Real Time Soil Analysis & Crop Prediction

A Minor Project Report submitted to
Rajiv Gandhi Proudyogiki Vishwavidyalaya
towards partial fulfillment of the Requirements for
the Degree of Bachelor of Engineering in
Computer Science & Engineering
(Session 2017-18)

Guided By:
Mr. Ambrish Srivastav
Asst. Professor
CSE Dept., SVCE Indore

Mr. Archit Shukla
Asst. Professor
CSE Dept., SVCE Indore

Submitted By:
Burhanuddin Saify (0822CS151025)
Neeraj Vyas (0822CS151060)

Department of Computer Science & Engineering
SWAMI VIVEKANAND COLLEGE OF ENGINEERING, INDORE

2017-18

Certificate

The Minor Project entitled **"Real Time Soil Analysis & Crop Prediction"** submitted by **Burhanuddin Saify (0822CS151025) and Neeraj Vyas (0822CS151060)** is a satisfactory account of the bonafide work done under my guidance is recommended towards the partial fulfillment for the award of **Bachelor of Engineering** in **Computer Science & Engineering** degree by **Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal** for the academic year 2017-18.

Date:

Mr. Ambrish Srivastav
(Project Guide)

Mr. Archit Shukla
(Project Guide)

Endorsed By
Head,
Department of Computer Science & Engineering

Approval Sheet

The Minor Project entitled **"Real Time Soil Analysis & Crop Prediction"** submitted by **Burhanuddin Saify (0822CS151025)** and **Neeraj Vyas (0822CS151060)** is approved as partial fulfillment for the award of **Bachelor of Engineering** in **Computer Science & Engineering** degree by **Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal** for the academic year 2017-2018.

Internal Examiner **External Examiner**

Principal
Swami Vivekanand College of Engineering,
Indore (M.P.)

Candidate Declaration

We hereby declare that the work which is being presented in this project report entitled **Real Time Soil Analysis & Crop Prediction** in partial fulfillment of degree of **Bachelor of Engineering** in **Computer Science & Engineering** is an authentic record of our own work carried out under the supervision and guidance of **Mr. Ambrish Srivastav and Mr. Archit Shukla**.

We are fully responsible for the matter embodied in this project in case of any discrepancy found in the project and the project has not been submitted for the award of any other degree.

Date:

Place: Indore

Burhanuddin Saify
(0822CS151025)

Neeraj Vyas
(0822CS151060)

ACKNOWLEDGEMENTS

I am thankful to the technical university Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal for giving me opportunity to convert my theoretical knowledge into the practical skills through this project.

Any work of this magnitude requires input, efforts and encouragement of people from all sides. In compiling this project, I have been fortunate enough to get active and kind cooperation from many people without which my endeavors wouldn't have been a success. The project work has been made successful by the cumbersome effort of the faculties.

I would like to express gratitude to my guide **Mr. Ambrish Srivastav and Mr. Archit Shukla** under whose valuable guidance, for encouraging me regularly and explain me each and every concept, I was able to execute my project smoothly.

I express my deep gratitude to **Prof. Vijay Birchha**, Asst. Professor and Head, Computer Science and Engineering Department who was involved right from the inception of ideas to the finalization of the work.

I express my profound gratitude to **Dr. Rajendra Tare**, Principal, Swami Vivekanand College of Engineering, Indore (M.P.), for making me confident about the research platform and helping me a lot in research work implementation.

I am thankful to all teaching and Non-teaching staff of the Computer science and Engineering Department for their timely help and co-operation for their continuous support and encouragement in success of this project.

Last but not the least; I am grateful to My Parents, and family members and friends, for their continuous support and encouragement in success of this project.

Burhanuddin Saify
(0822CS151025)

Neeraj Vyas
(0822CS151060)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

With evolution in technology various agricultural practices have shifted from traditional techniques to automated techniques like field irrigation system. One of the most important parameter in farming is soil fertility, i.e. ratio in which various nutrients and parameters essential for crops are present in the soil. And to monitor soil's fertility, pH of the soil is most commonly measured.

The proposed system will determine the average percentage of basic soil's N, P and K content, temperature, humidity, moisture, light intensity and the crops that can be grown on that soil.

The system will analyse soil nutrient content at real time and accordingly acknowledge farmer on the basis of result acquired. System will be built on Particle Photon and Augmented Reality in Android (IoT-AR).

Acronyms

1. pH – Potential of Hydrogen
2. N – Nitrogen
3. P – Phosphorous
4. K – Potassium
5. IoT – Internet of Things
6. AR – Augmented Reality
7. IDE – Integrated Development Environment

Abbreviations

1. RTSACP – Real Time Soil Analysis and Crop Prediction

Chapter - 1 Introduction

1.1 Rationale

For many years soil analysis has been used as an aid for assessing soil fertility and plant nutrient management.
Achieving and maintaining appropriate levels of soil fertility, especially plant nutrient availability is of paramount importance if agricultural land is to remain capable of sustaining crop production at an acceptable level. [1]

The 3 important steps in managing the nutrient requirement of plants are:

- Soil sampling and analysis.
- Interpretation of analytical data.
- Recommendation for nutrient addition as fertilizer or manure to optimize crop yields.

The Factors contributing to the chemical properties of soil that can be determined readily by analysis are:

- Soil Acidity/Basicity (pH).
- Total amount of soil organic matter.
- Readily available mineral nutrient such as N, P and K.

In automated farming practice, we intend to reduce human errors by monitoring the soil quality using various soil sensors via smartphones.

The key features of our system is to provide real time and continuous analysis of soil in which Temperature, Humidity, Light intensity, Moisture and pH level of soil will be analysed, and a suitable crop can be selected.

1.2 Problem Definition

Farmers visit soil testing laboratory to get the soil of their farm tested for the effective crop yield. If a compact and handy soil tester is available then the farmers may not have to visit to the lab and testing can be done in the farm itself whenever there is need of it. And it will also decrease the testing time and expenditure of the farmer.

There are many environmental factors that affects the crop severely. And some of them are :

- **Humidity**
- **Temperature**
- **Light Intensity**
- **pH level**
- **Soil Moisture**

which are the key parameters that mostly describes the soil, and by analysing this the soil's fertility can be measured easily and effectively.

Also the problems that are generally faced by the farmers includes:

- Inability to select which crop to grow to get a better yield.
- Also, if the land area of the field may be quite large enough then there is possibility that each section of soil may have varying properties.
- In such cases, farmers have to take more than 2 or 3 sample from different locations. This may result in expensive lab testing and time consuming procedures.

1.3 Proposed Solution

As every crop has its own environmental conditions, i.e. temperature, humidity and soil nutrients. So in the database, the dataset of crops containing these environmental conditions are stored, which will assist in mapping the tested soil for crops prediction, that can be grown on that particular patch of soil.[2]

Now, with the help of micro-controller i.e. particle photon in which the sensors are connected, the following can be detected:

- Temperature
- Humidity
- Moisture Content
- Light intensity

For pH detection keeping an eye on economic feasibility, manual pH determination can be done instead of pH sensor which stretches the cost. For this normal pH paper is used to check the soil pH, by dissolving the soil sample in the distilled water and then by dipping the pH strip in it, the colour obtained on the strip can be matched with the one given in the application and value can be determined to infer if soil is acidic or basic, which will help in deciding the appropriate fertilizer with adequate ratio of Nitrogen (N), Phosphorous (P), Potassium (K) and etc. that should be added to the soil according to the need.[3]

According to values fetched, it can be determined to infer if soil is acidic or basic, which will help in deciding the appropriate fertilizer with adequate ratio of Nitrogen (N), Phosphorous (P), Potassium (K) and etc. that should be added to the soil according to the need. [4]

Soil tester that can spontaneously and continuously keep the record of the moisture content of the soil which acts as a beneficial tool for the farmer in order to know, when to irrigate the field.

During photosynthesis and germination process the crop requires light as the key feature.

So if the farmer uses artificial lighting for farming, he/she has to use combination of red and blue lights which can be monitored using light intensity sensor.

1.4. Report Organization

In this report we have covered and described following topics and chapters:

1.4.1 Chapter 1

In the first chapter we have covered the Introduction of our minor project, where Rationale, Problem Definition, Proposed Solution and Report Organization is covered.

1.4.2 Chapter 2

In the second chapter we have covered the Literature Survey of our minor project, where the Related Works, Technologies and Tools used is covered.

1.4.3 Chapter 3

In the third chapter we have covered the Analysis of our minor project, where the Process Model that we have adopted is described, Requirement Analysis of the project, Feasibility Study, Architectural Specification, Use Case Model Diagram with its Description is mentioned.

1.4.4 Chapter 4

In the fourth chapter we have covered the Design process of our minor project, where Activity Diagrams, Sequence Diagrams and Class Diagrams along with the Database Design has been made.

1.4.5 Chapter 5

In the fifth chapter we have covered the Implementation and Testing of our minor project, where the Language Used Characteristics, Testing with its test cases are shown.

1.4.6 Chapter 6

In the sixth chapter we have covered the Conclusion and Discussion of our minor project, where the Learning, Achievements, Limitations and Future Scope of our project is mentioned.

Chapter - 2 Literature Survey

According to the scholarly research,

- ✓ The term soil health is often preferred to soil quality by farmers, while scientists relate the term "soil health" to the status of various biological properties in the soil (Haberem, 1992; Romig et aI., 1995; Harris et aI. 1996).

According to the Agro Services International Inc.

- ✓ pH is a scale that chemists use to measure acidity. Values below 7 are considered acidic, values above 7 are alkaline (the opposite of acidic) and 7 is neutral.

- ✓ Most plants can tolerate a wide pH range in solution culture, but they cannot tolerate a wide range of acidity in the soil.

- ✓ When soil acidity changes, the solubility of a number of metal ions also change. Plant growth is really affected by the varying concentration of these metals in solution rather than by the acidity itself.

- ✓ The aim in managing soil pH is not to achieve a particular pH value, but to adjust the acidity to the point where there are no toxic metals in solution and the availability of nutrients is at its maximum. This condition is usually achieved when the soil pH is between 5.8 and 6.5, however some plants have special acidity requirements.

- ✓ Some alkaline soils can be acidified using sulfur or acid forming fertilizers, but soils with free calcium carbonate cannot be easily acidified. It is often easier to manage the nutrient deficiencies that occur on alkaline soils than to acidify the soil.

Low fertility of soils is the major constraint to achieving high productivity goals. Soil should have to be rich in nutrients basically (N, P and K), these are the 'Master key to agriculture'.

This 'Do It Yourself' kit will adopt the appropriate management practices in order to boost the fertility status. Understanding soil function and land use is the first step in the determination of soil quality.

Assessing soil quality raises many questions:

- ✓ How is soil quality managed?
- ✓ What criteria should be used to evaluate soil quality?
- ✓ Which soil quality fertilizers should be used?
- ✓ What are the ideal conditions or values for each sensors?

These practice include site specific nutrient management, sustainable land use, and cropping systems, and appropriate agronomic practices.

