CULTIVATION OF EXOTIC CROPS USING GREENHOUSE AUTOMATION

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Declaration

We hereby declare that our research titled "Cultivation of Exotic Crops using Greenhouse Automation"; a thesis submitted to the Department of Computer Science and Engineering of BRAC University in partial fulfillment of the Bachelors of Science in Computer Science and Engineering, is our own work and has not been presented elsewhere for assessment.

The materials collected from other sources have also been acknowledged here.

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ABSTRACT

In the current world the system of automation is the era defining technology, the vision of our future and will cause the next manufacturing revolution. The automation systems are taking over the tedious work load to ease the burdens of their owners as these systems are able to detect, analyze, notify and control the atmosphere around it accordingly. These fantasies of a smarter planet where smart systems can do the hum drum routine jobs for the humanity and bring the ethical peace of working in our overall system is being developed bit by bit. And when it comes to an important factor, like agriculture, if the automation system is applied successfully in the area, it can boom the growth of the crops. In this paper, we are representing the idea that we can boost the growth of crops by manipulating the environmental parameters responsible for the growth of plants by designing an automated greenhouse. Moreover, our aim is to go one step further than just creating an automated greenhouse. As the environmental parameters decide what crops and plants grow in an area and if we successfully control all the environmental parameters then we can not only grow the crops or trees indigenous to that area but also, we will grow any crops we want in any area. That means we can grow green crops in the middle of a desert or even we can grow exotic crops. Thus, in a nutshell, the purpose of this automation system is to influence the environmental parameters to help in cultivating all kinds of crops. The system is designed with three primitives of robotics: sense, plan, and act. Developing countries like ours can be developed if we can apply this automated system for crops.

ACKNOWLEDGEMENT

We are thankful to our thesis supervisor Dr. Amitabha Chakrabarty, Assistant Professor, Department of Computer Science and Engineering (CSE), BRAC University, for giving us direction and providing valuable feedbacks throughout our thesis work to complete our thesis. We would also like to thank all our friends and classmates for supporting us and helping us by providing moral support and thank all other faculty members of School of Engineering and Computer Science from whom we gained our knowledge and helped throughout the thesis work. We are very thankful to the Almighty Allah, who gave us the opportunity, determination, courage, patience in hard times and gave us strength to complete our project. Our family members also gave us a lot of support throughout this project.

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Chapter 1

Introduction

Nowadays all areas have been blessed by science and technology advancements, so to help it progress a little bit, we have developed our automated greenhouse project, which makes sure that the plants grown indoors get adequate moisture, temperature and other climatic parameters in any possible environmental setup across Bangladesh [1].

By greenhouse we mean a controlled area or environment to grow plants but by an automated greenhouse we mean the involvement of the automatic monitoring and controlling of climatic parameters which directly or indirectly govern the plant growth and hence their production. This paper aims to raise awareness that there are now alternative ways to support farming. Modern farming techniques seek to diminish human involvement, escalate yield, and improve animal health. Economics, quality and consumer safety, all play its role in how animals are raised in the farm. The paper attempts to extend automation to the farm house level, by incorporating sophisticated home automation techniques, and adjusting them to suit a modern-day farm and by controlling the environmental parameters to take care of the growth of the crops and effectively and efficiently use the water for irrigation. If we introduce an affordable automation system to help with farming it can bumper the crop growth. Additionally, as this system also helps to manipulate the environmental factors, it is possible that we can grow any crop we want even the exotic crops with the help of this system, this can even be blueberries in our country (tropical region). To be able cultivate new and different fruits in our country could be revolutionary for our farmers and agricultural sector. Also this system inspires people to plant trees and to be more ethical about our environment.

1.2 Motivation

In our busy lives, we are running to and from round the clock to satisfy basic needs of life. Many of us value greenery and thus keep some greenery in our own abode through the presence of some plants. We want these plants to grow properly and its flowers to bloom beautifully. But due to our race with various deadlines and even while taking time off for vacations, those plants tend to get a little uncared for. To solve this problem, we have built this automated greenhouse which will not require constant manual care for the plant which makes it very convenient, especially for people in the urban area. Also sometimes the owner of the plant tends to pour more water than necessary on the plant and that can also result in harm of its growth. So, to ensure the exact amount of necessary environmental parameters, this will be very useful [5]. Furthermore, the environment as a whole has been ignored for quite a while, as a result of which fatal issues like global warming has been taking place worldwide. If we could grow more plants in a healthy way then this can be avoided. Also Bangladesh being an agricultural country primarily the need of something automatic like this has always been there. Moreover, according to the United Nations' Food and Agriculture Organization, food production must increase with 60% to be able to feed the growing population expected to hit 9 billion in 2050. Keeping all these factors in mind, we decided to go for this project [6].

1.3 Objective of our project:

Our objective is to make an automated environment at any place of Bangladesh to grow exotic crops, fruits and flowers that can also be monitored and controlled. To do so we aim to do as follows: The sensors monitor the atmospheric conditions like pH, humidity, water level, temperature, and other plantation factors. The devices match the atmospheric conditions with the idealistic conditions of a plant from the database and act accordingly to maintain the required atmospheric conditions. Notify all the connected user devices and display the conditions on the display monitor. We not only focus to cultivate exotic crops in our country through this project, but also to prevent the upcoming inadequacy of breads by developing the project at large scale.

1.4 Methodology:

In this system, we used Arduino Uno as the micro-controller to which all the sensors and devices are connected. The sensors measured and sent the current data of the environment of the system to the micro-controller and the micro-controller then compares the collected data with the required ones. The required parameters were already given by the user at the start of the system. When the data had been compared, the micro-controller generates an action by operating the devices accordingly, to retrain the desired values. A camera is also used to monitor the overall scenario of the system and the plant as well, which can be viewed by connecting the camera to the pc using USB cable. The user can get the readings in his phone over a text message at any time. Further the values recorded are also stored in an SD-card which allows the user to view the overall variations of the parameters over a long period of time as CSV.

1.5 Thesis Overview:

Chapter 1, we have described our current agricultural scenario of the world and our country, and had talked how our system can provide help to develop the agriculture.

Chapter 2, it contains from where we have got the inspiration to work on this project.

Chapter 3, describes all the components that we have used in our project.

Chapter 4, it has all the circuit set ups and how we have used the components to establish our project.

Chapter 5, contains data analysis and the result of our project

Chapter 6, contains the conclusion and how we can further develop our system.

CHAPTER 2

Literature Review

According to U.N’s report the current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 11.2 billion in 2100. By 2030, food demand is predicted to increase by 50% & 70% by 2050 [2].The main challenge facing the agricultural sector is not so much growing 70% more food in 40 years, but making 70% more food available on the plate. Moreover, according to Dr. Fred Davies who is a senior science advisor for the U.S.A [3].Agency for International Development said that food issues could become as politically destabilizing by 2050 as energy issues are today. He added that more efficient technologies and crops will need to be developed and equally important, better ways for applying these technologies locally for farmers, to address this challenge. Fresh water is a vital resource for the survival of our population and only 1% of world’s water is freshwater and available for us to consume. Unfortunately, farming accounts for 70 percent of the water consumed and most of its wasteful use, said representatives of 130 nations at the World Water Forum discussing water management, according to the article “Farms Waste Much of World’s Water” published by Wired in 19th March 2006 [4]. So, to feed the large population our farming should be more efficient than ever & automation in agriculture is the best option to do that. Other countries like U.S.A are already doing indoor farming successfully with the help of automation. The field of automation should be the leading technological advance in agricultural field [6].China has taken initiative to grow vertical forest to fight the pollution which involves automated greenhouse to nurture the plants, which will be the third vertical forest. The first two are in Italy and Switzerland [7]. Moreover, the world's first farm run entirely by robots is being created by Japanese lettuce production company 'Spread'. The indoor, vertical and LED-lit Vegetable Factory will use robots that can harvest 30,000 heads of lettuce a day.

Plus, agriculture is the largest employment sector in Bangladesh. A large number of farmers in Bangladesh depend on farming for their livelihood. But it is time consuming to manually look after the whole farm and livestock. The Bangladesh farms are slowly beginning to feel the stimulus for the instrumentation, control and automation industry.

