LCD display. The module is trained to take decision appropriately to maintain the optimized greenhouse environment for specific crop. The green house controller ON/OFF the actuators as per need.**

Keywords: **Green house, IoT, Wi-Fi Module (ESP8266), Arduino Uno, Greenhouse Sensors, Greenhouse Monitoring**

I. Introduction

Growth in agricultural sector is necessary for the development of economic condition of the country. Unfortunately, many farmers still use the traditional methods of farming which results in low yielding of crops. But wherever automation had been implemented and human beings had been replaced by automatic machineries, the yield has been improved. Hence there is need to implement modern science and technology in the agriculture sector for increasing the yield [1].

A greenhouse is a structure made mainly of transparent material such as plastic sheet, in which crop or plants are grown in a controlled environment. Greenhouse agriculture needs to control the environmental factors to obtain the optimum growth conditions for the crop. Currently, artificial management is the major way to detect and control the environment factors, wastes lots of manpower and relatively large of monitoring error, affecting the growth of crops. To achieve the intelligent monitoring of greenhouse environment parameters like temperature, humidity, soil moisture and light intensity and keeping the user continuously informed of the conditions inside the greenhouse using IoT technology [2].

The several authors have proposed IoT concept in agriculture for pollution monitoring [3], greenhouse [2]. An IoT Based Real-Time Environmental Monitoring System[4], An embedded system approach for monitoring greenhouse based on parameters such as humidity, pH of water, wetness of soil, temperature and light intensity [5-7]. These parameters are measured using sensors, processed, controlled and informed to the proprietor through Short Message Service technology using GSM modem. Prakash. H. Patil et. al. [8] developed a greenhouse monitoring system using GSM, which monitors the levels of temperature, humidity, light, and CO_2. Their proposed system uses sensors and Short Message Service technology.

The most of the existing systems employed GSM based SMS systems for continuously informed the farmers about conditions inside the green house; these type systems unaffordable, bulky, difficult to maintain and less accepted by the technologically unskilled workers. There are also some attempt has been made for IoT based monitoring but lacks of control facility.

This paper proposes an IoT based system to monitor and automatically control the four different greenhouse parameters that are temperature, humidity, light intensity and soil moisture. If the sensed data crosses a predefined threshold range an alarm will be triggered which will alert the user. The system in auto mode can control the parameters by actuating Fans, foggers, light and water pump. The sensed parameter logged on to thing speak server using IoT module. The customized internet channel is created on Thing speak server for displaying and analyzing data. In this way greenhouse can be monitored remotely at any time.

II. Material and Methods

A. Architecture of the system

The greenhouse monitoring system uses various sensors to sense the environmental parameters of the greenhouse. The parameters used to monitor the greenhouse are temperature, humidity, light intensity and soil moisture. The block diagram of developed system is shown in Fig. 1. It is built around Arduino MCU, DHT11 sensor for temperature and humidity sensing, YL-69 sensor for soil moisture sensing and LDR for light intensity sensing. ESP8266 Wi-Fi module is used for communicating sensor data from MCU unit to Thing speak server.

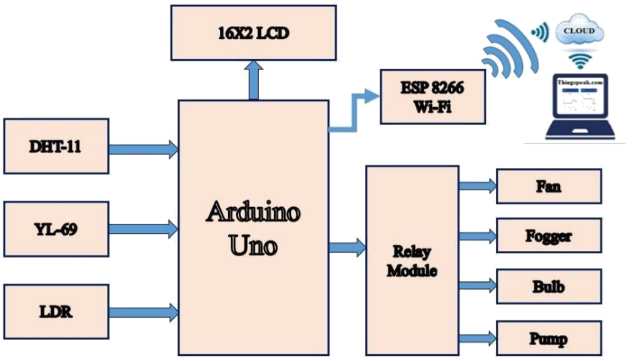

Figure 1 Block diagram of developed system

The data collected from the sensors are send to the microcontroller for processing. ATmega328 MCU based on Arduino platform is used. The microcontroller is also connected to a Wi-Fi module ESP8266 which connects the system to the internet. After processing, the data is send over the internet to be displayed on a customize webpage. From the thing speak based server the humidity, temperature, soil moisture and light intensity values can be seen graphically on from anywhere in the world. There are also auto controlling facility in system which control the parameters of greenhouse environment by switching on and off actuators.

B. Sensors and Hardware used in the system

Table 1 shows the various sensors, microcontroller and Wi-Fi IoT module used for system development.