According to Ines Marjanovic (Agronomy Expert)

- ✓ Farming in a Controlled Environment

In one of our previous blog posts, we wrote about farming in a controlled environment. Here is a snapshot of the meaning of this sustainable farm practice. Farming in a controlled environment is a type of urban farming where environmental conditions such as light, temperature, humidity, and nutrient cycles can be controlled. This practice refers to an indoor method of farming, such as vertical farms and greenhouses. Both farm practices manage crop growth by combining the hydroponic, aeroponic and aquaponic systems.

- ✓ Farming without Using Sunlight

Growing crops under artificial light is a revolutionary scientific farm practice. Initially, vertical farms used fluorescent lights to support the crop growth. However, with the development of LED light technology, fluorescent lights are slowly being replaced by the new, energy-efficient bulbs. The best practice is to use the pink lights, i.e. the combination of red and blue LED lights. Scientists claim that the mixing of red and blue wavelengths is all that a crop really requires in order to grow successfully.

- ✓ Influence of Pink Light to the Crop Growth

Blue wavelengths influence phototropism, the opening of stomata which regulates a crop's retention of water and chlorophyll production. Phytochromes absorb mostly red light. Red wavelengths produce a variety of responses in crops as well. They initiate seed germination, root development, and manage shade avoidance.

2.1 Related Works

In this paper Embedded Based Soil Analyzer is used to analyze various soil nutrients with the help of pH value. As per the availability of nutrients, recommendations of cultivating the particular crop will be given. This project uses microcontroller which determines PH of diluted soil sample using Glass ph electrode. PH is defined as the negative logarithm (base 10) of the activity of hydronium ions (H+or, more precisely, H3O+aq) in a solution. It ranges from 0 to 14, with 7 being neutral. A pH below 7 is acidic and above 7 is basic. The optimum pH range for most plants is between 5.5 and 7.0. The system includes Microcontroller Unit, Signal conditioning, Sensors, Display, Thermal Printer and Power supply. Output from pH sensors and EC sensor are analog in nature to process these analog signals to the system A/D converters are used. PIC18F458 Microcontroller has the inbuilt analog to digital converter and no need to connect the external A/D converter for the system. In this system, keypad is used to connect the user and the system. [6]

2.2 Technologies and Tools used

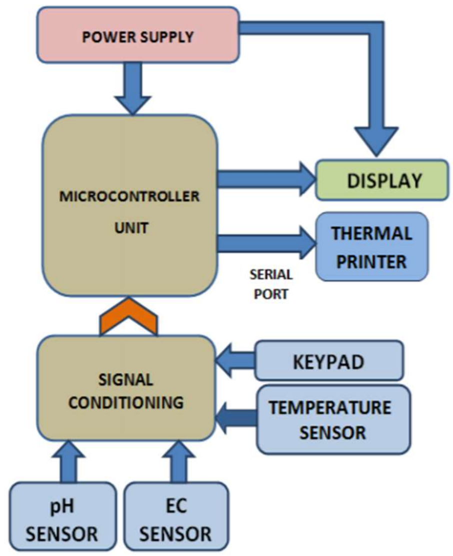

Fig. 2.1: System Architecture Diagram

System architecture is shown in figure 2.2.1, which includes

- Microcontroller Unit
  - ✓ A microcontroller is a small computer on a single integrated circuit. In modern terminology, it is similar to, but less sophisticated than, a system on a chip or SoC; a SoC may include a microcontroller as one of its components.

- Signal conditioning
  - ✓ Signal conditioning is the manipulation of a signal in a way that prepares it for the next stage of processing.

- pH Sensor
  - ✓ A pH sensor is a scientific instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or alkalinity expressed as pH.

- EC Sensor
  - ✓ An electrical conductivity sensor (EC sensor) measures the electrical conductivity in a solution.

- Temperature Sensor
  - ✓ A temperature sensor is a device, typically, a thermocouple or RTD that provides for temperature measurement through an electrical signal.

- Display
  - ✓ A display device is an output device for presentation of information in visual or tactile form.

- Thermal Printer
  - ✓ A printer in which fine heated pins form characters on heat-sensitive paper.

- Power supply
  - ✓ A power supply is an electrical device that supplies electric power to an electrical load.

Chapter-3 Analysis

3.1 Process Model Adopted

- Prototype Model is been used to build this project.

3.1.1 Description

• In prototyping model initially the requirement gathering is done.

• Developer and customer define overall objectives; identify areas needing more requirement gathering.

• Then a quick design is prepared. This design represents what will be visible to the user in input and output format.

• From the quick design a prototype is prepared. Customer or user evaluates the prototype in order to refine the requirements. Iteratively prototype is tuned for satisfying customer requirements. Thus prototype is important to identify the software requirements.

• When working prototype is built, developer use existing program fragments or program generators to throw away the prototype and rebuild the system to high quality.

• Certain classes of mathematical algorithms, subset of command driven systems and other applications where results can be easily examined without real time interaction can be developed using prototyping paradigm.

3.1.2 Advantages and Disadvantages

✓ Advantages:

• Increased user involvement in the product even before its implementation.

• Since a working model of the system is displayed, the users get a better understanding of the system being developed.

• Reduces time and cost as the defects can be detected much earlier.

• Quicker user feedback is available leading to better solutions.

• Missing functionality can be identified easily.

• Confusing or difficult functions can be identified.

✓ Disadvantages:

• Risk of insufficient requirement analysis owing to too much dependency on the prototype.

• Users may get confused in the prototypes and actual systems.

• Practically, this methodology may increase the complexity of the system as scope of the system may expand beyond original plans.

• Developers may try to reuse the existing prototypes to build the actual system, even when it is not technically feasible.

• The effort invested in building prototypes may be too much if it is not monitored properly.

3.1.1 Reason for Use

• In Software applications that are relatively easy to prototype almost always involve Human-computer Interaction (**HCI**) the prototyping model is suggested.

• A general objective of software is defined but not detailed input, Processing or output requirements. Then in such a case prototyping model is useful. When the developer is unsure of the efficiency of an algorithm or the adaptability of an operating System then Prototype serves as a better choice.

3.2 Requirement Analysis

Following Software and Hardware were required to build the project:

3.2.1 Software Requirements

A. **Unity** (engine) –
   - Unity 2017.2 offers out-of-the-box support for Vuforia 7.

B. **Mono Develop –**
   - It is an open source IDE whose focus is development of projects that use Mono and .NET frameworks.

C. **Vuforia** –
   - Vuforia provides cross-platform Augmented Reality support for Android, iOS, and UWP devices, through a single API.

D. **MySQL Workbench** –
   - MySQL Workbench is a visual database design tool that integrates SQL development into a single IDE for the MySQL database system.

E. **Sublime Text –**
   - Sublime Text is a proprietary cross-platform source code editor with a Python application programming interface.

F. **Development Kits –**
   - Android SDK
   - JDK 1.7-1.8

G. **Server –**
   - WAMP – Windows Apache MySQL PHP

3.2.2 Hardware Requirements

A. **Particle Photon** (micro-controller) -
   - Compact Size.
   - Wi-Fi accessibility.
   - Cloud availability.
   - Complete set of development tools.
   - Browser-based, online IDE hosted on Particle.io.

B. Smart Phone (Android Version 4.4+)

C. PC Processor : CORE i3+

D. PC RAM : 4GB+

E. Sensors -

S. No.	Sensor	Function
1.	Soil Moisture Sensor	Soil moisture sensors measure the volumetric water content.
2.	Humidity & Temperature	It senses, measures and reports both moisture and air temperature.
3.	Light Intensity	A light sensor is a device for measuring the intensity or brightness of light.

Table 3.1: Senor's used

F. Bread Board, connecting wires and batteries

3.3. Feasibility Study

3.3.1 Technical Feasibility

The project RTSACP is a complete IOT-AR based embedded and mobile application. The main technologies and tools that are associated with RTSACP are

- Software
  - Unity
  - Vuforia
  - Mono Develop
  - MySQL Workbench
  - Sublime text
  - WAMP server

- Languages
  - C#
  - Embedded C
  - JSON
  - MySQL
  - PHP

- Hardware
  - Particle Photon
  - Breadboard, Connecting wires
  - Soil Moisture Sensor
  - Temperature-Humidity Sensor
  - Light Intensity Sensor

Each of the technologies are freely (software's) and easily (hardware's) available and the technical skills required are manageable. Time limitations of the project development and these technologies are synchronized.

Initially the server of the project is hosted locally, but for later implementation it will be hosted in a paid web hosting space with a sufficient bandwidth. Bandwidth required in this application is very low, since it doesn't incorporate any multimedia aspect.

From this it's clear that the project RTSACP is technically feasible.

3.3.2 Economical Feasibility

Being an IoT-AR based application RTSACP will have an associated hardware cost.

1. Particle Photon – ₹ 1240
2. Breadboard - ₹ 70
3. Soil Moisture Senor - ₹ 120
4. Humidity and Temperature Sensor – ₹ 120
5. LDR and Resistance – ₹ 80

For pH detection keeping an eye on economic feasibility, manual pH determination can be done instead of pH sensor which stretches the cost.

The system will follow the freeware software standards no cost will be charge from the potential customers.

From these it's clear that project RTSACP is economical feasible as compared to laboratory tests.

