Integrated Knowledge & AI Technology In Farming

Capstone Project Report

END SEMESTER EVALUATION

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ABSTRACT

The use of modern computing technologies like machine learning and artificial intelligence in the field of agriculture has grown in developed countries but there is a need of low-cost technology development for farmers in developing countries like India. The major reason behind this growing popularity and demand is the ability of these machine learning models to accurately predict plant disease and suggest crop patterns that increase the yield of the land. The question we posed for our project was whether a holistic solution can be developed which is able to assist the Indian farmers at a low-cost. We have successfully built a hardware model which is able to collect readings from the soil used in farms. The analysis from these reading is used to suggest the correct crops and agricultural practices for the farm which can increase the productivity of the farmland. All this work is carried out using machine learning models and this can assist the farmers in short as well as long term. Further we have also successfully trained a machine learning model which can detect various plant diseases based upon the images uploaded by the farmer in our webapp. Our team's IKAT prototype is a very limited version of what could be created in a production facility using more advanced technology.

While optimizing the existing model we are also working to build a robocar which can successfully manoeuvre in a farm like terrain and can collect the required readings and click images of the disease affected crops. Also, our team is currently working implementing the webapp and also the ripeness detection model. We are trying to build a low-cost system for the small-scale farmers of developing nation like India.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled Integrated Knowledge & AI Technology in Farming is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr. Anil Singh during 6th semester (2022).

Date: 21st December 2022

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GPU	Graphical Processing Unit
IoT	Internet of Things
ML	Machine Learning
AI	Artificial Intelligence

INTRODUCTION

1.1 Project Overview

The following section will provide some brief insight on the project.

1.1.1 Technical Terminology

The Integrated Knowledge & AI Technology (IKAT) in Farming is the prominent technology through which data from several agricultural fields can be collected using different sensors. The collected data are analyzed by various machine learning models to draw conclusions based on different climatic patterns, soil fertility, the nature of crops, and the amount of water that needs to be supplied to the field using IoT devices. This project mainly focuses on predicting the appropriate crop based on the climatic situations, predicting the disease of the crop, identifying the weeds in the crop, ripeness of the fruits, and the yield of the crop based on the historic data by using supervised machine learning algorithms.

1.1.2 Problem Statement

In Farming, monitoring the huge fields has always been difficult and challenging for the farmers. As the monitoring the crops include various things such as need to water, identifying infected crops, checking of ripeness etc. Specifically the difficulty of not knowing when to water the crops and in what quantity can affect the crops and also lead to wastage of water. Plants and crops getting affected by diseases and pest has been a very common problem in farming. Moreover, there is no way to give an exact reference to the requirements. In the absence of enforceability of contractual provisions, either of the parties can breach their ends of the contract. Moreover, there is no means to monitor the crop and guide the farmer during the growing period.

1.1.3 Need

Agronomy has a significant contribution in shaping and boosting the economy of developing nations, especially India. The issues faced by the agricultural zones are hampering the growth of these economically developing nations. The only remedy to the crisis is to do all that is possible to make agriculture a profitable enterprise and attract the farmers to continue the crop production activities. As an effort towards this direction, this capstone project i.e., IKAT in farming would help the farmers in making appropriate decisions regarding the cultivations with the help of machine learning.

1.1.4 Solution

In the past farmers used to predict their yield from the previous year's yield experiences. Thus, for this kind of data analytics in crop prediction, there are different techniques or algorithms, and with the help of those algorithms, we can predict crop yield. By analyzing all the issues and problems like weather, temperature, and several factors, there is no proper solution and technologies to overcome the situation faced. The major benefit of this proposed work is the implementation of precision agriculture with cloud computing i.e., Integrating the Knowledge Management with Artificial Intelligence which will control the usage of water and monitor other plant parameters (soil moisture, temperature, humidity, and air quality index) and early prediction of crop diseases/weeds, thus enhancing the yield of the crops.

1.1.5 Scope of Improvement

I. **Crop Monitoring:** The various features of soil such as moisture and nutrients would be continuously monitored and that information would be provided to the farmer, instead of directly judging the quality of the final product, it will be better for both the firm and the farmer.

II. **Stating the requirements**: Stating the growing conditions (like maintaining soil humidity, pH, fertilizer concentration in a range) instead of verbally stating the quality requirements of final products will make the contracts more deterministic.

III. **Recording violations in an immutable database:** Machine learning can be used in these situations to get correct results, it is very essential to have the knowledge of when to harvest the crops as it can highly increase the amount yield that is produced. Thus the farmers will be saved from undue quality cuts and exploitation.

1.2 Need Analysis

Farming is the backbone of the Indian economy and it highly contributes to the GDP of our country. In India half of the population is involved in agriculture and contributes 7.6% of total agriculture yield, which is very limited and requires special attention. According to studies pests, weeds, and diseases cause India to lose 15-25 percent of its potential crop yield. If the pest and weed are controlled in their initial stages the loss can be reduced.

The need of this project focuses on countering these challenges via continuous crop monitoring and the deployment of technology such as artificial intelligence. This technology would deliver vital information to our farmers, allowing them to take essential safeguards early on to save their crops from damage.

We always have limited amount of water accessible to us for cultivation. Its commonly noted that the water is not utilized in an efficient way in farming, which leads to its a lot of wastage. So it becomes a crucial factor to use existing water resources sustainably. For sustainable use of water in farming there is an essential need to automate the irrigation which we will do in our project with IOT and AI technologies.

Yields of crops can be increased and a lot of workload can be reduced from the head of our farmers. This purpose can be fulfilled like:

- In this project, we will assist farmers in determining when the crop is ready to be harvested by analyzing its ripeness.

- The crop's productivity would be boosted by detecting critical characteristics such as soil pH, humidity in the environment, nitrogen/phosphorus content in the soil, rainfall in the region etc.
- We would also assist farmers in determining which crop would be best to cultivate in a given region based on the greatest needs anticipated by machine learning.
- A WebApp would provide farmers with easy access to crop monitoring information.

1.3 Research Gaps

The smart irrigation system that is being used in [2] for purpose of providing water to the plants through automated techniques essentially uses a setup which is based upon the concept of centralized technology. In this technology the dysfunction of the controller would result in whole network failure, to avoid such cases the whole system can be decentralized. The SVM algorithm used in [3] for the classification of the images that are being captured by rover would not give higher accuracy, and it also depends which types of diseases are considered for the process of classification. So better option would be to use concepts Convolution Neural Network, OpenCV or Xgboost as studies have shown they give better results in case of images classification. In this paper [4], a system has been proposed that locates, tracks, and estimates the ripeness and quantity of fruit in the field. The proposed approach consists of two sub-systems: a detection and ripeness estimation sub-system and a tracking subsystem, the results given by these respective systems could be increased using other different combinations of deep learning techniques or combining the results of different models to push the results in the range of 90 to 100%. In [6] the analyzing of the characteristics and quality of the soil is done with the hardware system consisting of various sensors like DHT11 sensor and Soil moisture sensor. Use of DHT11 could affect the results as the sensor is made of plastic, extreme heat can cause it to melt. Also, due to prolonged exposure to a high-humidity environment, the sensor may accumulate water vapors due to heat and humidity, which will eventually condense into liquid inside the covering. To avoid such scenarios the sensors such as DTH22 can be used which would also further provide better accuracy and measuring range. A Literature Study on Agriculture Production System Using IOT as Inclusive Technology is done in [8] which basically describes its role in solving problems in domain of agriculture. Although it brings various essential results, but cost of deploying such technology is higher. Also it has the problem of integration as there is currently no consensus regarding IOT protocols and standards. These can be solved by understanding the network and giving any required customizations like planning for extra time with device deployments to handle any troubleshooting.

1.4 Project Definition and Scope

Productivity of a farm can be enhanced by determining which crop variety has produced the greatest yield under similar soil, climate, fertilization, and irrigation conditions. The same data driven approach to crop selection can also address climate change, resource constraints and societal concerns around issues such as animal welfare, fertilizers, and environment that often impact agricultural production. Increased crop productivity is urgently needed, and it is the cornerstone of any solution for meeting food shortage and farm profitability problem. Smart farming involves the use of technology and in particular, the internet of things and related big data analytics to address these challenges via the electronic monitoring of crops, as well as related environmental, soil, fertilization, and irrigation conditions. Such monitoring data can be then be analyzed to identify which crops and specific crop varieties can best meet the productivity targets of any particular farm around the world. Crop variety identification involves the use of plant phonemics and related data analysis results with specific crop varieties. The association of information will revolutionize the way food is produced globally.