Table 1 Sensors and hardware used in the system

Sr. No.	Hardware	Work	Range/Specification
1	DHT 11	Temperature and Humidity Sensor	Temp: 0-50°C Humidity: 20-90% RH
2	YL-69	Soil Moisture Sensor	V_{out}: 0 ~ 4.2V
3	LDR	Light Sensor	V_{out}: 0-5V
4	ESP8266	Wi-Fi IoT Module	2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2)
5	Arduino Uno	Microcontroller	8 bit AVR family microcontroller

DHT-11: Temperature and Humidity sensor

The component is 4-pin single row pin. The MCU interface is shown in figure 2.

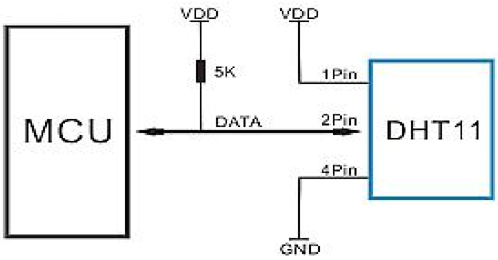

Figure 2 Interfacing DHT11 to MCU

The DHT11 is a commercially available digital temperature and humidity sensor. It is based on a capacitive humidity sensing and a thermistor for measurement of temperature of the surrounding air, and spits out a digital signal on the data pin. The sensor provides temperature and humidity data every 2 seconds. User must be careful about timing to grab data from data pin. Each DHT11 is strictly calibrated in the laboratory for humidity and temperature scale calibration. The single-wire serial interface makes system integration quick and easy.

Technical Specifications are: Measurement Range 20-90% RH 0-50°C, Humidity Accuracy ± 5% RH, Temperature Accuracy ± 2°C, Resolution 1, Package 4 Pin Single Row

YL-69 Moisture Sensor

The YL-69 is a hygrometer sensor for sensing the soil moisture. Sensor or the hygrometer is usually used to detect the humidity of the soil. The automatic watering system or to monitor the soil moisture of plants using this sensor is quite accurate. The sensor is set up by two pieces: the electronic board and the probe head with two pads that detects the water content .The sensor has a built-in potentiometer for sensitivity adjustment of the digital output (D0), a power LED and a digital output LED, seen in the following figure 3.

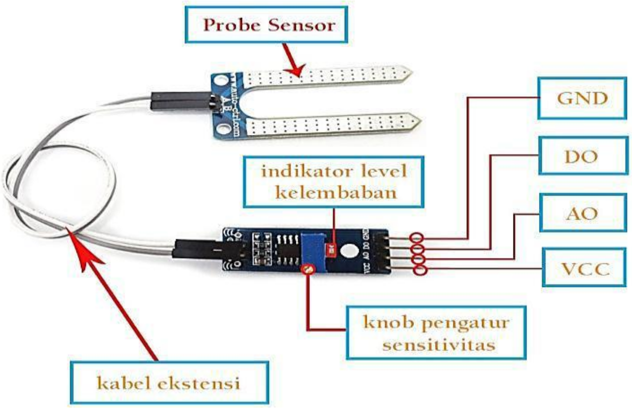

Figure 3 YL 69 Soil moisture sensor probe

The o/p voltage of sensor probe changes accordingly to the water content in the soil. When the soil is: Wet: the output voltage decreases and When the soil is: Dry: the output voltage increases. The output can be a digital signal (D0) LOW or HIGH, depending on the water content. The electronic board have op-amp based comparator. The sensor probe signal is compared with predefined value. If the soil humidity exceeds a certain predefined threshold value, the modules outputs LOW, otherwise it outputs HIGH. The threshold value for the digital signal can be adjusted using the potentiometer. The output can be an analog signal and so a MCU acquired value is between 0 and 1023 because ADC is 10 bit.

LDR

The LDR is used for light intensity sensing purpose. The sensing circuit arrangement is shown in figure 4. The LDR is connected in half bridge circuit where load resistor of 10K is used. The voltage across load resistor is fed to the analog pin of the Arduino. The analog Pin senses the voltage and gives some analog value to Arduino. The analog value changes according to the resistance of LDR. As the light falls on the LDR the resistance of it get decreased and hence the voltage value increase. Converse is true.

