SRI LANKA INSTITUTE OF INFORMATION TECHNOLOGY

ELECTRICAL AND ELECTRONIC ENGINEERING

SOLAR POWERED AUTOMATED HYDROPONIC CULTIVATION

Thesis submitted to Sri Lanka Institute of Information Technology in partial fulfilment of the requirement for the EC3061 Design Project Module

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Acknowledgements

First and foremost I would like to thank our supervisor Dr. Lasantha Senevirathna for his invaluable advice, continuous support, encouragement, guidance and motivation throughout this project. Also I am extremely grateful to our co-supervisor Mr. Nushara Wedasingha for his support throughout our project. I would also like to express my sincere gratitude to professors, lecturers, lab assistants, colleagues of Sri Lanka Institute of Information Technology for their assistance at every stage of the project. I am deeply grateful to my group partners for their contribution in making this project a success. My appreciation also goes out to my family and to everyone who helped us throughout this project.

Abstract of Thesis presented by Jayatissa K.T.D to Sri Lanka Institute of Information Technology.

SOLAR POWERED AUTOMATED HYDROPONIC CULTIVATION

ABSTRACT:

Soil cultivation or planting in soil is the most preferred and the common cultivation method used in most parts of the world at present. This has many challengers. In others words, farmers who do soil cultivation experiences a lot of challenges due to many reasons. Reducing of land suitable for agriculture, climatic changes, water scarcity and time management can be listed as the main challengers faced by farmers when doing soil farming. Due to this farming has become a complex, unpredictable and a very risky business. This has become issue throughout the globe.

In this thesis, an alternative method for soil cultivation and strategies to increase the efficiency of farming are discussed. So the solution we came up to tackle this issue is an IOT based solar powered automated hydroponic cultivation system. In this proposed model, the plants will be cultivated in a water solution instead of soil and the all the necessary parameters for plant growth will be monitored and supplied adequately through an automated system. In addition the proposed model is designed to display the readings of the monitored parameters in a LCD display and in a web application. From this farmers get the advantage of observing their cultivation from anywhere.

List of Abbreviations

Abbreviations

IOT – Internet of Things

LCD – Liquid Crystal Display

pH – Potential of Hydrogen

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Chapter 1

INTRODUCTION

Every plant in the world grows through a process called “photosynthesis”. Photosynthesis is the process which converts light energy into chemical energy inside plants with the help of a chemical inside their leaves called chlorophyll. The main two substances needed for photosynthesis are water and carbon dioxide. So, it is clear that plants do not need soil as the medium for their growth. What they need is water and nutrients. So if the plants can get these things by standing with their roots in a nutrient-rich solution that will be very effective towards their growth. This is the basic principle behind the hydroponic cultivation method. The word hydroponics is originated from the two words water and labour, which are “hydro” and “ponics” respectively. So simply, hydroponics is a method of growing plants in a mineral nutrient solution in a water solvent without using soil. [1]

At present farmers who are involving in soil cultivation are facing many challengers due to various reasons. So the farmers all over the world are under immense pressure to meet the changing needs of our planet and having to adjust accordingly. Due to this farming has become a complex, unpredictable and a very risky business. Some problems faced by farmers when doing soil cultivation are investigated below. [2, 3]

- Reduction of land suitable for agriculture.

  Over the past few centuries the land used for agriculture has increased at a rapid rate which resulted in decreasing of forests, grasslands and shrubbery etc. Wild habitats have been changed into agricultural lands. Throughout the last 1000 years the percentage of land used for agriculture in the world has increased from 4% to 40% according to the scientists of University of Wisconsin-Madison. And in Sri Lanka also there have been a 59% increase in land used for agriculture from 1961 to 2015. Figure 1.1 below shows the Share of land area used for agriculture till 2011 in the world. [4,5]

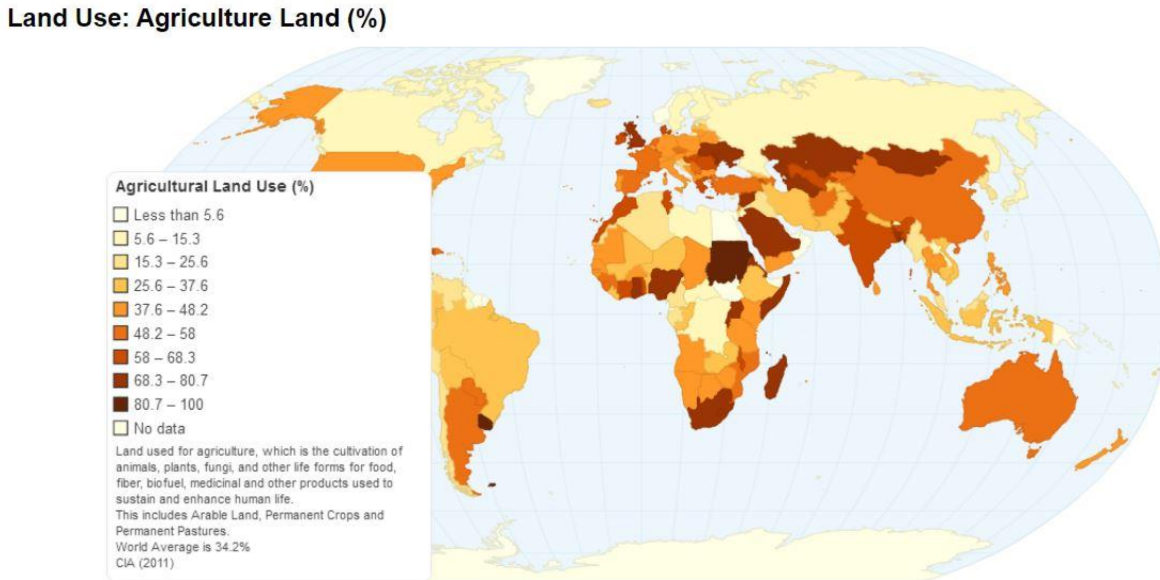

Figure 1.1: Share of land area used for agriculture till 2011 in the world.

- Water scarcity

Agriculture production is highly dependent on water and increasingly subject to water risks. So with the reduction of water sources in the world farmers are struggling to supply the necessary water to plants needed for plant growth. According to the World Development Indicators, 70% of the global water is used for agriculture and it is estimated that the water withdrawals for agriculture will increase by 15% by 2050.

Figure 1.2 shows the usage of fresh water in the world in 2014. [6,7]

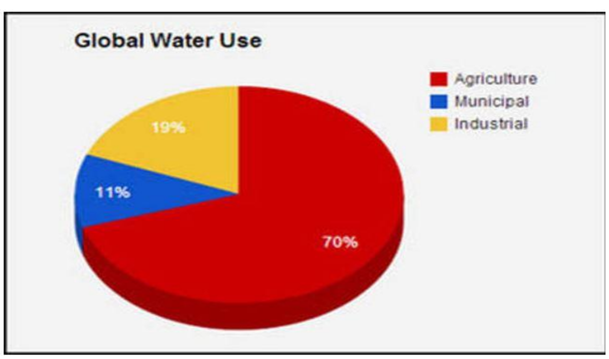

Figure 1.2: Usage of fresh water in the world in 2014.

- Heavy workload

A farmer should put in a heavy effort to make his cultivation a success. Farming requires a huge effort. Tasks such as fertilizing, watering and weeding the crops are done manually by the farmers. Sometimes in dry seasons plants should be watered daily. So that is really tough challenge to the farmers. University of Life Sciences in Lublin states that, a farmer normally spends 12 to 14 hours in his cultivation doing farming activities. In Sri Lanka Chena cultivation is a famous type of cultivation. When doing Chena cultivation, farmers have to even stay at night in the cultivated area to protect the cultivation from animals. So it is really a tough workload to manage for a person.

- Difficulties faced due to climatic changes.

Seasonal changes, floods, droughts and etc. are some climatic changes that a farmer should deal with when doing farming. Natural disasters can destroy an entire cultivation in an unexpected time period. Farmers also should alter their crops according to the seasonal variations. An in Asian countries, during dry seasons providing necessary water to the crops is a huge challenge. [8]

- Soil erosion

Huge problem faced when cultivation in soil is the erosion or crumbling of soil. Soil endures chemically, physically and biologically depending on the factors which lead to soil erosion. Soil cultivation also increases the soil erosion. Reduces the soil fertility, causes floods and etc. are some disadvantages of soil erosion. It is a well-known fact the Soil is eroding more quickly than it is being formed. So this is a huge problem not only towards agriculture but to all the world activities. [9]

- Biodiversity loss

  Biodiversity affects agriculture in a big manner. Biodiversity performs ecosystem services such as soil and water conservation, maintenance of soil fertility, pollination of plants and etc. which are very important to the growth of plants. [10]

- Pests and diseases for crops.

  There are many varieties of pests that damage crops. Pest species can include insects, birds and etc. Insects are the biggest threat as they eat leaves, burrow holes is stems, damages fruits, transmit bacteria such as viral or fungi, damage roots and etc. Birds such as pigeons are also a major issue as they can heavily damage edible crops with harvest. Other than pigeons birds such as sparrows, magpies, and rooks causes problems to crops. Rats and mice can also damage crops. [11]

  Plant diseases are caused by bacteria, fungi or viruses. These diseases can even result in death of a plant. Some common plant diseases are bacterial wilt, aster yellows, anthracnose, leaf blister and etc. [12]

- Takes some time to get the harvest.

  Normally most of the crops grow very slowly in soil due to reasons such as non-availability of seeds, fertilizer and irrigation etc. This results in farmers facing financial and economic problems.

- Farming has become a full time occupation.

  Due to the high work load of a farmer, the young generation in farming families tends to give up on their life ambitions and education to involve in farming. This scenario is very common in Asian region. Figure 1.3 shows the share of labour force employed in agriculture up to 2015.