Moreover, these types of projects have been used by International Space Station to grow crops in space, where earth like atmosphere is created to farm by astronauts and robots, popularly known as space-farming [8].

In addition to that, some projects initiatives were taken like the large-scale Arduino controlled greenhouse project made by Instrument Tek, Greenhouse Remote Monitoring System by Sensaphone, Growtronixetc [9].But most of these products are made by companies with a lot of resources and thus are very expensive[10].Also from a paper on "Internet of Things Greenhouse Monitoring and Automation System" and the project "Smart Greenhouse: The Future of Agriculture" we had this idea to create an artificial environment according to the required conditions for a specific plant to grow at any corner of the world in any climate[11]. The idea of the system we have represented was inspired to reduce food problems for the current world and for the future by making it easier for farmers to take care of the crops and cultivate them. In the above-mentioned paper and project, they had maintained an automated agricultural system, but using that we are to monitor and control the amounts of the factors involving plantation to give the plant an environment which would be suitable for a healthy growth even though how much unsuitable the outside environment is, within the affordable capability of most people in our country [12]. Additionally, this system will help the farmers drastically to grow more food to meet the current food demand and the future too, which is crucial for developing and under developed countries where the food scarcity is an intense problem.

Chapter 3

Equipment and Specification

Since we are planning to develop a system that can help in the sector of farming, we have tried to keep the total cost of developing such a system at minimum. So, to develop the system we have used equipment that can be found around us and are easy to afford, but have highest specifications and are up-to-date.

3.1 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

In our project we used two Arduino Uno, one to run and control all the sensors, lights bulb, water pump, GSM module. The second Arduino Uno is used only to operate the camera.

Figure 3.1: Arduino Uno R3

From the "*Arduino market*", we have come to know about the detailed specification of the Arduino Uno R3 as given below:

Table 3.1: Specification of Arduino Uno

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

3.2 DHT11 Temperature-Humidity Sensor

This is a calibrated digital temperature and humidity module with onboard sensor DHT11 (AM2302), which features higher accuracy and wider measuring range.

It can be used for detecting ambient temperature and humidity, through the standard single-wire interface.

In this project, we have used the DHT11 Temperature-Humidity sensor to sense the surrounding temperature and also the humidity of the system and collect the data and display the data on the LCD monitor and as well send to the micro-controller.

Table 3.2: Specification of DHT11 Temperature-Humidity sensor

Model	DHT11
Power supply	3.3-6V DC
Output signal	digital signal via single-bus
Sensing element	Polymer capacitor
Operating range	humidity 0-100%RH; temperature -40~80°Celsius
Accuracy	humidity ±2%RH(Max ±5%RH); temperature
Resolution or sensitivity	humidity 0.1%RH; temperature 0.1°Celsius
Repeatability	humidity ±1%RH; temperature ±0.2°Celsius
Humidity hysteresis	±0.3%RH
Long-term Stability	±0.5%RH/year
Sensing period	Average: 2s
Interchangeability	fully interchangeable
Dimensions	small size 14x18x5.5mm; big size 22x28x5mm

Figure 3.2: DHT11 Temperature-Humidity Sensor

3.3 Moisture Sensor

Waveshare SKU**:** 9527 Moisture Sensor detects moisture and irrigates when dry.

Table 3.3: Specification of Moisture Sensor

Item	Condition	Min	Typical	Max	Unit
Voltage	-	3.3	-	5	V
Current	-	0	-	35	mA
Output value	Sensor in dry soil	0	-	300	-
	Sensor in humid soil	300	-	700	-
	Sensor in water	700	-	950	-

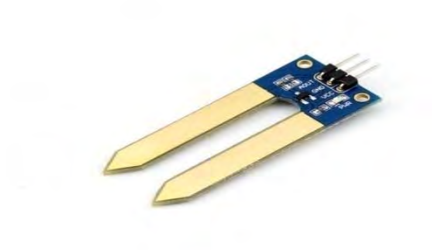

Figure 3.3: Waveshare Moisture sensor

3.4 Servo Motor

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servo motors.

In our project we have used three servo motors. One is used with the water spray to press the spray and sprinkle water at a certain clock period. Another we had back engineered and have attached an elastic string to it, so when the system is switched ON, it first rotates in anti-clockwise direction and winds the string and once the camera reaches a limit, it rotates is the opposite direction and unwind the string and thus used for the back and forth movement of the camera. The third servo motor is used with the camera to make it move left and right.

As per the "*servo-motor specification"* by "*RAPIRO*" the following specifications are found:

Table 3.4: Specification of servo motor

Size	38 x 11.5 x 24mm (Include tabs) 28 x 12.7 x 27mm (Not include tabs)
Weight	17g (Not include a cable and a connector) 18g (Include a cable and a connector)
Speed	0.14sec/60degrees (4.8V) 0.12sec/60degrees (6.0V)
Torque	2.5kgf-cm (4.8V) 3.0kgf-cm (6.0V) 4.8V-6.0V
Connector type	JR type '(Yellow: Signal, Red: VCC, Brown:GND)'

Figure 3.4: Servo Motor

3.5 Camera

For the operation of camera, we have used a webcam in our project, which is known to feed or stream its image in real time to or through a computer to a computer network. Unlike an IP camera (which connects using Ethernet or Wi-Fi), a webcam is generally connected by a USB cable, or similar cable, or built into computer hardware, such as laptops.

In our project we have used a mini sized web-camera and had attached it with 2 servo motors and a separate Arduino to control and record the real-time stream. The servo motors help the camera to move in the 4 directions and get the overview of the system.

Figure 3.5: Webcam

3.6 LCD Display

The Standard HD44780 LCDs are useful for creating standalone projects as said in the online shop "*adafruit*". We had used such LCD to display the current temperature and humidity values. Along with the monitor we have attached 2 potentiometers, through which the user can insert the required temperature and humidity values.

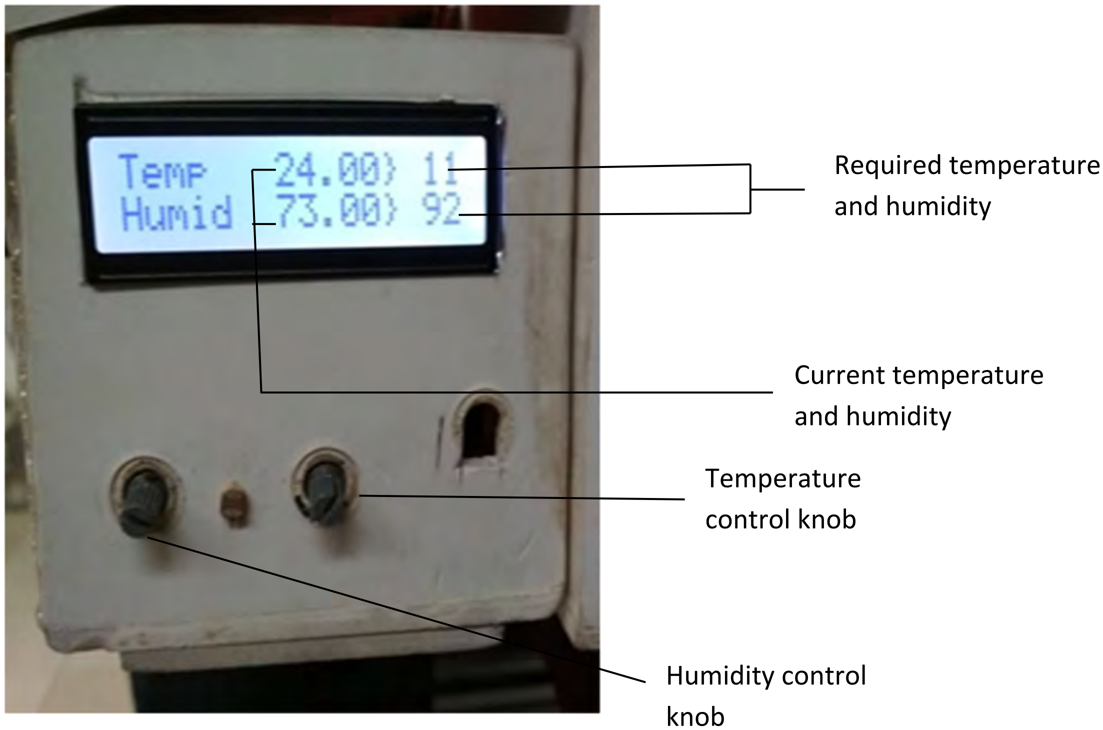

Figure 3.6.1: Setup of the LCD Monitor with Potentiometers

From an article "*Dot Matrix Liquid Crystal Display Controller/Driver*" published by *HITACHI*, we get the detailed specification of the LCD monitor as followed:

- 5 × 8 and 5 × 10 dot matrix possible
- Low power operation support: 2.7 to 5.5V
- Wide range of liquid crystal display driver power -3.0 to 11V
- Liquid crystal drive waveform - A (One-line frequency AC waveform)
- Correspond to high speed MPU bus interface -2 MHz (when VCC = 5V)
- 4-bit or 8-bit MPU interface enabled
- 80 × 8-bit display RAM (80 characters max.)
- 9,920-bit character generator ROM for a total of 240-character fonts - 208 character fonts (5 × 8 dot) - 32-character fonts (5 × 10 dot) HD44780U 2
- 64 × 8-bit character generator RAM - 8-character fonts (5 × 8 dot) – 4-character fonts (5 × 10 dot)

- 16-common × 40-segment liquid crystal display driver
- Programmable duty cycles - 1/8 for one line of 5 × 8 dots with cursor - 1/11 for one line of 5 × 10 dots with cursor -1/16 for two lines of 5 × 8 dots with cursor
- Wide range of instruction functions: Display clear, cursor home, display on/off, cursor on/off, display character blink, cursor shift, display shift
- Pin function compatibility with HD44780S
- Automatic reset circuit that initializes the controller/driver after power on
- Internal oscillator with external resistors
- Low power consumption

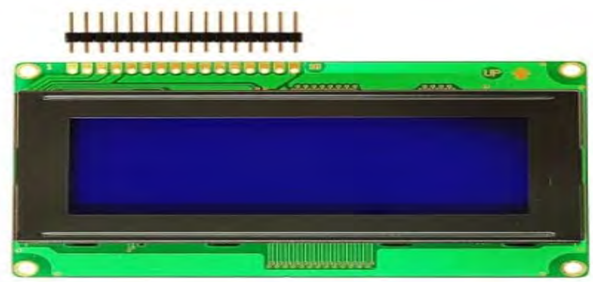

Figure 3.6.2: LCD Display (20x4)

3.7 Fan

We have used three of the DC fans, which are usually used inside the casing of computer's CPU for cooling. We have used two of them, one for cooling the temperature and the other for reducing the humidity from the atmosphere inside the box. And another one is used with the power supply box, to restrain the heat generated by the micro-controller while it operates.

From a datasheet of "*Farnell, elment14*" we get the specification of the DC fans, as given below:

Table 3.7: Specification of DC Fans

Rated Voltage	12V
Rated Current	0.25A
Dimension	90mm x 90mm x 25mm

Figure 3.7: DC Fans

3.8 Light Bulb

In our project we have used an incandescent light bulb, which consists of an air-tight glass enclosure (the envelope, or bulb) with a filament of tungsten wire inside the bulb, through which an electric current is passed. Contact wires and a base with two (or more) conductors provide electrical connections to the filament. An incandescent light bulb, incandescent lamp or incandescent light globe is an electric light with a wire filament heated to such a high temperature that it glows with visible light. The heat which is produced by a 100-watt bulb is enough to raise the temperature inside the box significantly. So, we have used this bulb to raise the temperature inside the box, whenever required.

Figure 3.8: Incandescent Light Bulb

3.9 Water Pump

A small water pump is used in our project which is used to pump water inside the box when the soil moisture is very low or lower than the required to maintain a balanced humidity inside the system.

From "*Engineering360, Powered by IEEE*, *Global Spec*" we found the following specification for the water pump:

Table 3.9: Specification of Water Pump

Operating Voltage	12V	6V
Power Consumption	14.5W	4.8W
Max Flow	2 liters/minute	1 liter/minute
Self-Priming Height	2'	10"
Inlet/Outlet Width	6mm	
Compatible Tubing	3/16" Airline Tubing for Aquariums	
Operating Temperature	-10°C - 100°C (Does not account for frozen liquids)	
Weight	.5 lbs.	

Figure 3.9: Water Pump

3.10 GSM Module

The SIM900 is a complete Quad-band GSM/GPRS solution in a SMT module which can be embedded in the customer applications. Featuring an industry-standard interface, the SIM900 delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. It is used in our project to send notifications via SMS to the user about the atmosphere inside the box. A sim-card is installed in the GSM module, when the user sends '*A*', the code as SMS to the installed sim-card, the sim-card sends the temperature and humidity readings of that particular time to the user’s phone as feedback.

Table 3.10: Specification of GSM Module

PCB size	71.4mm X 66.0mm X1.6mm
Indicators	PWR, status LED, net LED
Power supply	5V
Communication Protocol	UART
RoHS	Yes

Figure 3.10: GSM Module

Chapter 4

Design and Implementation

4.1 Proposed System

This system is built on three primitives of robotics which are sense, plan and act. The base device is implemented with Arduino. The sensors are used to detect the condition of environmental parameters, such as soil moisture, temperature, air humidity and so, manipulate them accordingly [13].

Basically, in our project we had used sensors and a controller to create an automated system, where the current level of the environmental parameters responsible for a plant’s growth; such as soil moisture, humidity, temperature can be identified. While the control part than does the comparison of the current values with the required ones and utilize the motor pump, fans, light bulb to maintain the optimum environment [9]. We plan to establish this optimum environment for a plant through interfacing between hardware and software, using the micro-controller Arduino.

4.2 Temperature Control

The temperature is one of the most essential factors for the growth of trees or crops. The DHT11 basic temperature-humidity sensor would detect the surrounding temperature. The sensor sends the data to the micro-controller and the micro-controller is programmed in a way so that when the temperature is 4 degrees lower than required temperature the light bulb (that represents heater) will turn on. And, if the temperature is found to be 4 degrees higher than required temperature then the cooling fan (that represents air conditioner) would turn on.

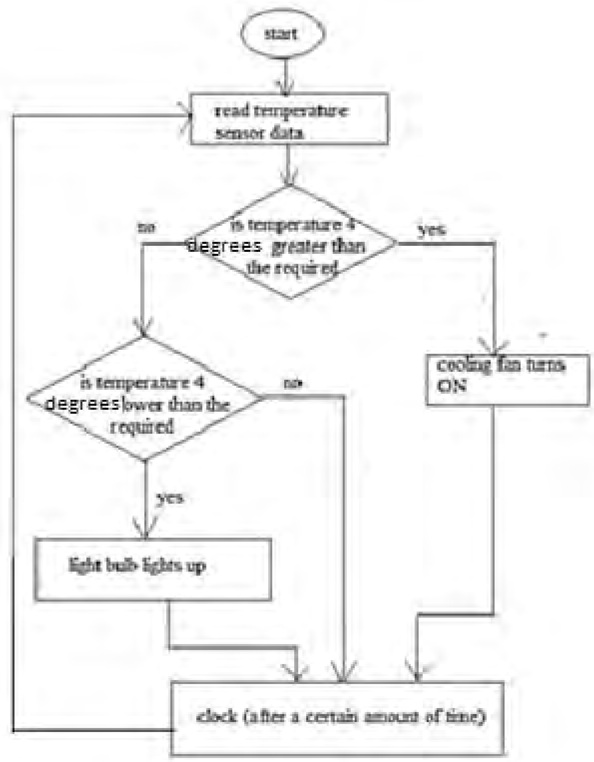

Figure 4.2(a): Flow chart of the working procedure of the temperature sensor

From the flow chart (Figure 4.2(a)), we can see that, at the start of the system, the sensor takes up the temperature reading of the system and sends the data to the micro-controller. The micro-controller compares the data with the value of temperature that the user requires for a particular plant and has given as input. If the required value is higher by 2units than that from the data, the exhaust fan and the cooling fan would turn on for a certain clock time, until the whole system's temperature cools down to the required temperature. When the required value is 2 units lesser than the required one, then the system would cause the light bulb to light up and heat up the surrounding for a certain clock time to reach the required temperature.