3.4 Architectural Specification

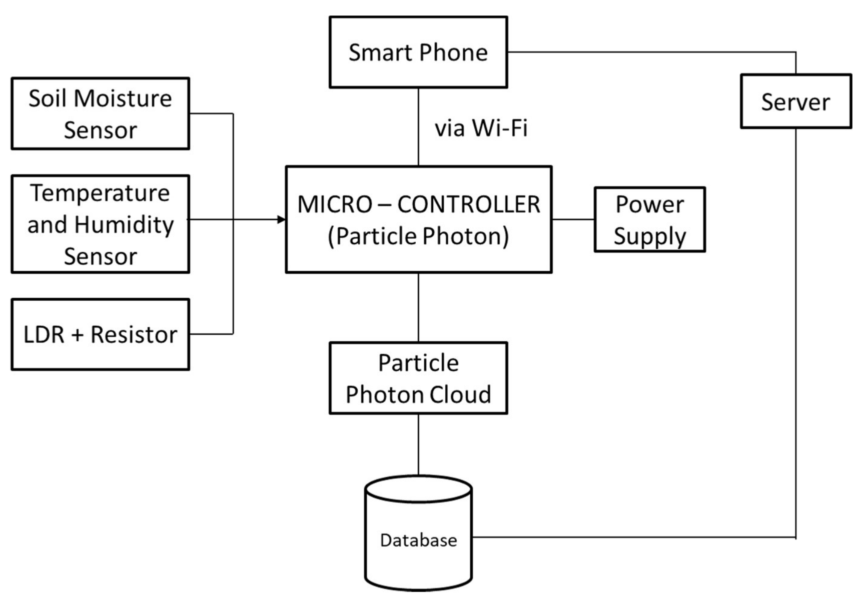

Fig. 3.1: Architecture Specification Block Diagram

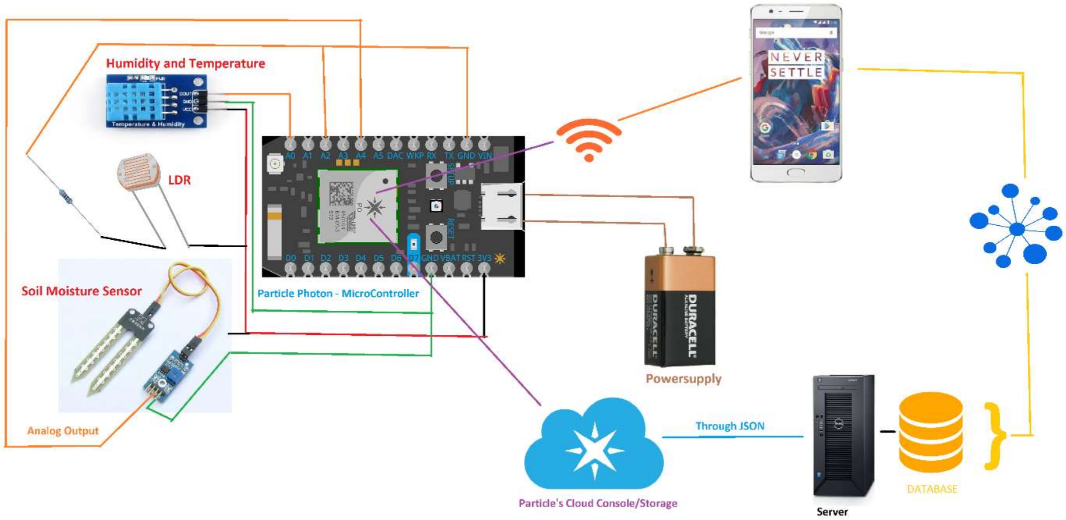

Fig. 3.2: Architecture Specification Diagram

3.5 Use Case Model

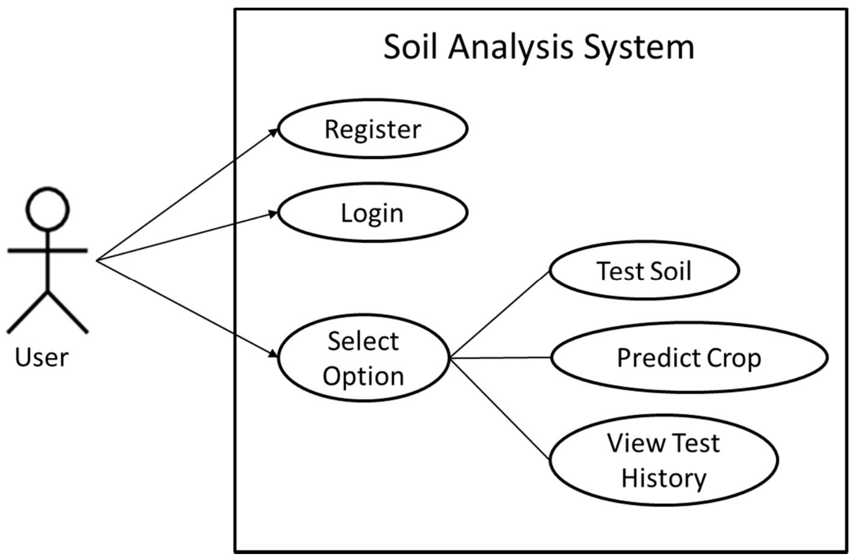

Fig. 3.3: Use Case Diagram

3.6 Use Case Description

- **Name: Register**
  User: Actor

✓ Brief Description
This use case describes how a user registers into the Soil Analysis System.

✓ Flow of Events
This use case starts when the actor wishes to register into the Soil Analysis System.
1. The system requests that the actor enter his/her Username, Mobile Number and Password.

2. The actor enters his/her username, mobile number and password.
3. The system validates the entered mobile number via OTP message check and then registers the actor into the system.

- ✓ Alternative Flows
  - o Invalid Mobile Number
    If in the Basic Flow, the actor enters an invalid mobile number, the system displays an error message. The actor can choose to either to resend the OTP or return to the beginning of the Basic Flow or cancel the registration, at which point the use case ends.

- ✓ Special Requirements
  None.

- ✓ Pre-Conditions
  None.

- ✓ Post-Conditions
  If the use case was successful, the actor is now registered into the system. If not, the system state is unchanged.

- ✓ Extension Points
  None.

- **Name: Login**
  User: Actor
  - ✓ Brief Description
    This use case describes how a user logs into the Soil Analysis System.

  - ✓ Flow of Events
    This use case starts when the actor wishes to log into the Soil Analysis System.
    1. The system requests that the actor enter his/her Mobile Number and Password.
    2. The actor enters his/her mobile number and password.
    3. The system validates the entered mobile number and password and then logs the actor into the system.

- ✓ Alternative Flows
  - o Invalid Mobile Number/Password
    If in the Basic Flow, the actor enters an invalid mobile number and/or password, the system displays an error message. The actor can choose to either return to the beginning of the Basic Flow or cancel the login, at which point the use case ends.

- ✓ Special Requirements
  Internet Connectivity is required.
- ✓ Pre-Conditions
  None.

- ✓ Post-Conditions
  If the use case was successful, the actor is now logged into the system. If not, the system state is unchanged.

- ✓ Extension Points
  None.

- **Name: Select Option**
  User: Actor
  - ✓ Brief Description
    This use case describes what activity user wants to perform into the Soil Analysis System. This includes Test Soil, Predict Crop and View Test History.

  - ✓ Flow of Events
    This use case starts when the actor wishes select an option into the Soil Analysis System.
    1. The system requests that the actor to specify the function he/she would like to perform (either Test Soil, Predict Crop or View Test History).
    2. Once the user provides the requested information, one of the subflows is executed.
    If the User selected "Test Soil", the **Test Soil** subflow is executed.
    If the User selected "Predict Crop", the **Predict Crop** subflow is executed.
    If the User selected "View Test History", the **View Test History** subflow is executed.

    - ❖ **Test Soil**
      1. The system requests that the user choose the type of test. This includes:
         - Manual pH Test
         - Climatic Soil Test via Sensor
      2. Once the User provides the requested information, the system generates the test result and displays it to the user and stores it into the database according to the uses choice.
      3. The system stores the test result with the new test id.

❖ **Predict Crop**

1. The system requests that the user choose the type of values on the basis of which the prediction occurs. This includes:
   - Enter dynamic values manually for prediction
   - Prediction on the basis of values fetched by the sensor
2. Once the User provides the requested information, the system generates the prediction and displays the list of crops that can be grown on that patch of soil to the user.
3. The system predicts the crop by mapping the credentials stored in the database to the values selected by the user.

❖ **View Test History**

1. The system requests the user to choose that which history he wants to monitor. This includes:
   - pH Test History
   - Climatic Test History
2. Once the User provides the requested information, the system loads the history and displays the history graph on the basis of date and time on which the test was done.
3. The system shows the values of pH or soil moisture content, temperature, humidity and light intensity of the soil that was stored in the database according to the time and date of the test.

✓ Alternative Flows

- o Particle Photon is off

  If in the Test Soil, the particle photon (microcontroller) is either off or the sensors are not connected, the system displays an error message. The actor is requested to make sure that the proper connection are made, at which point the use case ends.

- o Test's not performed before

  If in the Predict Crop/ View Test History, the actor wishes for crop prediction or to view the test history without performing and storing the data of a single test before, the system displays an error message. The actor can choose to either return to the Test Page or cancel the prediction request, at which point the use case ends.

✓ Special Requirements

- Standard sensors should be used for accurate result.
- AR-Marker is required for displaying the results.

- ✓ Pre-Conditions
  - Soil moisture sensor should be inserted in the soil.
  - All the other sensors should be in the field.
  - Particle photon should be connected.
  - The User must be logged onto the system before this use case begins.

- ✓ Post-Conditions

  If the use case was successful, the user performed Test of the Soil, Predicted the Crop and Viewed the Test History. Otherwise, the system state is unchanged.

- ✓ Extension Points

  None.

