FARMTECH

(Portable Real Time Soil Quality Monitoring System)

Capstone Report

END-SEMESTER EVALUATION

SUBMITTED BY

(101690002) Baldeep Singh

(101510032) Jaskaran Singh

(101510033) Jaswinder Singh

(101510042) Lovejot Singh

CPG NO.:- 66

Under the Mentor ship of

Dr. Rinkle Rani

Associate Professor

Mr. Harpreet Singh

Lecturer

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

BE FOURTH YEAR COMPUTER ENGINEERING

COMPUTER SCIENCE AND ENGINEERING

DEPARTMENT

THAPAR INSTITUTE OF ENGINEERING AND TECHNOLOGY

PATIALA 147004

Abstract

Soil fertility is an important factor to measure the quality of the soil as it indicates the extent to which it can support crop life. The fertility of soil is measured by the amount of macro and micro nutrients, water, pH etc. Soil nutrients are depleted after every harvest and hence must be replenished. To maintain nutrient levels in the soil in case of deficiency, fertilizers are added to soil. Most of the farmers choose to approximate the amount of fertilizers and add them manually. However, addition of fertilizers in right amount is a matter of great importance as excess or insufficient addition can harm the plant life and reduce the yield. Use of modern trends and technology promises to provide a solution to the above problem. Though automated techniques for seeding, weeding, harvesting the crops etc. have been proposed and implemented, none of the techniques target at maintaining soil fertility and it's real time values. The proposed report aims at restoring the levels of Nitrogen, phosphorous, potassium, moisture, pH level in the soil by the measuring the soil nutrients. Also, measurement of soil temperature, light intensity on crops. The presence of nutrients is determined by chemical processes and quantified using sensors. An integrated system will be developed for the real time measurement of nutrients for exact addition of fertilizers in order to avoid excess/ deficient fertilizers in the soil.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled FarmTech (Portable Real Time Soil Quality Monitoring System) is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr. Rinkle Rani and Mr. Harpreet Singh during 6th-7th semester (2018).

Roll No	Name	Signature
101690002	BALDEEP SINGH	
101510032	JASKARAN SINGH CHANA	
101510033	JASWINDER SINGH VIRK	
101510042	LOVEJOT SINGH PANNU	

Signature

Dr. Rinkle Rani

Associate Professor

Signature

Mr. Harpreet Singh

Lecturer

ACKNOWLEDGEMENT

We would like to express our thanks to our mentor Dr. Rinkle Rani and Mr. Harpreet Singh. Both has been of great help in our venture, and an indispensable resource of technical knowledge.

We are also thankful to Dr. Maninder Singh, Head, Computer Science and Engineering Department, entire faculty and staff of Computer Science and Engineering Department, and also our friends who devoted their valuable time and helped us in all possible ways towards successful completion of this project. We thank all those who have contributed either directly or indirectly towards this project.

Lastly, we would also like to thank our families for their unyielding love and encouragement. They always wanted the best for us and we admire their determination and sacrifice.

Date:

Roll No.	**Name**	**Signature**
101690002	BALDEEP SINGH	
101510032	JASKARAN SINGH	
101510033	JASWINDER SINGH	
101510042	LOVEJOT SINGH	

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

Agriculture contributes nearly 18.1 percent to the Indian annual gross domestic product (GDP). It faces a number of unique social, economic and environmental challenges, including increasing globalization and international competitiveness, climate variability, shortages in labor, urban pressure on farmland. Increasing population requires food production to be increased to meet the demand which requires better cultivation in the form of proper utilization of seeds and fertilizers with minimum labor work. Techniques for automatic seeding, weeding, herbicide spraying, harvesting the crops has been proposed and implemented. Use of advanced techniques like automatic systems for irrigation and modern crop varieties reduced the dependence on manual labor and increased the yield obtained at the same time. Though much advancement in the field of agriculture has reduced the reliability on manual labor, there is a strong need to look into modern methods to maintain soil quality.

This is because soil serves as a growth medium for all the crops. Agricultural soil quality is a measure of the ability of the soil to function as a suitable growth medium for plants, by providing required amounts of water and nutrients necessary for plant growth. Plants extract nutrients that they need for their growth from the soil, which are classified as macro nutrients and micro nutrients. Macro nutrients are those that are needed in large amounts, while those needed in small amounts are called micronutrients. Nitrogen, Potassium and Phosphorous (NPK) are primary macro nutrients. Secondary macronutrients include Calcium, Sulphur and Magnesium. The primary goal of soil testing is to ensure efficient and effective management of available fertilizers, and to decide optimum dosage levels necessary to obtain maximum produce, which is achieved by soil testing. Nitrogen is a very important nutrient to ensure proper plant growth. It is present in the soil as either Nitrate ion (NO^{3-}) or as Ammonium ion (NH^{4+}). Deficiency can result in yellow colouring of the leaves and reduction in the flowering and fruiting. Phosphorous in the soil present as phosphate, provides plants a means of using the energy obtained by process of photosynthesis to carry out activities as a part of its metabolism. Deficiency of this nutrient can lead to impaired vegetative growth, low quality of fruits and seeds, reduced yield of crop and weak roots. However, excess Phosphorous is harmful to the quality of surface water. Potassium is the other macronutrient apart from nitrogen that is absorbed in large quantity by plants and is present as cation K+. If the amount of Potassium is found to be scarce, then plants are generally incapable of utilizing the available water efficiently and are highly prone to diseases. When a nutrient is to be supplied by externally by means, a suitable fertilizer is used. Fertilizers may be classified as:

1) Single nutrient fertilizers they provide single nutrient to the soil.

2) Multi nutrient fertilizers

a) Binary fertilizers these fertilizers provide two nutrients to the soil.
b) NPK fertilizer these fertilizers provide all the 3 primary macro nutrients (in certain fixed ratio) when added to the soil [1].

1.1 Project Overview

1.1.1 Technical Terminology

Agriculture is considered as the basis of life for the human species as it is the main source of food grains and other raw materials. It plays vital role in the growth of country's economy. It also provides large ample employment opportunities to the people. Growth in agricultural sector is necessary for the development of economic condition of the country.

1.1.2 Problem Statement

Many farmers still use the traditional methods of farming which results in low yielding of crops and fruits. But wherever automation had been implemented and human beings had been replaced by automatic machineries, the yield has been improved. Hence there is need to implement modern science and technology in the agriculture sector for increasing the yield. Most of the papers signifies the use of wireless sensor network which collects the data from different types of sensors and then send it to main server using wireless protocol. The collected data provides the information about different environmental factors which in turns helps to monitor the system. Monitoring environmental factors is not enough and complete solution to improve the yield of the crops. There are number of other factors that affect the productivity to great extent.

1.1.3 Goal

In our project we are measuring several values of soil. We are having sensors for measuring Humidity, temperature, NPK values, moisture sensors. Different crops require different amount of temperature, moisture, fertilizers for their better growth. Although farmers are providing specified fertilizers but they are not putting these fertilizers in the soil as per their required amount. They usually have the idea that if they put more fertilizers they will get more yield. And when they do so it results in degradation of soil which will cause problems for future generation. Our project will measure the required amount of fertilizers that are sufficient for the soil. It will also measure the temperature humidity moisture level of the soil [2].

Nowadays farmers have to go to the specialized labs for the testing of the soil which is very cumber- some as they take a lot of time. Farmers need portable devices that can be easily used for measuring the specified nutrients in the soil which will help the farmers for the good growth of their crops but not at the expense of soil degradation [3].

We will be using a color sensor which will detect the amount of Nitrogen potassium and calcium in the soil. We will put the soil sample in front of a color sensor that will observe the reflected light by the sample. The RGB values are calculated from transmitted light. The color obtained gives a lot of information regarding these soil nutrients. Then the farmers can add the required amount of fertilizers without any difficulty. We will be measuring the temperature value of soil in degree Celsius which will tell which crop is more suitable to grow in this environment. The values of humidity and moisture sensor will also be used and combined to give the right amount of water to be given to the crop. As in today's scenario farmers waste water during paddy season. Many a times there is a problem of water logging in the fields which is directly affecting our underground water level [2].

1.1.4 Solution

We are preparing a soil quality testing sensor for testing specifically Nitrogen, phosphorous, potassium present in soil which will be real time and portable testing kit will be provided at customer end. This sensor will be integrated with other sensor like humidity sensor, rainfall sensor, temperature sensor using raspberry pi3 into a fully real time soil quality testing device.

1.2 Need Analysis

In today's era there are no such device which provides real time soil testing, in fact all the testing can be conduct soil testing labs which is a cumbersome task.

1. Affordability: To provide our service to each farmer (weather rich/poor) in the country. Our product will target mainly the village heads as the main customers who can afford the cost, then the farmer can rent the device at lower cost from the village head.

2. Sustainability: The need and unavailability is the key to sustainability of our product. Our product is the need of today's era, since other methods of the soil testing are inconvenient as it takes 2-3 days for end results. If this technique will not be used in future it can result in drastic condition of the soil.

1.3 Research Gaps

Our aim in this study is to integrate the positive and the negative research agenda by developing and proposing problematization as a methodology for identifying and challenging assumptions that underlie existing theories and, based on that, generating research questions that lead to the development of more interesting and influential theories within management studies. Challenging assumptions is often risky, since it means questioning existing power relations in a scientific field, which may result in upsetting colleagues, reviewers, and editors and, thus, may reduce the chances of having an article published. But since our idea is innovative and non-existing we can challenge the assumptions.

1.4 Problem definition and Scope

The process of soil testing that is adopted typically involves chemical tests conducted in laboratories, which takes at least a few days. The farmer estimates the quantity of fertilizers based on the area of field, crop to be grown and amount of nutrients present, which is a cumbersome task. This leads poor yield, excess wastage and a great loss to farmers. This increases the farmer suicide rate drastically which is a curse for our country.