1.5 Assumptions and Constraints

Although the factors on which the growth of a crop depends on are many, but w a naming that it only depends on the most significant four humidity of the air, moisture of the soil, temperature and wind.

The sheets on the outer of the Greenhouse can still be damaged if there is a strong windstorm or rain. We are assuming that weather conditions do not vary to that extent.

The constraints for the project include the following

- Arduino Uno Board has only 13 input/output ports, out of which 2 are used for Receiver-Transfer logic; so, we are only lett with 11 ports. Therefore, we must mold the logics such that at maximum, we use 11 ports.
- We cannot put our model in an open field, since our model is not that much impregnable that it would withhold and withstand rains and strong winds or hails. In addition, there is always a danger of animals and birds too.

1.6 Standards

Software System

- Tools: Web browser, Arduino IDE.
- Language: Python (version 3.6.5), Javascript (ES6) etc.
- Plugins & libraries: Primarily inbuilt Arduino plugin and libraries, Tensorflow, cupy, cuml library etc.
- Techonolgy Used: Machine Learning, Deep Learning and Data-preprocessing etc.

Hardware System

- Sensor: soil moisture sensor, temperature/humidity sensor, rain detector sensor and PIR sensor.
- Data Processing: Processor used is nodemcu (ESP 8266).
- Device: Smart Phone/Tablet.

1.7 Approved Objectives

- The irrigation system which is used to water the plants is planned to be automated, in which the water would be supplied according to the readings taken from the sensors.
- Disease is automatically detected in the crops through the images of their leaves and it would be passed to the AI model to classify the type of disease.

- All the aspects that would be required to check the conditions of the crops are measured through sensors. The parameters that would be checked are humidity, temperature etc.
- The crop prediction would be done on the basis of the region where we have to do the farming. And the best type of crop suitable to grow in that region would be shown on the website.
- All the systems are connected to the website and the user is provided with the master control of all the systems.
- All the measurements or the readings related to crops would be provided on the website. These reading will tell about the soil conditions.

1.8 Methodology

We achieve these tasks for projects by firstly, implementing the hardware design of the embedded system we are using. This embedded system, to be installed at some elevation in the fields, would contain all the sensors, including wind current sensor, temperature and rain detector. These statistics would keep on getting updated on the online database that could be accessed by the owner of the field on his android application.

In the Robo car, a human controls the car by remote control. This is done by sending and receiving the signals from the car. The car can thus cover the whole farm and capture the picture of plants which can further be sorted by machine learning that which crops are having any disease. The receiver has been configured to take input coordinates from the web app designed to make it autonomous.

Raspberry Pi will be used to analyze the crop field and provide possible points to check in the agriculture field. The webapp would be made that would have the master control over the whole control system. The user can also see the database with this application so one can evaluate the conditions over his field.

1.9 Project Outcomes and Deliverables

Our project is based on both hardware as well as software implementation.

Physical Model:

Our project is to be built on a physical model. All the conditions as well as the second outcome, i.e. webapp is also based on this. The model would contain all sensors that would be deployed to check the weather conditions of the soil. And on the basis of that there would be certain actuators which would regulate the weather system so that it is favorable for the plant. At the successful completion of the project a fully autonomous robot that can move in a farm environment without damaging existing plants or soil and use object detection to find and mark diseased crops with an environmentally safe color. And all the data of the conditions would be uploaded over to an online database through the Arduino and web app. This will help farmers in producing a good yield and also prevent them from any kind of loss of seeds etc. which get rotten if they are given an amount of water higher than their requirement.

Web App:

Our second outcome is the app for the integrated knowledge & AI technology in farming. This site would be able to access the database that was used to upload all the weather data by the model. Thus, able to check all the statistics, the user would be able to analyze the crop growth so as to control the condition ranges that are to be inputted by the user. This webapp would thus have to be built such that it gives master control over all the sensors of the physical model, and their ranges.

1.10 Novelty

Our Project is different from other available products in market as follows

- Cost: The total cost of implementing the microcontrollers and sensors very less as compared to other products available in market. Hence, ever mall scale farmers can implement that in their small fields
- Scalability: The product is highly scalable, as the number of users inrease there will be very small modification needed to implement the system.

- Open Source Application: The Android application used is open source and the whole source code is available on Github. Hence, the users can tweak the application specifically for their needs and requirements.

- Ease of Use: The product is very easy to use. Just install the sensors in the Gremhouse and connect them to specified ports in Microcontroller. Then we just need to install Android application to use the system.

2.1 Literature Survey

The following chapter covers the details about the literature survey done, discussing about the existing technology, the technology on which the team worked and theory associated to the problem area.

2.1.1 Theory Associated with Problem Area

Farming is the backbone of the Indian economy and it highly contributes to the GDP of our country. In India half of the population is involved in agriculture and contributes 7.6% of total agriculture yield, which is very limited and requires special attention. According to studies pests, weeds, and diseases cause India to lose 15-25 percent of its potential crop yield. If the pest and weed are controlled in their initial stages the loss can be reduced. Agriculture 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. Use of advanced techniques like making use of machine learning and artificial intelligence to predict the nature of crop to be grown, to detect crop diseases and to check the ripeness of the fruits can reduce 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 use advance computer technologies for increasing the productivity of the farmland.

2.1.2 Existing System and Solutions

Following are some of the major players that are operating in the market.

- **Plain Sight** is a USA based vision AI platform that enables livestock and crop producers and processors to increase efficiency and generate more revenue .

- **Gro Intelligence** is a USA based analytic platform that provide a unified view of climate, agriculture and economy insights. They help in managing the food security and help farmers in making short term and long term decisions,
- **Dickey John** is a USA based organization that works in a lot of domains and provide a lot of smart products and sensors that can help in better monitoring of crops.
- **Gamaya** is a Swiss based AgTech start up that uses cutting-edge system for mapping and diagnosing farmland to address the need to boost the productivity and sustainability of the agricultural industry. Their product mainly focusses on using drones to diagnose the farmland and optimize the farming area to provide better re-planting decisions.
- **Farmers Edge** is a Canadian based group that analyses existing crop data and helps in better decision making by suggesting seeds , manure and other tools required for farming.

2.1.3 Research Findings for Existing Solution

Table 1 : Research Findings for Existing Solution

S.No	Roll No.	Name	Paper Title	Findings	Citations
1	101903072	Karan Singh Pathania	Reliable Data Fusion of Hierarchical Wireless Sensor Networks with Asynchronous Measurement for Greenhouse Monitoring	data fusion problem of wireless sensor networks for the green house monitoring system	[1]
2	101903072	Karan Singh Pathania	Smart Irrigation System: IOSR Journal of Electronics and Communication Engineering	Water Conservation by automatically providing water to plants based on needs.	[2]

3	101903202	Tarunvir Singh	Smart Irrigation with Field Protection and Crop Health Monitoring system using Autonomous Rover	An autonomous rover that monitors the field and, a system for identification and classification of affected plants	[3]
4	101903202	Tarunvir Singh	Fruit Quantity and Ripeness Estimation Using a Robotic Vision System	A system that locates, tracks, and estimates the ripeness and quantity of fruit in the field	[4]
5	101903334	Amritpal Singh	Smart Farming Using Machine Learning	ML-ASC performance framework proposed in the study can transform the existing production systems into data-driven smart manufacturing systems.	[5]
6	101903334	Amritpal Singh	Special Issue of Second International Conference on Advancements in Research and Development	a software application that provides suggestions to farmers when the hardware system analyses the soil	[6]
7	101903343	Inderpal Singh	Robotic applications in the automation of agricultural production under green house: A review	agricultural automation under greenhouse through the use of robotics platforms as a source	[7]

				to solution to different problems that arise in the agricultural sector	
8	101903343	Inderpal Singh	A Literature Study on Agriculture Production System Using IOT as Inclusive Technology	data collection, network service, date fusion and computation, analysing the technologies, based on which further the technological system framework of the internet of things are brought forth	[8]

- **Reliable Data Fusion of Hierarchical Wireless Sensor Networks with Asynchronous Measurement for Greenhouse Monitoring** [1]

  This paper investigates the data fusion problem of wireless sensor networks for the green house monitoring system. Considering the characteristics of local consistency and slow change of the greenhouse environmental information, the hierarchical structure of WSNs is proposed for the greenhouse monitoring system, and the two-stage data fusion scheme is presented for the hierarchical network. The multi-rate measurement mode is proposed to reduce the energy consumption of WSNs under the premise of satisfying the information sensing performance of the system. The data fusion at the sink node is conducted on the support function with the consistency analysis of data from different clusters.
- **Smart Irrigation System: IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)** [2]

  With the water requirements in irrigation being large, there is a need for a smart irrigation system that can save about 80% of the water. This prototype aims at saving time and avoiding problems like constant vigilance. It also helps in water conservation by automatically providing water to the plants/ gardens depending on their water requirements. It can also prove to be efficient in Agricultural fields, Lawns & Parks. As technology is advancing, there is always a chance of reducing risks and making work simpler. Embedded and microcontroller systems provide solutions for many problems. This application precisely controls the water system for gardens by using a sensor microcontroller system. It is achieved by installing sensors in the field to monitor the soil temperature and soil moisture, which transmits the data to the microcontroller for estimation of water demands of plants.