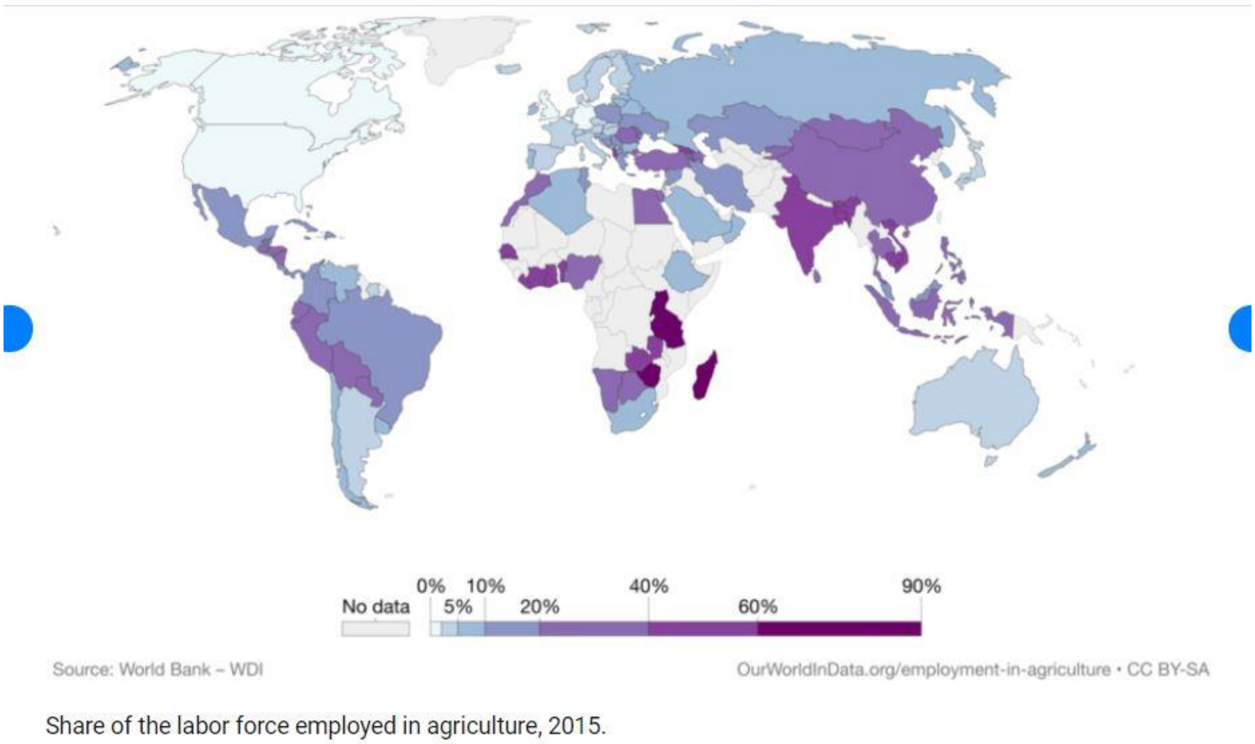

Figure 1.3: Share of the labour employed in agriculture, 2015

So it is clear that farming in soil is becoming tough job and that has become a global issue.

Table 1.1: Rank order, weighted score and mean values of climatic factors affecting the crop management practices

Factors	Rank order	Weighted score	Mean value	S. D
Rainfall variation	1	456	3.80	0.64
Floods	2	424	3.53	0.66
Drought	3	322	2.68	0.75
Temperature fluctuation	4	307	2.56	0.62
Frequency of rainfall	4	307	2.56	0.64
Hailstorm	5	241	2.00	0.59
Precipitation	6	235	1.95	0.57
Humidity	7	188	1.57	0.63

Table 1.1 above shows the summary of the problems affecting the farmers when doing soil cultivation. [30]

An IOT based solar powered automated hydroponic cultivation system is our proposed solution for the global issue discussed above. In here plants are cultivated in nutrient rich water solution instead of soil. All the parameters needed for plant growth are monitored using sensors automatically and also these parameters are supplied adequately to the plants through an automatic system. Sensor readings are displayed in a LCD screen and in a web application.

Some benefits of the proposed solution are discussed below.

- Plants grow faster.

  Plants in hydroponic cultivations grow faster than the plants in soil. Because when the roots are submerged in a nutrient rich water solution the roots can absorb the necessary nutrients much easily and transport them to the upper part of the plant through the stem. Normally plants grown in hydroponic systems grow 30% to 50% faster than those grown in soil. [14]

- Saves space

  Hydroponic farming uses a very minimum amount of land. So events such as soil erosion is also minimized.

- Water conservation

  In a hydroponic cultivation system, the plant's roots will only take up the amount of water they need at any one time and leave the rest in the reservoir for later use. So by this process it saves a lot of water compared to soil cultivation. Normally hydroponic Plants can grow with just 5-10% of the water that's need when growing with soil. [15]

- Farmers don't have to cope with climatic changes and biodiversity loss.

  Hydroponic environments provide total control over climate. Farmers have the luxury of growing any type crop regardless of the seasons or climatic changes. Also any type of plants can be grown in any part of the world. Also biodiversity losses does not affect hydroponic environments.

- Higher yields

  Hydroponics can produce higher yields at less time because plants grow quickly when compared to soil cultivation.

- Less chemicals and no weeding required.

  As the plants grow in a controlled nutrient solution, they are less exposed to pests and free from weed growth. [16]
- Time savings
- Less pest attacks and soil born plant diseases.

Automating the hydroponic cultivation provides the benefits mentioned below.

- Reduces workload and saves times of farmers.

  When the cultivation is automated farmers do not have to manually water, weed and fertilize crops in the cultivation. Those processes are done through an automated system. So the work load of farmers reduces in a big manner which results in time savings.

- Less labour intensive.

  Since the system is automated the human labour required is minimum.

- Parameters needed for plant growth are supplied to the necessary level.

  When supplying nutrients manually the farmers cannot properly decide whether it is enough or not. Supplying excess amount of nutrients can also damage the crops. So when the system is automated it supplies the adequate amount of nutrients needed for plant growth. Especially parameters like pH are supplied properly from an automated system. This also reduces the wastage of nutrients.

- Farming can be done as a part time job.

  Because the sensor readings are displayed in a web page, farmers can monitor their cultivation from anywhere. So they can spend their valuable time to another field also.

So these are the major advantages of our proposed solution.

1.1 Research Objectives

The main goal of the proposed work is to promote hydroponic cultivation and to make life of a farmer much easier. Addressing this problem, the thesis focuses on the following specific objectives:

- To investigate about the most important necessary parameters needed for plant growth and identify the necessary amount of these parameters to each type of plants.

- To study about sensors that control each parameter needed for plant growth.

- To study and develop a system which supplies nutrients and parameters when needed according to the sensor readings.

- To investigate about solar power systems and how to power up an automated hydroponic system using solar power.

- To investigate about IOT and displaying sensor readings in a web page using Wi-Fi.

- To make each system user friendly as possible.

- To study and become familiar with Arduino microcontrollers and coding.

- To investigate and study about web page development and app development.

- To develop skills such as time management, team work, project planning and demonstration, leadership and etc.

- To study about comprehensive engineering techniques and how to use them in relevant situations.

1.2 Contribution of the Thesis

The thesis provides the following contributions:

- An automated cultivation system which measures the temperature, humidity, light intensity, water level and pH value of the water solution , which are the most important parameters for a plant growth in a hydroponic system using suitable sensors.

- A system is implemented to provide the necessary parameters adequately to the plants according to the sensor readings using relays.

- A system which displays the sensor readings in a LCD display and in a web application using IOT.

1.3 Structure of the Thesis

The thesis is about an IOT based solar powered automated hydroponic cultivation system which can control the parameters needed for plant growth automatically. Below is a short introduction about the structure of thesis.

- **Chapter 2:** This chapter presents an overview of the background readings and literature reviews about the automated hydroponic cultivation projects which are already available. This also includes the background and history of IOT techniques.

- **Chapter 3:** In this chapter, a comprehensive overview of the hardware implementation and the software implementation of the proposed solution is discussed. The implementation of the project is discussed starting from project selection to the ongoing state of the project. The techniques and theories used about sensors are also discussed in this chapter.

- **Chapter 4:** In this chapter, the results of our hardware and software implementations are discussed and analysed. The challengers faced during the implementations are also discussed and the future enhancements of our work is discussed within this chapter.

- **Chapter 5:** This chapter mainly presents the final conclusion of our project.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the existing approaches that address the same problem of Hydroponic Automated cultivation system. The methodologies and techniques used by those approaches will be briefly discussed in this chapter.

2.2 Background and Motivation

Hydroponic technology has been addressing the main challenges in traditional soil cultivation such as limited land space, low harvest efficiency to fulfil the high food demand, labour cost, unsuitable environment conditions for agriculture, and challenges in indoor cultivation. Simply Hydroponic is let humans grow any crop in soil less hostile environment regardless of any other factors that affect to tradition cultivation like space, climate or weather. Hydroponic uses aquatic based medium; it mainly uses water which included mineral nutrition. Compared to the traditional cultivation hydroponic growing required less amount of water and manpower. And hydroponic helps crop cultivations to avoid several problems like cutworms and soil borne diseases which soil grown crops deal with. As hydroponic medium farmers can use. Groundwater, municipal tap water, rainwater and mixtures of these [18].

Although inventing hydroponic was happened in near past, it could enslave both outdoor and indoor cultivation within short time period. Hydroponic has been used in all types of crop productions. And hydroponic cultivation is more environment friendly than soil-based cultivation as it could set free soil from toxic chemicals which are used in traditional cultivation as fertilizers.

In hydroponic cultivation artificial methodologies are being used to provide relevant climate factors for each crop cultivation. Climate conditions like temperature, humidity, wind speed and light must be controlled using man made technologies in hydroponic cultivation. That makes hydroponic greenhouse production complicated than traditional cultivation. Therefore, the main challenge in hydroponic greenhouses is controlling all these factors and yield the target harvest with target efficiency. As a solution for this challenge automated hydroponic systems were invented. There are number of automated hydroponic systems which supports for different cultivation types, costs and technologies.

Our implementing automated hydroponic system mainly reliant on sensor technology and Internet of things technology. Multiple sensors were used in this system for control water level, pH value, and temperature and humidity levels in hydroponic greenhouse environment. [17]

Internet of Things (IOT)

Automated Hydroponic system using Internet of Things to get the sensor reading data to the Automated Hydroponic website. Internet of Things refers to a network of objects interconnected via internet to exchange real time data with embedded sensors. Although the most significant component of the IOT, the Internet started on 1962, IOT is a very young technology. It was officially named as a concept in 1990. But earlier it was used in 1980's for a coca cola machine at the Carnegie Melon University. Then since 2013 the concept Internet of Things was embedded with various technologies mainly with the automation field. Throughout the past decades the ordinary house hold items like refrigerators, security cameras, bulbs, baby monitors were transformed by embedding sensors into them and make them to hear see and touch the world around them, then they can create digital data from the physical information they read. That's a basic example for IOT. With the innovation of IOT there is a possibility to interconnect any device with one or more either device(s). In present there are over 27 billion devices have connected with IOT. [26, 27, 28, 29]

2.3 Similar Existing Projects for Hydroponic Automated Cultivation Systems

2.3.1 Hydroponic Expert System

This system mainly run-on knowledge base architecture. They use both rule base and database. Human experts also have control over Knowledge base in unpredicted situations. The two main essences of the Hydroponic Expert System are Input parameters and output parameters. They have chosen those parameters based on the factors that frequently using in existing studies. The System obtains input parameter values by evaluating the data of output parameters by considering optimum plant growth process. [17]

Figure 2.1 below shows the user interface of hydroponic expert system.