The system used in the project addresses the difficulties incurred by farmers. Our device will fetch the data directly from soil using sensors and display the results on a GUI. Hence, provide a solution to the above problems. The NPK SENSOR for real time data is unavailable. So, the development of a NPK sensor is included in our project that provides real time values and will be used for testing soil.

1.5 Assumptions

1. Affect due to impurities in the environment are ignored.
2. Small tolerance in the sensor values have been considered.
3. Neglected the changes over a small duration in soil.
4. Soil sample over a small region (Punjab)will be taken in beginning.

1.6 Approved Objectives

1. To construct a smart agriculture system to detect the contents of the soil for real time.
2. Development of real time NPK sensor.
3. Integration of this system with other sensors.
4. Development of android application interface with hardware.

1.7 Methodology Used

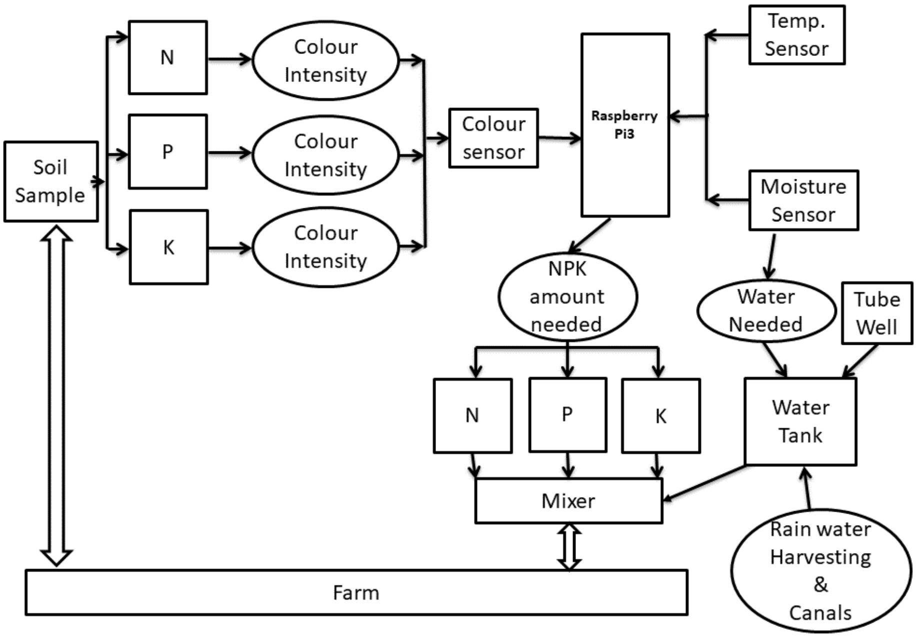

Figure 1.1 Block Diagram

The block diagram (Fig. 1.1) follows the steps given below for its working

1. Soil testing will be done in test tubes to check presence of NPK quantities.
2. The obtained color will have detected by color sensor.
3. Soil temperature, moisture and rainfall will be detected by respective sensors using raspberry pi.
4. Motion sensor can be used for security against rodents and intruders.
5. Based on the above inputs proper amount of fertilizers and water can be added to the land using irrigation system.
6. All the obtained input can be viewed by the user through GUI.

1.8 Project Outcomes and Deliverables

1. The proposed system focuses on the integration of discrete IOT smart agriculture systems for real time values which is unavailable commercially. The obtained results will be moisture level of soil, PH level, temperature, NPK levels and rainfall in that area.
2. Detection of soil nutrients will help the farmers to plan accordingly rather than estimation and prevent the unconditional crop damage, thus increasing the GDP.

Chapter 2

REQUIREMENT ANALYSIS

In software engineering, requirements analysis encompasses those tasks that go into determining the needs or conditions to meet for a new or altered product or project. Requirements analysis is critical to the success or failure of a systems or software project. The requirements should be documented, actionable, measurable, testable, traceable, related to identified business needs or opportunities, and defined to a level of detail sufficient for system design.

2.1 Literature Survey

2.1.1 Background

Agriculture contributes nearly 18.1 percent to the Indian annual gross domestic product (GDP). It faces a number of unique social, economic and environmental challenges, including increasing globalization and international competitiveness, climate variability, shortages in labour, urban pressure on farmland. Increasing population requires food production to be increased to meet the demand which requires better cultivation in the form of proper utilization of seeds and fertilizers with minimum labour work. Techniques for automatic seeding, weeding, herbicide spraying, harvesting the crops has been proposed and implemented. Use of advanced techniques like automatic systems for irrigation and modern crop varieties reduced the dependence on manual labour and increased the yield obtained at the same time. Though much advancement in the field of agriculture has reduced the reliability on manual labour, there is a strong need to look into modern methods to maintain soil quality. This is because soil serves as a growth medium for all the crops. Agricultural soil quality is a measure of the ability of the soil to function as a suitable growth medium for plants, by providing required amounts of water and nutrients necessary for plant growth. Plants extract nutrients that they need for their growth from the soil, which are classified as macro nutrients and micro nutrients. Macro nutrients are those that are needed in large amounts, while those needed in small amounts are called micronutrients. Nitrogen, Potassium and Phosphorous (NPK) are primary macro nutrients. Secondary macronutrients include Calcium, Sulphur and Magnesium. The primary goal of soil testing is to ensure efficient and effective management of available fertilizers, and to decide optimum dosage levels necessary to obtain maximum produce, which is achieved by soil testing. Nitrogen is a very important nutrient to ensure proper plant growth. It is present in the soil as either Nitrate ion (NO_3^-) or as Ammonium ion (NH_4^+). Deficiency can result in yellow colouring of the leaves and reduction in the flowering and fruiting. Phosphorous in the soil present as phosphate, provides plants a means of using the energy obtained by process of photosynthesis to carry out activities as a part of its metabolism. Deficiency of this nutrient can lead to impaired vegetative growth, low quality of fruits and seeds, reduced yield of crop and weak roots. However, excess Phosphorous is harmful to the quality of surface water. Potassium is the other macronutrient apart from nitrogen that is absorbed in large quantity by plants and is present as cation K^+. If the amount of Potassium is found to be scarce, then plants are generally incapable of utilizing the available water efficiently and are highly prone to diseases. When a nutrient is to be supplied by externally by means, a suitable fertilizer is used.

2.1.2 Existing System

Currently soil testing is done in labs using chemical tests. The chemical tests are performed to measure NPK and PH value of the soil. Mainly the chemical tests occur in two steps. First step is generating colour in a test tube containing soil sample using specific reagents that give a particular colour for NPK and PH respectively. The intensity of colour depicts the amount of nutrient present in soil. To measure quantitatively, second step of our chemical test is performed which is titration. The mass of reagent used in the burette is directly proportional to the intensity of colour of our sample. Then by using this data and appropriate formulas we obtain the value of NPK and PH. The values of temperature, moisture, rainfall and other parameters is obtained through independent sensors.

2.1.3 Related Work

Paper 1 - AUTOMATIC SOIL NUTRIENT DETECTION AND FERTILIZER DISPENSARY SYSTEM by Amrutha A, Lekha R, A Sreedevi (2016)

1. Findings of paper

   The proposed research paper aims at restoring the levels of Nitrogen, phosphorous, potassium in the soil by the measuring the amount of nutrients present. The presence of nutrients is determined by chemical processes and quantified using sensors.

2. Relevant Findings

   Development of a Sensor system for estimation of nutrients present in the soil The principle used for the identification of the NPK nutrients in the soil is colorimetry. By this principle, as the concentration of the element or compound in a solution increases, its colour intensity increases linearly [1].

Paper 2 - IOT BASED SMART AGRICULTURE by Nikesh Gondchawar, Prof. Dr. R. S. Kawitkar (2016)

1. Findings of paper

   The project aims at making agriculture smart using automation and IoT technologies. It includes smart irrigation with smart control and intelligent decision making based on accurate real time field data. Smart warehouse management which includes temperature maintenance, humidity maintenance and theft detection in the warehouse.

2. Relevant findings

   Controlling of all these operations will be through any remote smart device or computer connected to Internet and the operations will be performed by interfacing sensors with microcontroller and raspberry pi [3].

2.1.4 Problem Identified

The process of soil testing that is adopted typically involves chemical tests conducted in laboratories, which takes at least a few days. The farmer estimates the quantity of fertilizers based on the area of field, crop to be grown and amount of nutrients present, which is a cumbersome task. This leads poor yield, excess wastage and a great loss to farmers. This increases the farmer suicide rate drastically which is a curse for our country. The system used in the project addresses the difficulties incurred by farmers by integration of existing isolated agriculture systems into one. Hence, provide a solution to the above problems by eliminating the discrete processes to measure soil nutrients. Also, the development of integrated NPK SENSOR that provides real time values that will be integrated too and used for testing soil.

2.1.5 Methods and Tools Used

Our system emphasis to eradicate the role of labs since visiting labs is time consuming and inconvenient. The main focus currently is to eradicate the titration step using a colour sensor. Programming of colour sensor to measure the colour in test tube sample is the basic concept. This will upgrade the colour sensor to NPK and a PH sensor. Then this NPK sensor will be integrated with temperature, rainfall, moisture sensor using raspberry pi3 to develop a fully integrated soil quality testing system. Based on these inputs the proper amount of fertilizers and water will beaded to land using irrigation system. All the inputs will be viewed using mobile app.