- **Smart Irrigation with Field Protection and Crop Health Monitoring system using Autonomous Rover** [3]
  In this research paper work has been done on an autonomous rover that monitors the field and, a system for identification and classification of affected plants. For the purpose of monitored and sustainable irrigation, a DTH11 module and a water level sensor module has been combined to draw the conclusion whether the crop can be watered or not. When the water level in the soil is below the required water level essential for the plant, the temperature and humidity are checked. This is done considering the necessity of water during inevitable plight. Classification of disease is done using a support vector machine algorithm, which helps in identifying the type of disease that has affected the plant. Also, when the farmer wishes to check his land personally, the rover may be manually operated using IoT and accordingly take suitable actions. A smart autonomous gardening rover, which can be controlled remotely has been fabricated which automatically identifies, classifies the plant species and measures the key parameters for farming such as temperature, humidity, heat level, wind speed, wind direction and soil moisture. Based on the acquired data and history, actions are taken to maintain the farm more effectively.
- **Fruit Quantity and Ripeness Estimation Using a Robotic Vision System** [4]
  In this paper they have proposed a system that locates, tracks, and estimates the ripeness and quantity of fruit in the field. The proposed approach consists of two sub-systems: a detection and ripeness estimation sub-system and a tracking subsystem. The detection and ripeness estimation sub-system uses the Deep Fruits technique and proposes a new network structure that jointly learns detection and ripeness estimation. With Deep Fruits, they have fine-tuned a pre-trained FRCNN network. Tracking via detection provides a simple framework to count the number of fruits that can be deployed using off-the-shelf cameras without the need for three-dimensional, inertia, or odometry information. Overall, in their first approach, they pose a multi-class task where each ripeness is its own class to be detected, referred to as Multi Class-

FRCNN. The second approach poses the task as two parallel layers (Parallel-FRCNN): one layer to perform detection; and a second to estimate ripeness. Evaluation of these two approaches outlines the improved performance of the parallel layer, where they achieve an F1 score of 77.3 for the parallel technique yet only 72.5 for the best scoring multi class implementation.

- **Smart Farming Using Machine Learning** [5]

  The study focuses on ML applications in analysing the data, and less attention is paid on how the data from different innovative technologies is captured, stored, analysed, and shared across the different phases in ASC. More research is required in this direction. The findings indicate that ML helps to enhance ASC visibility. However, it would be interesting to know the impact of such influence. The future studies should aim at measuring the impact of ML on ASC and provide specific guidelines on how the ASCs should deploy ML for enhanced supply chain visibility. The ML-ASC performance framework proposed in the study may be used as a guiding framework for such studies. The future studies should focus on how ML can transform the existing production systems into data-driven smart manufacturing systems. The future studies should aim at developing focused customer frameworks, which should capture insights on customer buying behaviour.

- **Special Issue of Second International Conference on Advancements in Research and Development (ICARD 2021)** [6]

  The smart Farming using IOT system mentioned in this research paper is a hardware integrated with a software application that provides suggestions to farmers when the hardware system analyses the soil. After analysing the characteristics and quality of the soil with the hardware system consisting of various sensors like DHT11 sensor and Soil moisture sensor, it provides the analysed data to the application via the Internet. Then this application compares the data in the database and provides user suggestions and also remotely monitors and controls equipment like drip irrigation systems and electric fencing, etc. The databases system analyses the data provided by the hardware as input and gives the user suggestions like, which crop is best suited for this soil, its organic farming methods and irrigation methods, etc. After that, it can also predict any animal intrusion by using a PIR sensor. This application mainly uses data analytics and database management techniques to derive suitable crops and their cultivation methods from the data sets that were collected from the research centres and organic farmers. And also helps to monitor and control farmland using IoT.

- **Robotic applications in the automation of agricultural production under green house: A review** [7]

  This article shows a review of the state of the art in the agricultural automation under greenhouse through the use of robotics platforms as a source to solution to different problems that arise in the agricultural sector specially under controlled conditions; the writing is part of a wide review of the agricultural automation under greenhouse and a set of proposals that consider applications in various fields of research, autonomous localized irrigation, neural networks, automatic learning, monitoring and control systems among others. It is intended to determine the most recent advances in techniques for sowing, applications of chemicals for sanitary control, fertilization, harvest, where robotics is used as a source to solve agricultural problems. The review includes consultation in well-known national and international journals, research carried out in centres and research groups or companies dedicated to implementation addressed to the agricultural sector, finally it is
  determined the solutions that can be implemented to propose new topics, research lines, development and technology transfer to the agricultural sector.

- **A Literature Study on Agriculture Production System Using IOT as Inclusive Technology** [8]

  Directing at the current development condition of the internet of things and based on the available technology analysis of the internet of things, analysis and research on the internet of things in terms of technological levels and systems are made. Started from three aspects, respectively, data collection, network service, date fusion and computation, analysing the technologies, based on which further the technological system framework of the internet of things are brought forth. Moreover, analysis and research work on the sensor nodes of the system, analysis and discussion on the various technologies involved are carried on. Based on the current IOT technology analysis, by analysing and discussing the technological levels and systems of IOT, it is going to start the research on the architecture and the frame work of IOT. Started from intelligent transportation, logistic scheduling and tracing and base station monitoring, IOT extends its application domain to public oriented personal medical treatment, intelligent home furnishing and so on, and its applications can be found in all walks of life.

2.1.4 Problems Identified

We analysed all the solutions available in the market and concluded that there is very less Indian based solution available. Since India has a unique climate and soil features which are different from the rest of the countries there is a dire need of AgTech based start-ups in India which focus primarily on the Indian Market and help in increasing the productivity of the farmers. Further there are very less systems available yet which automate the task of pest detection, ripeness detections, moisture control, humidity control and analyse the data to provide short term and long-term solutions to the farmers that increase the productivity of the farmland. The available systems are either for a specific purpose or are expensive hence a small-scale Indian farmer is not able to afford them. We are aiming to build a holistic solution which primarily targets the Indian Market.

2.1.5 Survey of Tools and Technologies Used

Following are the components that will be used in Integrated Knowledge & AI Technology in Farming in no particular sequence

Hardware Parts Used: -

- Nodemcu Esp8266
- Soil Moisture Sensor
- Temperature Sensor
- Humidity Sensor
- Mini Water Pump
- Raindrop Sensor
- PIR Sensor
- Arduino UNO
- Breadboard

Software Used: -

- Tensor Flow
- Anaconda
- Visual Studio Code
- Mongo DB Atlas
- Postman

- MS Word
- MS Power Point

2.2 Software Requirement Specification

The following sections describe the Software requirement specification for this project.

2.2.1 Introduction

2.2.1.1 Purpose

The website is going to be developed and all the sensors and actuators will be controlled by Nodemcu whose programming will be done in Arduino IDE. ML model will be developed for detecting the disease of the crops.

2.2.1.2 Intending Audience and Reading Suggestions

The intended use of this project revolves around the farmers for helping them to connect with a new technology which can be useful in a way that can produce a good yield of the crop and also reduce their time wastage and loss.

2.2.1.3 Project Scope

This project aims towards developing a website and blynk app-controlled Intelligent System, which will automate the water pump and will help provide a better user experience by providing users with all the data in real-time. On a brief account, the website will be used on the phone of the farmer, so that they would be able to irrigate their farms over to the internet and the website will also be used to monitor the data.

It would be easy to use and easy to carry. The disease can be detected using a pre-trained machine learning model. The project focuses on providing the farmers with something completely different that will save them the hard job of reaching every corner of the field to check for some abnormality.

