Smart Greenhouse using ThingSpeak IoT Platform

Nang Noom Yein Sang
Faculty of Computer Systems and Technology, University of Computer Studies (Taunggyi)
noomyeinsang@ucstgi.edu.mm

Nang Kaythi Hlaing
Faculty of Computer Systems and Technology, University of Computer Studies (Taunggyi)
nangkaythihlaing@ucstgi.edu.mm

Abstract

Greenhouse deployment of farms gives hope for the farmers on higher crop yield, through lowering risks against pests, insects and adverse climatic conditions. Automation of greenhouse benefits the farmers in various ways by detection of soil and water quality and environment temperature. Smart greenhouses are introduced to cultivate any plants in any seasons and to reduce the employee costs. In this paper, a smart greenhouse system is implemented by using microcontroller Arduino Mega, relays and Wi-Fi module with various sensors namely moisture, temperature and light sensors. Our system is aimed to be capable of providing fully automatic environmental controls. System monitoring is possible with the support of ThingSpeak open-source Internet of Thing platform

Keywords: Arduino Mega; Relay; Wi-Fi module; ThingSpeak Internet of Thing

1. Introduction

Myanmar has wide range of terrain and ecological and climatic zones. But, recently as the consequences of climatic changes, the main problems such as insufficient rainfall in the dry season, insufficient funding for the sustainable operation of water resources management infrastructure, and so on, are facing. One of the possible solutions to these problems is Automatic greenhouse system. Greenhouse farming is considered as an implementation of intensive agriculture and can provide an increase in crop production. It can able to grow more plants per square feet compared to growing crops in an open field.

To cultivate any plants in any seasons, we need to analyze the environmental condition of the desired plants. The significant environmental factors for the quality and better productivity of the plants are temperature, relative humidity, lighting, and amount of soil moisture in the greenhouse. [3]. Continuous monitoring of these factors gives relevant information pertaining to the individual effect of obtaining maximum crop production [1]. Therefore, the corresponding sensing value of these factors is needed to assign in sensors to measure the value of environmental condition in greenhouse. Researches on IoT based smart greenhouse has been popular recently. The IoT 'ThingSpeak' web service acts as a host for the variety of sensors to monitor the sensed data using a channel ID and read API key is presented in [2].

In this paper, an automated greenhouse farming system is designed by using an Arduino Mega, relays and ESP8266 Wi-Fi module as main components. In our system, the temperature, moisture and light sensors are also used for collecting the data from the greenhouse environment.

2. Overview of the System

In our system, there are two main parts: system control unit and system monitoring unit. Overview of the proposed system layout can be seen in Figure 1.

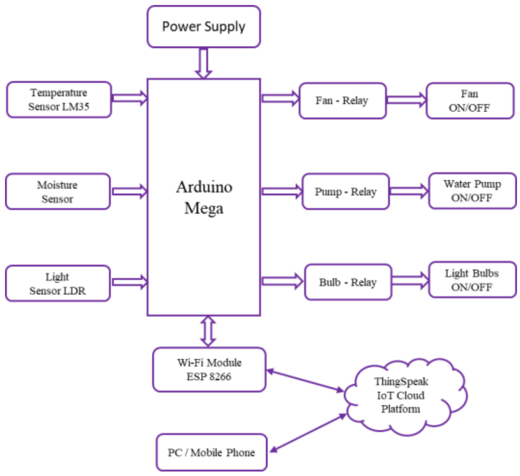


Figure 1. Greenhouse system layout

2.1. System Control Unit

The main control part contains Arduino mega microcontroller and the **three relays**. It is responsible to provide suitable climate conditions for plants in the greenhouse. This condition is adjusted by the controller which obtains the output values from temperature sensor, moisture sensor, LDR as the input, and then determines to send the appropriate output to the relays that controlled the fan, the water pump and the bulb.