2.2 STANDARDS

Standards for IOT based Project:

2.2.1 Infrastructure

1. **UDP (User Datagram Protocol)** - A simple OSI transport layer protocol for client/server network applications based on Internet Protocol (IP). UDP is the main alternative to TCP and one of the oldest network protocols in existence, introduced in 1980. UDP is often used in applications specially tuned for real-time performance.

   Aeron - Efficient reliable UDP unicast, UDP multicast, and IPC message transport.

2. **DTLS (Datagram Transport Layer)** - "The DTLS protocol provides communications privacy for datagram protocols. The protocol allows client/server applications to communicate in a way that is designed to prevent eavesdropping, tampering, or message forgery. The DTLS protocol is based on the Transport Layer Security (TLS) protocol and provides equivalent security guarantees."

3. **NanoIP-**"NanoIP, which stands for the nano Internet Protocol, is a concept that was created to bring Internet-like networking services to embedded and sensor devices, without the overhead of TCP/IP. NanoIP was designed with minimal overheads, wireless networking, and local addressing in mind."

2.2.2 Discovery

1. **mDNS (multicast Domain Name System)** - Resolves host names to IP addresses within small networks that do not include a local name server.
2. **Physical Web** - The Physical Web enables you to see a list of URLs being broadcast by objects in the environment around you with a Bluetooth Low Energy (BLE) beacon.
3. **HyperCat** - An open, lightweight JSON-based hypermedia catalogue format for exposing collections of URIs
4. **UPnP (Universal Plug and Play)** - Now managed by the Open Connectivity Foundation is a set of networking protocols that permits networked devices to seamlessly discover each other's presence on the network and establish functional network services for data sharing, communications, and entertainment.

2.2.3 Communication / Transport layer

1. Ethernet

1. **WirelessHart**

   "WirelessHART technology provides a robust wireless protocol for the full range of process measurement, control, and asset management applications.

2. **DigiMesh**

   "DigiMesh is a proprietary peer-to-peer networking topology for use in wireless end-point connectivity solutions.

3. **ISA100.11a**

   "ISA100.11a is a wireless networking technology standard developed by the International Society of Automation (ISA). The official description is "Wireless Systems for Industrial Automation: Process Control and Related Application"

4. **IEEE 802.15.4**

   IEEE 802.15.4 is a standard which specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs). It is maintained by the IEEE 802.15 working group. It is the basis for the ZigBee,ISA100.11a, WirelessHART, and MiWi specifications, each of which further extends the standard by developing the upper layers which are not defined in IEEE 802.15.4. Alternatively, it can be used with 6LoWPAN and standard Internet protocols to build a wireless embedded Internet.

2. WiFi

WiMax

WiMax is based on the standard IEEE 802.16 and is intended for wireless metropolitan area networks. The range is different for fixed stations, where it can go up to 50 km and mobile devices with 5 to 15 km. WiMAx operates at frequencies between 2.5 GHz to 5.8 GHz with a transferrate of 40 Mbps.

Raspberry Pi 3 Standards:

1. **UART:** setting up and reading/writing fron/to a UART port is fairly easy. However, UARTs typically cannot be driven at very high speeds and there could be issues with baud rate inaccuracies as well as insuring that the baud rate is the same on both sides.
2. **I2C:** since the master drives the clock, there are no issues with clock synchronization on the slave side. And, in theory, i2c can be driven as high as 3.4MHz. However, i2c is a half duplex bux...you're either writing or reading to/from the slave. Also, there are electrical design considerations if high speed is needed.
3. **SPI:** as with i2c, the master drives the clock, so there are no clock synchronization issues to speak of and, if implemented correctly, this is a full duplex bus and can be driven at very high speeds. However, there are more signals on this bus - Chip Select, Clock, Master In Slave Out (MISO) and Master Out Slave In (MOSI).
4. **GPIO:** some people try to emulate a true parallel bus with this method, but personally, I would forget about this option because of the complexity.

Android Application standards:

Communication protocol which will be http. you can use socket, ftp or smtp but those are for specific purpose and won't be needed in general. For security purpose you can choose https which will come with some additional cost of security certificates. So in any communication protocol there is request and response. http protocol is stateless protocol so you(client) make one request to get some data and it (server) returns you the required data for that request again you make another call to get another data. Example of typical request and response

2.3 Software Requirement Specifications

2.3.1 Purpose of this Document

The purpose of this SRS document is to provide a detailed overview of our software Product, its parameters and goals. This document describes the project's target Audience and its user interface, hardware and software requirements. It defines how our customers see the product and its functionality.

2.3.2 Scope of the Development of the Project

Farmtech is a portable real time soil quality measuring system. It aims to reduce inconvenience caused to farmers due to soil testing in labs and to add proper amount of fertilizers to the soil. Following things are in service of a farmer: -

1) Exact amount of fertilizers needed in soil.

2) Real time values for temperature, moisture, rainfall, NPK and ph.

3) It saves the time wasted to visit labs and the inconvenience caused.

The mobile app will show the following:

Table 2.1 Graphical User Interface

SCREEN	**PARAMETER ASSOCIATED**
TEMPERATURE	Present temperature value of soil
MOISTURE	Moisture content of soil, water needed
NPK	NPK value, fertilizer needed

2.3.3 Product Functions

1. Firstly, the farmer will dig temperature and moisture sensor into the soil to get the respective real time values.
2. Then the different colour samples will be prepared by him using the directions given in the manual.
3. This sample will be placed in front of colour sensor to get value of NPK and PH.
4. All these values will be displayed on mobile app with the interface description given in above table.

2.3.4 Functional Requirements

1. It displays Moisture value.
2. It displays Soil Temperature Value.
3. It displays N, P, K & PH value.
4. Connectable to android smart phones.

2.3.5 Non-Functional Requirements

1. Minimum distance between colour sensor and test tubes should be 1 cm.
2. The user will be able to operate in any weather conditions.
3. Hardware maintenance of the device after one year.
4. High Reliability and accuracy of sensors.

2.3 Cost Analysis

Table 2.2 Cost Analysis

Item	Cost(Rs)
Temperature sensor	195
Moisture sensor	150
Color sensor	445
Raspberry pi3 kit	5500
Soil testing kit	650
ADC(MCP3002)	310
TOTAL	7250

2.4 Risk Analysis

Mainly the risk is of improper sample preparation. To keep this under check we will perform the following operations.

1. First we have to conduct hazardous identification. It means the limit after which chemicals in the soil become hazardous. The threshold value for every sensor will help in hazardous identification
2. The agriculture based guidance levels are available on internet or can be obtained from any agriculture related agency.
3. We have to exposure assessment after this. This can be checked by the amount of soil in the sample. Also the concentration of chemicals plays an important role for exposure assessment.

Chapter 3

METHODOLOGY ADOPTED

3.1 Investigative Techniques

The investigative technique used in our project is experimental. The experiments aims at preparing the colored solutions in a test tube. By using the capsules from soil testing kit and adding them to mixture of soil and water in attest tube a a particular color is developed. We have conducted experiments in soil testing labs to get the npk values from color sensor. We will be using a color sensor which will detect the amount of Nitrogen potassium and calcium in the soil. We will put the soil sample in front of a color sensor that will observe the reflected light by the sample. The RGB values are calculated from transmitted light. The color obtained gives a lot of information regarding these soil nutrients.

3.2 Proposed solution

In our project we are measuring several values of soil. We are having sensors for measuring Humidity, temperature, NPK values, moisture sensors. Different crops require different amount of temperature, moisture, fertilizers for their better growth. Although farmers are providing specified fertilizers but they are not putting these fertilizers in the soil as per their required amount. They usually have the idea that if they put more fertilizers they will get more yield. And when they do so it results in degradation of soil which will cause problems for future generation. Our project will measure the required amount of fertilizers that are sufficient for the soil. It will also measure the temperature humidity moisture level of the soil [2].

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3.3 Work Breakdown Structure

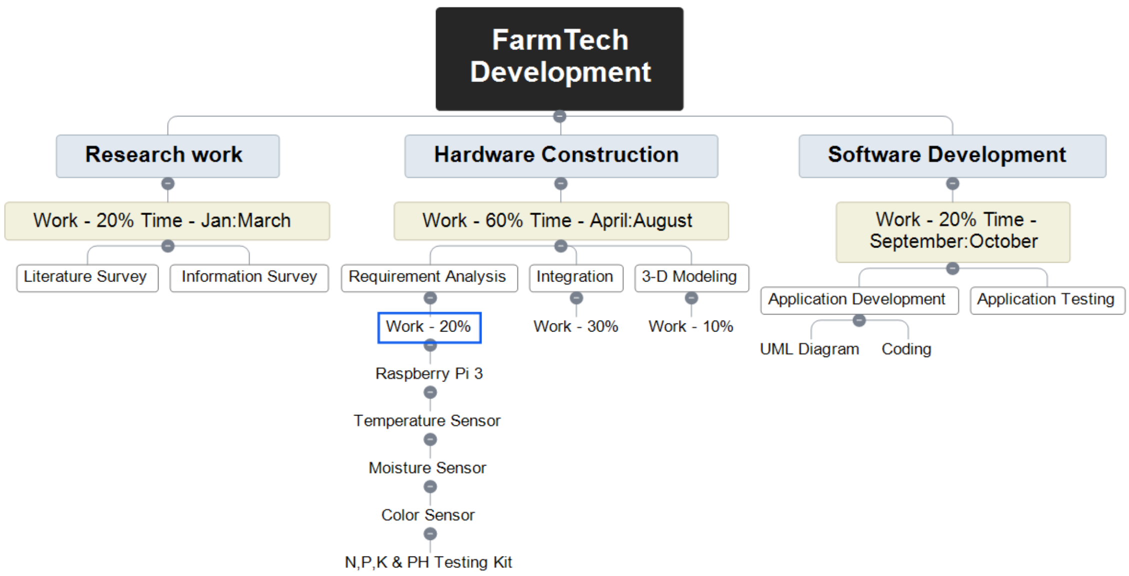


Figure 3.1 Work Breakdown Structure

A work breakdown structure (WBS) is a key project deliverable that organizes the team's work into manageable sections. The Project Management Body of Knowledge (PMBOK) defines the work breakdown structure as a "deliverable-oriented hierarchical decomposition of the work to be executed by the project team.