Chapter-4 Design

4.1 Activity Diagrams

- Registration

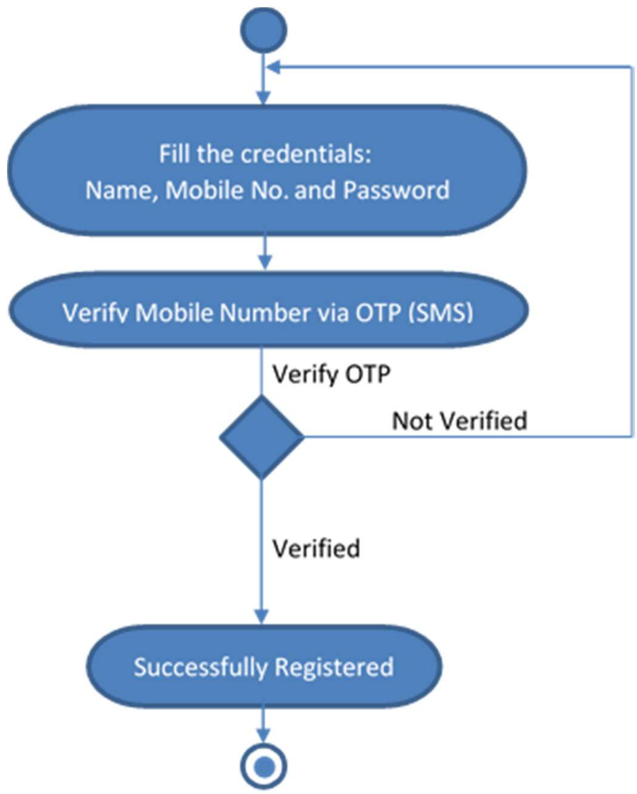

Fig. 4.1: Registration Activity Diagram

- Login

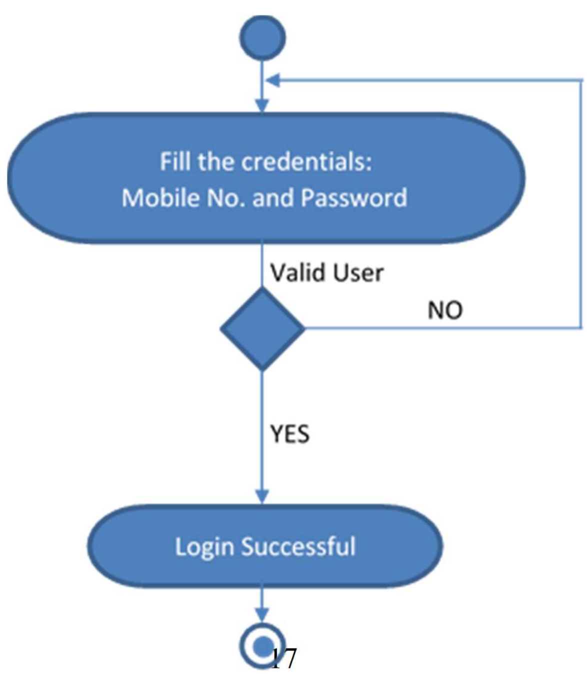

Fig. 4.2: Login Activity Diagram

- Test Soil

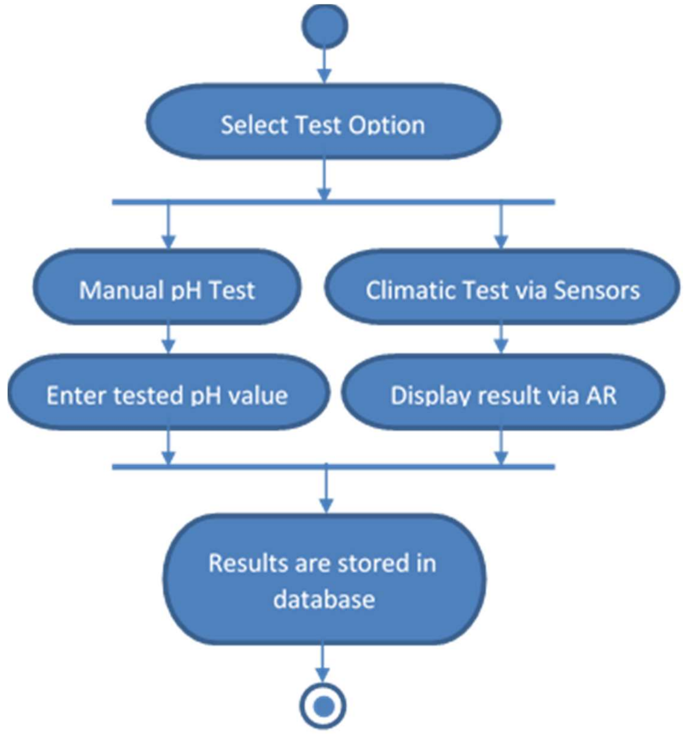

Fig. 4.3: Test Soil Activity Diagram

- Predict Crop

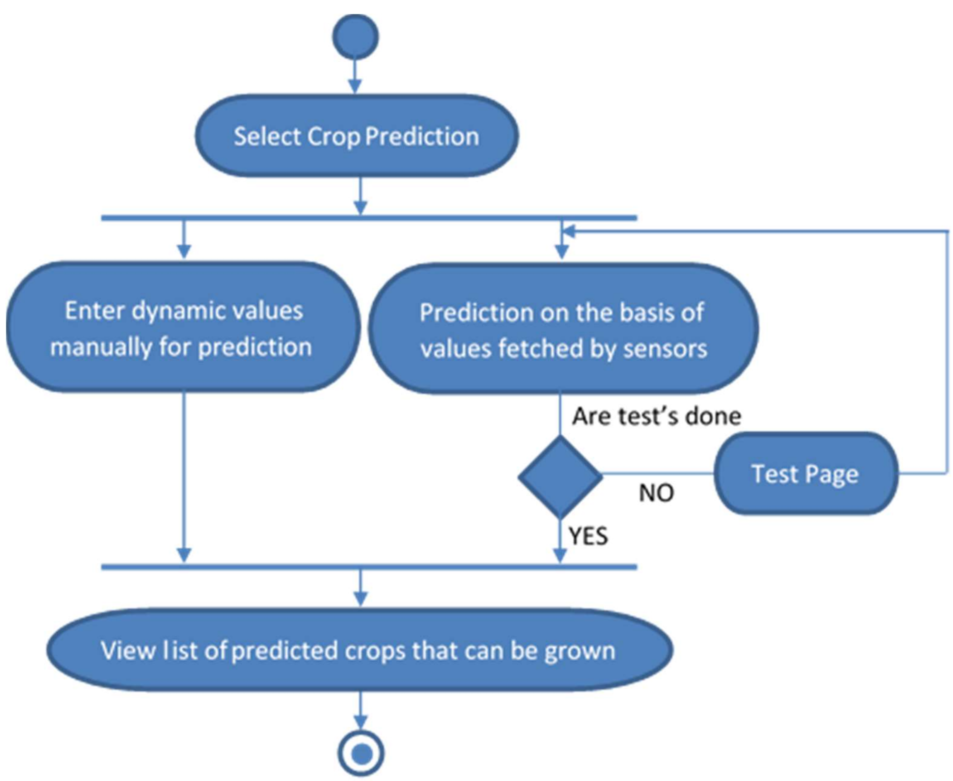

Fig. 4.4: Predict Crop Activity Diagram

- View Test History

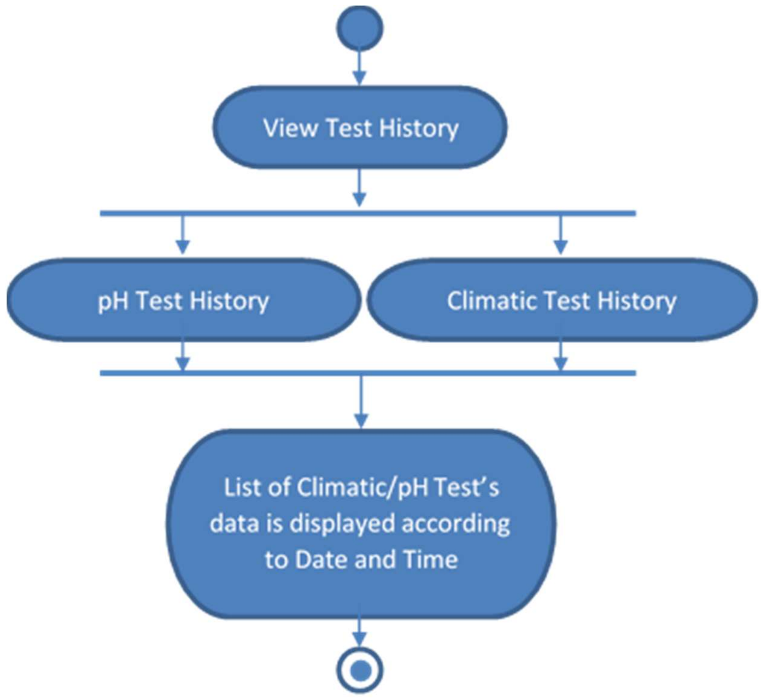

Fig. 4.5: Test History Activity Diagram

4.2 Sequence Diagrams

- Registration

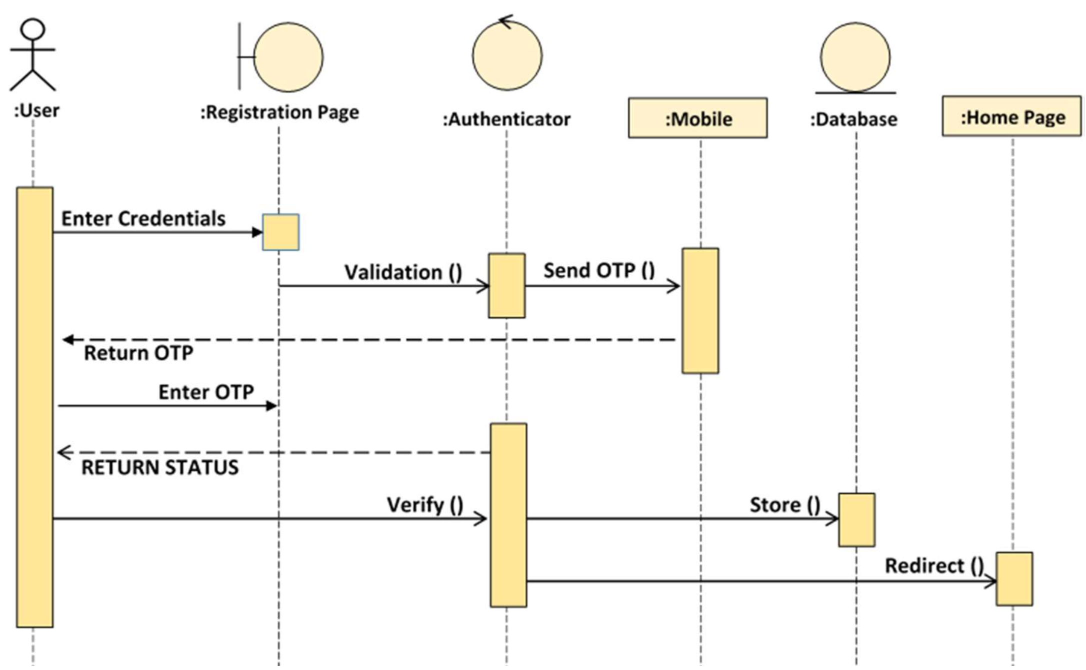

Fig. 4.6: Registration Sequence Diagram

- Login

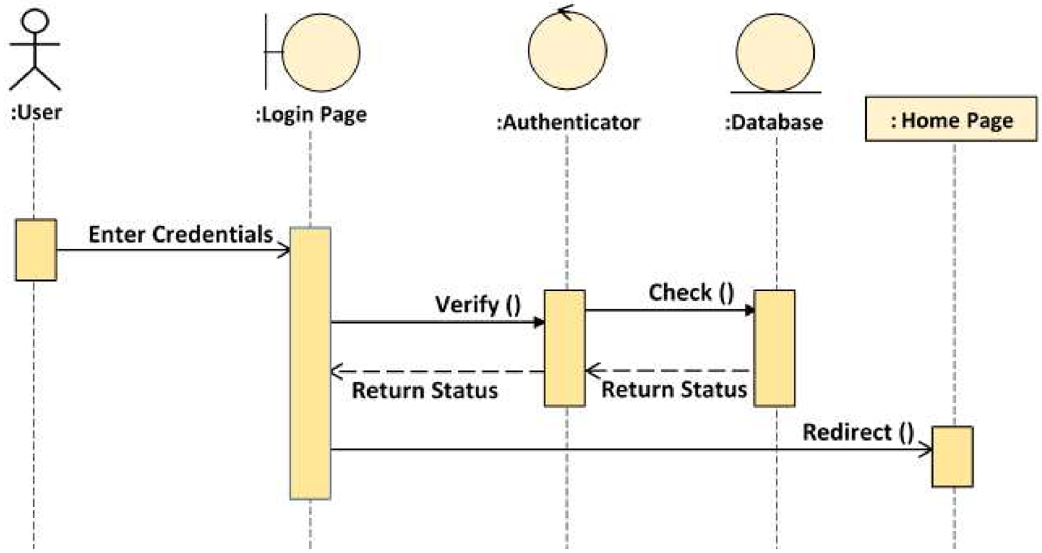