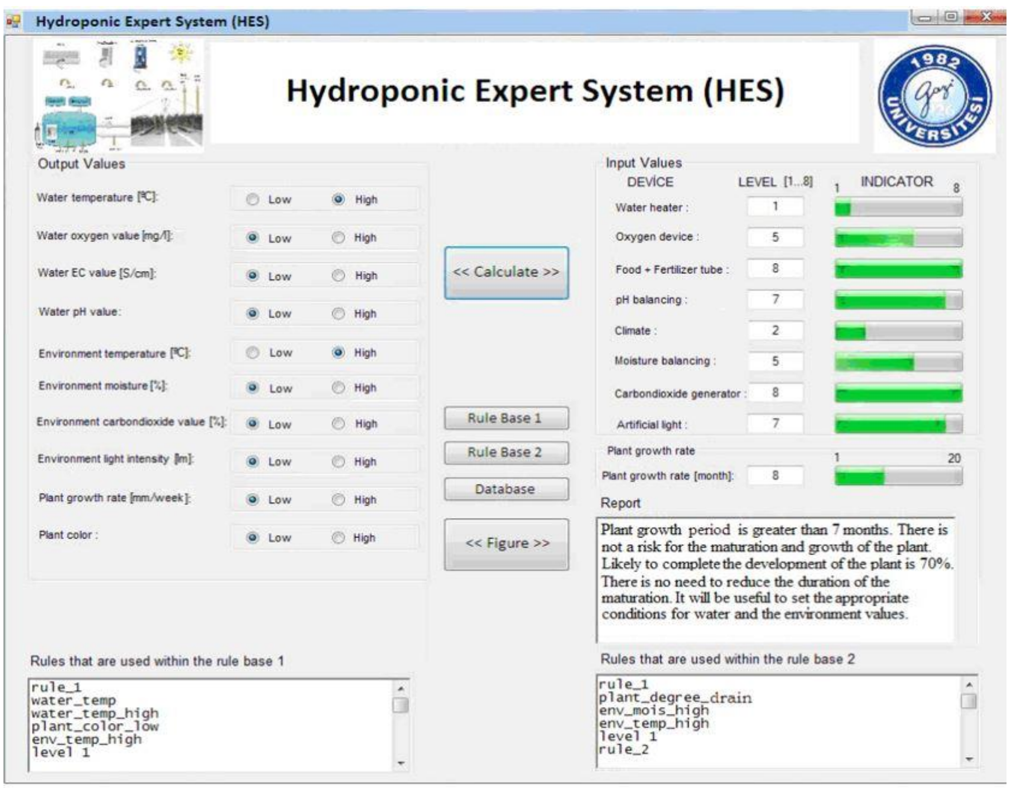

Figure 2.1: User interface of hydroponic expert system

Hydroponic Expert system mainly focuses on controlling plants growth periods in hydroponic greenhouse. The levels that showing on figure 2.1 has been defined by considering personal experience of the expertise. The optimum values for the parameters are obtained by rule base mechanism. [17]

The table 2.1 below shows the parameters that they have used for this study.

Table 2.1: The input and output parameters of hydroponic expert system

Order	Output Parameters	Input Parameters
1	Water temperature	Water heater
2	Water oxygen value	Oxygen device
3	Water EC value (Hardness of water)	Food + Fertilizer tube
4	Water pH value	pH balancing
5	Environment temperature	Climate
6	Environment moisture	Moisture balancing
7	Environment carbondioxide value	Carbondioxide generator
8	Environment light intensity	Artificial light
9	Plant growth rate	
10	Plant color	

2.3.2 Autonomous Hydroponic System

This system also address the effect of soil, local weather and other environmental factors for crop cultivation. They are supporting there proposed solution by producing mini greenhouse farm. In their prototype they are only targeting a targeting crop. They use sensors to read the temperature, light, humidity, chemical level, pressure and so on. Using the copper coil loops under water to maintain the temperature can be identified as the main uniqueness of this system. [18]

Figure 2.2 below shows the structure of the autonomous hydroponic system. [18]

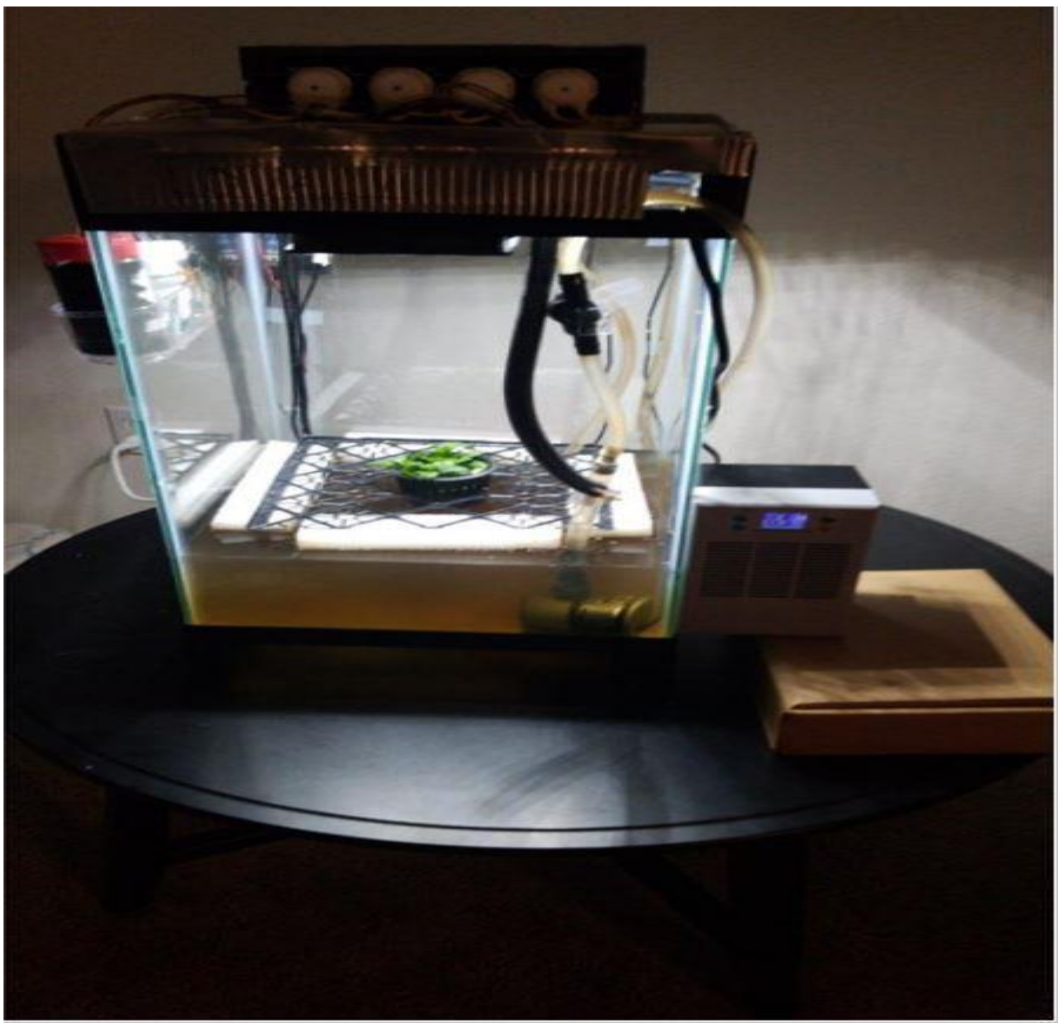

Figure 2.2: Structure of the autonomous hydroponic system

2.4 Summary

This chapter has addressed two similar approaches to our implementing solution. It has briefly discussed the technologies and methodologies used by those approaches. Chapter 3 will be discussing the methodology of our implemented solution and how it differs from the other approaches we discussed in this chapter.

Chapter 3

METHODOLOGY OF OUR WORK

3.1 Introduction

This chapter discusses an overview of the hardware implementation and the software implementation of the proposed work from the start of the project to the ongoing state. The key theories and strategies used when implementing the projects is also discussed.

3.2 Overview

The proposed work is an IOT based solar powered automated hydroponic system which automatically controls the parameters needed for plant growth. Firstly we found the parameters that are most important to plant growth. After investigating a lot we finalized five parameters that we are going to control in this proposed work. Temperature, humidity, light intensity, water level of the nutrient rich water solution which the roots are submerged and the pH value of the water solution which the roots are submerged are five parameters we finalized for controlling throughout this project.

The programming language for our work was Arduino. Arduino is rather a basic programming language which is highly used in the modern world. The software used for programming is the “Arduino IDE” software. In this software the sketch should be compiled and uploaded to the Arduino board for execution after the program is finished writing. C and C++ are functions used when programming in the Arduino software.

So in the proposed work, the plants absorbs the nutrients from the water basket that the roots are submerged in. So nutrient level in the water basket should be well controlled. The pH value of the water solution can determine the nutrient level of the water solution because many factors contribute towards the pH value. So if we control the pH value of the water in the water solution, we can control the nutrient level in the water solution. The pH value can be measured by a pH sensor. And the water level of the nutrient rich water solution should also be controlled using a sensor. Our next challenge was to implement a suitable way to supply or control these parameters adequately. For that we thought of using water valves, fans and etc.

Figure 3.1 below shows the basic overview diagram of our proposed work.