3.4 Tools and Technologies used

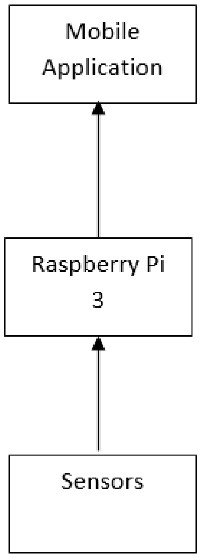
Our system emphasis to eradicate the role of labs since visiting labs is time consuming and inconvenient. The main focus currently is to eradicate the titration step using a colour sensor. Programming of colour sensor to measure the colour in test tube sample is the basic concept. This will upgrade the colour sensor to NPK and a PH sensor. Then this NPK sensor will be integrated with temperature, rainfall, moisture sensor using raspberry pi3 to develop a fully integrated soil quality testing system. Based on these inputs the proper amount of fertilizers and water will beaded to land using irrigation system. All the inputs will be viewed using mobile app.

Chapter 4

DESIGN SPECIFICATIONS

4.1 System Architecture

4.1.1 Three – Tier Architecture



Presentation Layer

The presentation layer comprises the software components through which information is presented to the user. Common presentation layer standalone components Windows-based are web pages graphical user interface.

Application Layer

The Logical layer comprises software components that implement business logic and business rules.

Data Layer
The data the layer consists of systems that maintain the persistence of information, such as a person's information in database system.

Figure 4.1 Three – Tier Architecture

The above is the three-tier architecture of our project which shows the transfer of data from sensors to raspberry pi and raspberry pi to mobile application.

4.1.2 MVC Architecture

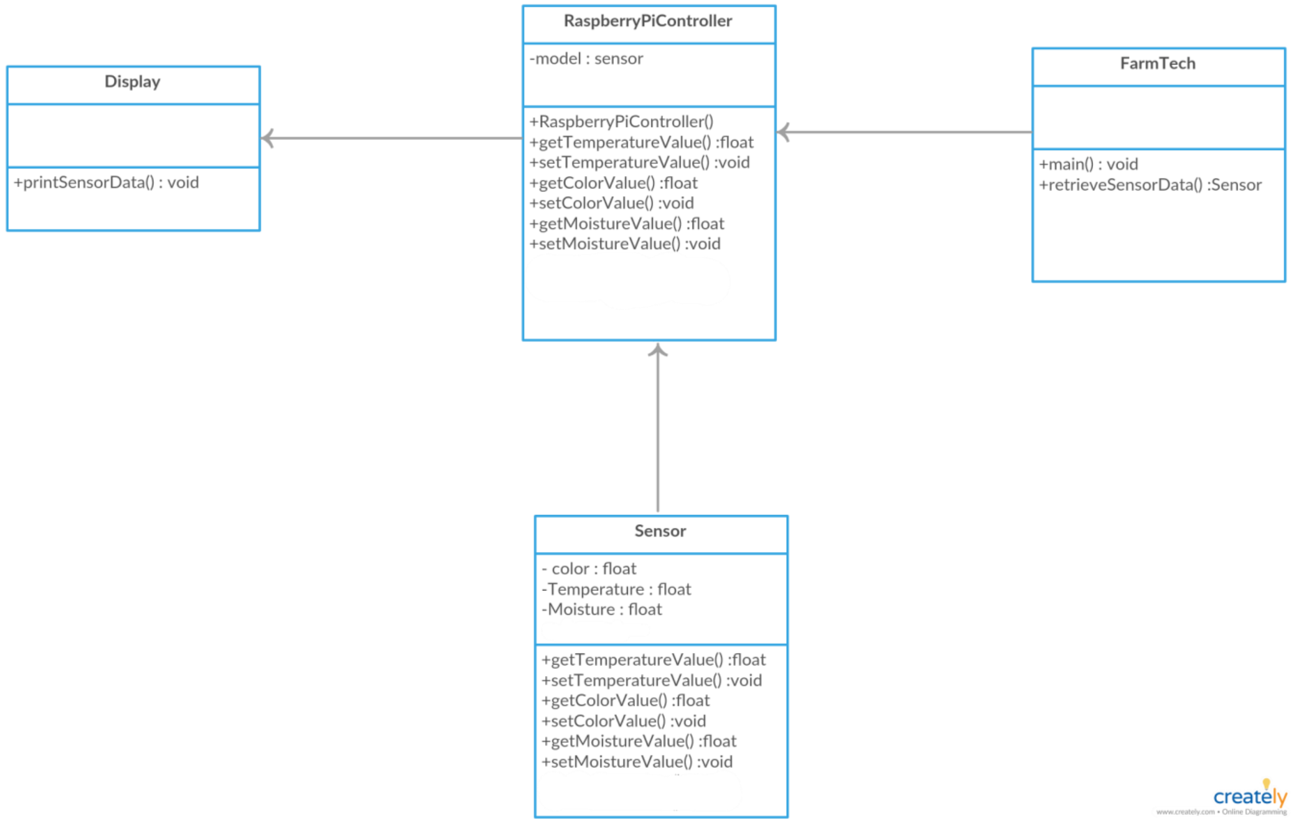


Figure 4.2 MVC Architecture

Model View Controller (MVC) is a software architecture pattern, commonly used to implement user interfaces: it is therefore a popular choice for architecting web apps. In general, it separates out the application logic into three separate parts, promoting modularity and ease of collaboration and reuse.

The above MVC depicts the methods and attributes used and passed through the interfaces of our raspberry pi, sensors and mobile application.

4.2 Design level diagram

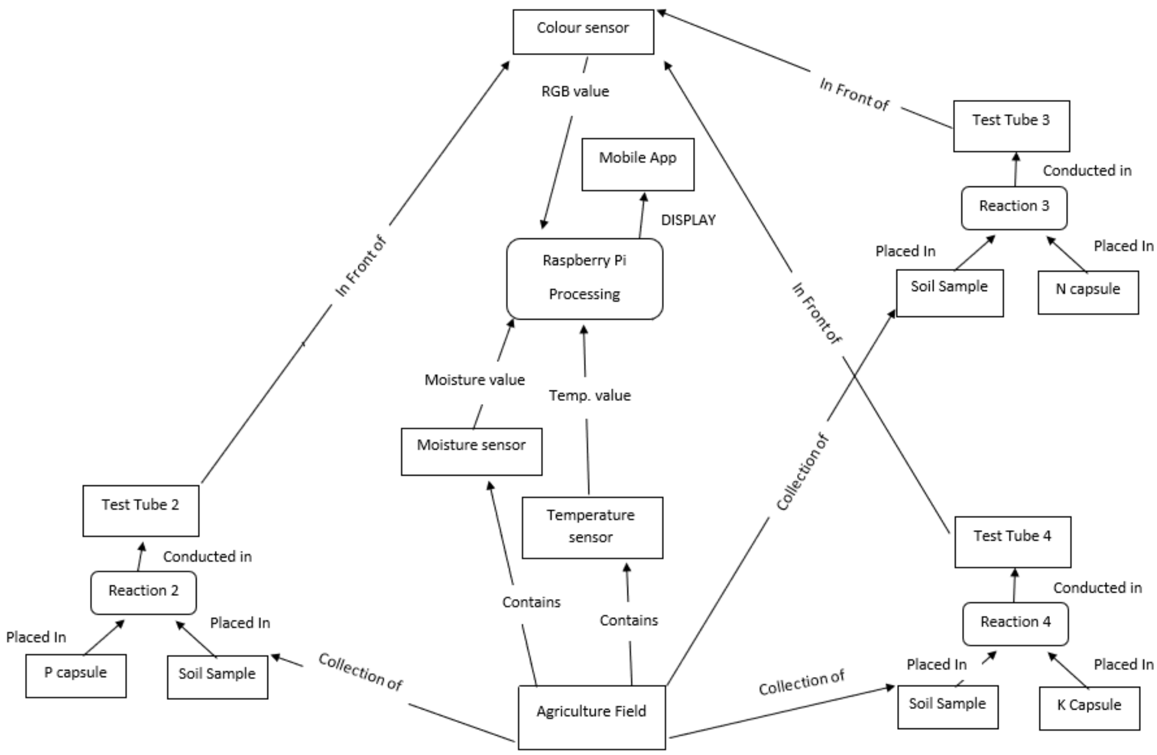


Figure 4.3 Data Flow Diagram

A DFD shows what kind of information will be input to and output from the system, how the data will advance through the system, and where the data will be stored. It does not show information about process timing or whether processes will operate in sequence or in parallel, unlike a traditionally structured flowchart which focuses on control flow, or a UML activity workflow diagram, which presents both control and data flows as a unified model. The above DFD shows the flowing of data from one module to other.