Fig. 4.7: Login Sequence Diagram

- Test Soil

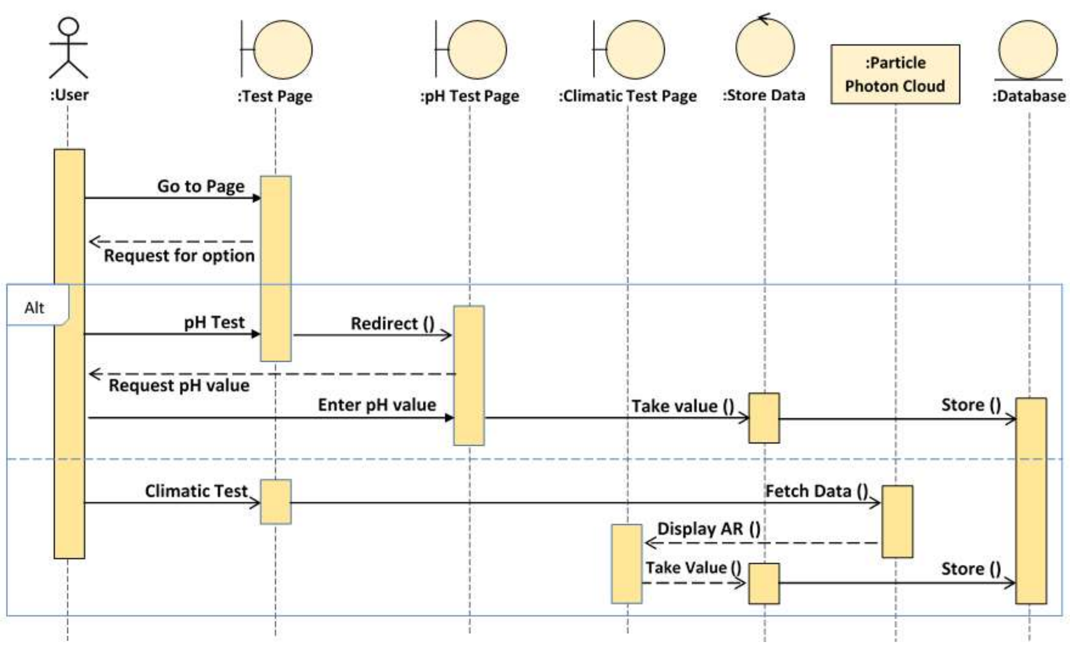

Fig. 4.8: Test Soil Sequence Diagram

- Predict Crop

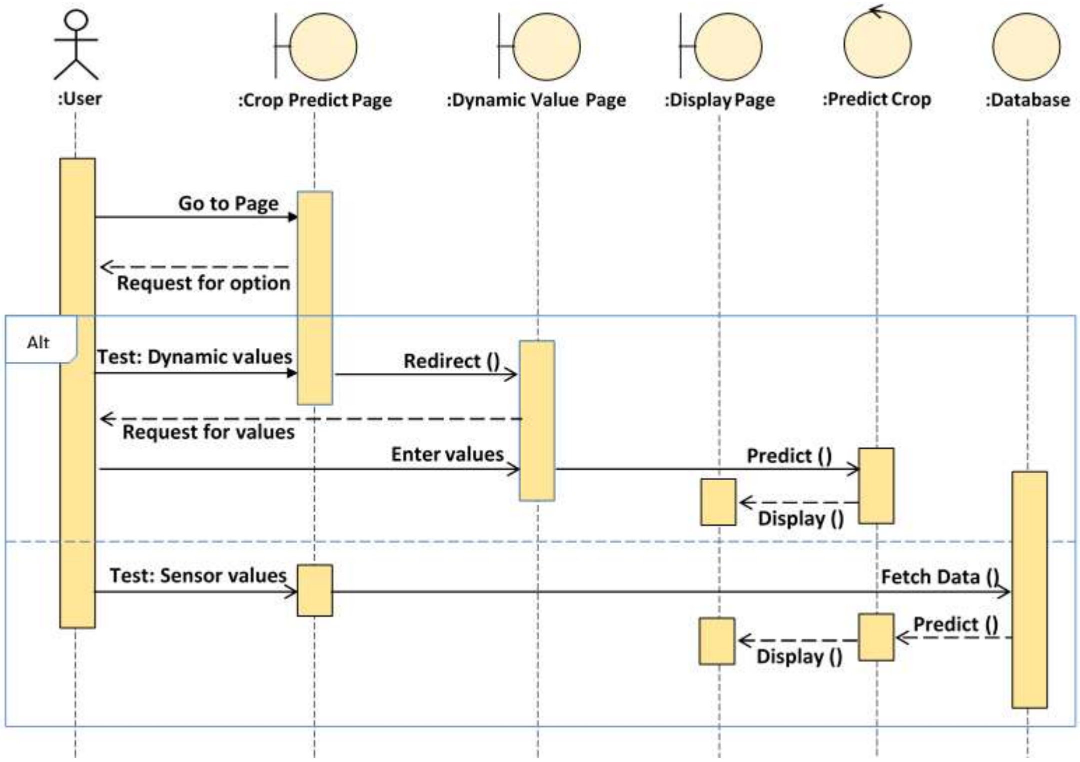

Fig. 4.9: Prediction Crop Sequence Diagram

- View Test History

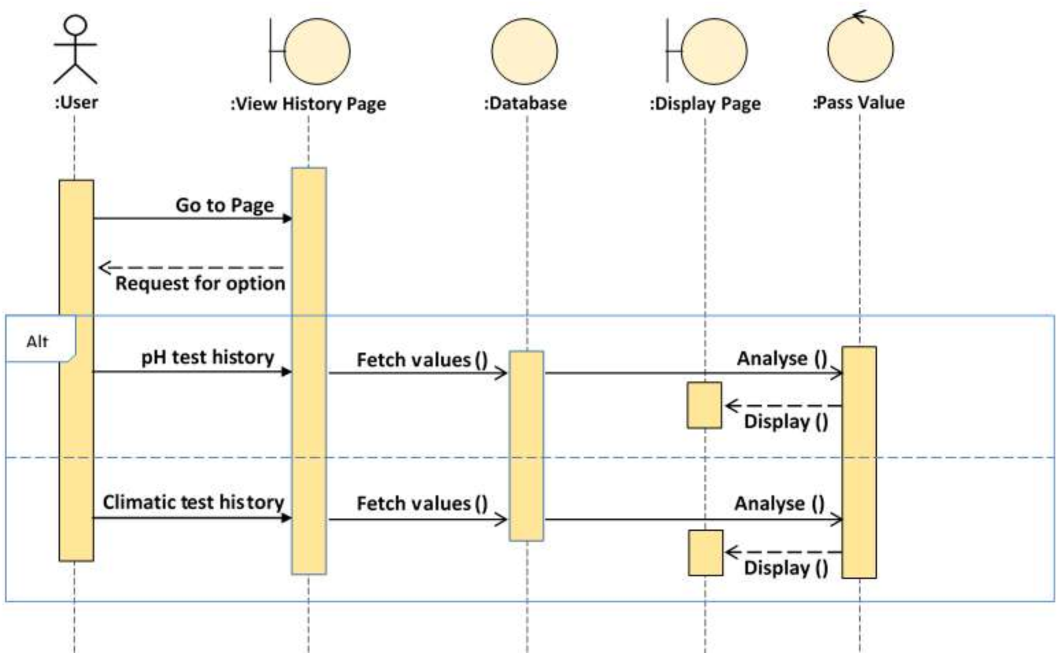

Fig. 4.10: View Test History Sequence Diagram

4.4 Database Design

4.4.1 E-R Diagram

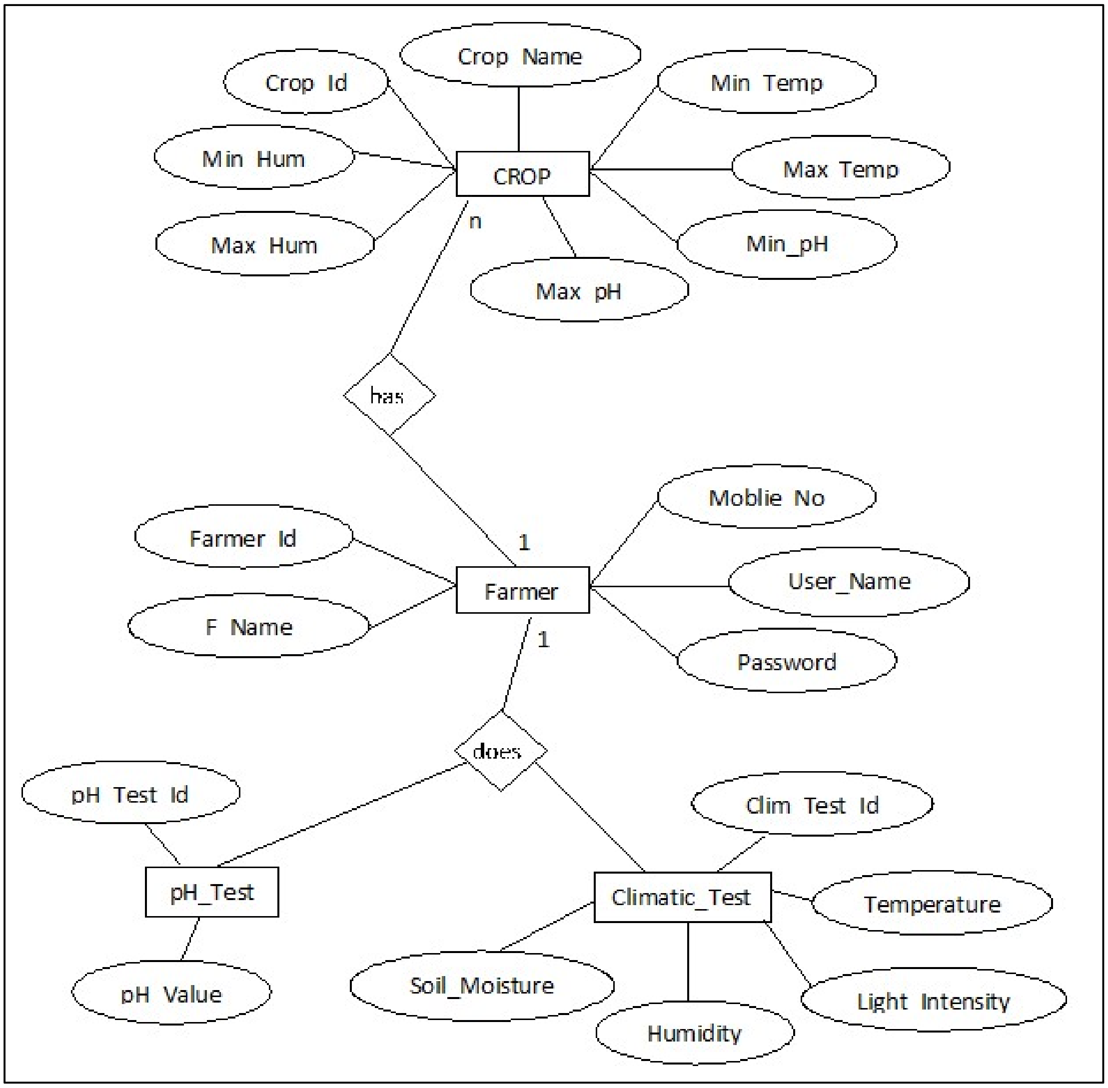

Fig. 4.11: E-R Diagram

4.4.2 Structure of Database Tables

- Farmer Table

Field	Type	Null	Key	Default	Extra
Farmer_id	int(11)	NO	PRI	NULL	auto_increment
F_name	varchar(70)	NO		NULL	
Mobile_No	varchar(13)	NO	UNI	NULL	
Password	varchar(20)	NO		NULL	