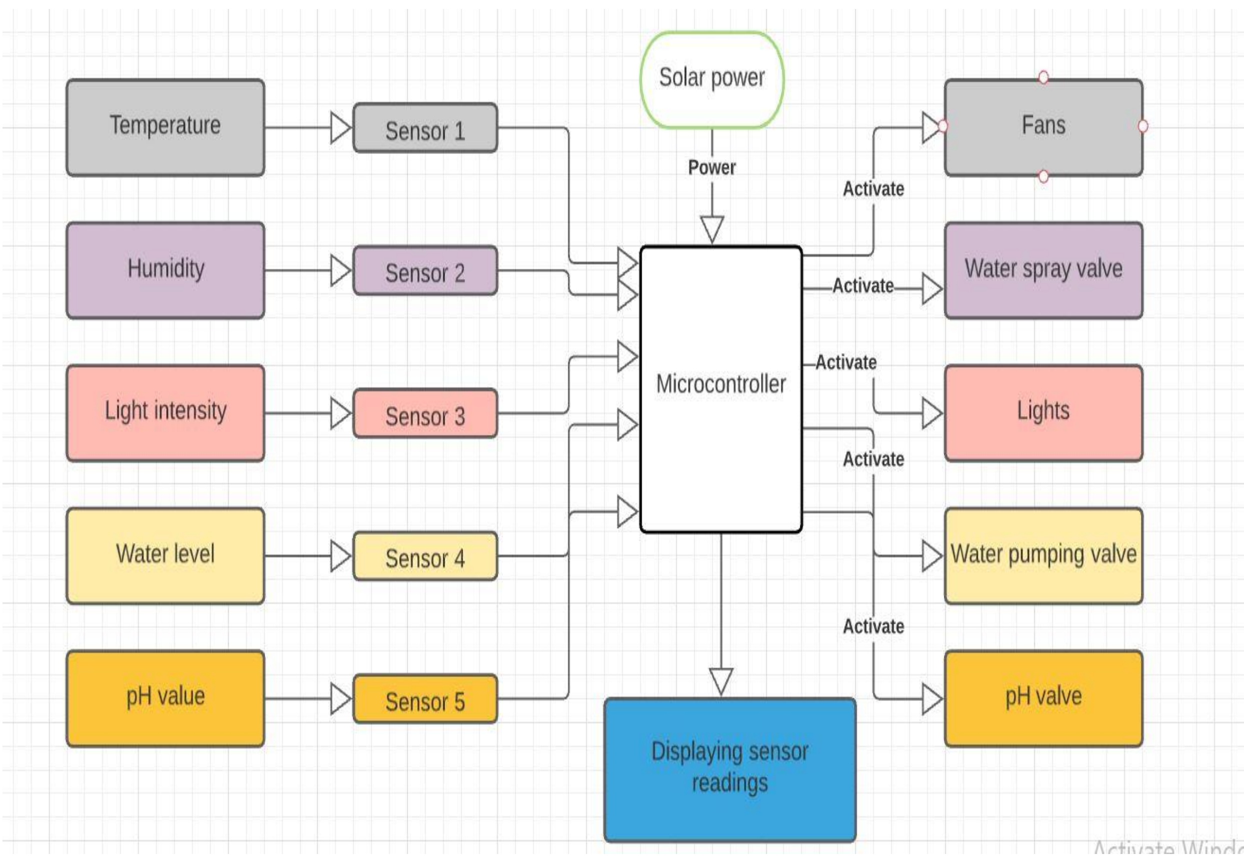

Figure 3.1: Basic overview diagram

Then we referred about the sensors to control each and every parameter mentioned above. When choosing sensors we considered reasons like availability in the local market, cost, simplicity and etc. After considering those factors we finalized the sensors for each parameter.

- Temperature and Humidity – DHT11 sensor
- Light intensity – LDR module 3 pin sensor
- pH value of the water solution – pH value full module sensor
- Water level of the water solution – Ultra sonic sensor

Then we divided the responsibility of each controlling each parameters among the three group members.

Figure 3.2 below shows the overview diagram with relevant sensors and tasks of each group member.

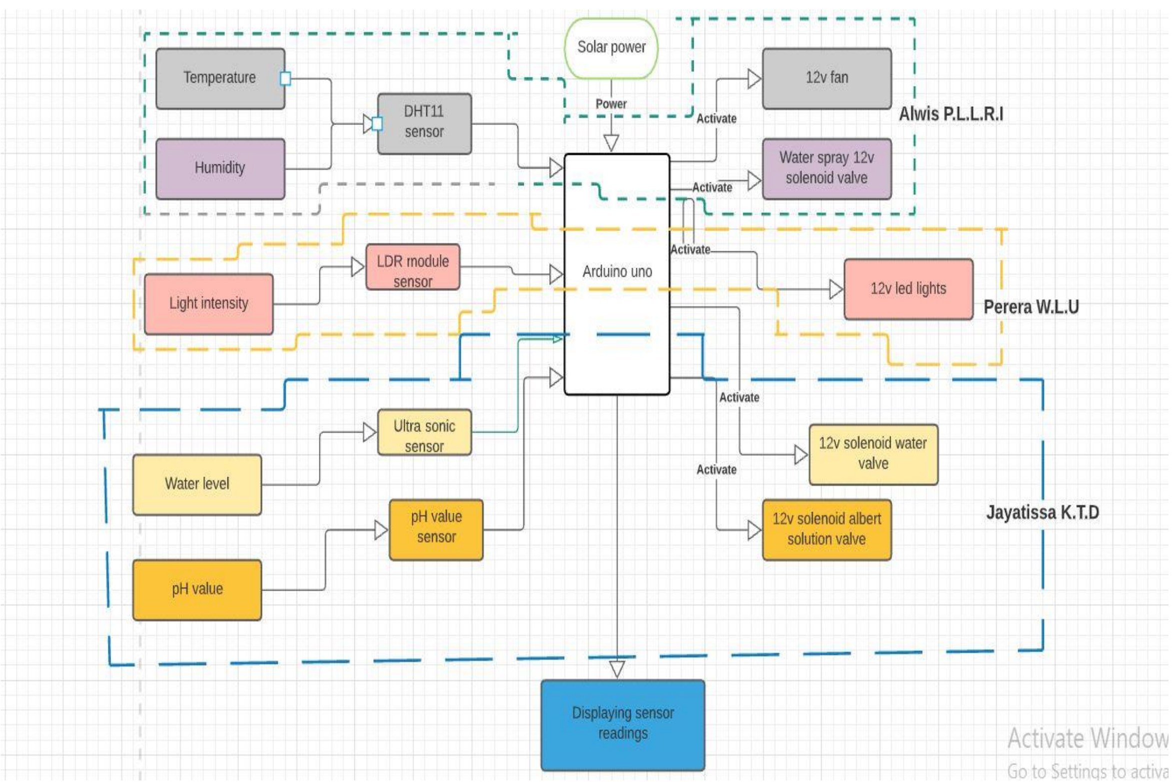

Figure 3.2: Overview diagram with relevant sensors and tasks of each member

3.3 Individual Contribution

My part was to control the water level and the pH value of the water solution in which the roots are submerged.

3.3.1 Identification of sensors

For the measuring of the water level and the pH value an ultra-sonic sensor and a pH sensor module was used respectively,

<u>Ultra-sonic sensor</u>

An ultra-sonic sensor is an electronic device which measures the distance of how far an object is placed from the sensor by emitting ultrasonic sound waves. Then it converts the reflected sound wave into an electrical signal. An ultrasonic sensor consists with two main parts. They are the transmitter and the receiver. The function of the transmitter is to emit the sound signal from the sensor and the function of the receiver is to encounter the sound after it has travelled to and from the targeted object. To calculate the distance between the object and the sensor, the ultra-sonic sensor measures the time it takes from the emission of the sound signal to until the receiver receives the sound signal. [19]

The ultra-sonic sensor consists of four pins. They are Vcc pin, Trigger pin, Echo pin and the ground pin. [20]

- Vcc pin – This is the pin which powers the ultra-sonic sensor. It is normally +5V.
- Ground pin – This is the pin which connects to the ground of the system.
- Trigger pin – This is the input pin of the ultra-sonic sensor.
- Echo pin – This is the output pin of the ultra-sonic sensor. [20]

Some important features of the ultra-sonic sensor:

- Power supply is normally -5V to +5V.
- Ranging distance is from 2cm to 400cm.
- Working current is about 15mA.
- Measuring angle is around 30 degrees. [21]

The following figure 3.3 shows the front and back view of an ultra-sonic sensor. It clearly shows the four pins. [21]

Figure 3.3: Front and back view of an ultra-sonic sensor.

PH sensor

The pH scale is used to measure whether a liquid is acidic or basic. It ranges from 1 to 14. From 1 to 14 the acidic level of the liquid decreases and the basic level increases. Normally pH value of 7 can be called as neutral. The pH sensor is used to measure the pH value of a solution. And it gives a reading in the range of 1 to 14 depending on the substance. The pH sensor kit consists of mainly two parts. They are the pH meter board and the probe which contains an electrode. The probe is made using a glass like material. The pH meter board is the part which is connected to the Arduino board. The probe is submerged in the solution which we need to measure the pH value. The board consists of a voltage regulator chip which supports voltages from normally 3.3V to 5V DC. [22]

The pH sensor consists of 6 pins such as V+ pin, two Ground pins, Po pin, Do pin and the To pin.

- V+ pin – This is the pin which the power is supplied. Normally it is 3.3V to 5V DC.
- Ground pins – These are the pins which is connected to the ground of the systems.
- Po pin – This is the analog output pin.
- Do pin – This is the digital output pin.
- To pin – This is the temperature output pin. [22]

Some features of the pH sensor:

- Supply voltage normally in between 3.3V to 5V.
- Detection range is from 0 to 14.
- High accuracy
- Operating temperature range is from 5 to 60 Celsius.
- Easy calibration. [22]

The pH sensor should be calibrated to get accurate readings. There are many ways to calibrate a pH sensor. For the calibration we need an acidic solution, basic solution and a neutral solution with exactly known pH values. Then we need to put the probe into each solution one at a time and we need to rotate the variable resistor in the motor board until pH value is measured correctly. The correct pH value of the solutions should be known. That's why it is important to take solutions with exactly known pH values. [24]

Figure 3.4 below shows the basic structure of pH electrode or the probe. Electrode is inside the probe. [23]