4.3 User Interface Diagram

4.3.1 Activity Diagram

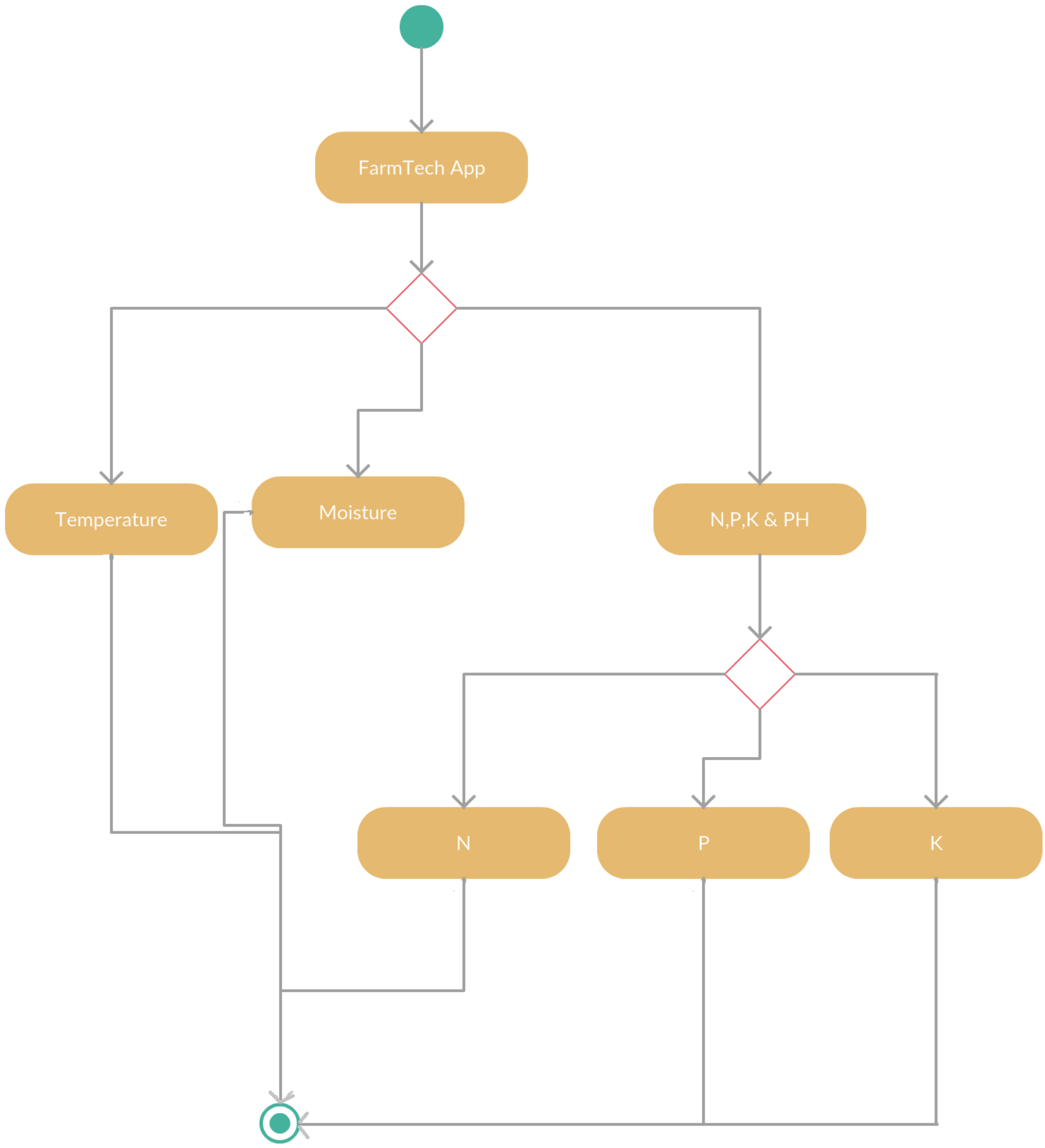


Figure 4.4 Activity Diagram

This Activity Diagram shown in the figure depicts various stages through which a person has to pass. User will have to open the application. After this the user will be forwarded to next window which contains Temperature, moisture and NPK & PH buttons. After this the related activities will be done on the hardware device.

4.3.2 Use Case Diagram

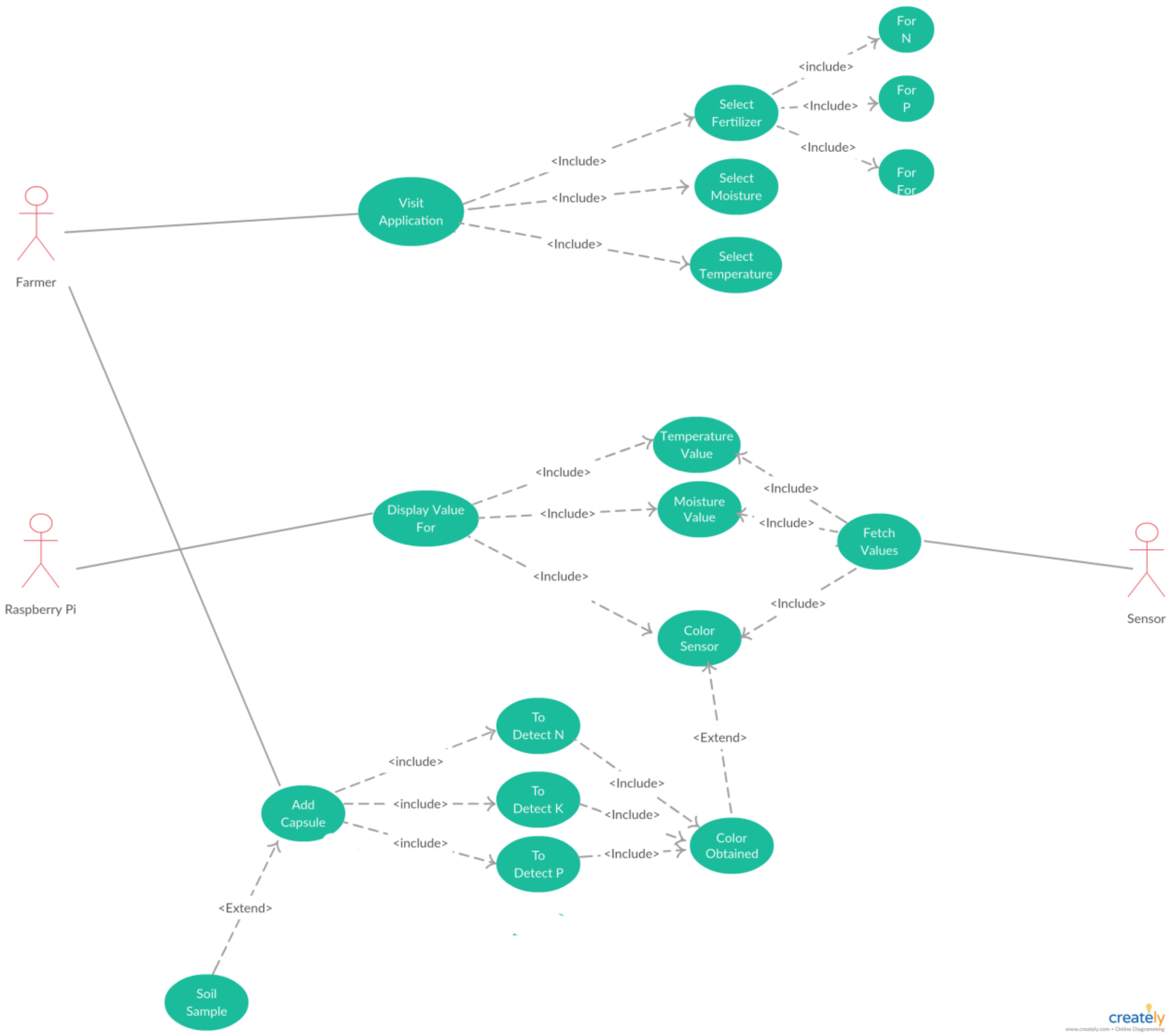


Figure 4.5 Use Case Diagram

In software and systems engineering, a use case is a list of actions or event steps typically defining the interactions between a role (known in the Unified Modeling Language as an actor) and a system to achieve a goal. The actor can be a human or other external system. In systems, engineering use cases are used at a higher level than within software engineering often representing missions or stakeholder goals. The detailed requirements may then be captured in the Systems Modelling Language (SysML) or as contractual statements.

4.3.3 System Components

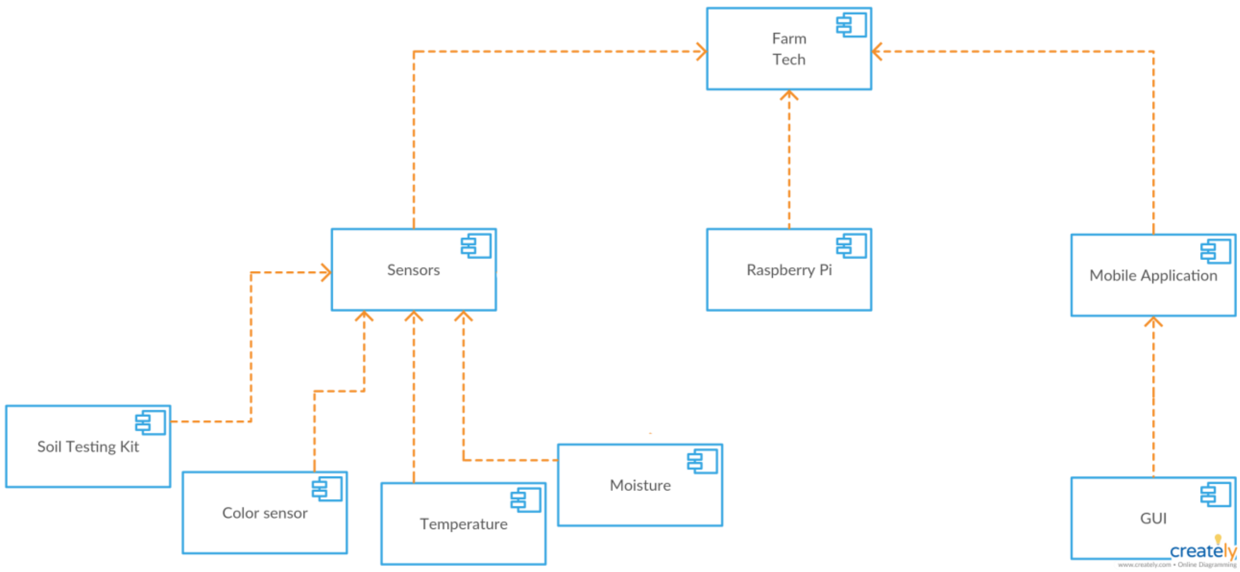


Figure 4.6 Component Diagram

The component diagram is a special kind of diagram in UML. The purpose is also different from all other diagrams discussed so far. It does not describe the functionality of the system, but it describes the components used to make those functionalities.