2.2.2 Overall Description

2.2.2.1 Product Perspective

Agriculture employs more than 50% of the Indian workforce. In addition, it is the backbone of our GDP. The Intelligent Farming system aims to automate the process of irrigation and disease detection. With our project, we will bring the power of computing to the Indian Farmer. We would reduce the need of being physically present on the farm. We are making a smart irrigation system, which automatically irrigates the fields of farms by checking the moisturizer in the soil also our project will irrigate, the fields by checking the weather conditions. With this greenhouse environment shielding and temperature control system, etc. will all be automated. The farmer would be able to control these tasks through his smartphone from anywhere around the world. He would be able to see the statistics and warnings related to the farm on his smartphone. By this, our system can boost the productivity of the same piece of land, as all the resources will be micromanaged by the software system.

2.2.2.2 Product Features

The software will be able to perform the following operations:

1. Live Notification: Live feedback to the farmer to check the abnormality in the field (if present).

2. Manual Mode Operations: When logged in to the manual mode, the farmer will be allowed to change the state of any actuator without any consideration for the sensor

ata. For example, the farmer can turn on/off any of the motor, sprinkler, etc. manually without sensor data interruption.

3. Show Sensor Data: The data from the sensors will be displayed in this mode in real- time. Data will be collected from sensors including temp/humidity sensor, soil moisture sensor, rain sensor, etc. Initially, we plan to implement these functionalities for one crop under that as part of the Pilot Phase. Once the Pilot Phase is successful, we plan to spread this application across multiple crops.

2.2.3 External Interface Requirements

The External Interface Requirements are defined in the following sub-sections.

2.2.3.1 User Interfaces

An android device/ Pc would be used for this purpose to fetch the current values of sensors and actuators and it would display all of them and the statistics of all the crop data. A website solely made for this purpose is made.

2.2.3.2 Hardware Interfaces

Devices: Smart Phones or Tablets, Nodemcu

Sensors or Modules: Soil Moisture Sensor, Temp/Humidity Sensor, Rain Sensor, PIR sensor, Water Pump

2.2.3.3 Software Interfaces

Operating System: Android (Latest), Windows Tools: Android studio, Arduino IDE

Language: Python

Plugins & libraries: Primarily inbuilt android and Arduino plugins and Libraries

2.2.4 Other Non- functional Requirements

Following are some of the non-functional requirements of the project.

2.2.4.1 Performance Requirements

- The system is designed for smartphones/Pc and hence requires a smartphone running android or windows pc to access the system.
- Only textual information will be handled by the website. The amount of information to be handled can vary from user to user.
- For normal conditions, automatic mode will work fine. If the user wants to access manual mode, he can do that too.

2.2.4.2 Safety and Security Requirements

- The source code developed for this system shall be maintained in the configuration management tool.
- The whole system is secured. Only the registered farmers can access the data.
- Moisture sensor pens should be taken care of because they are very brittle.
- There will be no issue of loss or theft of user personal data as our device requires no such information.

2.3 Cost Analysis

List of all the components along with their cost that will be used in the project:

Table 2 : Cost Analysis

S. No.	Component	Price
1.	Nodemcu Esp8266	350/-
2.	Soil Moisture Sensor	180/-
3.	Temp-Humidity Sensor	260/-
4.	5V Relay One Channel	150/-
5.	Jumper Wires	240/-
6.	Mini Water Pump	250
7.	Raindrop Sensor	200/-
8.	PIR Sensor	100/-
9.	Breadboard	160/-
10.	Battery	60/-
	TOTAL	1950/-

Total cost for one unit is Rs 1950/-

2.4 Risk Analysis

Four Things to Consider Before Developing Your Smart Farming Solution:
As we can see, the use cases for IoT in agriculture are endless. There are many ways smart devices can help you increase your farm's performance and revenue. However, agriculture IoT web development is no easy task. There are certain challenges you need to be aware of if you are considering investing in smart farming.

1. Hardware
To build an IoT solution for agriculture, you need to choose the sensors for your device (or create a custom one). Your choice will depend on the types of information you want to collect and the purpose of your solution. In any case, the quality of your sensors is crucial to the success of your product- it will depend on the accuracy of the collected data and its reliability.

2. The Brain
Data analytics should be at the core of every smart agriculture solution. The collected data itself will be of little help if you cannot make sense of it. Thus, you need to have powerful data analytics capabilities and apply predictive algorithms and machine learning to obtain actionable insights based on the collected data.

3. Maintenance
Maintenance of your hardware is a challenge that is of primary importance for IT products in agriculture, as the sensors are typically used in the field and can be easily damaged. Thus, you need to make sure your hardware is durable and easy to maintain. Otherwise, you will need to replace your sensors more often than you would like.

3.1 Investigative Techniques

Table 3: Investigative Techniques

S.No	Technology used in project	Investigative Techniques	Investigative Description
1	Sensor based technology	Descriptive	Soil moisture, water & light management, humidity & temperature control
2	Software based technology	Comparative	Machine Learning Methods for appropriate medicine recomendor for plant disease
3	Deep Learning- based technology	Comparative	Plant Disease Recognition, Artificial Intelligence in Crop Yield Prediction
4	Data analysis related technology	Experimental	Decision making and prediction processes and managing all crop and weather information
5	Hardware based technology	Experimental	Capturing images of plants using camera with all sensors attached to carbot

3.2 Proposed Solution

We achieve these tasks for the project by implementing the hardware design of the embedded system we are using. This embedded system, to be installed at some elevation in the fields, would contain all the sensors including a soil moisture sensor, temperature and humidity sensor, PIR sensor and rain detector. These statistics would keep on getting updated on the online Blynk platform that could be accessed by the owner of the field on his Blynk application.

Also, this embedded system would be connected to the water pump which can be switched on from the blynk platform itself whenever the soil moisture is low. Mobile notifications

will come on the user's application which would be indicating low moisture levels, or whenever rain is there in the field, about watering your field indication or whenever some motion is detected in the field. We will use Nodemcu to make this whole control system in the field.

One can use the pictures of diseased crops/plants and use these pictures to check if there is an outbreak of the disease in any part of the field using a Machine Learning Model which is trained well using various algorithms for the best accuracy.

The website would be made that would have the master control over the whole control system. The user can also see the current readings with the blynk application so he can currently evaluate the conditions over his field and can alter anything he wants to on the field.