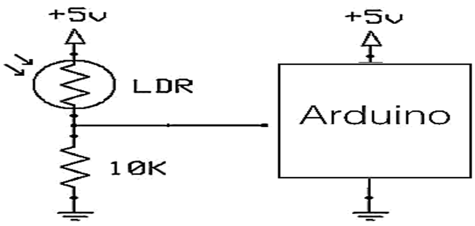

Figure 4 LDR used as light intensity sensor

IoT module and Think speak server

ESP8266 Wi-Fi module is used to connect the greenhouse monitoring system to the internet. It is Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Espressif Systems [9]. Thing-speak server is used in this project for creating internet webpage for uploading data. Thing-Speak server is an open source data platform and API for the Internet of Things that enables us to collect, store, analyze, visualize, and act on data from sensors [10]. Channel ID: 670603 is created on Thing speak server for data uploading, analyzing and visualizing.

C. System software implementation

Arduino IDE was used to program the MCU for data acquisition from sensor modules and data communication to the cloud. Wi-Fi module ESP8266 works as client and Thing speak as server. It was initialized by sending AT commands in the required pattern to make it work as a client. Wi-Fi module ESP8266 is initialized as a TCP/IP client. Once various sensor data are read by the microcontroller and uploaded it to the cloud, IoT analytics service of Thing Speak is used to aggregate, visualize and analyze live data streams. Thing Speak provides instant plot of the real-time uploaded data by the system. The Wi-Fi module communicate data to the cloud through its assigned IP. An API key is assigned to observe the results over Thing Speak channel. Figure 5 shows the flowchart of the program.

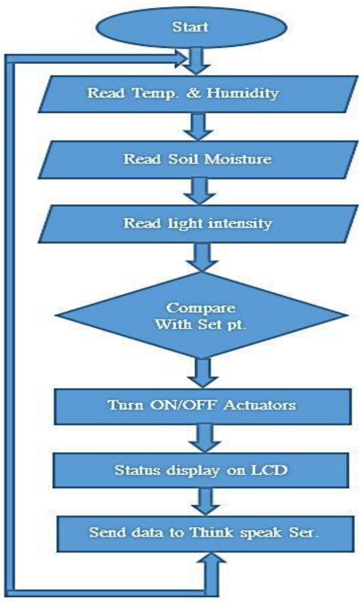

Figure 5 Flowchart of the system software

III. Result and Discussion:

Figure 6 shows the live data of four sensors with respect to time. The first graph is of temperature vs. time.15 seconds are required for updating.

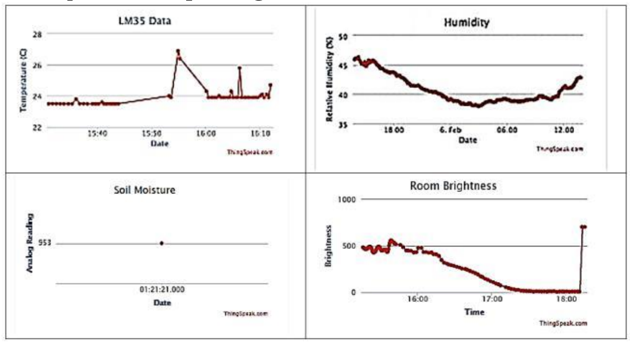

Figure 6 Thing speak channel user interface

The system is programmed for automatic controlling the environmental parameters in greenhouse. For testing temperature controller, hair dryer and fan is used for increasing and decreasing the temperature respectively. The threshold value of 25^0 C is kept to examine the performance of the system. We observe, the system automatically ON/OFF the dryer and fan to control the temperature. The action of dryer and fan when crossing the set point is given in table 2. The spike can be viewed in the thing speak plot after which the temperature is settled to ambient value. The system have auto humidity control facility. The fogger is used to test the humidity controlling action. The threshold is kept at 40RH. If humidity crosses below the said limit then automatically fogger is made ON to lower it.The humidity sensor data plot also made visible on thing speak channel. In same manner light intensity and soil moisture control facility tested using bulb and water pump respectively. Below table 2 shows the set point values kept for controller action and the status of various actuator after crossing threshold set point.

Table 2 System auto parameter control observations

Sr. No.	Condition	Actuators
1	Temperature < 25	Fan OFF
2	Temperature > 25	Fan ON
3	Humidity<40	Fogger ON
4	Humidity>40	Fogger OFF
5	Light<100	Bulb ON
6	Soil>700	Motor ON

IV. Conclusion

The developed IoT based smart greenhouse system is a complete system designed to monitor and control the environmental parameters inside a green house. The traditional system for greenhouse monitoring is labor-intensive and time consuming. The developed system efficient in sense time saving, cost effective and require less labour and human effort. The system provides a controlled environment for the crop to prevent them from damage and thus increasing the overall produce. The smart greenhouse controller automatically controls the various environmental parameters needed for the crop and sends the sensory data to a customized internet channel or server from which continuous and effective monitoring is possible.

ACKNOWLEDGEMENT

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