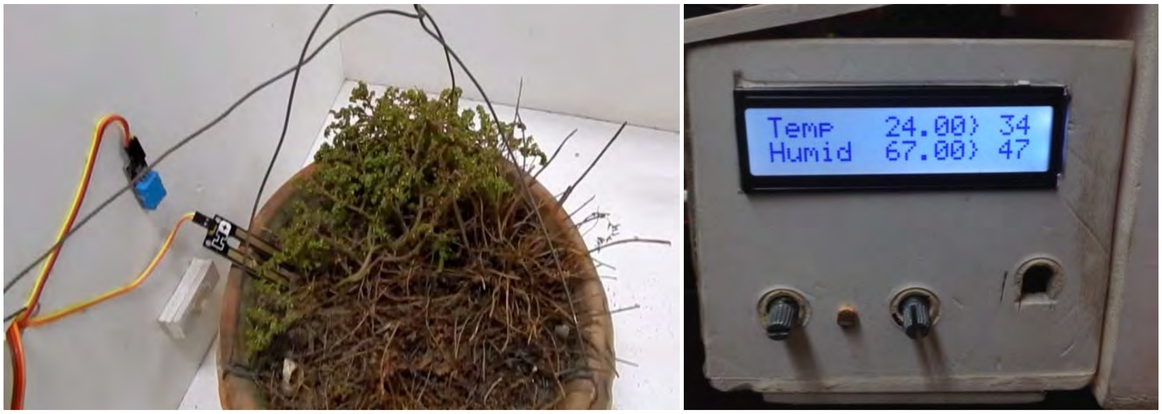

Figure 4.2(b): DHT11 Temperature and Humidity Sensor and their readings

4.2.1 Circuit setup of Fan

The complete setup of the fan is shown in Figure 4.2.1 (a) and Figure 4.2.1 (b).

Connect pin 7 Arduino to IN 1 relay module.

5V to V_{cc} of relay module, GND to GND of relay module.

Connect NO of relay module with fan's positive. Connect COM of relay module with battery's positive. Connect fan's negative with battery's negative.

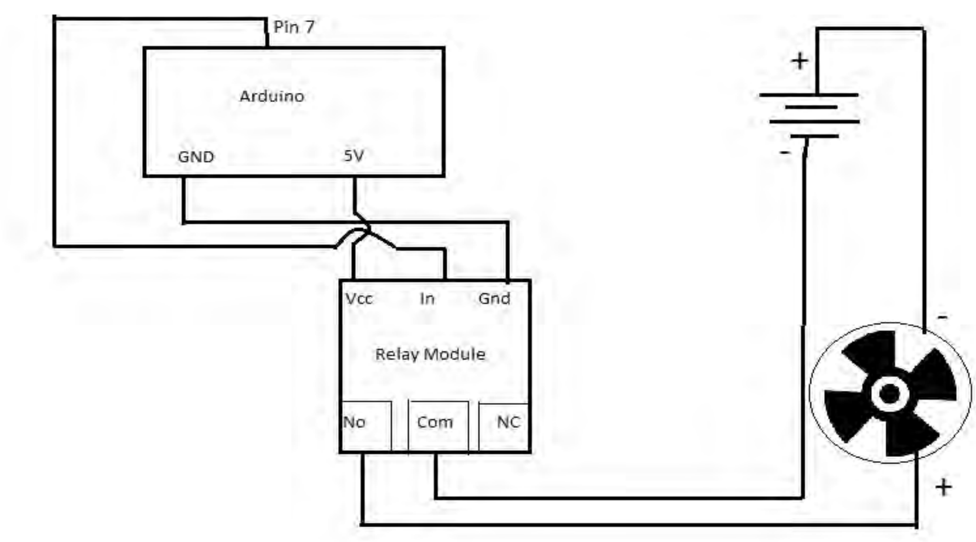

Figure 4.2.1(a): Circuit diagram of the Temperature Sensor and Fan

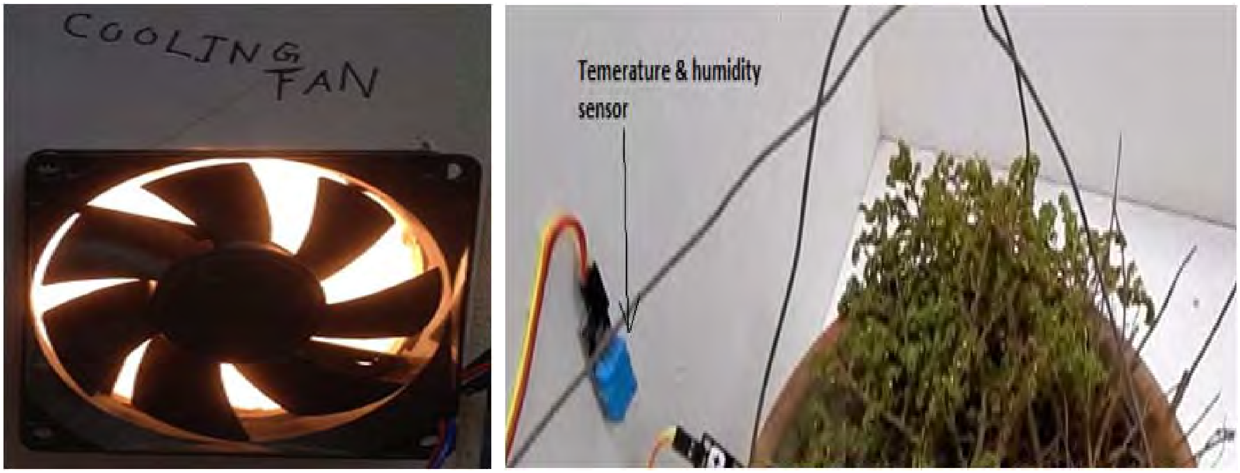

Figure 4.2.1(b): Fan and the DHT11 sensor

4.2.2 Circuit setup of Light Bulb

The next step is to connect the AC light bulb with Arduino based on the temperature sensor's reading, as shown in Figure 4.2.2 (a) and 4.2.2 (b). The connection of the control of light bulb is as followed:

Connect pin 7 Arduino to IN 1 relay module.

5V to V_{cc} of relay module. GND to GND of relay module.

We have used normally open connection in relay. So, we can trigger on and off the light.

Hot line from supply is connected to COM. Supply line to the AC light is connected to NO.

GND or - or other terminal in light is connected directly.

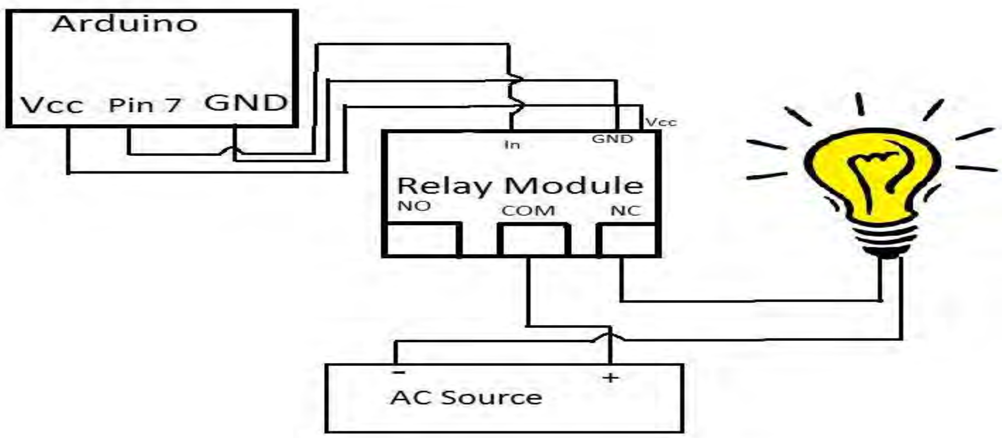

Figure 4.2.2(a): Circuit diagram of the Light bulb

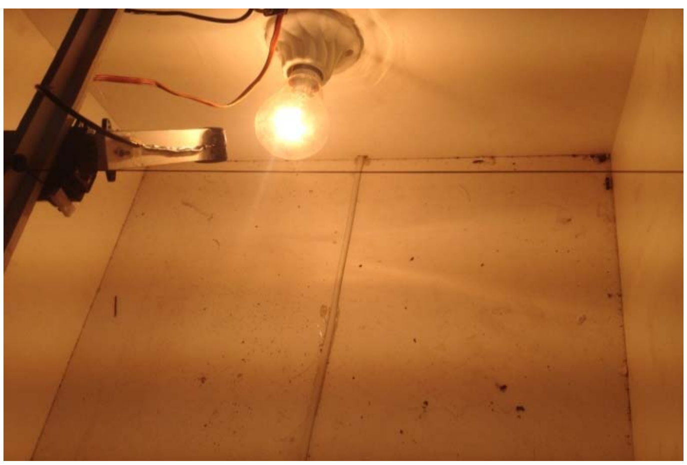

Figure 4.2.2(b): Setup of Light bulb in the system

4.3 Soil Moisture Control

Soil moisture sensor detects if the soil is moist or dry. If it's dry the soil is watered by the water pump and if it is sufficiently watered the water pump is turned off. Here we have used Grove-Moisture sensor, which itself can read the current moisture value and act accordingly to maintain an adequate moisture level.