3.3 Work Breakdown Structure

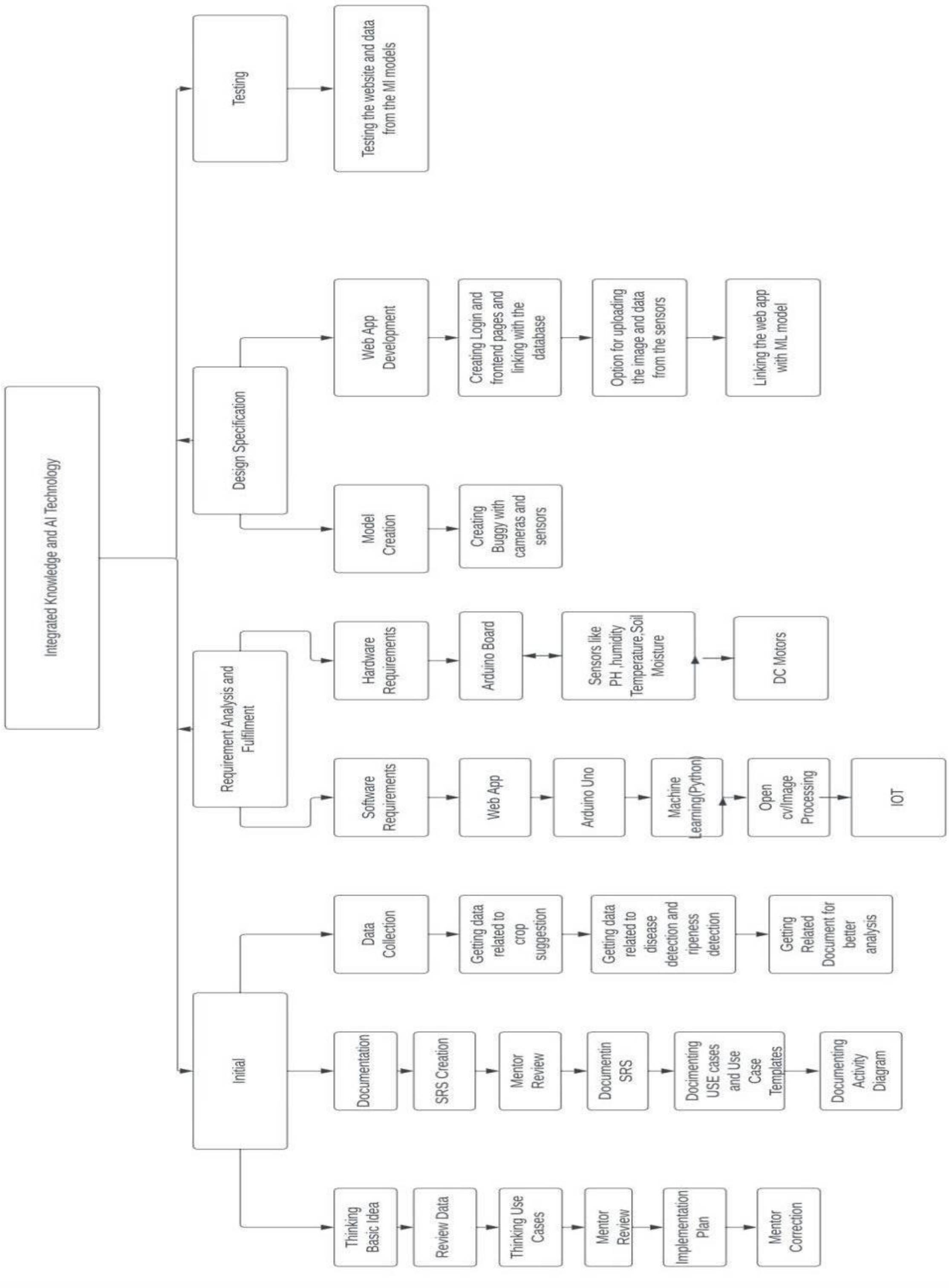


Figure 3.3.1 Work breakdown structure

3.4 Tools And Technology

- Hardware used- Nodemcu (ESP 8266), Soil moisture sensor, Temperature and humidity sensor, Rain Detector sensor, PIR sensor, Water pump
- Software used- Arduino IDE, Python
- Libraries used- Tensorflow
- Technologies used- Machine Learning and data pre-processing.

4.1 System Architecture

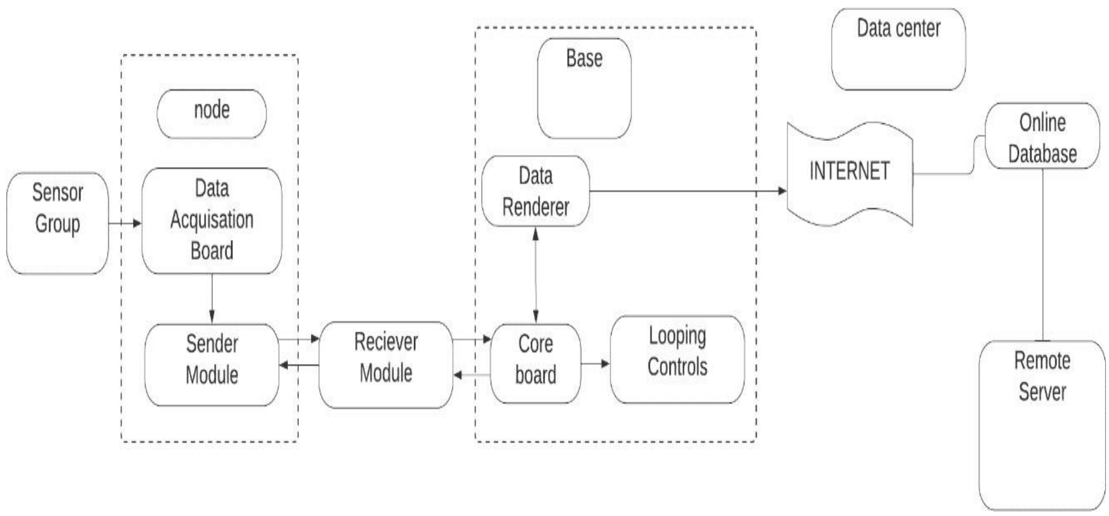


Figure 4.1.1 System Level Architecture

A system architecture, shown in Figure 4.1.1, is a conceptual model that describes the composition, operation, and other aspects of the system. This architecture is a formal description and representation of a system that is set up to facilitate analysis of its components and actions. It consists of developed subsystems and system components that will interact to construct the overall system.

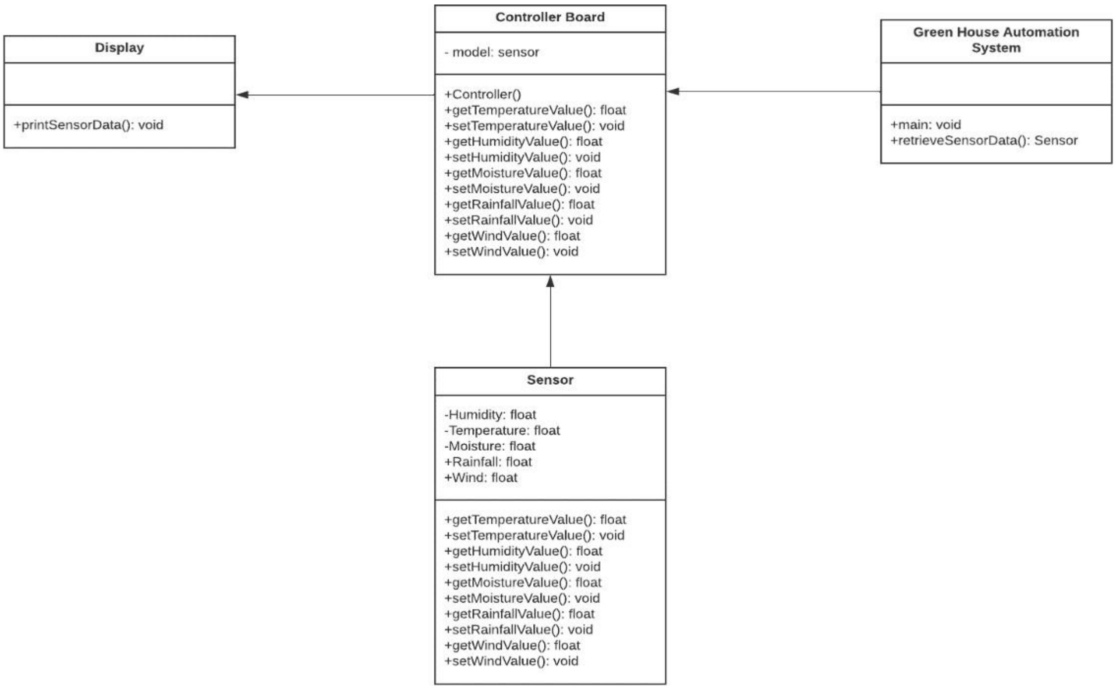


Figure 4.1.2 Software Level Architecture

A software architecture, as illustrated in Figure 4.1.2, outlines the components that make up a software system as well as the methodology used to develop them. Each structure is made up of software elements, their connections, and the attributes of both the elements and the connections.