The diagram depicts various components contained in FarmTech at different levels. It shows how External Interface includes the use of GUI and Internet to carry out various processes. It shows the various hardware modules which are used in the development of the portable device.

4.4 System Screenshots

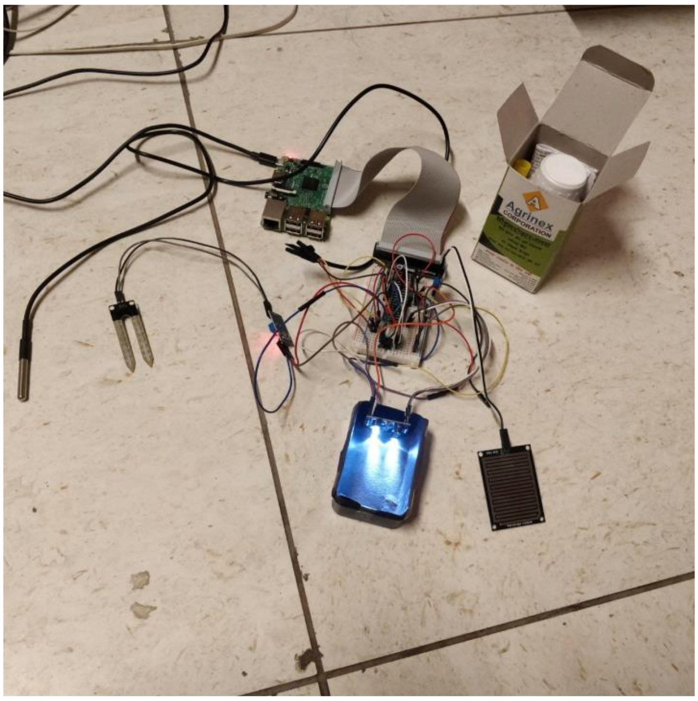


Figure 4.7 Working Prototype

Figure 4.8 Future Prototype 1

Figure 4.9 Future Prototype 2

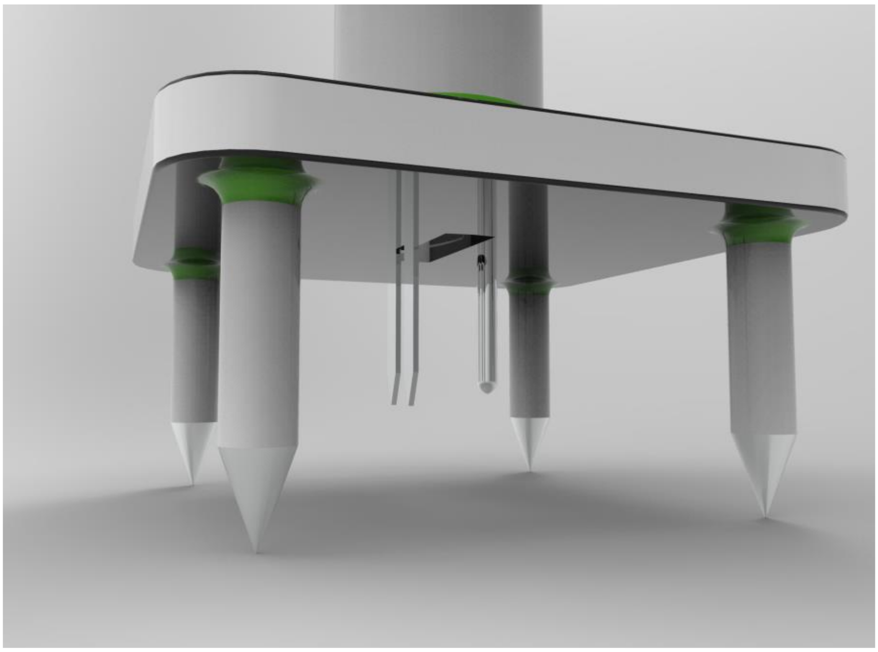


Figure 4.10 Future Prototype 3

Chapter 5

IMPLEMENTATION AND EXPERIMENTAL RESULTS

5.1 Experimentation

For testing of soil nutrient there are three types of capsule i.e. Nitrogen, Phosphorous, Potassium. These capsules chemical react with soil extracted nutrients and appear colour of different intensity. To assess the soil nutrient, follow the process as given below.

5.1.1 Preparation of Soil Sample Extract Solution

1. Take 3 to 4 soil samples of half kilograms each from different locations of a fertile soil field with depth of 15 cm. Now mix these samples and take a half kilogram sample from it
2. Mix this soil sample with water (use rain water OR distilled water) with 1:2 ratios in volume (i.e. one cup of soil with 2 cap water) and mix it thoroughly.
3. Wait 10-30 min for settling soil in bottom and clear water separation (wait at least water upper soil extract should be clear in case of not clear up to 30 min please try to filter by normal filter paper).

Figure 5.1 soil sample preparation

5.1.2 Nitrogen test.

Open nitrogen capsule carefully. Put the chemical inside the test tube and transfer 4.0 ml clear soil extract with dropper. Cap it and mix gently until the chemical is dissolved. Wait 20 minutes for the color to develop.

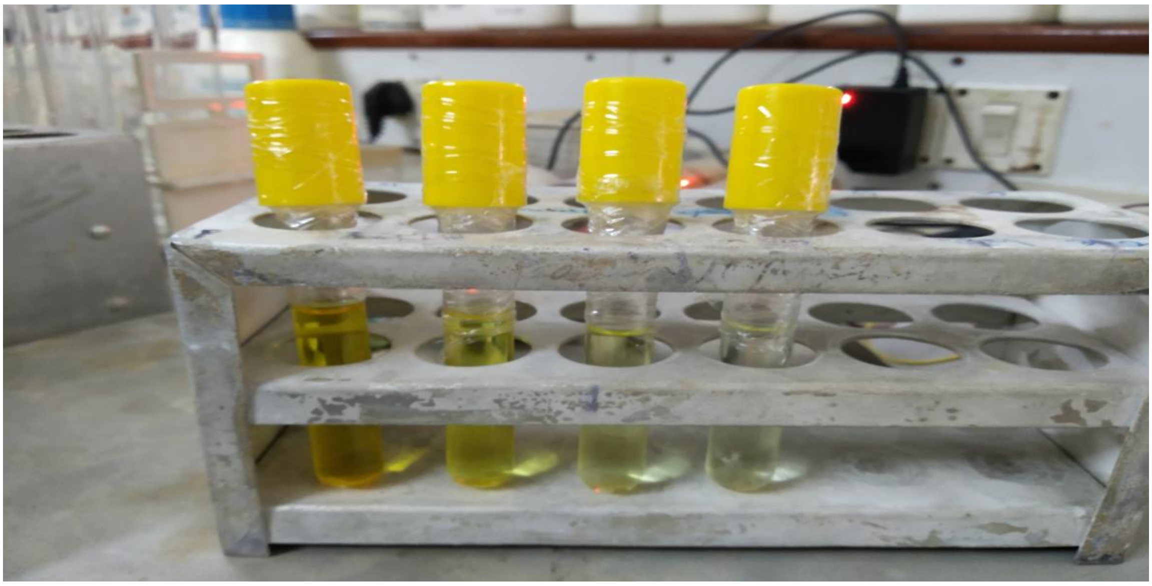


Figure 5.2 Nitrogen test

5.1.3 Phosphorous test

Open phosphorous capsule carefully. Put the chemical inside the test tube and transfer 4.0 ml clear soil extract with dropper and add 4 drop of TCA reagent carefully. Cap it and mix gently until the chemical is dissolved. Wait 20 minutes for the color to develop.