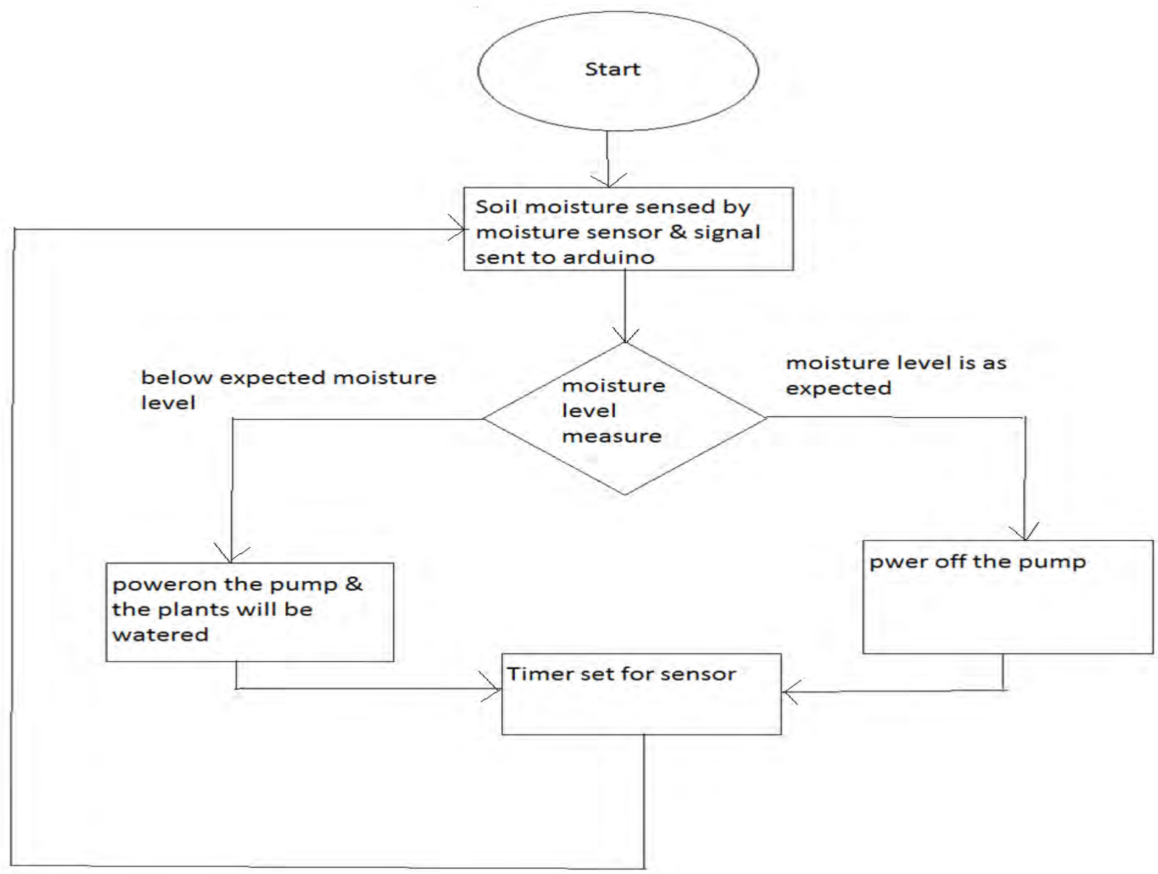

Figure 4.3: Flow chart of the Working procedure of the Moisture Sensor

4.3.1 Circuit setup of Soil Moisture Sensor and Water Pump

The moisture sensor if water or moisture not detected will turn on the motor to pump water and if detected will turn OFF and the connection is shown in Figure 4.3.1 (a) and Figure 4.3.1 (b).

The set-up is as following:

Motor positive is connected with Relay switch 1 COM input. Motor negative is connected with Relay switch 2 COM input.

7.4V battery positive is connected with Relay switch 1 NO and Relay switch 2 NO.

7.4V battery negative is connected with Relay switch 1 NC & Relay switch 2 NC.

In this project, both wires from the motor are connected to both of the COM (middle) inputs of the relay switches.

The positive wire from the 7.4V battery connected to both of the NO (top) inputs.

The negative wire from the 7.4V battery connected to both of the NC (bottom) inputs.

This external power supply (7.4V battery) will be used to power the motor.

Connection with Arduino:

Arduino 5V pin is connected with Relay module V_{CC} pin. Arduino GND pin is connected with Relay module GND pin. Arduino pin#7 is connected with Relay module IN1.

Arduino pin#8 is connected with Relay module IN2.

After we finish connecting the motor, all we need to do is power the relay switch module itself. Using the Arduino, we can connect the wires and send signals to activate the relay switches.