4.2 Design Level Diagram

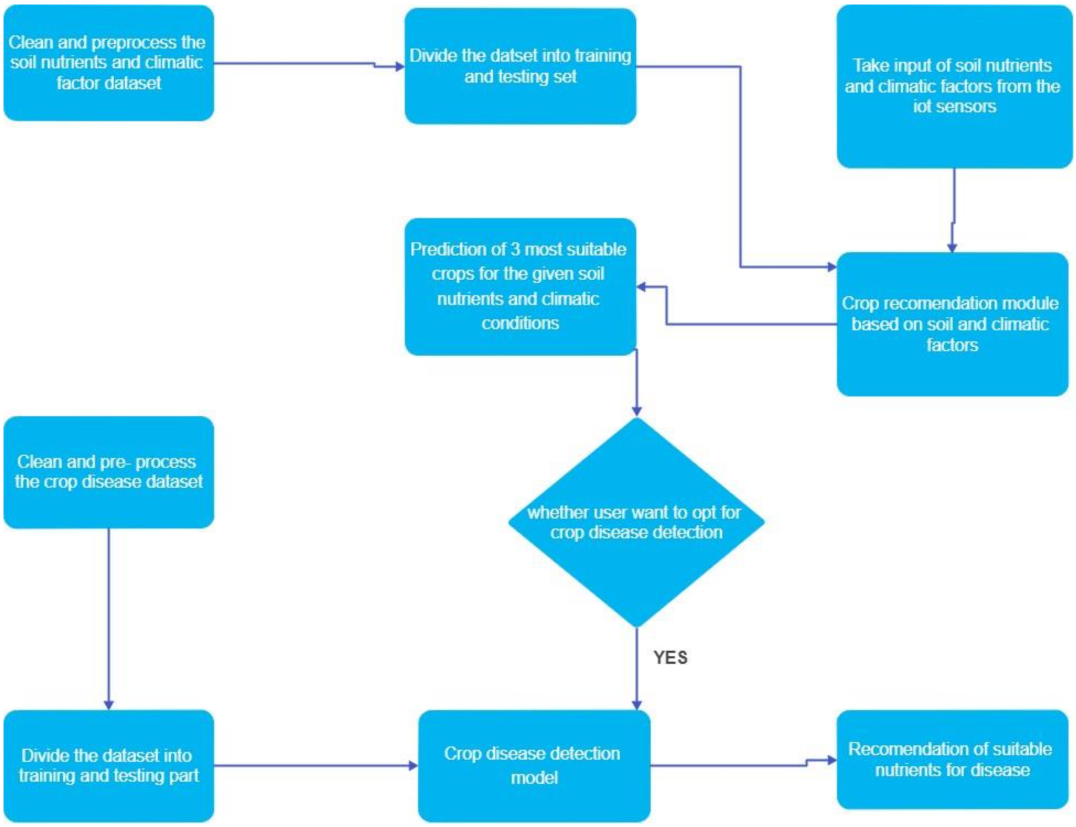


Figure 4.2.1 Dataflow diagram

Figure 4.2.1 shows Data Flow Diagram. It is a type of flowchart that illustrates how to design or debug relational databases in the fields of software engineering, business information systems, education and research.

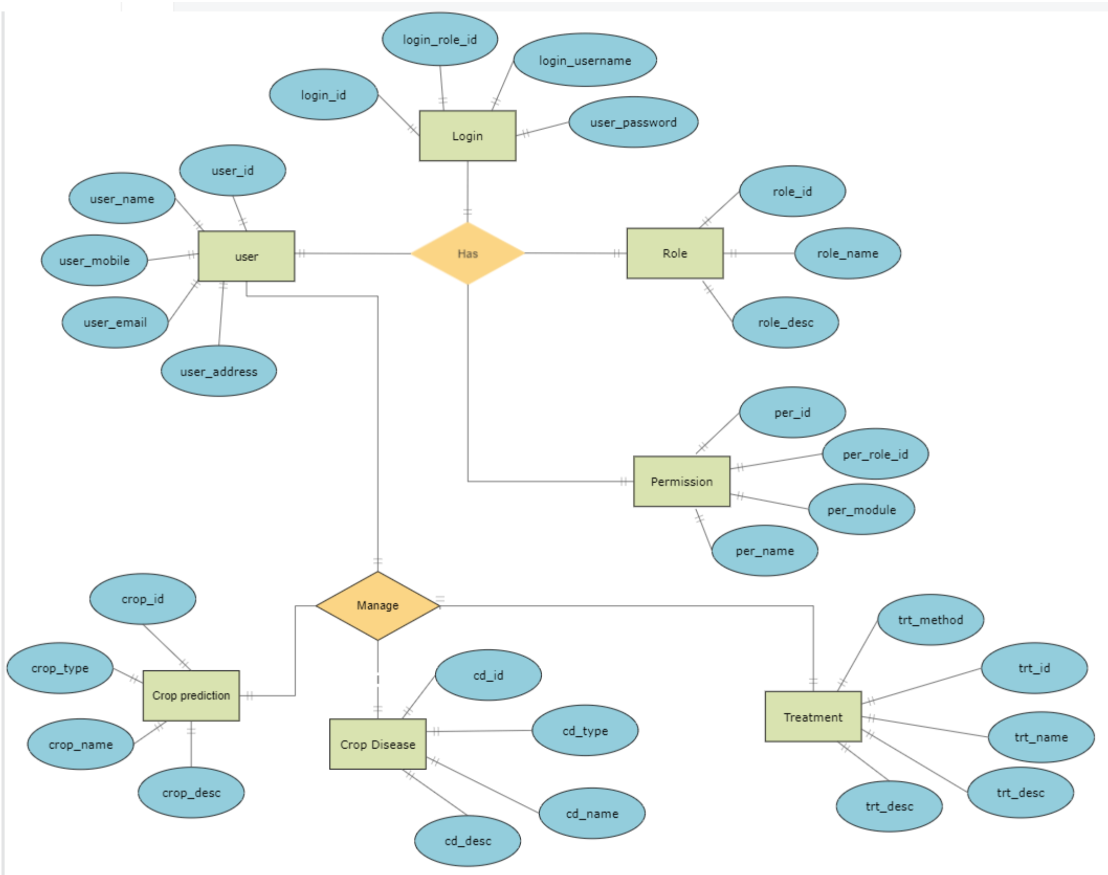


Figure 4.2.2 ER diagram

Figure 4.2.2 shows Entity Relationship (ER) Diagram. It is a type of flowchart that illustrates how "entities" such as people, objects or concepts relate to each other within a system. ER Diagrams are most often used to design or debug relational databases in the fields of software engineering, business information systems, education and research.

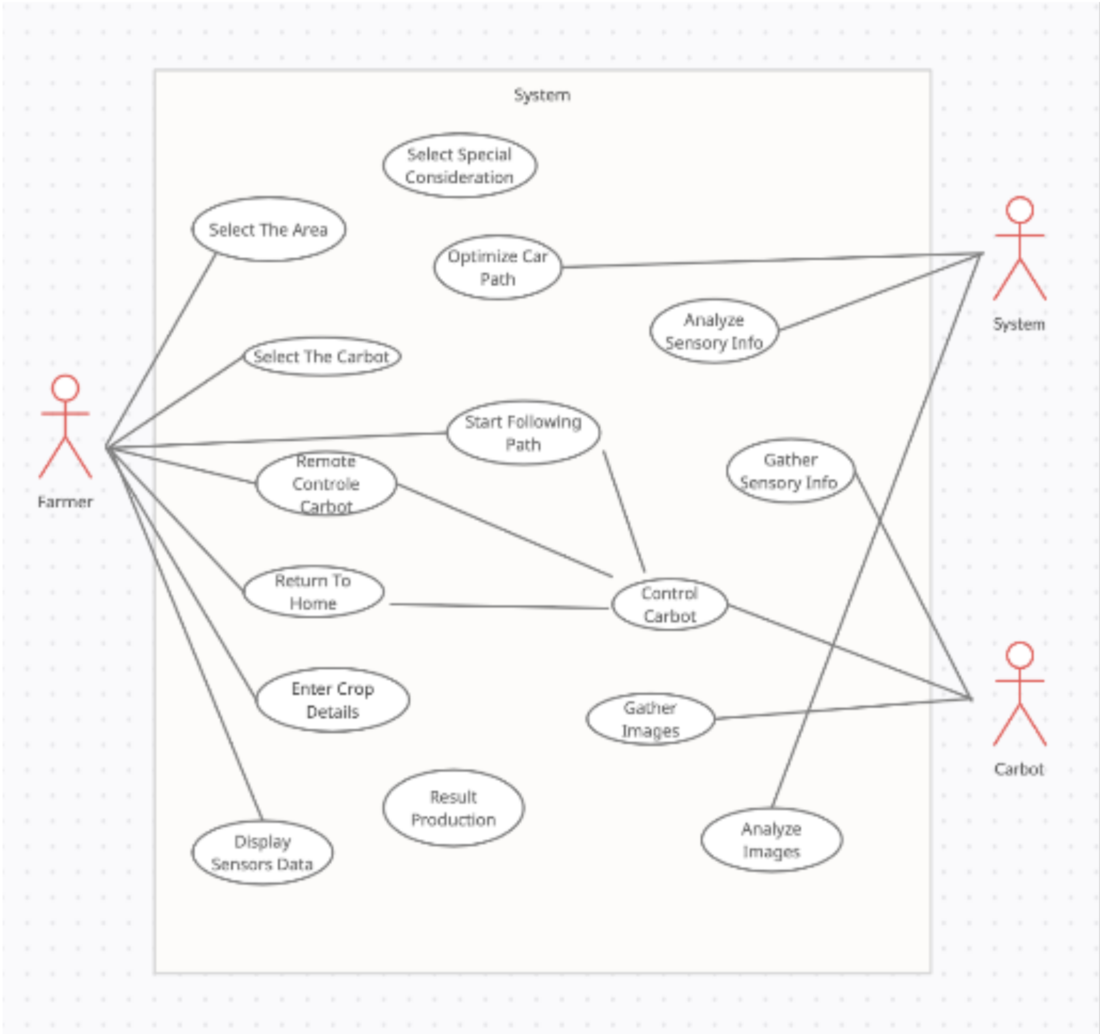


Figure 4.2.3 Use case diagram

Use-case diagram help to capture the requirements of the system by modelling the behaviour of the system. It gives the system's high-level operations and domain. The diagram show's how the user interact with the system. Use-case diagrams' use cases and user describe what the system does and how the user use it, but they do not explain how the system functions internally. The context and requirements of either the entire system and the key components of the system are illustrated and defined by use-case diagram.