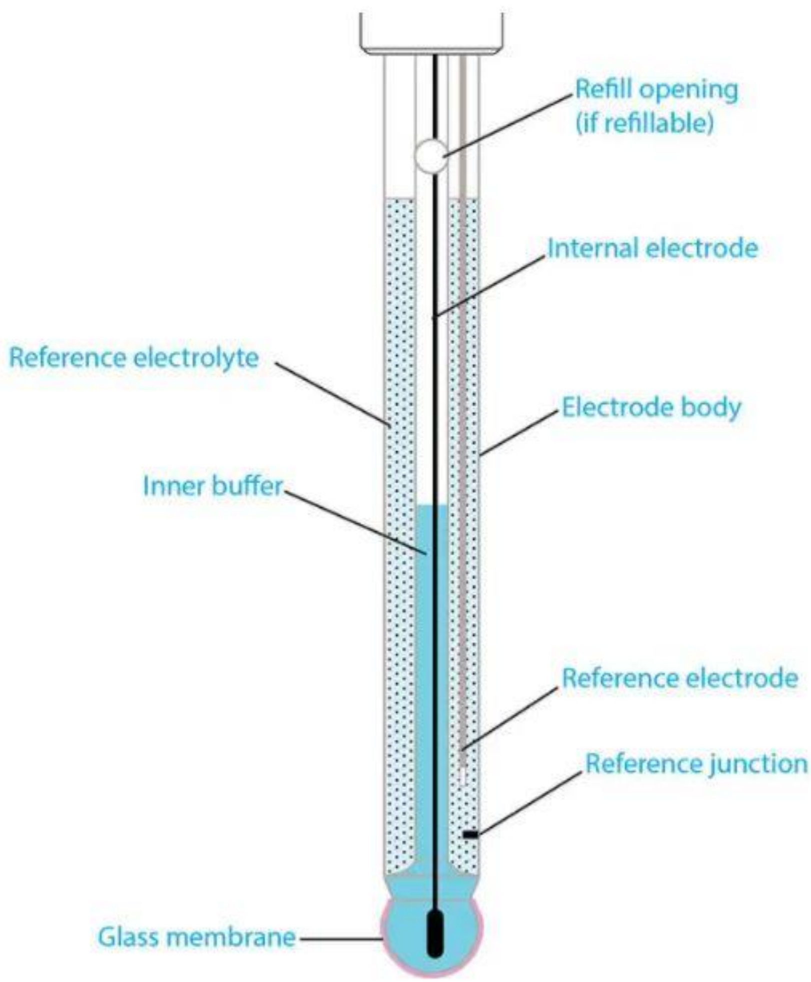

Figure 3.4: Basic structure of a pH electrode

Figure 3.5 below shows the pH meter board which contains the pins. [25]

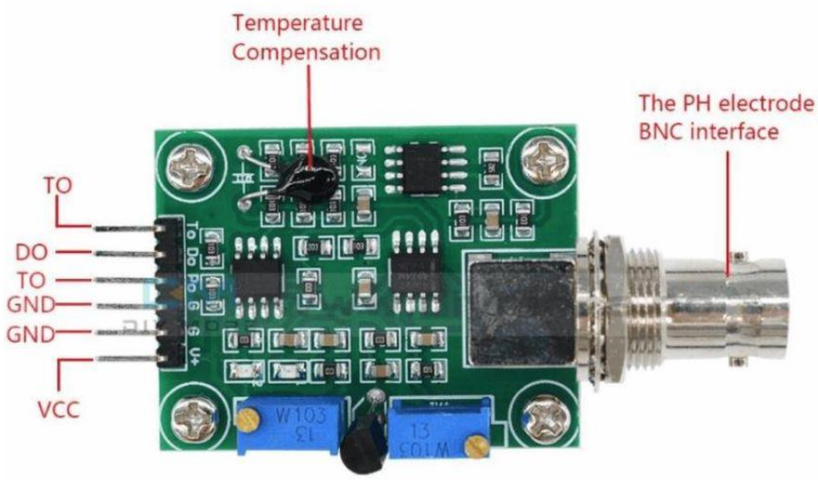

Figure 3.5: Structure of the pH meter board

3.3.2 Implementation

In here the implementation of the system which controls water level and the pH value of the water solution will be discussed.

<u>Measuring and controlling the water level</u>

For the measurement of the water level in the water basket I used an ultra-sonic sensor. From that we can measure the distance between the top of the water level and the sensor. So if we place the sensor on the top of the basket with the transmitter and receiver pointing downwards, the distance measured by the sensor is the distance to the top level of the water in the basket. So we can get the height of the water level by subtracting the sensor reading value from the depth of the water basket.

$$\boldsymbol{Height\ of\ the\ water\ level = Height\ of\ the\ water\ basket - Distance\ measured\ by\ the\ sensor}$$

Figure 3.6 below shows the mechanism of calculating the water level with an ultra-sonic sensor.

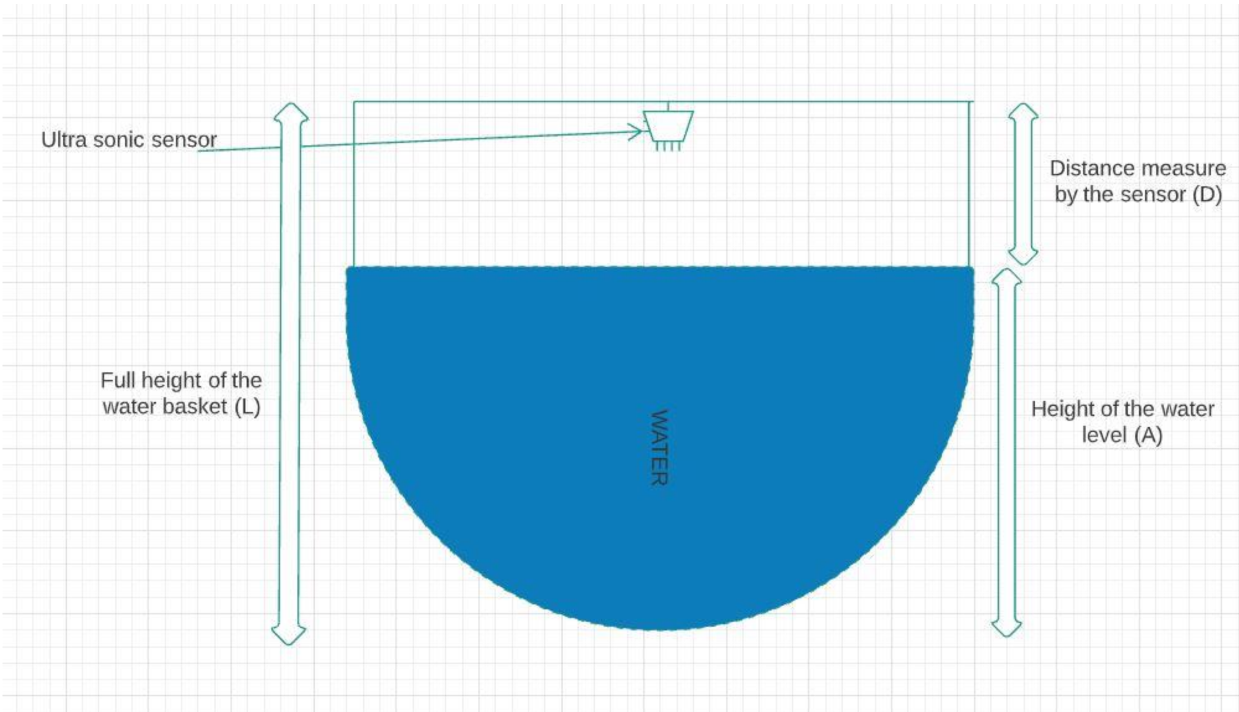

Figure 3.6: Mechanism of calculating the water level

$$\boldsymbol{Height\ of\ the\ water\ level = Height\ of\ the\ water\ basket - Distance\ measured\ by\ the\ sensor}$$

$$\boldsymbol{A = L - D}$$

At first the circuit was built in the proteus software and the simulation was done to display the value measured by the ultrasonic sensor in a 16*2 LCD display.

Figure 3.7 shows the simulation circuit.

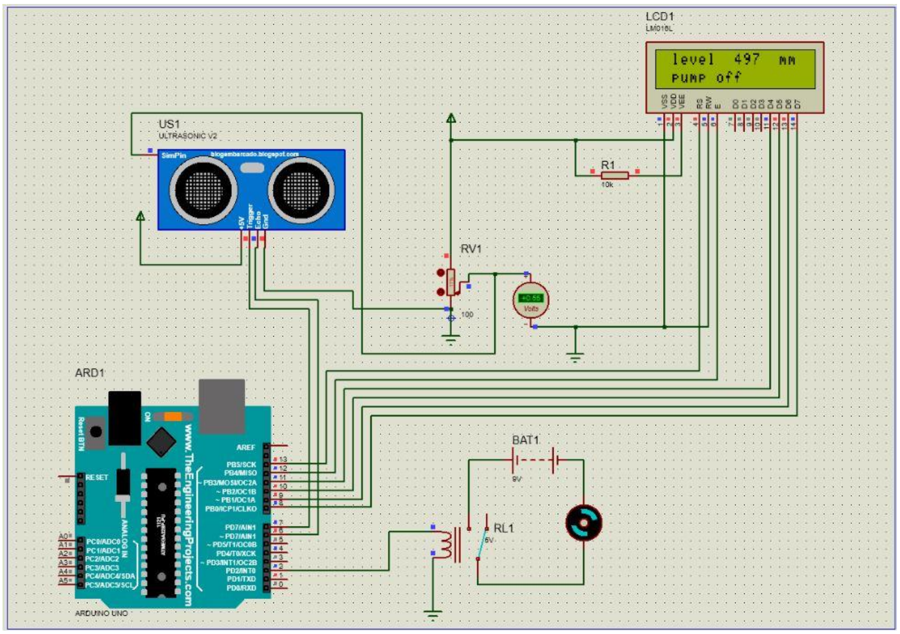

Figure 3.7: Simulation circuit

The code used for the simulation circuit is shown by figure 3.8 below.