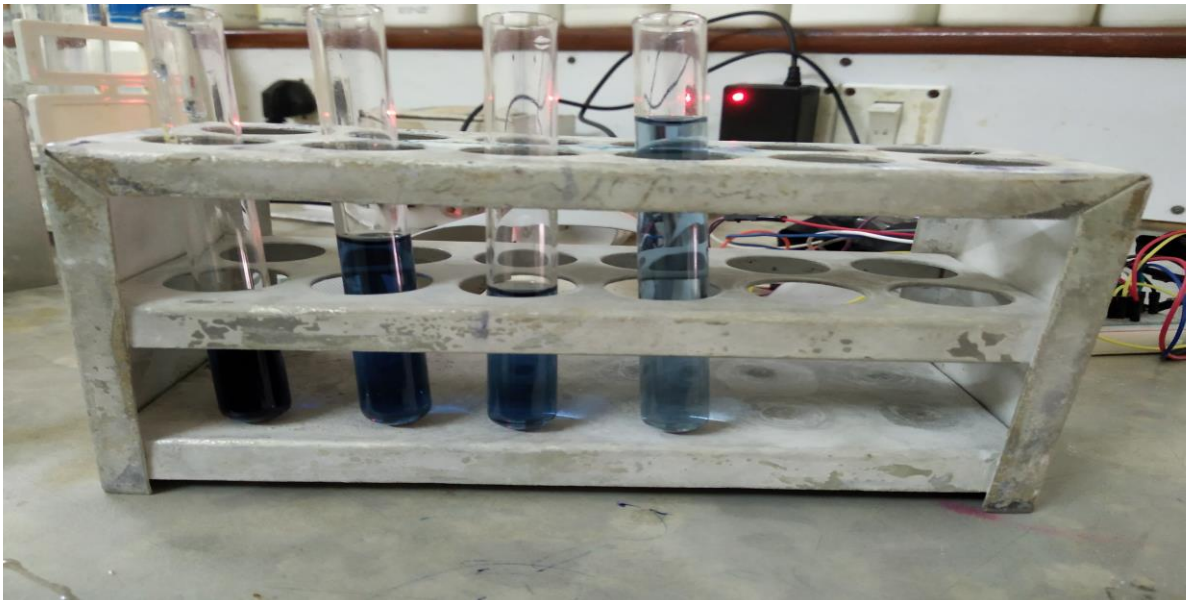


Figure 5.3 Phosphorous test

5.1.4 Potassium test

Open potassium capsule carefully. Put the chemical inside the test tube and transfer 4.0 ml clear soil extract with dropper and mix gently until the chemical is dissolved. Wait 20 minutes for the colour to develop.

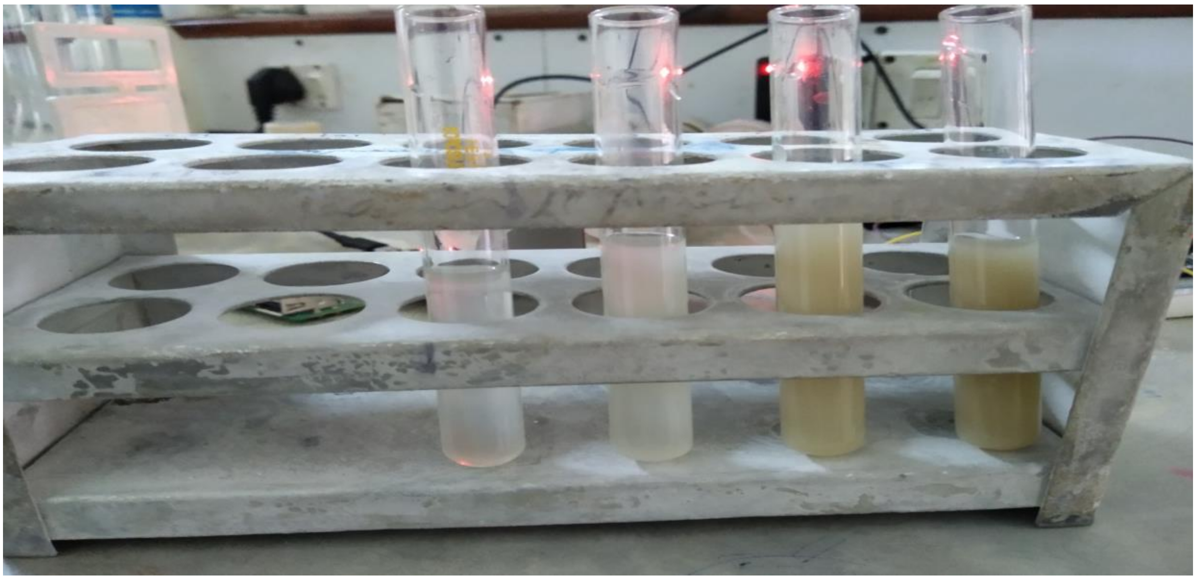


Figure 5.4 Potassium test

5.2 Results and Discussions

The following tables and graphs have been obtained as the output of the color sensor.

Table 5.1 Potassium

Concentration	Color intensity	Mg/ml
High	165.206	40
Medium	187.552	30
Low	204.905	25
Trace	219.098	20

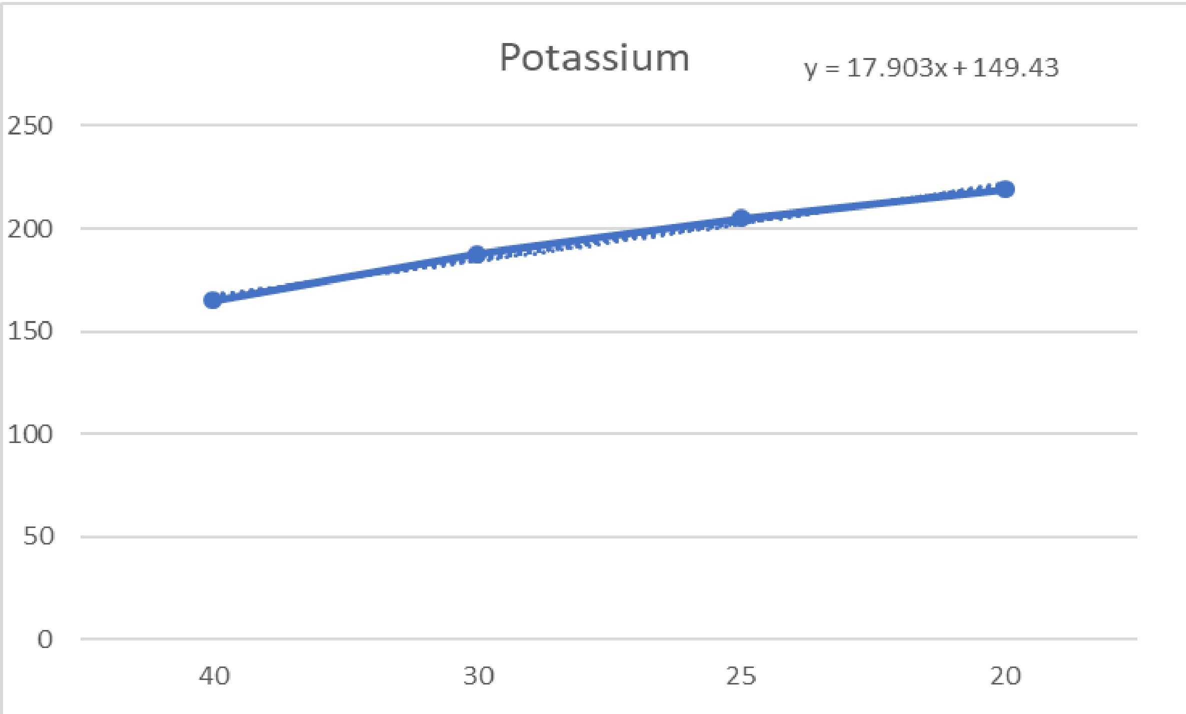


Figure 5.5 Standard Curve I

Table 5.2 Nitrogen

Concentration	Color intensity	Mg/ml
High	132.68	40
Medium	127.734	33
Low	134.685	30
Trace	157.558	25

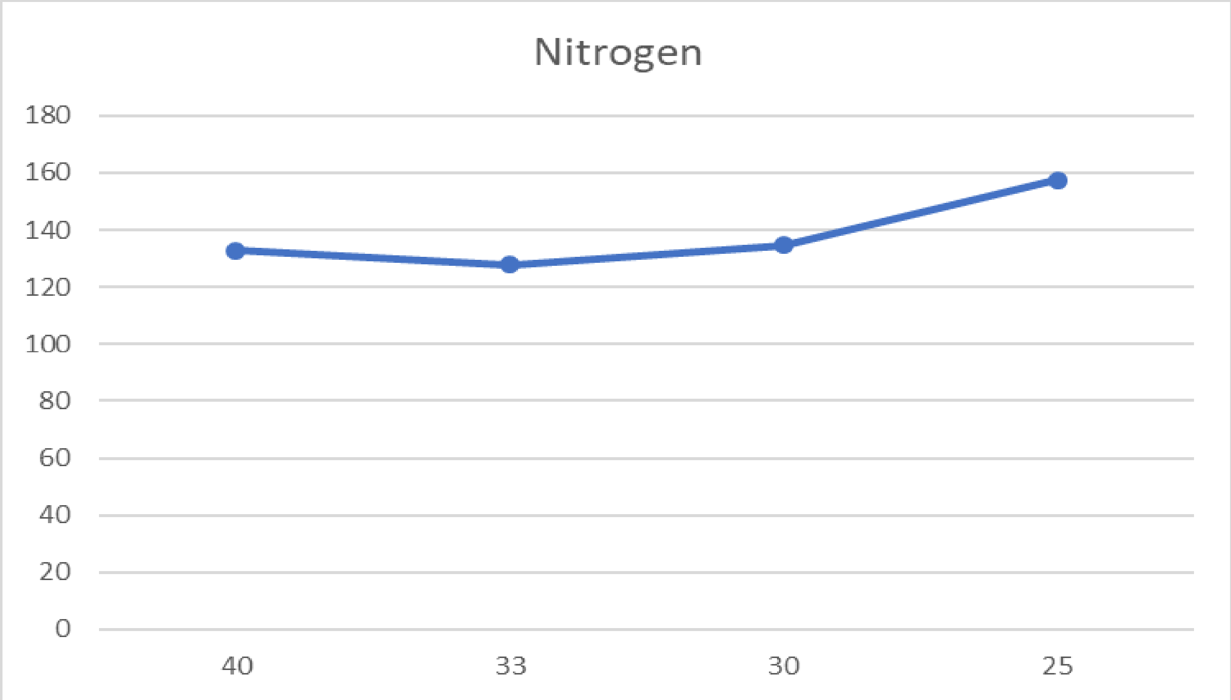


Figure 5.6 Standard Curve II

Table 5.3 Phosphorous

Concentration	Color intensity	Mg/ml
High	113.798	18
Medium	114.702	15
Low	118.895	12
Trace	121.7694	10