4.3 User Interface Diagram

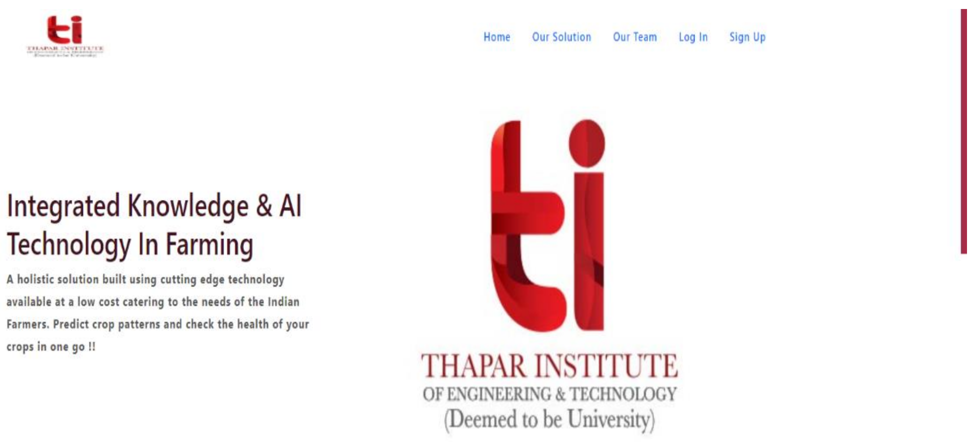


Figure 4.3.1 Webpage describing the problem statement and solution of the project