Table 4.1: Structure of Farmer Table

- Crop Table

Field	Type	Null	Key	Default	Extra
crop_Id	int(20)	NO	PRI	NULL	auto_increment
crop_Name	varchar(50)	NO		NULL	
min_Hum	varchar(20)	NO		NULL	
max_Hum	varchar(20)	NO		NULL	
min_Temp	varchar(20)	NO		NULL	
max_Temp	varchar(20)	NO		NULL	
min_PH	varchar(20)	NO		NULL	
max_PH	varchar(20)	NO		NULL	

Table 4.2: Structure of Crop Table

- pH Test Table

Field	Type	Null	Key	Default	Extra
Ph_Test_id	int(11)	NO	PRI	NULL	auto_increment
c_id	int(11)	NO	MUL	NULL	
pH_value	varchar(50)	NO		NULL	

Table 4.3: Structure of pH Test Table

- Structure of Climatic Test Table

Field	Type	Null	Key	Default	Extra
Clim_Test_id	int(11)	NO	PRI	NULL	auto_increment
c_id	int(11)	NO	MUL	NULL	
Humidity	varchar(50)	NO		NULL	
Temperature	varchar(50)	NO		NULL	
Moisture	varchar(50)	NO		NULL	
Light	varchar(50)	NO		NULL	

Table 4.4: Structure of Climatic Test Table

Chapter-5 Implementation and Testing

5.1 Language Used Characteristics

- C#
  C# is a multi-paradigm programming language encompassing strong typing, imperative, declarative, functional, generic, object-oriented, and component-oriented programming disciplines.

- Embedded C
  Embedded C is a set of language extensions for the C programming language by the C Standards Committee to address commonality issues that exist between C extensions for different embedded systems. Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.

- JSON
  In computing, JavaScript Object Notation or JSON is an open-standard file format that uses human-readable text to transmit data objects consisting of attribute–value pairs and array data types.

- PHP
  Hypertext Preprocessor is a server-side scripting language designed for web development but also used as a general-purpose programming language.

- MySQL
  MySQL is an open-source relational database management system. Its name is a combination of "My", the name of co-founder Michael Widenius's daughter, and "SQL", the abbreviation for Structured Query Language.

5.3. Testing

5.3.1 Testing Objectives

- ✓ Finding defects which may get created by the programmer while developing the software.
- ✓ Gaining confidence in and providing information about the level of quality.
- ✓ To prevent defects.
- ✓ To make sure that the end result meets the business and user requirements.
- ✓ To ensure that it satisfies the BRS that is Business Requirement Specification and SRS that is System Requirement Specifications.
- ✓ To gain the confidence of the customers by providing them a quality product.

Software testing helps in finalizing the software application or product against business and user requirements. It is very important to have good test coverage in order to test the software application completely and make it sure that it's performing well and as per the specifications.

5.3.2 Testing Methods and Strategies

Listed here are the major methods used while conducting various Software Testing Types during various Software Testing Levels:

Method	**Summary**
Black Box Testing	A software testing method in which the internal structure/design/implementation of the item being tested is not known to the tester. These tests can be functional or non-functional, though usually functional. Test design techniques include Equivalence partitioning, Boundary Value Analysis, Cause-Effect Graphing.
White Box Testing	A software testing method in which the internal structure/design/implementation of the item being tested is known to the tester. Test design techniques include Control flow testing, Data flow testing, Branch testing, Path testing.
Gray Box Testing	A software testing method which is a combination of Black Box Testing method and White Box Testing method.
Agile Testing	A method of software testing that follows the principles of agile software development.
Ad Hoc Testing	A method of software testing without any planning and documentation.

Table 5.1: Software Testing Methods

5.3.3 Test Case

- **Registration Page**

✓ **Test 01** : Test case for Successful Register

User Name: ABCD
Mobile No.: 9876543210
Password: 12345678
Re-Enter Password: 12345678
System Output: Successful Login

- ✓ **Test 02** : Test case for Password less than 8 characters

  User Name: ABCD
  Mobile No.: 9876543210
  Password: 12345
  Re-Enter Password: 12345
  System Output: Password should be minimum 8 characters long

- ✓ **Test 03** : Test case for Password and Re-Enter Password do not match

  User Name: ABCD
  Mobile No.: 9876543210
  Password: 12345678
  Re-Enter Password: 1236788
  System Output: Password and Re-Enter Password do not match

- ✓ **Test 04** : Test case for left empty Username

  User Name:
  Mobile No.: 9876543210
  Password: 1234678
  Re-Enter Password: 12345678
  System Output: Please enter the Username

- ✓ **Test 05** : Test case for left empty Mobile No.

  User Name: ABCD
  Mobile No.:
  Password: 1234678
  Re-Enter Password: 12345678
  System Output: Mobile No. can't be left blank

- ✓ **Test 06** : Test case for Mobile No. less than 10 digits

  User Name: ABCD
  Mobile No.: 9876543
  Password: 1234678
  Re-Enter Password: 12345678
  System Output: Please enter valid Mobile No.

- **View OTP Verification Page**

  - ✓ **Test 01** : Test case for Successful Verification

    Enter OTP: 786
    System Output: Mobile Verified Successfully

  - ✓ **Test 02** : Test case for Unsuccessful Verification

    Enter OTP: 724
    System Output: Please enter a valid OTP

- **Login Page**

  - ✓ **Test 01** : Test case for Successful Login

    Mobile No.: 9876543210
    Password: 12345678
    System Output: Successful Login

  - ✓ **Test 02** : Test case for incorrect Mobile No./Password

    Mobile No.: 9876543210
    Password: 12356545
    System Output: Incorrect Mobile No. /Password

- **Test Soil Page**

  - ✓ **Test 01** : Test case for Successful Test

    Input: Values from connected sensors
    System Output: Displayed values through AR

  - ✓ **Test 02** : Test case for 0 values in the test

    Input: Values from connected sensors
    System Output: Please make sure that the sensors and particle photon are logged in and are connected properly

- **pH Value Enter Page**

✓ **Test 01** : Test case for values entered in between 0-14 in pH Test

Enter the pH Value you tested: 4.5
System Output: Click on the below button to store this pH value

✓ **Test 02** : Test case for values not entered in between 0-14 in pH Test

Enter the pH Value you tested: 17
System Output: Please enter a valid pH value

- **Crop Prediction Page**

✓ **Test 01** : Test case for Successful Prediction of Crop

Input: Values fetched and mapped from the database
System Output: List of crops that can be grown on that particular patch of soil

✓ **Test 02** : Test case when not a single test is performed before

Input: Values fetched and mapped from the database
System Output: Please perform the test for crop prediction of that soil

✓ **Test 03** : Test case when pH value is not entered of that soil

Input: Values fetched and mapped from the database
System Output: Please enter the pH value you tested for crop prediction

- **View Test History Page**

✓ **Test 01** : Test case for Successful History Displayed

Input: Values fetched from the database
System Output: Graph depicting the pH or soil moisture, temperature, humidity and light intensity values is displayed according to date and time

- ✓ **Test 02** : Test case when pH value is not entered once for pH History

  Input: Values fetched from the database
  System Output: Please enter and submit the pH value first

- ✓ **Test 03** : Test case when not a single test is performed before

  Input: Values fetched from the database
  System Output: Please perform the test and submit it first to view history

Chapter-6 Conclusion and Discussion

- **Learning and Achievements**
  - ✓ IoT-AR (use of new technology)
  - ✓ Project Management
  - ✓ Documentation-SDLC
  - ✓ UML
  - ✓ Team Work
  - ✓ Time Management
  - ✓ Presentation Skills

- **Expected Outcome**
  - ✓ The data of current soil's temperature, humidity, moisture, light intensity, pH will be fetched by the sensors and through IoT will be displayed to the user on his device by the application of Augmented Reality.
  - ✓ Real-Time analysis of the soil's fertility will be achieved which will benefit the farmer's, resulting in better yields of the crops when worked accordingly.
  - ✓ Crop Prediction will be made possible by analysing the content of the soil.
  - ✓ Continuous evaluation will be possible without lab tests.

- **Limitations of the Project**
  - ✓ Micronutrients present in the soil can't be detected.
  - ✓ Internet connectivity is required.
  - ✓ High maintenance is needed.
  - ✓ Use of pH paper for detecting pH of soil is complex method.
  - ✓ AR-Marker is required whenever the user wants to see output using AR.

- **Future Expansion**
  - ✓ If any other sensors are invented related to this project, that can be integrated and implemented easily so as to achieve more accurate and variety of results.