2.2. System Monitoring Unit

Thingspeak is an open source platform that enables the establishment of sensor logging application for IoT and API to store as well as retrieve the data from things using HTTP protocol over the internet. The Internet of Things provides access to an extensive range of embedded devices and web services [7]. In our work, system monitoring is done with the help of ThingSpeak IoT platform.

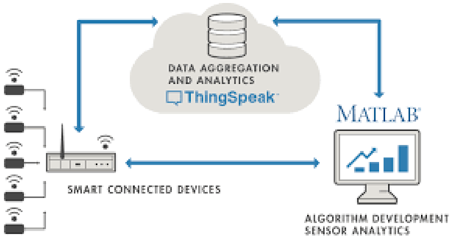


Figure 2. Connecting to ThingSpeak

Figure 2 depicts how the system components interact with ThingSpeak. On the left, smart devices (the "things" in IoT) that live at the edge of the network can be seen. The right side depicts the algorithm development associated with the IoT application. In this case, the data is pulled from the IoT platform into a desktop by getting channel on ThingSpeak dashboard freely [8].

3. System Design and Requirements

Hardware and software components which are interfaced to implement this system are described in the following sections.

3.1. Software Requirements

Hardware- software interfacing is done using MikroC. Proteous Design Suite is also used for designing, testing, and debugging our system prior to actual system implementation.

3.2. Hardware Requirements

The hardware components required for our test bed are as follows:

- Microcontroller Arduino Mega
- Temperature Sensor LM 35(3.3V)
- Light Sensor LDR (3.3V)
- Moisture Sensor (Spark fun 3.3V)
- Three 5V-Relay
- LCD board
- 12-V fan
- Wi-Fi Module (Node MCU ESP 8266)
- Light Bulb
- Water pump

The prototype for our greenhouse system is shown in Figure 3.

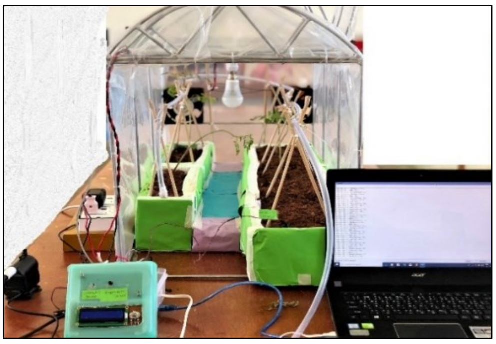


Figure 3. Greenhouse system design

The following sections discuss about the two main components used in our system.

3.2.1. Arduino Mega

The Arduino Mega 2560 in Figure 4 is a microcontroller board based on the AT mega 2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. [4]. In our system, Arduino Mega acquired the sensors' values and processed them to adjust the desired environmental conditions.

Figure 4. Arduino Mega 2560

3.2.2. Wi-Fi Module (Node MCU ESP 8266)

The ESP8266 Wi-Fi Module in Figure 5 is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to Wi-Fi network. It is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor [5]. In our system, it helps in transferring the sensed data to be processed on the Thingspeak Cloud.

Figure 5. Wi-Fi module

3.2.3. 5-V Relay Module

A relay is a device which let low current consumed device like Arduino mega to control high current consumed device like water pump. The relay behaves like a switch. The relay has three terminals on the low current side: VCC, GND, and IN. The relay also has three terminals on the high current side: NO, C, and NC, which stand for Normally Open, Common, and Normally Closed, respectively. In our system, we used three 5V-relay modules; each controls the ON and OFF of the fan, the water pump, and the bulb.

4. Implementation and function of the System

There are two parts in system implementation: control part and monitoring part.

4.1. Control System Implementation

We implement the control system as the schematic design shown in Figure 6 in which Arduino Mega is main part of the control system interfaced with other components.