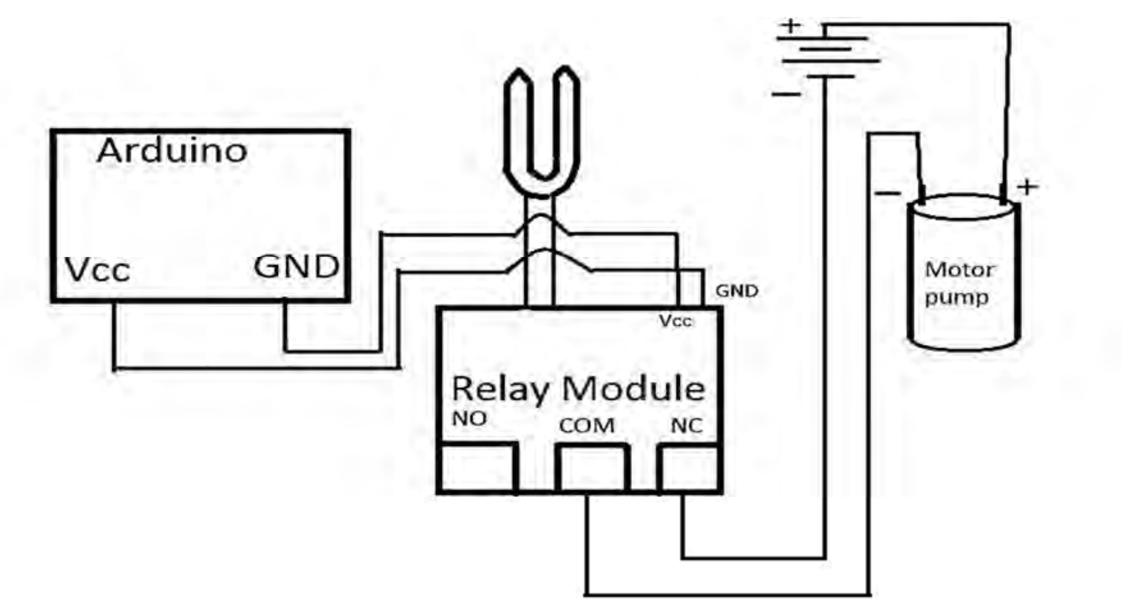

Figure 4.3.1(a): Circuit diagram of the Moisture Sensor and the Pump motor

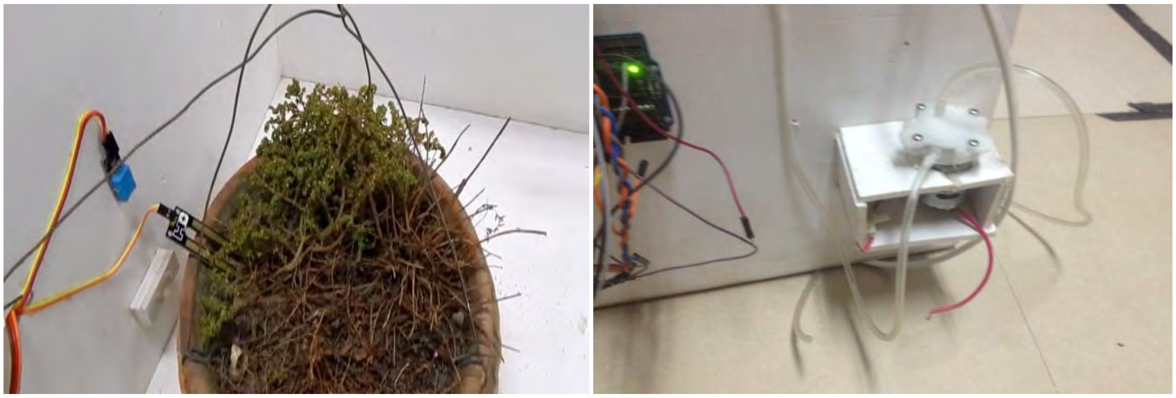

Figure 4.3.1(b): Setup of Moisture Sensor and the Water Pump in the system

4.4 Humidity Control

If the humidity rises above the required humidity then the DHT11 temperature-humidity sensor will detect it and Arduino will be programmed to act accordingly.

4.5 Exhaust Fan and Spray

When the humidity of the system increases above the input which is the required humidity of the system, the exhaust fan is programmed to turn on which derive the extra humid air out of the system. The humidity control setup of exhaust fan and the temperature control setup of the fan are similar. And when the air is less humid than the given humidity the spray will turn on.

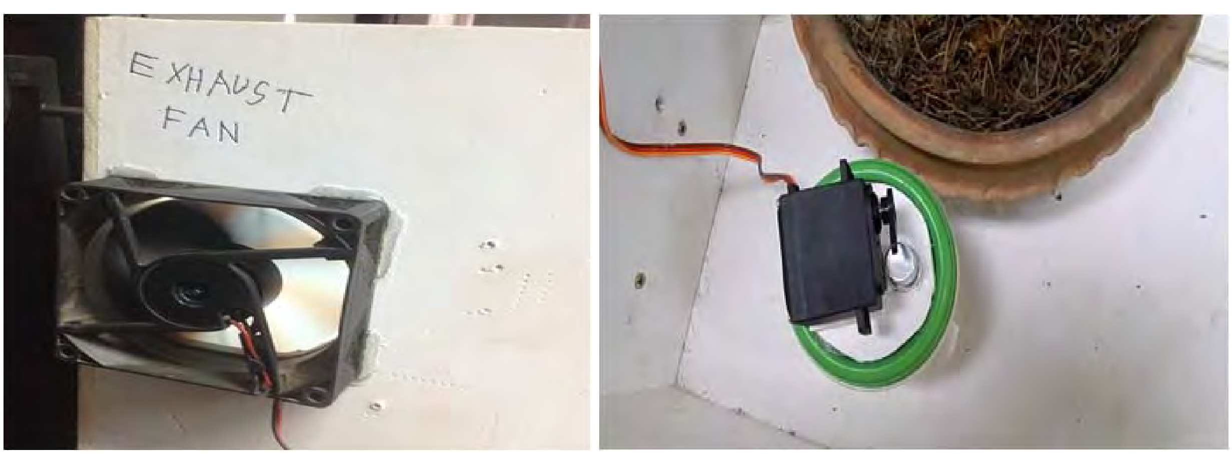

Figure 4.5(a): Exhaust fan and Spray

4.6 Circuit Diagram of the Control System

The Following figures, Figure 4.6 (a) and Figure 4.6 (b), show the complete circuit setup of our system.