Appendix

- **Screen Shots of the Project**
  - ✓ Software

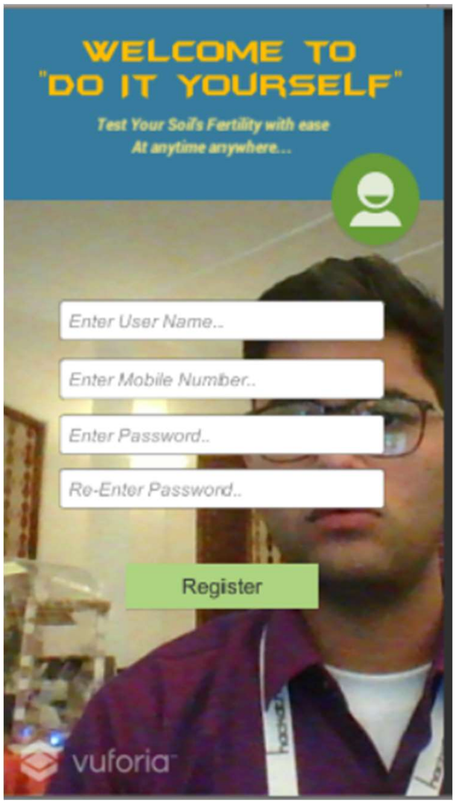

Fig 7.1: Registration Page

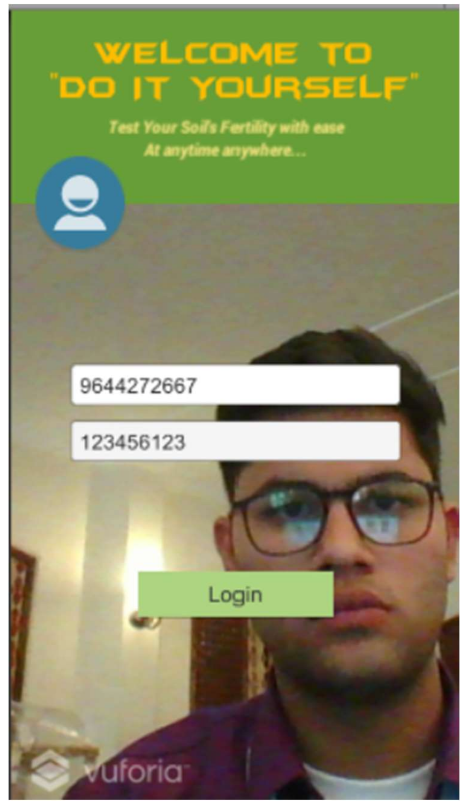

Fig 7.2: Login Page

Fig 7.3: Home Page

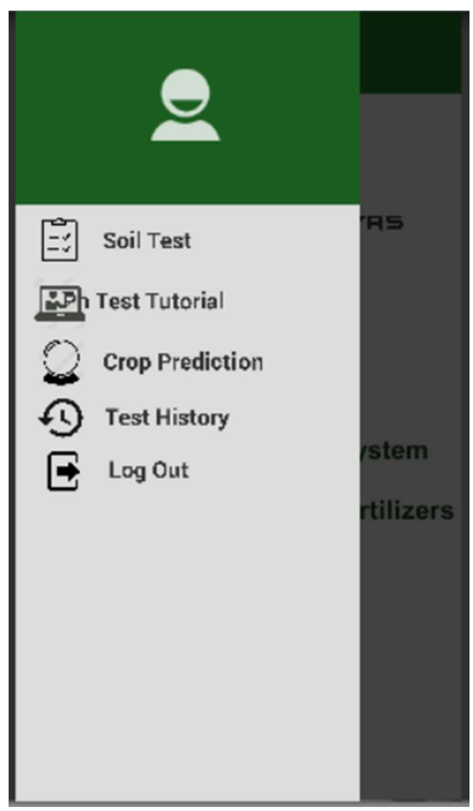

Fig 7.4: Option Drawer

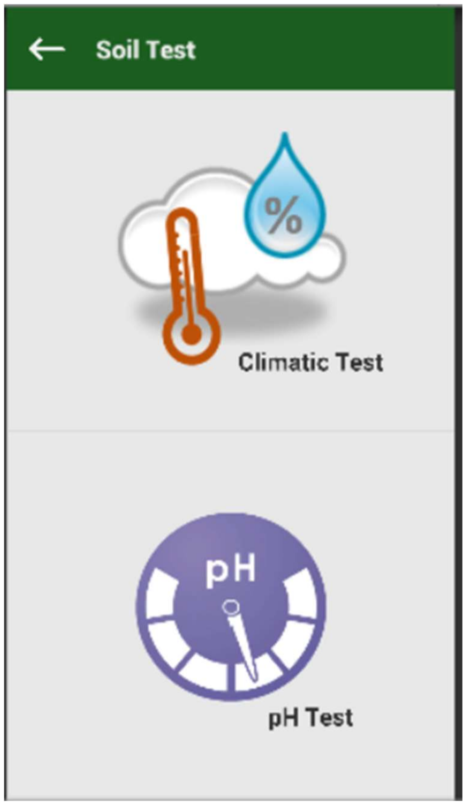

Fig 7.5: Soil Test Page

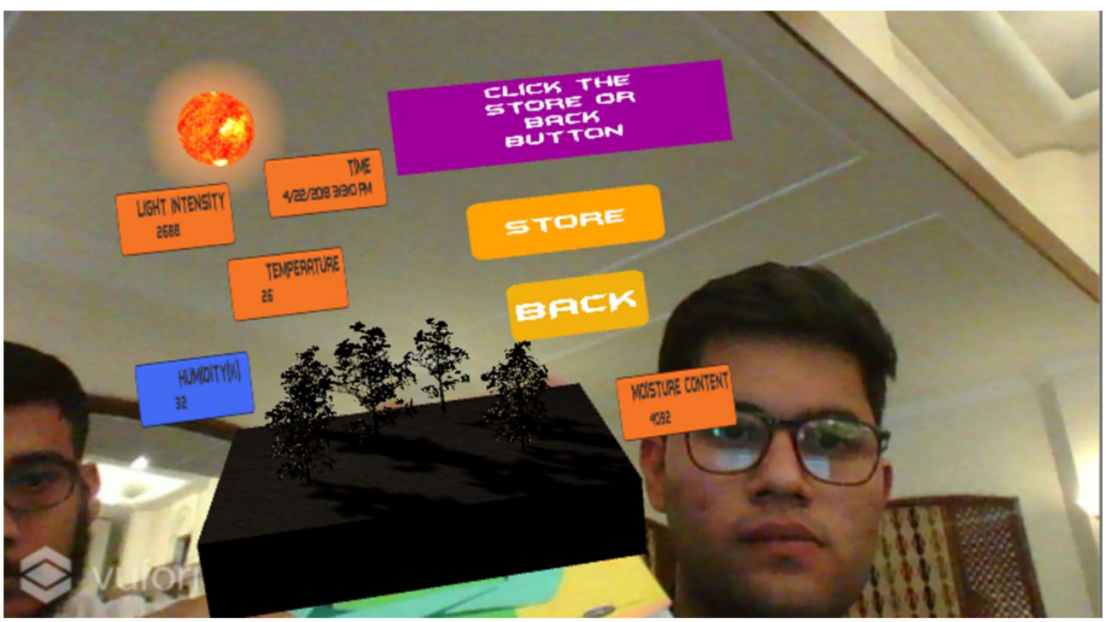

Fig 7.6: Climatic Test Result through AR

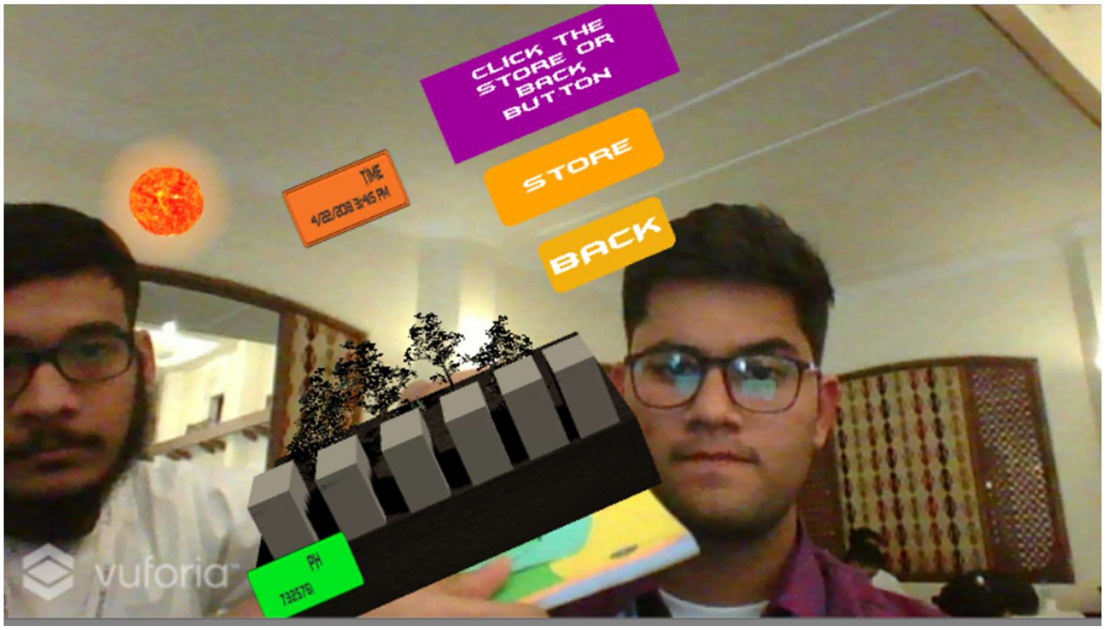

Fig 7.7: pH Test Result through AR

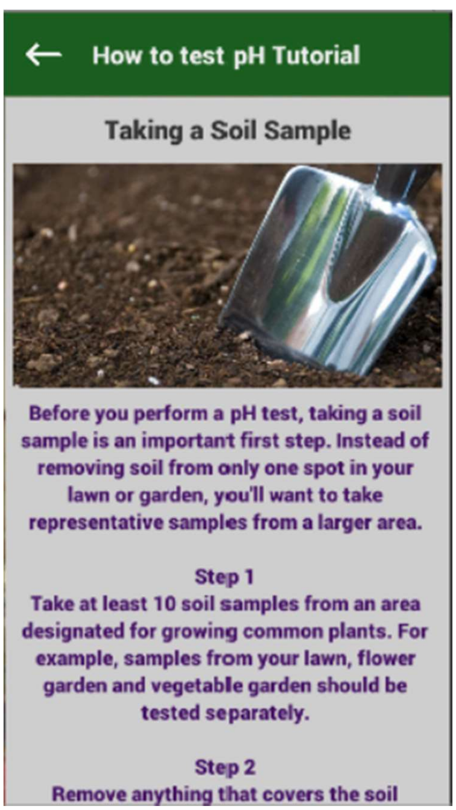

Fig 7.8: pH Test Tutorial Page

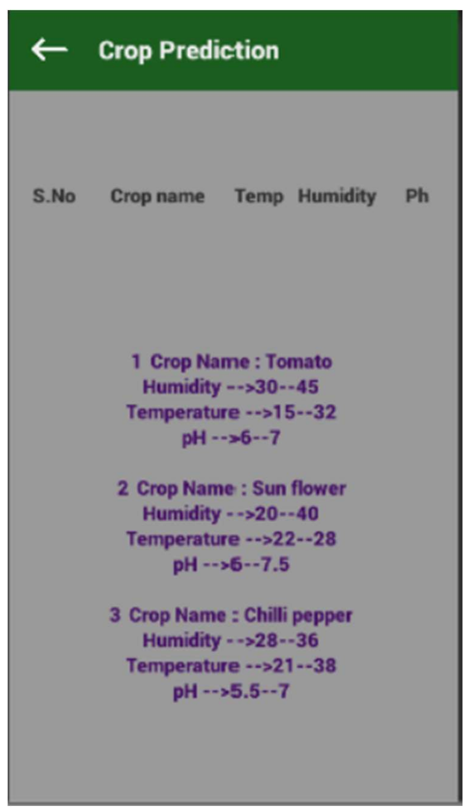

Fig 7.9: Crop Prediction Page

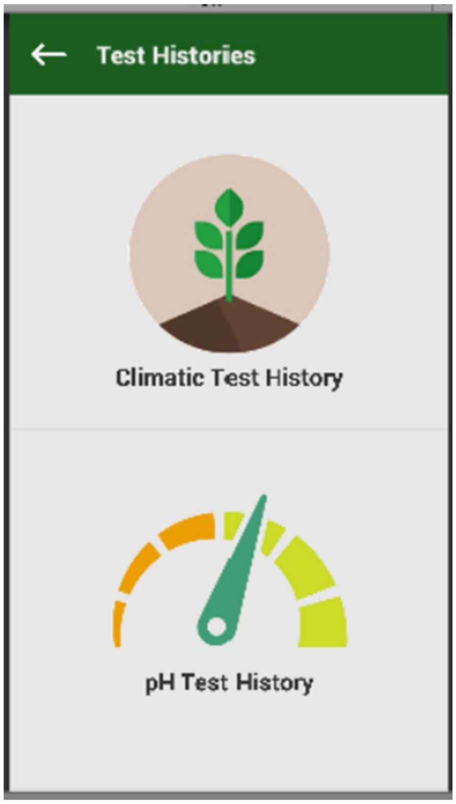

Fig 7.10: Test History Page

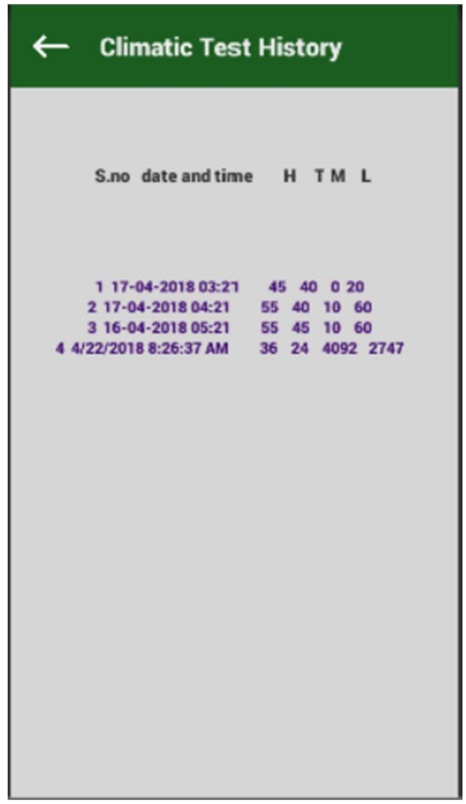

Fig 7.11: Climatic History Page

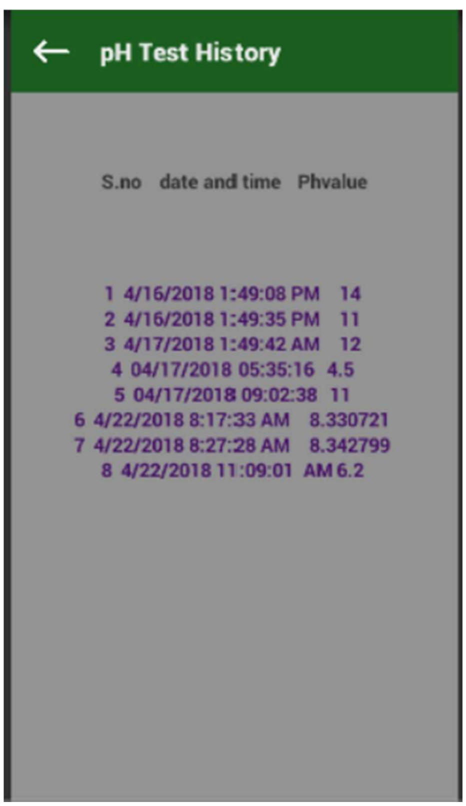

Fig 7.12: pH Test History Page

✓ Hardware

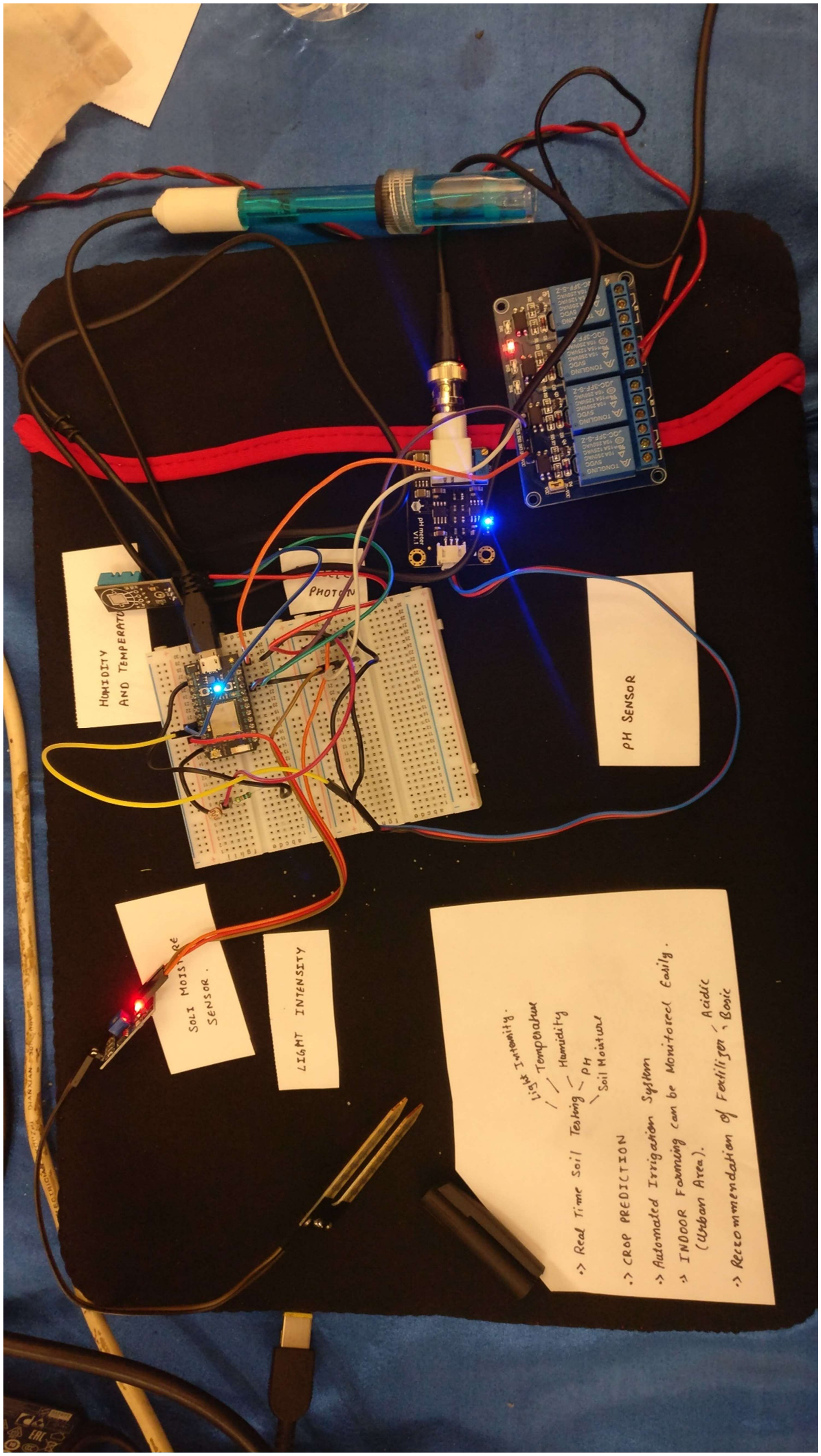

Fig 7.13: Sensor Setup

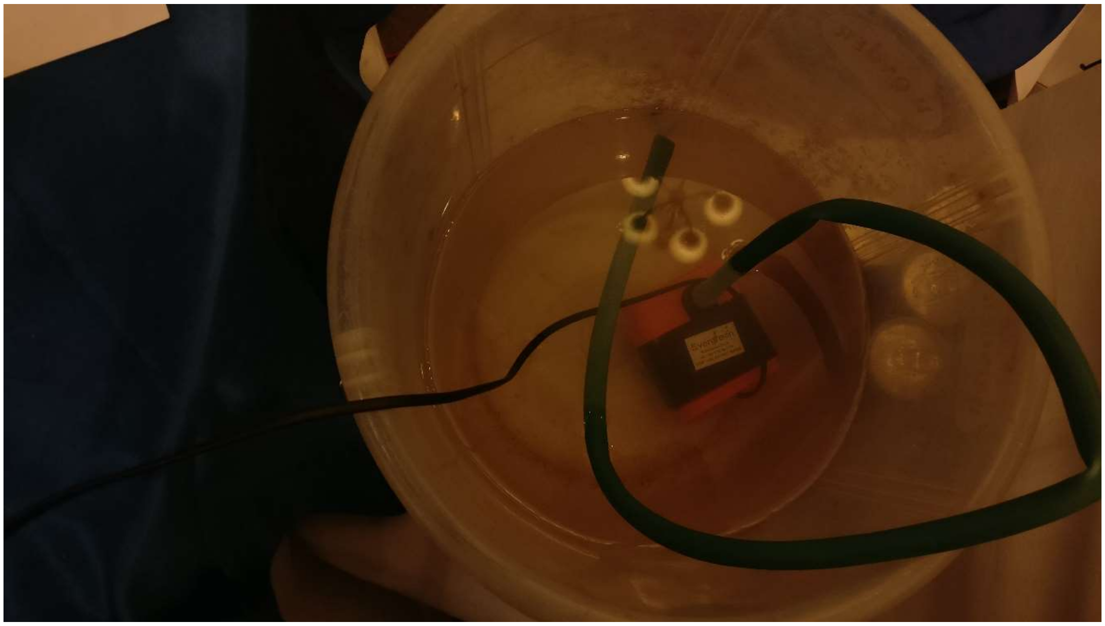
Fig 7.14: Water Motor

Bibliography

- Following are the links of the sites with the help of which we were able to build this successful project:

[1] https://en.wikipedia.org/wiki/Soil_fertility
[1] http://www.cropnutrition.com/