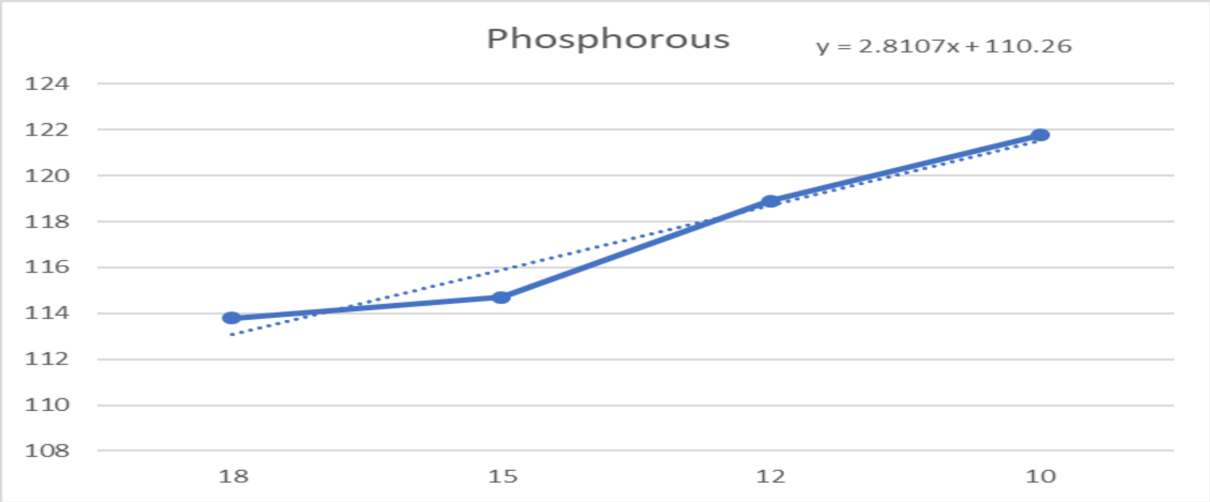


Figure 5.7 Standard Curve III

5.3 Inference drawn

After performing the experiments for phosphorous, nitrogen, potassium, the following color intensity thresholds have been obtained for the optimum level of NPK in soil for wheat.

Table 5.4 Result

	Color intensity	Optimum value
Phosphorous	114.702	23kg/ha
Nitrogen	127.734	49.5kg/ha
Potassium	187.552	45kg/ha

Now any unknown sample can be tested and a comparison between it and standard curve will depict the amount of fertilizer is in excess or less or optimum in the soil.

5.4 Validation of Objectives

Table 5.5 Validations

S. No.	**Objectives**	**Status**
1	Development of real time NPK sensor.	Successful
2	Integration of this system with other sensors.	Successful
3	Development of android application interface with hardware.	Successful

Chapter 6

CONCLUSION AND FUTURE DIRECTION

6.1 Conclusion

Internet of things is widely used in connecting devices and collecting information. The system is designed for real time detection of soil parameters in farms. After collecting and analysing the data, algorithm is designed to provide accuracy. All the results are calculated by taking several readings. The testing is done in small area say kitchen garden. This project can undergo for further research to improve the functionality of device and its applicable areas.

6.2 Environmental Benefits

The unavailability of Farmtech is causing drastic damage to soil. The current status of the soil macronutrients (NPK RATIO) is 103: 32: 5.3 in north region in India whereas the optimum level must be nearly 3: 2: 1.

The optimum soil nutrients will increase the yield of the crops that will increase the overall GDP of our country. The farmers will eliminate the extra addition of fertilizers into soil by farmtech application that will save their money as well.

6.3 Reflections

Agriculture accounts for 7.68 percentage of total GDP output. In today's modern era a lot of advancements have been achieved in other fields like industry, medical research etc. When we started our project, we had little knowledge about this domain but presently, we believe that lot of progress and development is required in this field. Our project focuses on the expansion of IOT in agricultural empire. The basic need of soil monitoring which is absent but required in today's era is satisfied by our project.

6.4 Future Work

The results of the work point to the following directions of research that are likely to be needed for further improvement [2].

1. Full automation of the system using actuators.
2. Disease prediction of crops can be done using image processing.
3. Machine Learning implementation for detection of crops to be sown.
4. NLP implementation for easy understanding of farmers.

Chapter 7

PROJECT METRICS

7.1 Challenges Faced

1. Hardware Related - Calibration of the color sensor using different soil samples and development of standard curve.
2. Software Related - Development of code to fetch values from the sensors. . To get the data into firebase and finally into our android app.
3. Team related – As we have team members from biotechnology department too, we have to face communication gaps.
4. Project Related - Research required to choose the subject to work on. It took almost two months to reach to this outcome of farmtech.

7.2 Relevant Subjects

1. Python
2. Embedded system and design
3. Android studio

7.3 Interdisciplinary Knowledge Sharing

During the course of the project members had various group sessions to discuss the feasibility and utility of the idea. The sharing of knowledge between human psychology and utilitarian thoughts helped develop farmtech as it is today. The principles management as well ancient rules of stoic helped us stick together as a team. Sharing knowledge made soil testing a lot better and easier. The farmtech strides in android app and iot that helped bring real time data and solved the problem of manual testing.

7.4 Peer Assessment Matrix

Table 7.1 Evaluation

		Evaluation of			
		jaskaran	baldeep	jaswinder	lovejot
Evaluation By	jaskaran	5	5	5	5
	baldeep	5	5	5	5
	jaswinder	5	5	5	5
	lovejot	5	5	5	5

7.5 Role playing and Work Schedule

Table 7.2 Roles

	Baldeep	Jaskaran	Jaswinder	Lovejot
Interfacing of raspberry pi with colour sensor	*	-	*	-
Implementation of colour sensor code	*	-	*	-
Literature Survey	*	*	*	*
Hardware Requirement Analysis	*	*	-	-
Software Requirement Analysis	-	-	*	*
Documentation				
• Report	*	*	-	-
• Presentation	-	-	*	*
Interfacing of raspberry pi with temperature and moisture sensor	-	*	-	*
Implementation of temperature and moisture sensor code	-	*	-	*

Design analysis				
• DFD	*	*	-	-
• Sequence diagram	*	-	-	-
• Activity diagram	-	-	*	*
• MVC	-	-	*	*
• 3 tier architecture	-	*	-	-
Experimentation	*	*	*	*

Table 7.3 Work Schedule

	Jan	Feb	Mar	April	May	Jun	July	Aug	Sep	Oct
Research Work										
Hardware Development										
Requirement Analysis										
Integration										
Calibration										
Software Development										
App Development										
App Testing										

7.6 Student Outcomes (A-K Mapping)

Table 7.4 AK mapping

SO	Description	Outcome
A1	Applying mathematical concepts to obtain analytical and numerical solutions.	Used for unit conversion during soil testing.
A2	Applying basic principles of science towards solving engineering problems.	Intrigued idea to develop a real time soil quality monitoring system.
A3	Applying engineering techniques for solving computing problems.	Developed the android app and interfacing of sensors with raspberry pi.
B1	Identify the constraints, assumptions and models for the problems.	Used to contain the problem in a very definitive boundary
B2	Use appropriate methods, tools and techniques for data collection.	Used android studio, firebase, raspberry pi to fetch data.
D1	Fulfill assigned responsibility in multidisciplinary teams.	Every member was assigned different roles and communicated information in bi-monthly discussion hours.
D2	Can play different roles as a team player.	Most of the time our team members helped each other if stuck on some problem
E1	Identify engineering problems.	Lack of real time system for soil testing.
F1	Showcase professional responsibility while interacting with peers and professional communities.	Team conducted regular discussions with the assigned mentor in punctual manner
G2	Deliver well-organized and effective oral presentation.	Regular presentation to the panel to explain idea and the progress made were done by the team
I1	Able to explore and utilize resources to enhance self-learning.	Each member studied various research papers to implement new and effective technologies in the project
K3	Use software tools necessary for computer engineering domain	Mainly three software tool were used which are raspbian os, android studio and firebase.

7.7 BRIEF ANALYTICAL ASSESMENT

Q1. What sources of information did your team explore to arrive at the list of possible Project Problems?

Ans: Most of the exploration was achieved via research papers and already established patents on agriculture. Besides that all the team members have an agriculture background so the difficulty for selection of project was minimal.

Q2. What analytical, computational and/or experimental methods did your project team use to obtain solutions to the problems in the project?

Ans: The methods were purely experimental. Different chemical tests were performed for npk testing in soil. The temperature and moisture contents were fetched directly by sensors.

Q3. Did the project demand demonstration of knowledge of fundamentals, scientific and/or engineering principles? If yes, how did you apply?

Ans: Scientifically, the deep knowledge regarding chemical procedure for soil testing was required. Computer engineering principles of python, firebase and android studio were required to display the sensor output onto mobile app.

Q4. How did your team shares responsibility and communicate the information of schedule with others in team to coordinate design and manufacturing dependencies?

Ans: The whole team worked together with equal responsibilities and co-ordination with each other's. What's app group was established to decide the daily working schedule and to prevent communication gaps. Apart from this, regular team meetings were held to discuss the project design and manufacturing dependencies.

Q5. What resources did you use to learn new materials not taught in class for the course of the project?

Ans: The basic knowledge regarding the soil testing was obtained from research papers and in person meeting with the heads at the soil testing centres in Patiala. Also, meetings were held with the farmers to look into the issue from their perspective. The technical knowledge regarding python coding and java was taught in class. Technical help from our mentor was always available.

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