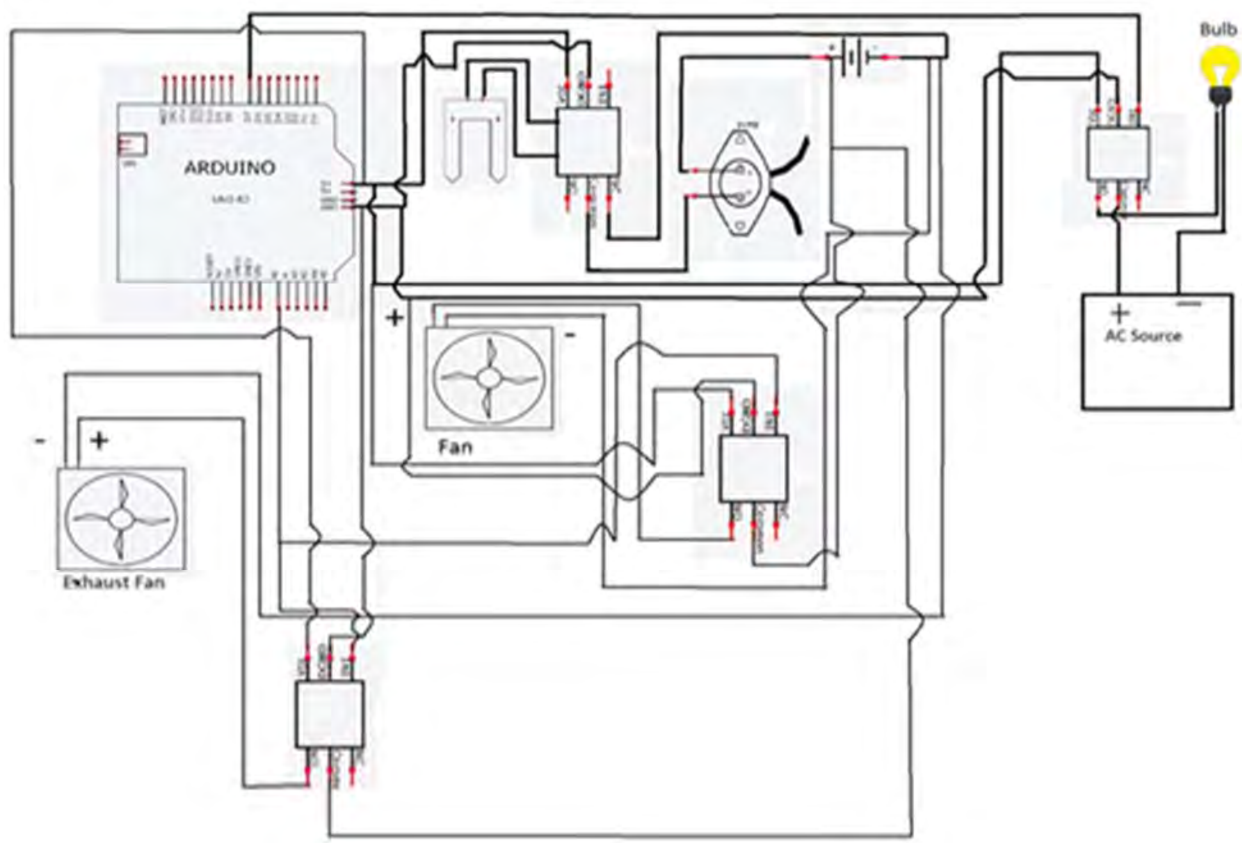

Figure 4.6(a): Circuit diagram of the Control System

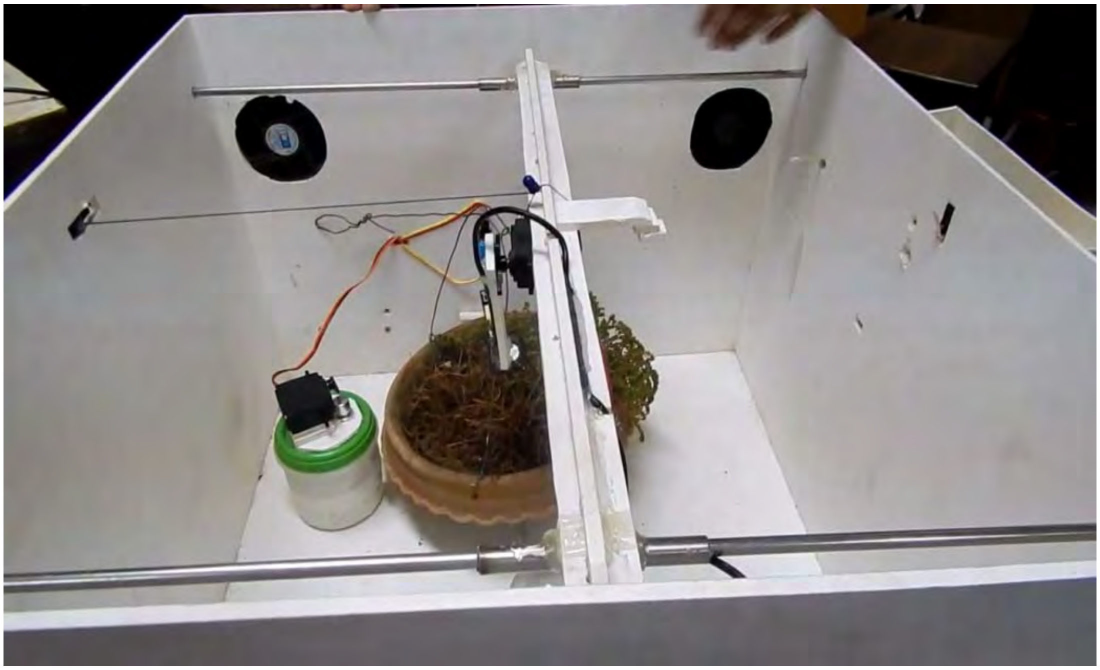

Figure 4.6(b): Overall system

4.7 Monitoring

The monitoring system is divided into 3 parts: LCD Monitor, CNC Camera and Cell phone notification.

4.7.1 LCD Monitor

There is an LCD monitor connected with the Arduino where we can see the surrounding temperature and humidity. There are potentiometer which we are using to alter the required temperature and required humidity of the system, as shown in Figure 4.7 (a).

Figure 4.7.1: LCD Monitor displaying the parameters

4.7.2 Cell Phone Notification

Using a GSM Module, the user can ask the system about the present condition and would get the data as a text message from anywhere at any time, as shown in Figure 4.7.2(a) and in Figure 4.7.2(b) the circuit setup of the GSM module with Arduino.

Figure 4.7.2(a): The GSM Module sent message to the user

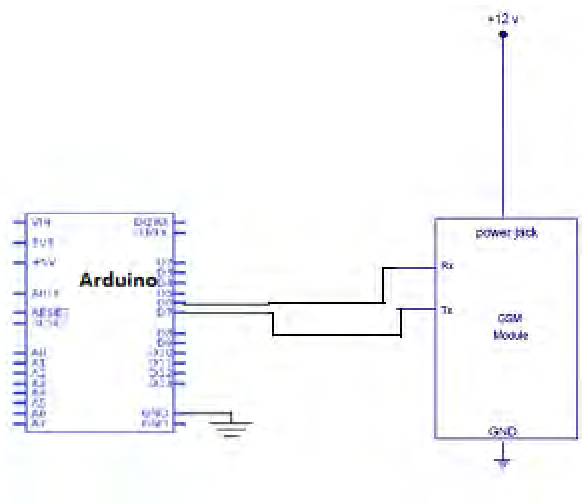

Figure 4.7.2(b): The GSM Module setup

4.7.3 CNC Camera

The camera installed inside using stepper motors is programmed to move back and forth around the y axis and in a semicircular motion (90 degrees) around the x axis as shown in figure 4.7.3(b), where the blue lines are the x and y axis and red arrows are the movement of the camera around those axis. Using a USB cable the camera is connected to a computer, so that, we can monitor the video feedback and observe the entire scenario of the inside of the system from outside without disturbing the environmental parameters. This monitoring system helps the user to observe the real-time condition of the current atmosphere system.

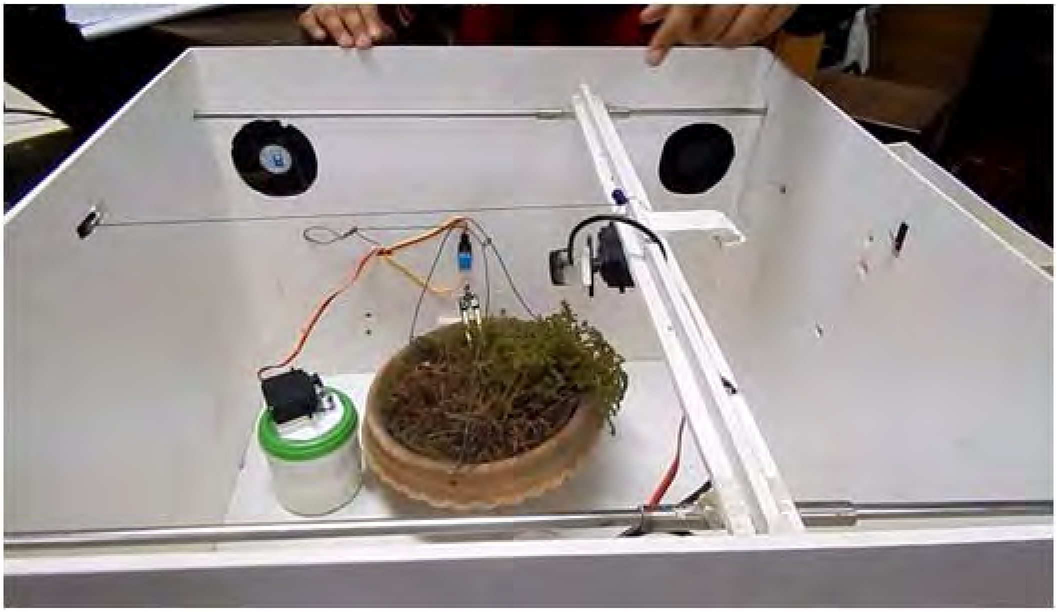

Figure 4.7.3(a): Camera connected with servo motors

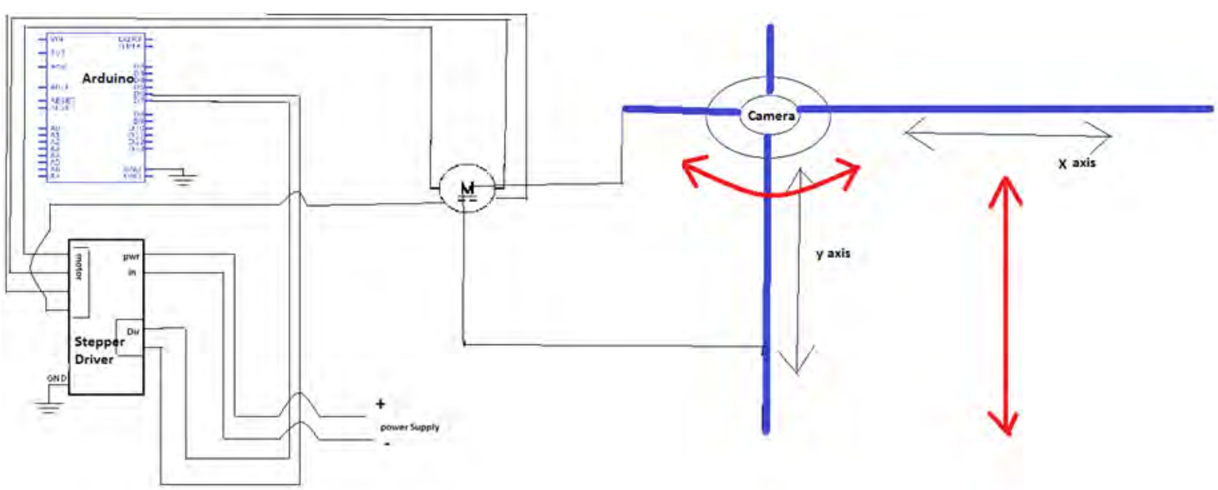

Figure 4.7.3(b): CNC Camera basic setup

Chapter 5

Test Result and Data Analysis

For analysis, we had run our system on a money plant. Money plant requires a temperature of about 22.2 degree Celsius and a humidity of about 48%. The room temperature was 25-degree Celsius and humidity was 57%. Via the potentiometer we gave the required temperature and humidity value in the system and recorded the data for the next 30 minutes at 3 seconds interval, as shown in Table 5.1.