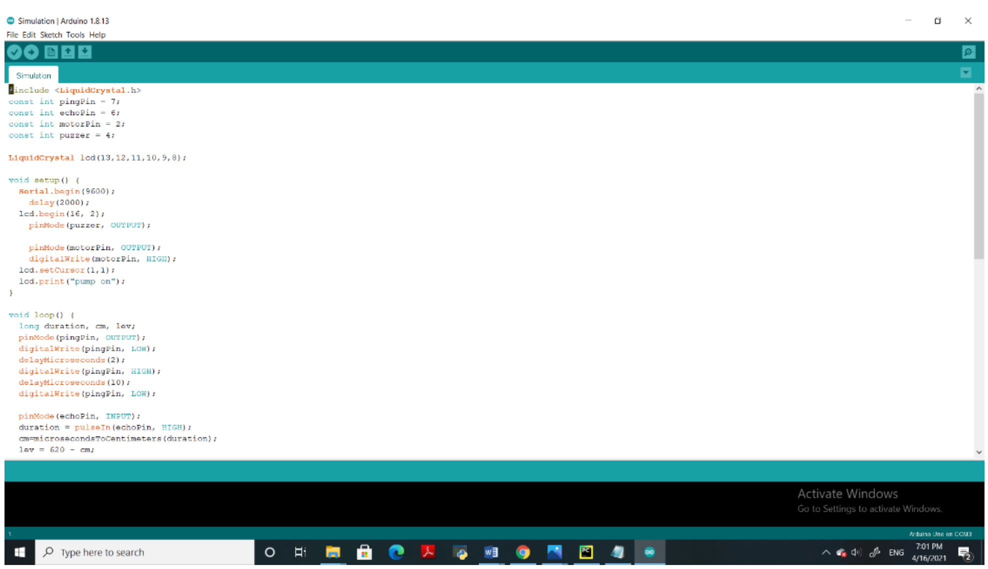

Figure 3.8: Code used for the simulation circuit

Firstly the trig and echo pins are defined with the ports they are connected in the Arduino board. In the void setup part the trig pin was set as the output and the echo pin was set as the input. And also the LCD display is called in the void setup part. Inside the void loop, the trig pin condition is cleared by setting it to low before it is set to HIGH. The trig pin should be in HIGH state for at least 10 micro seconds. Then it is again set to low sate.

digitalWrite(trig,LOW);

delay(1);

digitalWrite(trig,HIGH);

delay(1);

digitalWrite(trig,LOW);

Then by reading the echo pin the sound wave travel time is measured and then it is turned into centimeters.

long t = pulseIn(echo,HIGH);

long cm = t / 29 / 2;

Then the value in centimeter is printed in the LCD screen.

lcd.clear();

lcd.setCursor(0,0);

lcd.print(cm);

lcd.print("cm");

Then I adjusted the cord the code display the values in the serial monitor. Figure 3.9 below shows the basic circuit of the ultra-sonic sensor.

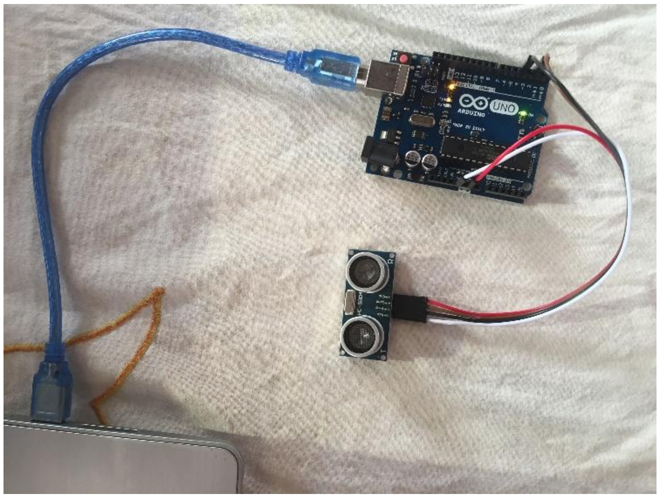

Figure 3.9: Basic circuit of the ultra-sonic sensor

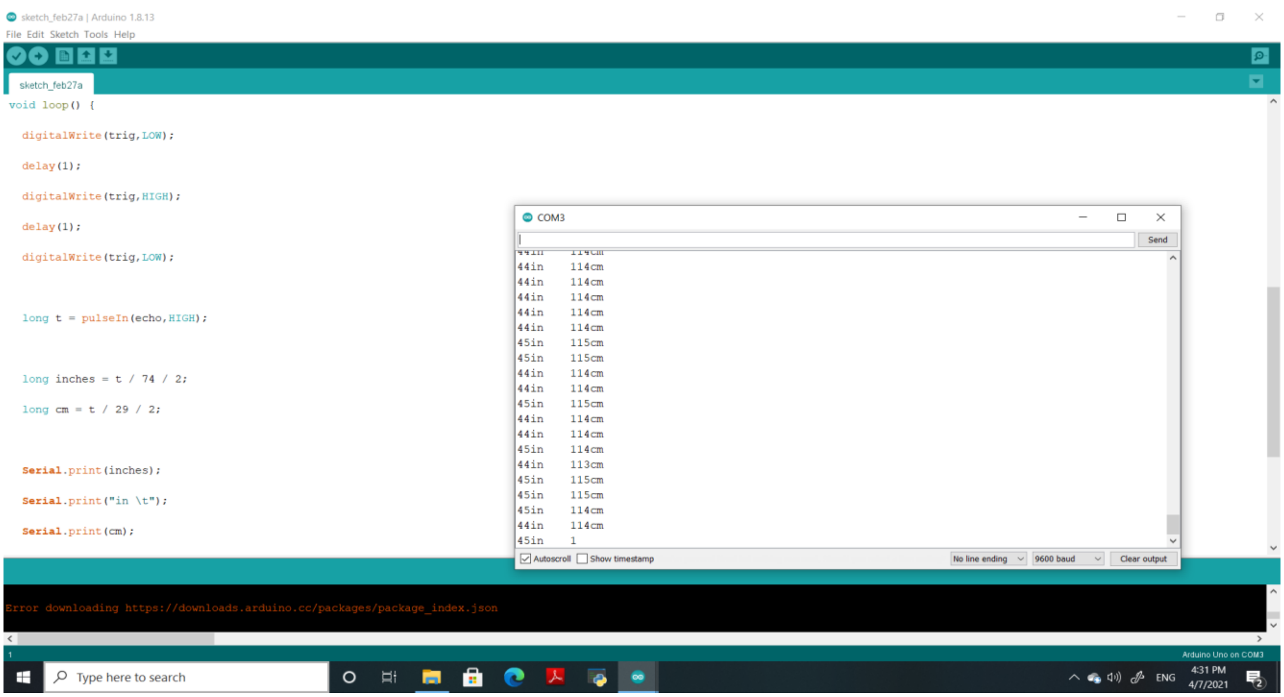

Figure 3.10: Code for the serial monitor displaying for ultra -sonic sensor

Figure 3.10 above shows the code for the measured values to display in the serial monitor. For the serial monitor to begin a 9600 baud rate is given. Here the measured value is also turned into inches.

Then the code was developed to display the readings in the 16*2 LCD display.

Figure 3.11 below shows the code to display the reading in the display.

```
 lcd.clear();
lcd.setCursor(0,0);

lcd.print(cm);
lcd.print("cm");

delay(1000);
```

Figure 3.11: Code to display the readings in the LCD display ultra-sonic sensor

Figure 3.12 shows the circuit with the LCD display.

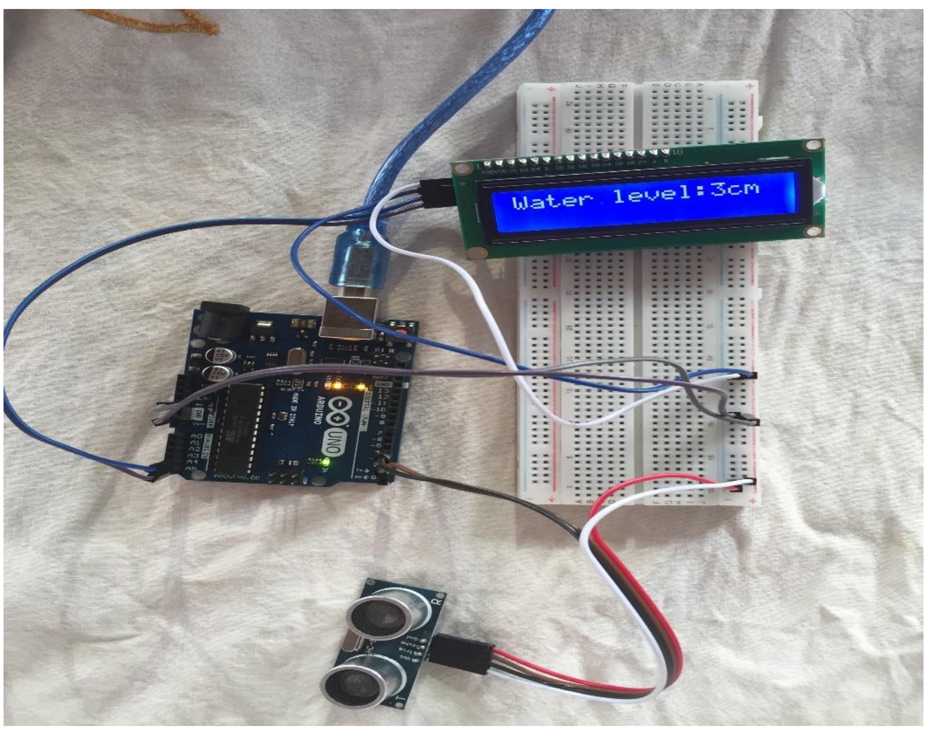

Figure 3.12: Circuit with the LCD display ultra-sonic sensor

Then I develop the circuit to an automatic water valve to open when the water level is low. For this I used a 12V automatic solenoid water valve. When the water level is low the valve gets open automatically and fill the water basket. When the water is filled to the sufficient amount the valve will close again automatically. In this code, if the water level is lower than 30 cm, the relay will switch on and the water will flow through the valve.

Figure 3.13 below shows the coding part updated to the relay to switch on.

```
  if (cm < 30) {
    digitalWrite(tap, HIGH);
    delay(1000);
  }
  else {
    digitalWrite(tap, LOW);
  }
  delay(1000);
}
```

Figure 3.13 Coding part for the relay to switch on ultra-sonic sensor

Figure 3.14 below shows the full circuit with relay on. In this we can see the water level is 2 cm. So the output LED light of the relay is on.