The output of LM35 is connected to analog pin A0 of Arduino. Because the Arduino analog-to-digital converter (ADC) has a resolution of 1024 bits, and the reference voltage is 5 V, the equation used to calculate the temperature (in degree Celsius) from the ADC value is:

temp = ((5.0 * analogRead(TemperaturePin)) / 1024) * 100

Soil moisture sensor module has both analog and digital output. Regarding analog values output, it output low values for high moisture and high values for low moisture. Our Arduino can read this signal in between 0 to 1023 range. In the test run, when we took the readings from the dry soil, the sensor value was 300 and in the wet soil, the sensor value was 200. So, we set 200 as the threshold in our system. The analog pin of moisture sensor is interfaced with pin A1 of Arduino. The analog pin of LDR sensor is interfaced with analog pin A2 of Arduino. Here again, threshold value for light sensitivity is chosen as 500.

We used pin D10, D11, and D12 of Arduino to connect to the three 5V relay modules which control the fan, the water pump, and the bulb, respectively. We connect the pump circuit between NO and C of the relay so that the pump is initially OFF. Giving a LOW signal to the IN pin of the relay will cause the relay to close the circuit, and the pump will run, and vice versa. The same connection layout is used for the fan and the bulb while connecting to the respective relays. The 16x2 LCD is connected to controller's pin 2,3,4,5,6, and 7 which displays the sensors' values in real time.

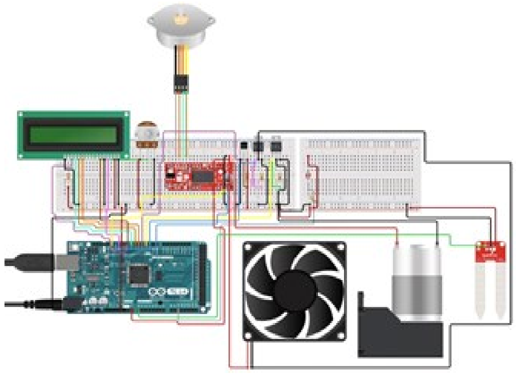
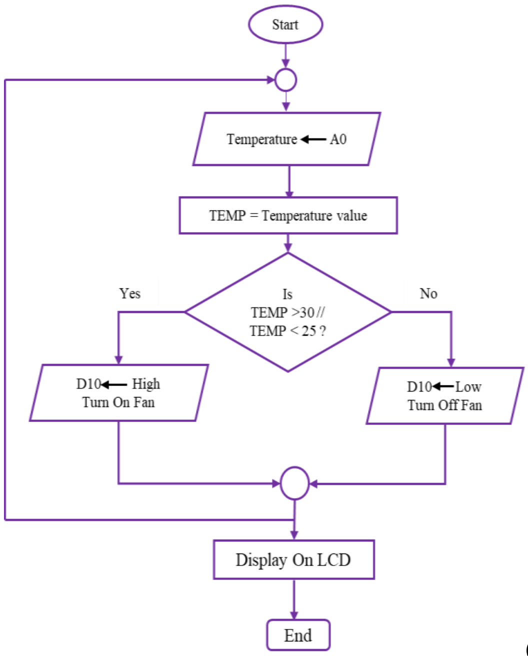


Figure 6. Circuit Diagram of System

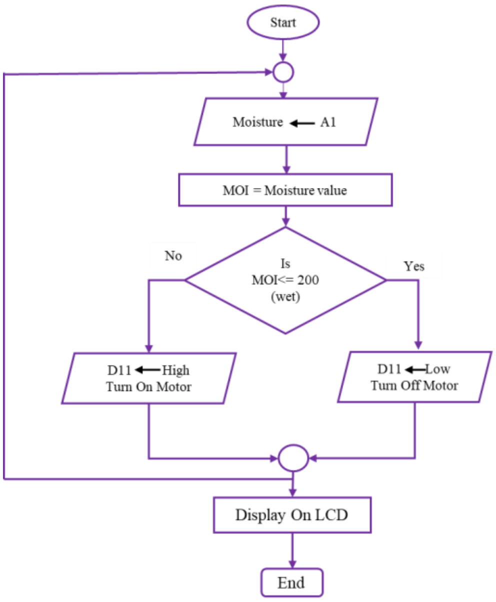
4.2. Function of the Control System

Our test bed is prepared for a Strawberry farm. The desired environmental values for Strawberry farm are set to the sensors as the threshold values. For temperature sensor, we set 30 degree Celsius as maximum and 25 degree Celsius as minimum value. The flow diagram of the system function is shown in Figure 7 (a), (b), and (c).