Table 5: Data Table of Temperature and Humidity with time

Time (s)	Temperature (◦C)	Humidity (%)
0	25	57
3	25	57
6	25	57
9	24	57
12	25	69
15	25	58
18	24	57
21	25	68
24	25	55
27	24	55
30	25	55
33	25	52
36	25	53
39	24	53
42	24	56
45	25	53
48	24	52
51	24	52
54	25	53
57	24	52
60	24	52
63	24	50
66	23	52
69	24	52
72	24	50
75	24	53
78	23	54

81	24	53
84	24	52
87	23	52
90	24	53
93	23	51
96	23	52
99	24	52
102	23	52
105	23	51
108	23	51
111	24	52
114	23	52
117	23	51
120	23	51
123	23	51
126	22	52
129	23	51
132	23	51
135	23	51
138	22	52
141	23	50
144	23	50
147	22	50
150	23	47
153	23	47
156	22	45
159	22	47
162	23	48
165	22	48
168	22	48

The required temperature and humidity are given as 22°C and 49% and the current temperature and humidity is 24°C and 63%, respectively, shown in the figure below (Figure 5).

Figure 5: LCD reading, at the start

5.1 Graph representation of the data

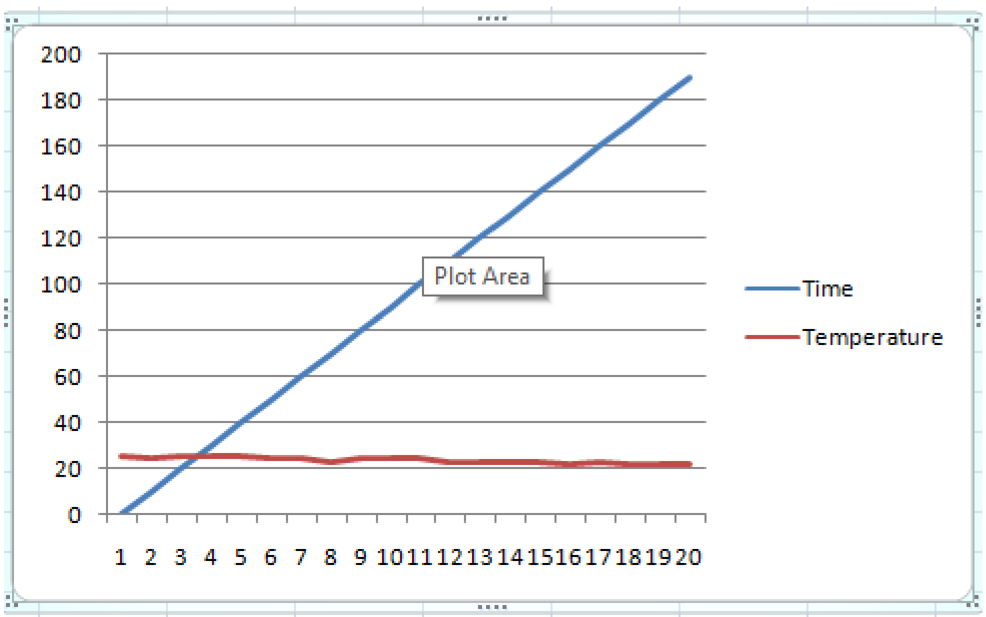

Figure 5.1(a): Graph representation of the temperature drop through time

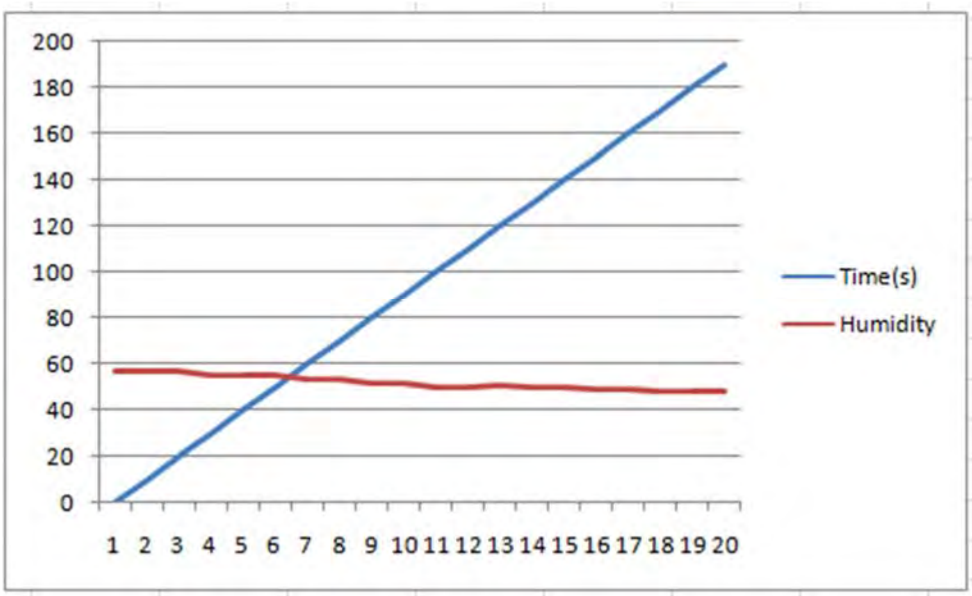

Figure 5.1(b): Graph representation of the humidity drop through time

The temperature has decreased and became equal to the required temperature, and the humidity is also decreasing. The result is shown in figure below (Figure 5.1(c))

Figure 5.1(c): Temperature's set as the input temperature

Chapter 6

Conclusion and Future Plan

6.1 Conclusion

The technology and automation systems are taking over the daily lives, but, the sad truth is it's not taking over the farming or reforestation projects as the ever-growing battle between the technological development and environmental ethics. The greenhouse automation system is our effort to change that. To develop the system in a way so that it helps environmental ethics [15].And, if applied to farming it will be a huge help to eliminate the food crisis. The idea represented on the paper has been implemented successfully and we are still working on it to make it much better automation system for the future. It's not just an automated greenhouse for farmers or garden enthusiasts, if applied in a large scale it can be a pioneer of urban agriculture movement. Additionally, if we think outside the box its wide range use ought to be much more than that. There are new projects taken by various countries to encourage reforestation to revive the pollution choked large cities. Our project could be a small step toward a better world where we can cultivate crops not depending on the mercy of the calamities or even geography. In addition to that, our automation system is impeccable, because, human error, physical hard work & monotony of constant monitoring can be minimized with its help.

6.2 Future Plan

The system is open to numerous development, where the plants or crops will be monitored by automata, IoT enabled and in future this project can be enhanced using the following ways:

- pH sensor
  pH level of soils determines the presence of nutrients in the soil. By using the pH meter, we can monitor the pH levels to ensure that an ideal pH is maintained both in water and soil, and also detect any problems at a very early stage. Other uses of a pH meter in agriculture may include:
    - Measuring plant leaf sap pH
    - Measuring foliar and hydroponic fertilizers
    - Measuring pH of rain and irrigation water
    - Testing pH of crop juices
- Enabling IoT
  The Internet of Things (IoT) could be key to the farming industry, increasing food production by 70% to feed the 9.6 billion global population expected by 2050, according to Beecham Research. IoT deployment in agriculture can address many challenges and increase the quality, quantity and cost-effectiveness of agricultural production.
- Early pest control using image processing
  If pests are detected, appropriate measures can be taken to protect the crop from a big production loss at the end. Early detection would be helpful for minimizing the usage of the pesticides. Continuous video monitoring will stream and send the real-time streaming to the PC and would be further processed through image processing for detecting any irregularity in the appearance of the leaves or any other part of the plants.

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