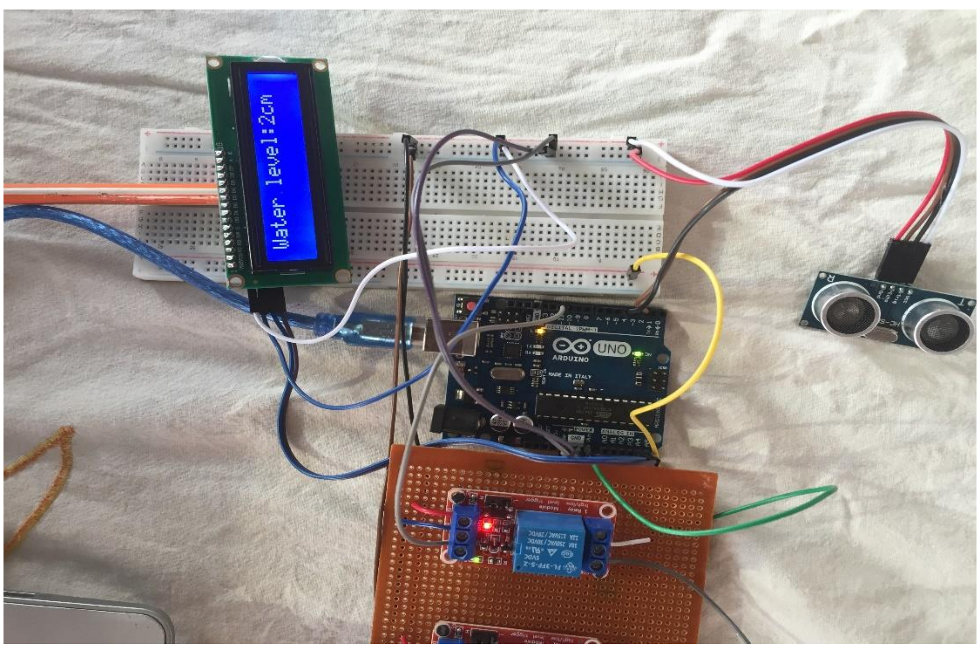

Figure 3.14: Full circuit with the relay on ultra-sonic sensor

Measuring and controlling the pH value

The pH sensor kit is used for measuring the pH value of the of the water solution. When the probe with the electrode inside it is put in a solution, the pH value of the solution is measured. When doing this the first challenge I faced was the pH sensor library for proteus was not available. I referred many sites but I could not found it. So a simulation was not done for the pH sensor.

So firstly the code was written to display the measured values in the serial monitor.

Figure 3.15 shows the code for displaying readings in the serial monitor.

```
int pHSense = A0;
int samples = 10;
float adc_resolution = 1024.0;

void setup()
{
  Serial.begin(9600);
   delay(1000);
  Serial.println("pH Sensor");
}
float ph (float voltage) {
  return 7 + ((2.5 - voltage) / 0.18);
}
void loop () {
  int measurings=0;
  for (int i = 0; i < samples; i++)
  {
    measurings += analogRead(pHSense);
    delay(10);
  }
    float voltage = 5 / adc_resolution * measurings/samples;
    Serial.print("pH= ");
    Serial.println(ph(voltage));
    delay(3000);
}
```

Figure 3.15: Code for displaying values in the serial monitor pH sensor

The following figure 3.16 shows the serial monitor displaying the measured pH values.

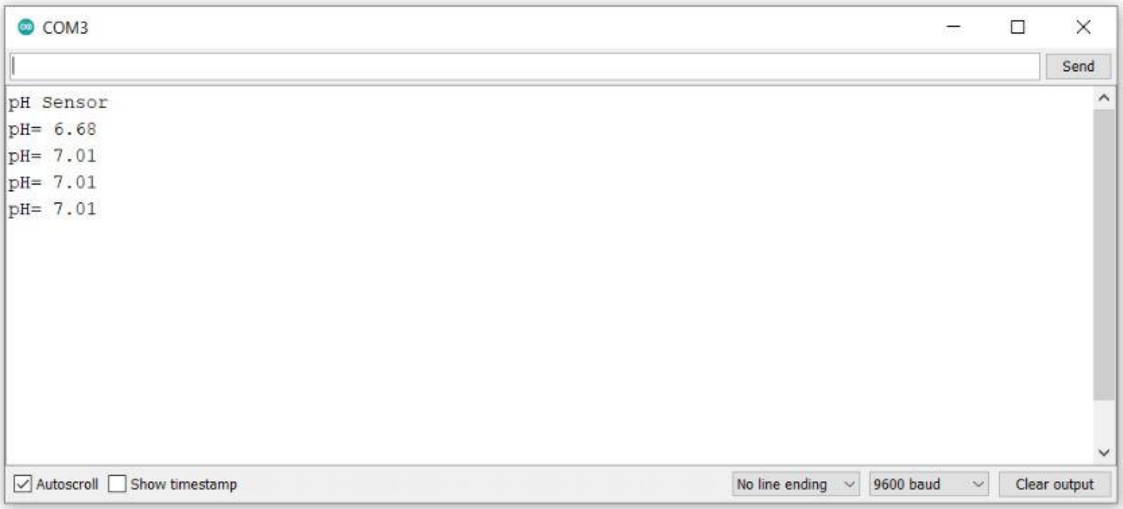

Figure 3.16: Serial monitor displaying values pH sensor

The pH sensor is connected to an analog port of the Arduino board because I have used the Po pin of the pH sensor board. Po pin is the analog pin of the pH sensor.

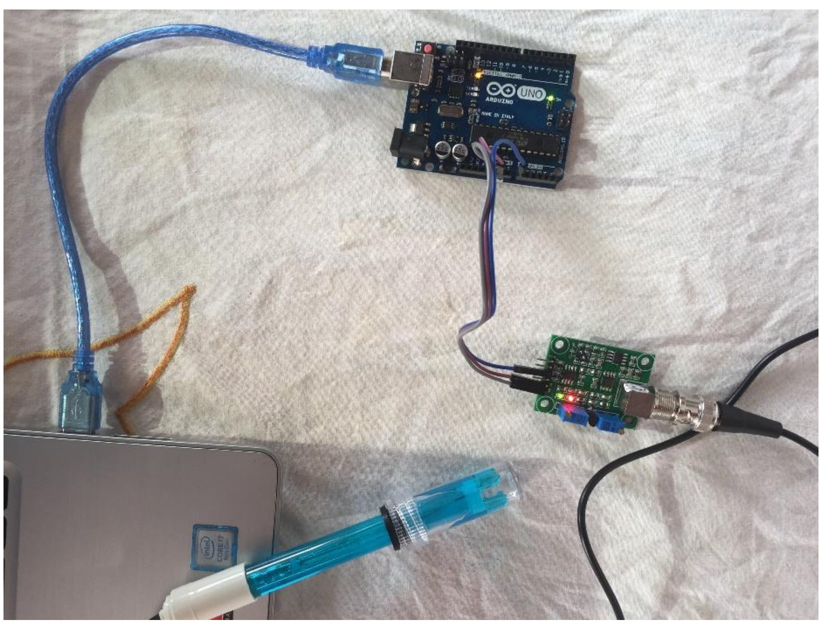

Figure 3.17: Basic circuit of the pH sensor circuit

Figure 3.17 above shows the basic structure of the pH sensor circuit used to only display values in the serial monitor.

Then the code and the circuit was adjusted to display the measured values in a 16*2 LCD display.

Figure 3.18 below shows the coding part added additionally to the before code to display the values in the LCD display.

```
lcd.clear();
lcd.print("pH= ");
lcd.print(ph(voltage));
delay(3000);
```

Figure 3.18: Code to display the readings in a LCD display pH sensor

Figure 3.19 below shows the circuit with the LCD display

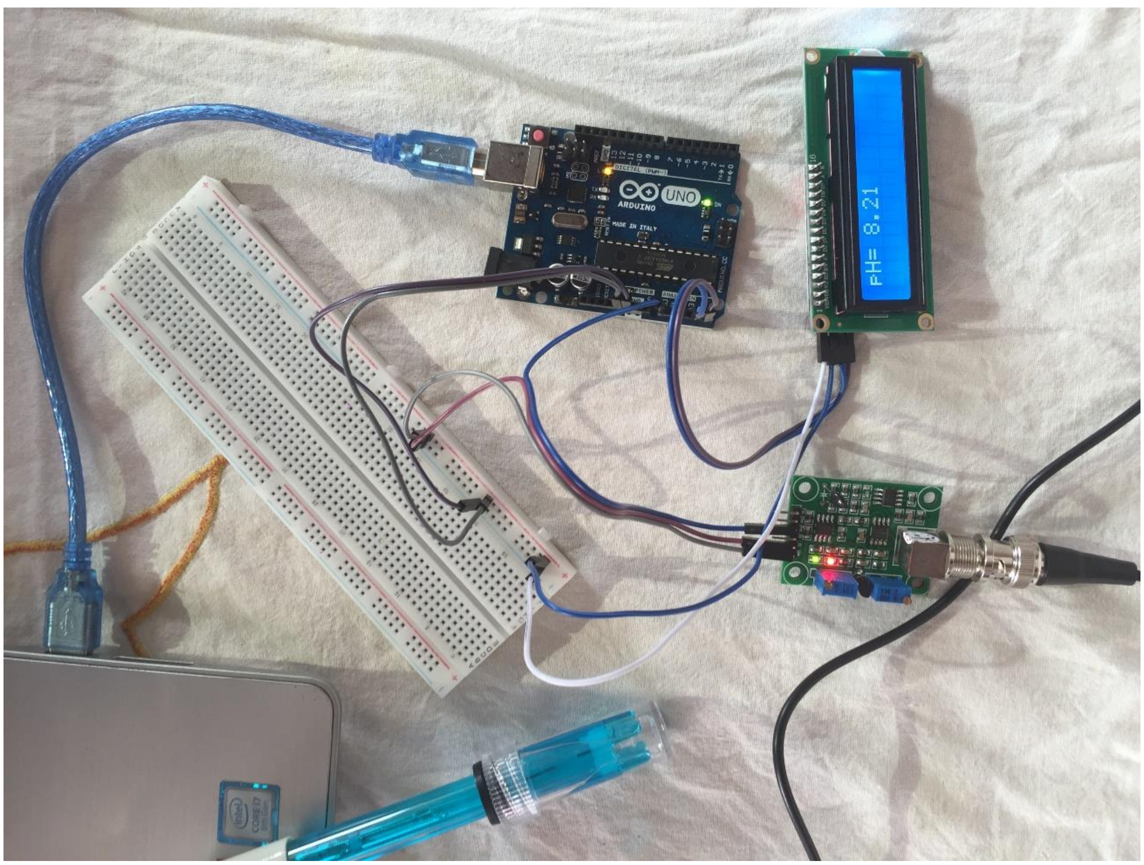

Figure 3.19: pH circuit with the LCD display

Then the circuit and the code was adjusted to work with a relay. When the relay gets on, the Albert solution valve will also get on. So the Albert solution will flow into the water basket through the valve. 12V solenoid water valve was used for this as well. In this code, if the pH value reading is greater than 6, the relay will be turned on and the valve will open.