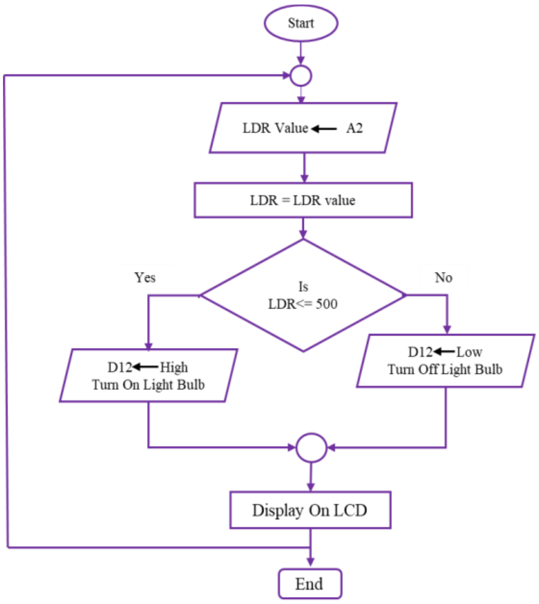


(a)

Initially, the controller acquired the sensors' values and then processed them individually and sequentially. Firstly, it checks the temperature value. If the temperature is between 25 and 30 degree Celsius, the controller will send high signal to the fan-relay which will turn ON the fan. Otherwise, it will turn OFF the fan. Secondly, the controller checks the soil moisture value. If the moisture value falls below the threshold, the controller will trigger the pump-relay to switch OFF the pump, and vice- versa. Finally, light intensity is checked. If this value is beyond the threshold value, the controller will trigger the bulb-relay to turn OFF the bulb. All the sensors' values checked by the controller is sent to display on liquid crystal display (lcd). These processes will be automated continuously.



(b)



(c)

Figure 7. System function flow diagram

4.3. Monitoring System Implementation

In this phase, we create three free channels on ThingSpeak for monitoring the data from temperature sensor, moisture sensor and LDR. To upload sensor data to Thingspeak website, we get a unique API key which is used in our programming code. After the above steps, we navigate to Thingspeak page and open the channel where the output of the sensors is shown.

4.4. Function of the Monitoring System

Sensor values are uploaded to ThingSpeak through ESP8266 Wi-Fi module. With the ability in ThingSpeak, online analysis and processing of the data are performed. The available sensor values in greenhouse can be monitored easily either on PC or Mobile as shown in Figure 8, 9, and 10.