[2] https://www.hunker.com/12148559/how-to-test-soil-ph-with-ph-paper
[3] https://www.pioneer.com/home/site/us/agronomy/library/managing-soil-pH
[4] https://www.particle.io/products/hardware/photon-wifi/
[5] http://www.agroservicesinternational.com/Balanced/pH.html
[6] Real Time Embedded Based Soil Analyzer. International Research Journal of Engineering and Technology (IRJET). Volume: 3 Issue 3 | March 2014
[7] http://homeguides.sfgate.com/soil-planting-tomatoes-25144.html
[8] http://www.allotment-garden.org/vegetable/how-to-grow-your-own-tomatoes/ideal-temperatures-for-growing-tomatoes/
[9] www.fao.org/potato-2008/en/potato/cultivation.html
[10] https://harvesttotable.com/how_to_grow_potatoes/
[11] www.graysflowergarden.com/uploads/3/4/1/5/34154142/growingpotatoes_faq.pdf
[12] http://www.yourarticlelibrary.com/cultivation/cultivation-of-rice-suitable-conditions-required-for-the-cultivation-of-rice-6-conditions/25491
[13] https://www.researchgate.net/post/What_are_the_criteria_of_an_ideal_rice_soil
[14] http://www.agrifarming.in/ladies-finger-farming/
[15] nhb.gov.in/pdf/fruits/apple/app012.pdf
[16] www.dogr.res.in/index.php/en/onion/o-climent-and-soil
[17] http://homeguides.sfgate.com/ideal-climate-soil-corn-growth-37426.html