Figure 3.20 below shows the functionality of the relay.

```
if (ph(voltage) > 6) {
    digitalWrite(RELAY5, HIGH);
    delay(2000);
  }
  else {
    digitalWrite(RELAY5, LOW);
    delay(2000);
  }

delay(3000);
```

Figure 3.20: Code for the functionality of the relay of the pH sensor circuit

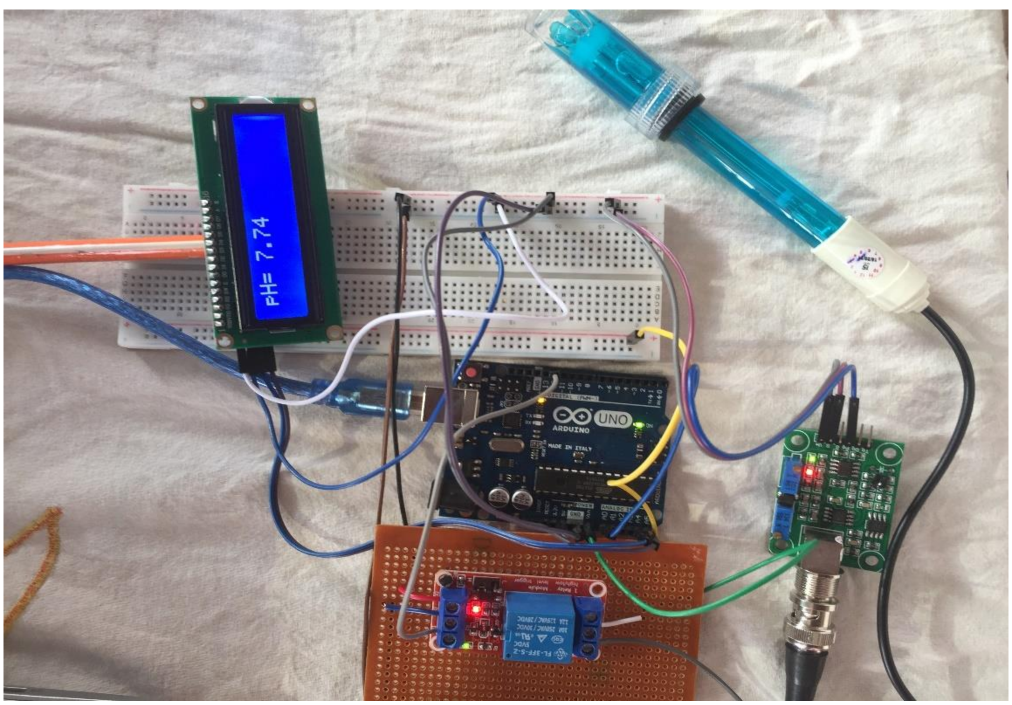

Figure 3.21: Circuit with the relay of the pH sensor circuit

Figure 3.21 above shows the basic circuit of the pH sensor with relay on. In that the pH sensor reading is 7.74. So we can clearly see that the output of the relay is on.

<u>Web page development</u>

The front end of the web page was developed using the PyCharm software and Django.

Figure 3.22 below shows a screenshot of web designing using the PyCharm software.

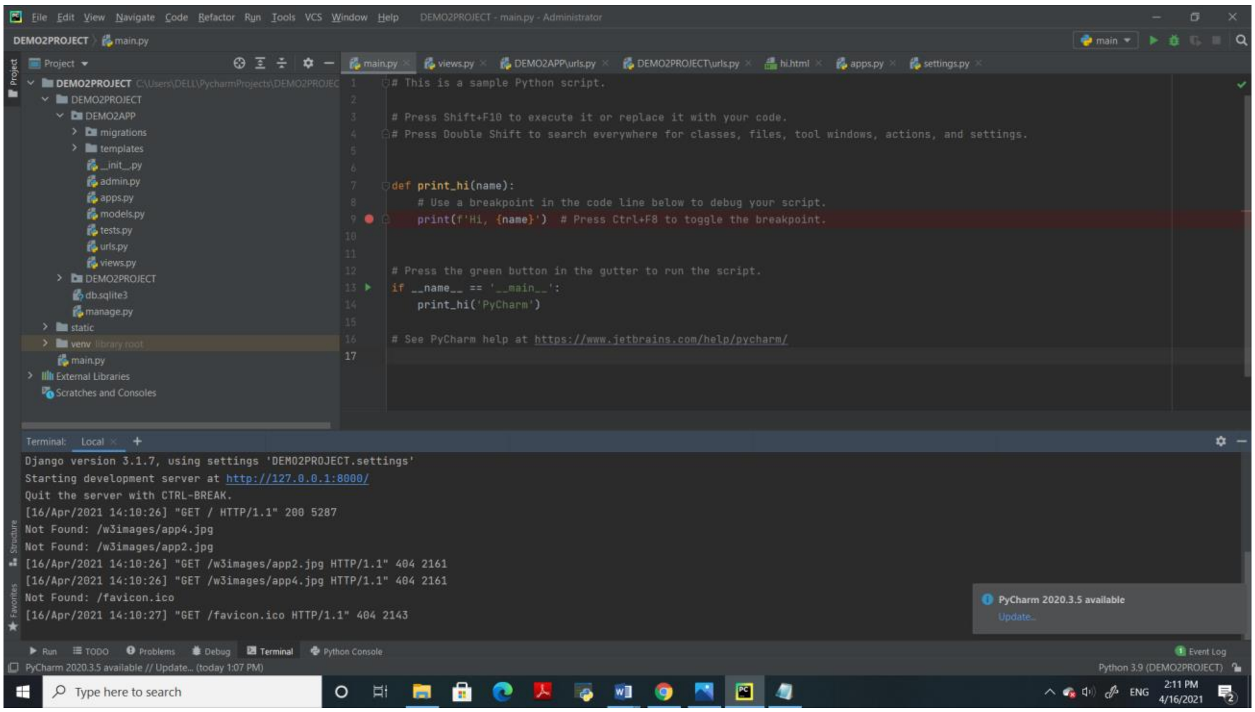

Figure 3.22: Screenshot of web designing using the PyCharm software

Designing of the physical structure

The physical structure of our machine was made using iron because iron gives the strength and durability.

Figure 3.23 below shows some photos taken during making the structure.

Figure 3.23: Photos taken during the structure preparation

Figure 3.24 below shows the final structure of our work.

Figure 3.24: Final structure of our work

Chapter 4

REULTS AND FUTURE WORKS

In this study, the Automated Hydroponic cultivation system aims to address the complexity in Hydroponic cultivation which is proven as an effective solution to improve the growth efficiency of a cultivation than the traditional soil-based cultivation. The best way to address that challenging complexity was identified as automating the hydroponic system. The proposed and the Implemented system is working with five main environment factors which are mainly affect to the cultivation growth. Those are water level, Temperature, pH value of the water, Humidity and light. Current system-controlled water level by circulate water supply and measure the water level using ultrasonic sensor and maintain the required water level using relays and an embedded water extension tank. Temperature of the environment also measures using sensor, and control the temperature using fans. The pH value of the water is measuring using pH sensor kit and controls the pH value of the water base using embedded Albert solution tank and relay kit. Humidity of the environment also measures through a sensor and controls the environment humidity by maintaining the wet level of the surrounded wet curtains. The final factor is the light. It also measures using a LDR module and maintain the required level of light using LED bulb system connected to a relay.

Future Implementations

- Complete the Automated Hydroponic Cultivation web application. As only the front end of the application was completed yet, Back end has to be completed.

- Develop the Automated Hydroponic Cultivation mobile application. Mobile application for the system which may include the same functionalities of the web application has proposed to be implemented.

- Enhance the system to set up the environment factors of the cultivation relevant to the type of the cultivation. The system was implemented and tested only to support a single crop type. It has to be enhanced to support different types of cultivation and handle the environment factors required by each of them.

- Develop the system to control the water temperature using water temperature sensors, water controller/heater and relays. Currently we only measure and control the environment temperature. For more accurate and processive system temperature of the water level also has to be measured and controlled.

- Enhance the system using dispensers to get more accurate water level. System could improve to supply exact level of water using water dispensers.

- Develop the system to follow user input factor levels as well through web application or mobile application. System may be improved to set the environment factors regarding to user inputs of the embedded applications instead of proposed values from the system.

Chapter 5

FINAL CONCLUSION

Hydroponic systems and greenhouses address most of the challenges in soil-based traditional crop cultivation, such as limited farming areas, unsuitable mixing levels for in the soil for a desired crop type, polluting environment by mixing fertilized chemicals to the soil, unsuitable environmental factors for the cultivation and mainly low efficiency of cultivation. Automation Hydroponic Cultivation System address the main problems in a basic hydroponic cultivation such as complexity and manpower. Automation Hydroponic Cultivation System handling the complexity by automatically measuring and maintaining the main environmental factors (water level, pH level of water base, Temperature, Humidity level, Light level). And this automated system has driven the required human interference to a minimum level.

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APPENDIX

Full code of my implementation

```
#define RELAY4 11
#define RELAY5 12
#define trig 4

#define echo 2

#include <Arduino.h>

#include <Wire.h>
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,16,2);

int pHSense = A0;
int samples = 10;
  float adc_resolution = 1024.0;

String WL="Water level:";



void setup() {
  Serial.begin(9600);

  lcd.clear();
  lcd.init();
  lcd.init();
```

```
 lcd.backlight();
 lcd.setCursor(0,0);
 lcd.print("HYDROPONIC");

pinMode(trig, OUTPUT);

 pinMode(echo,INPUT);

pinMode(RELAY4, OUTPUT);
   pinMode(RELAY5, OUTPUT);
 }

float ph (float voltage) {
  return 7 + ((2.5 - voltage) / 0.18);



}

void loop() {

 int measurings=0;
  for (int i = 0; i < samples; i++)
  {
    measurings += analogRead(pHSense);
    delay(10);
  }

  float voltage = 5 / adc_resolution * measurings/samples;

  lcd.clear();
  lcd.setCursor(0,0);
```

```
    lcd.print("pH= ");
    lcd.print(ph(voltage));
    delay(3000);

if (ph(voltage) > 6) {
    digitalWrite(RELAY5, HIGH);
    delay(2000);
  }
  else {
    digitalWrite(RELAY5, LOW);
    delay(2000);
  }

delay(3000);



digitalWrite(trig,LOW);

  delay(1);

  digitalWrite(trig,HIGH);

  delay(1);

  digitalWrite(trig,LOW);




  long t = pulseIn(echo,HIGH);
```

```
 long cm = t / 29 / 2;
delay(3000);

Serial.print(WL + cm);
Serial.println("cm");

 lcd.clear();
    lcd.setCursor(0,0);
    lcd.print(WL + cm);
    lcd.print("cm");

    delay(3000);

if (cm < 30) {
   digitalWrite(RELAY4, HIGH);
   delay(2000);
 }
 else {
   digitalWrite(RELAY4, LOW);
   delay(2000);
 }
 delay(3000);
}
```