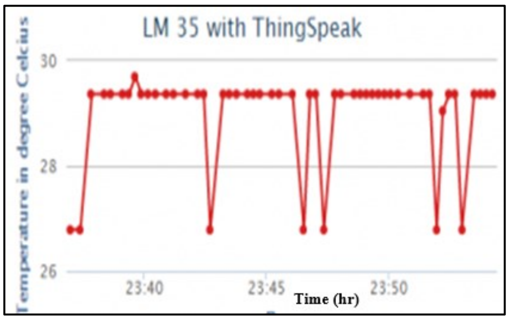


Figure 8. Temperature sensor values on ThingSpeak

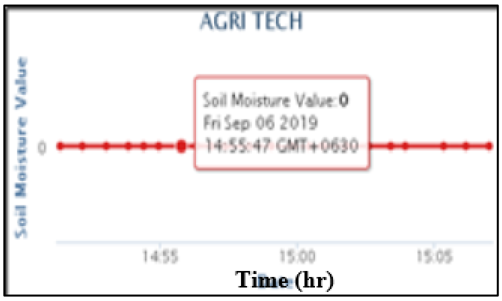


Figure 9. Moisture sensor values on ThingSpeak

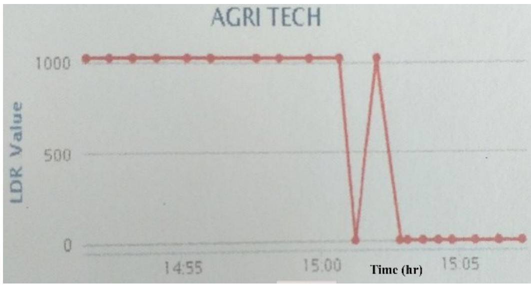


Figure 10. LDR values on ThingSpeak

5. Results and Discussion

In Figure 8, 9, and 10, the values of temperature, moisture and LDR which are measured on September 6 in 2019 is described. According to the data at that time interval, the temperature value is between 25 and 30 degrees Celsius. As a result, the fan will be Off for that time. Regarding the output shown in Figure 9, the soil moisture is lowest with the value of 0 and as a result, the pump will be switch ON. The light sensitivity values in Figure 10 says that it is needed to turn ON the bulb around 15:05hr.

It would be beneficial for the users that the environmental information in greenhouse can be available easily on users' PC or mobile in real time from anywhere as long as he is in Wi-Fi coverage. On the other hand, the graphical output at ThingSpeak cloud can be able to observe only after logging in to ThingSpeak website with the help of created username and password. So, having high technical skills will be a must for the users to access that information. More important thing is instant availability of Wi-Fi or Internet.

Absolutely higher yield of crops can be expected from greenhouse farming where the desired crops can be grown all year round without experiencing severe climate change. Moreover, growers can get more benefits from off-season production of crops.

With this greenhouse farming, unlimited water resource consumption can be reduced and control effectively. The environmental conditions suitable for the crops can be compensated easily. But the drawback is the system's high reliability on electricity.

6. Conclusion

In this paper, we present the design of automatic greenhouse farming system based on Arduino and IoT technology. ThingSpeak platform is used to monitor the environmental conditions required for the crops in greenhouse which are controlled to be at their usual values. Obviously, the system depends on advanced technology, high accuracy, and short time response sensors. By using the automatic controlled system rather than the traditional farming system, it's possible to save time, to reduce employee costs and to conserve energy sources like water and human effort. It can also support the standard lifestyle in agriculture and improve the production rate of crops which in turn increase yearly income.

6. Acknowledgment

The authors would like to thank Dr. Hsu Mon Maung for her invaluable discussions on this work.

References

[1] J. W. Yoon, "Distribution of Vascular Plants in the Ulleung Forest Trail Area, Korea", *Journal of Asia-Pacific Biodiversity Vol. 6, No. 1, pp. 1-30, 2013*

[2] S. Pasha, "ThingSpeak Based Sensing and Monitoring System for IoT with Matlab Analysis", *International Journal of New Technology and Research (IJNTR) ISSN: 2454-4116, Volume-2, Issue-6, June 2016, pp. 19-23*

[3] https://www.novagric.com

[4] https://store.arduino.cc/usa/mega-2560-r3

[5]https://www.sgbotic.com/index.php?dispatch=products.view&product_id=1825

[6]http://www.circuitstoday.com/arduino-soil-moisture-sensor

[7] T. Jagdale, M. Mali, "Greenhouse Wireless Network Monitoring and Management Using IoT", IJIREEICE .Vol. 4, Issue 1, January 2016.

[8] D. Shirsath, P. Kamble, R. Mane, A. Kolap, and R. More, "IoT Based Smart Greenhouse Automation Using Arduino", *IJIRCST*, ISSN: 2347-5552, Volume-5, Issue-2, March 2017.

[9] www.ThingSpeak.com

[10] S. Patil, and M. Jadhav, "Smart Agriculture Monitoring System Using IoT", *IJARCCE*, Vol. 8, Issue 4, April 2019.