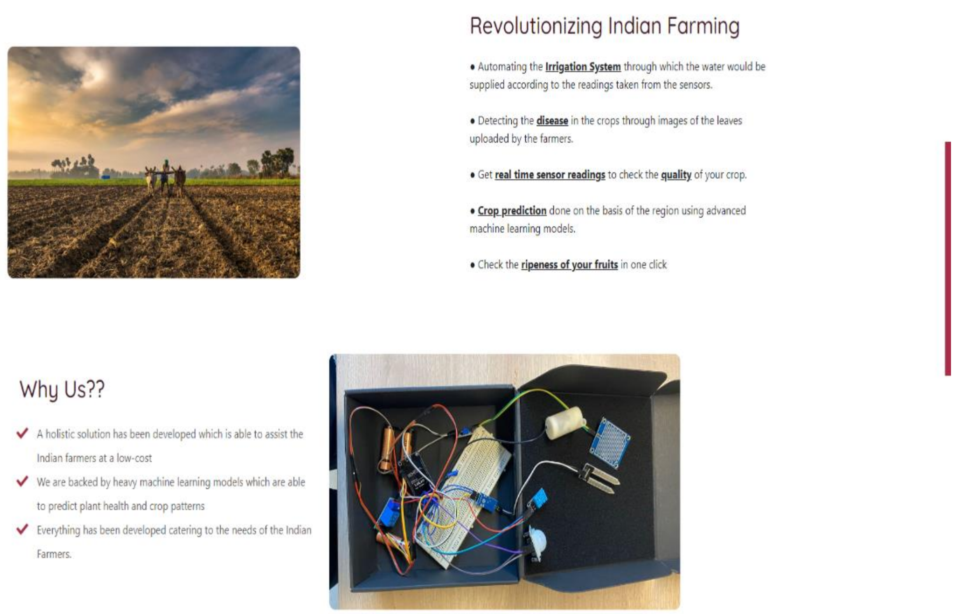


Figure 4.3.2 Webpage describing our project

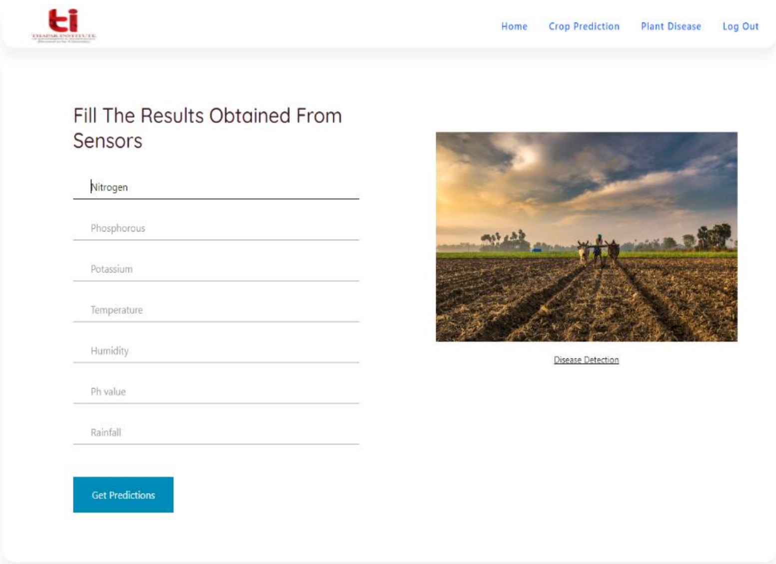


Figure 4.3.3 Webpage to enter the sensor data

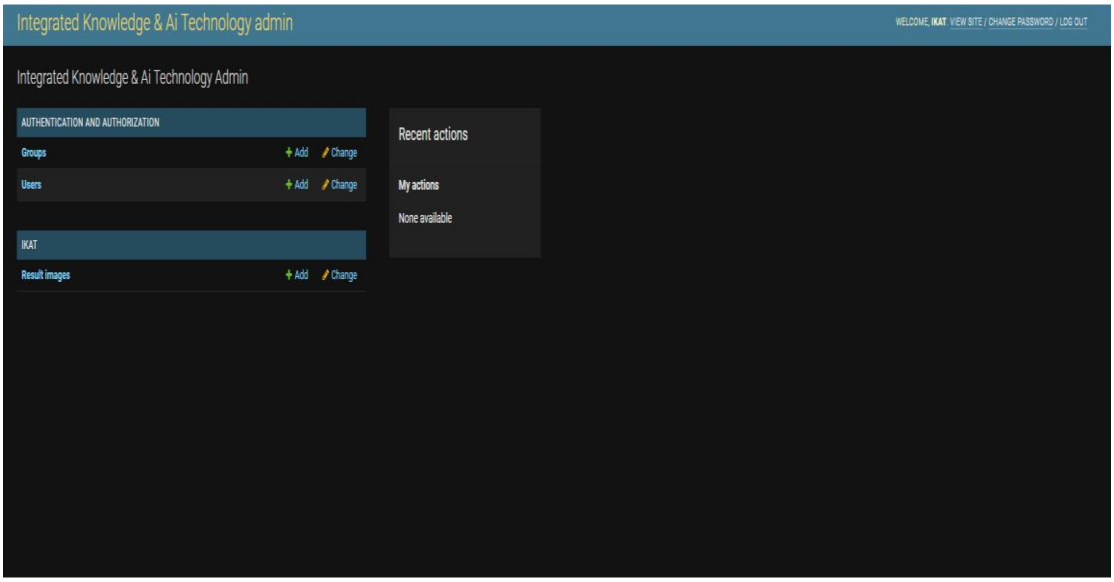


Figure 4.3.4 Database of the website

4.4 Snapshots of Working Prototype

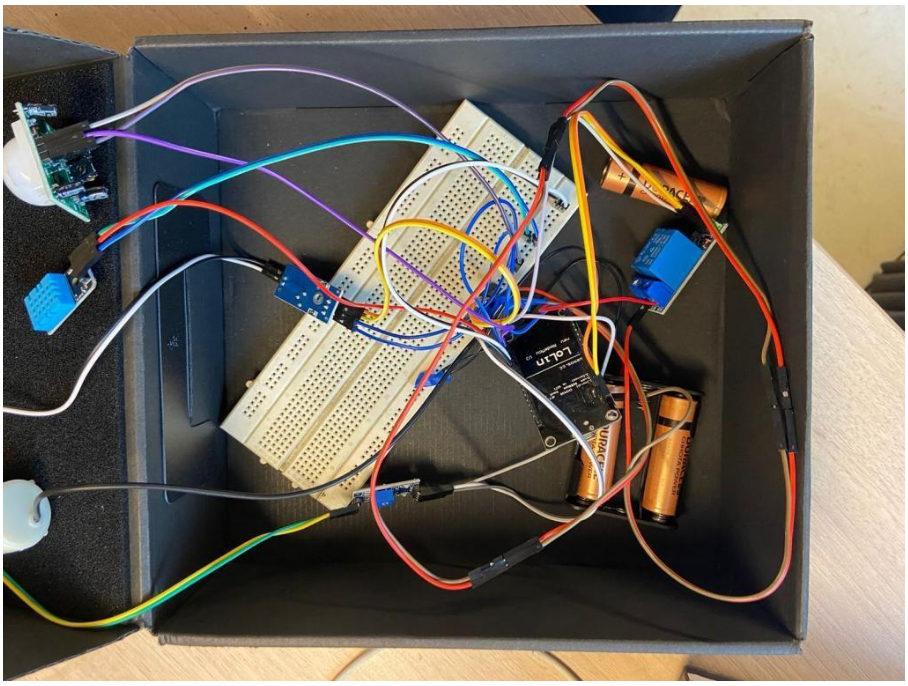


Figure 4.4.1 Hardware Circuit connection using breadboard

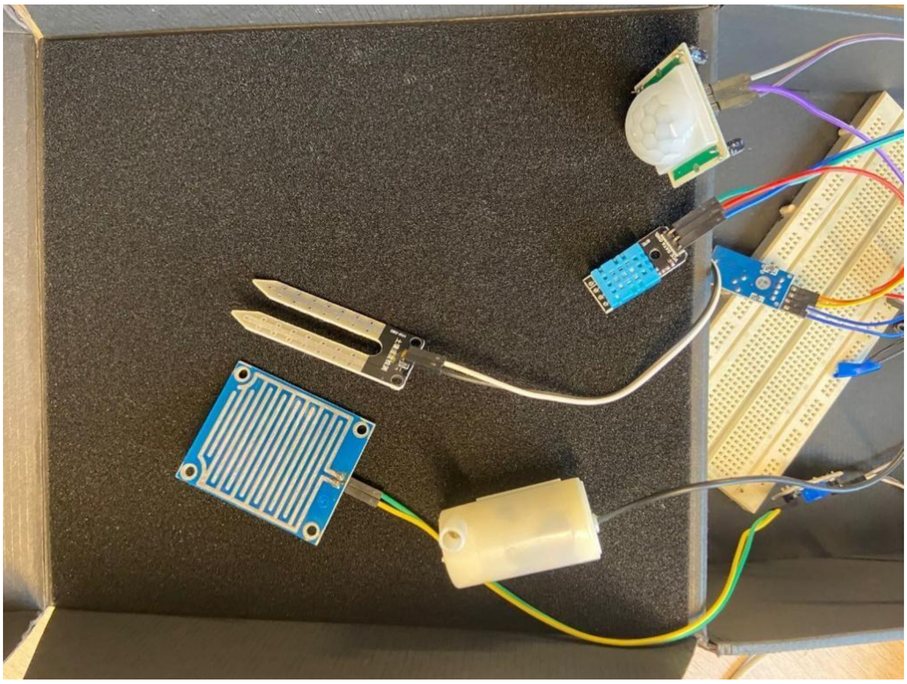


Figure 4.4.2 Microprocessor connected to the sensors

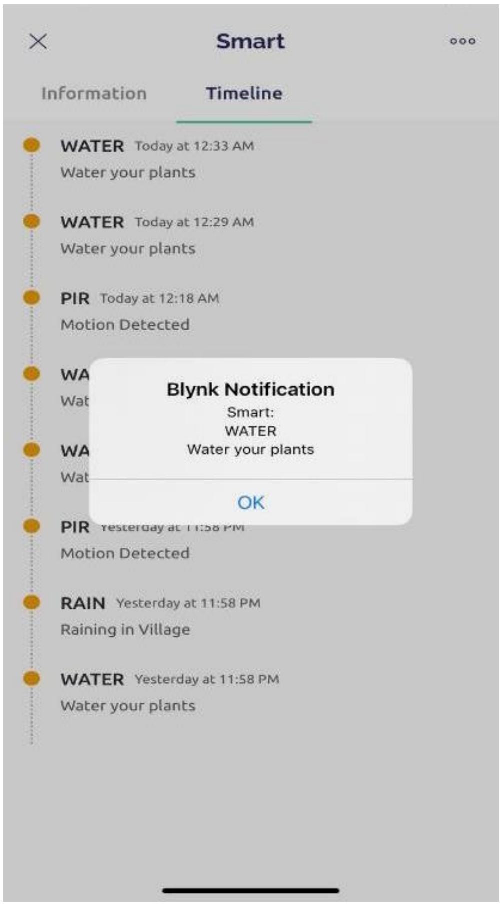


Figure 4.4.3 Activity showing crop requirement

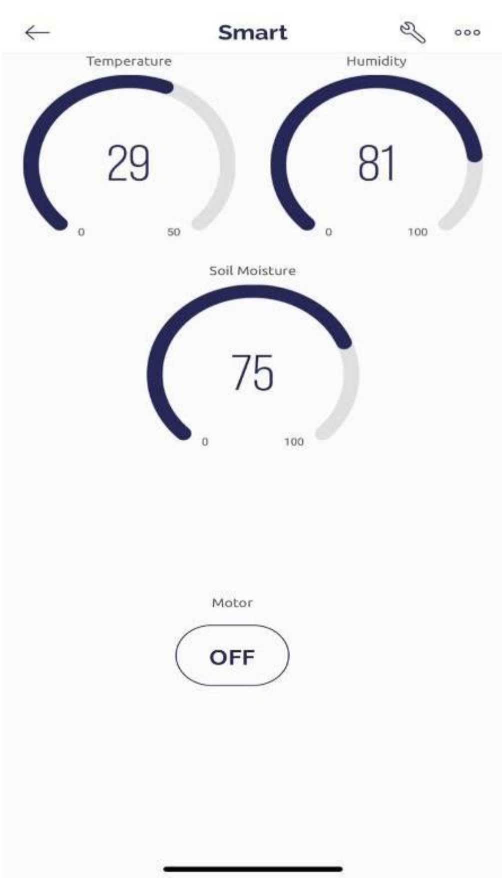


Figure 4.4.4 Activity showing sensor reading

IMPLEMENTATION AND EXPERIMENTAL RESULTS

5.1 Experimental Setup

We are using the website as the face of this project. We are giving website access to the farmer. First of all, he would log in or sign up if existing on this website. The site would check this information by cross-validating it with the Firebase account holder's credentials. If not found, the error will be shown. Then the suitable data for the crop is inputted, which is stored in Firebase. After this, the crop prediction process would initiate. This data would be taken from the hardware model, i.e from nodeMCU. Then, if unsuitable, the values would be changed with the help of the actuators. These results would be incepted with the help of experimental results and inferences we are doing by the time we initiate the procedure.

The next part of the implementation is all in nodeMCU. The circuitry that is adjoined helps connect the internet to the NodeMCU. We just experiment with the actuators for the sensors and the data that is to be automated. All this data would be available on the Blynk platform. So this would help verify the experiments fully.

5.2 Experimental Analysis

5.2.1 Data

The image dataset for the plant disease detection model was collected from Kaggle (called Plant Village). For disease detection we took coloured images of the plant leaves. Since the dataset is relatively huge, 500 images are acquired for each class in order to train the model. Before sending the image to the model, the image's size was decreased during pre-processing, and many variations of the images were also created. Using functions included into the model, a graph of the model summary was created. The dataset for the crop recommendation system was taken from Kaggle. Pre-processing was applied due some present data inconsistencies in the dataset. Further the model was trained using the Random Forest Classifier.

5.2.2 Performance Parameters

Throughout the experimental phase, the performance is examined by focusing on a few particular criteria. The main factors are the length of time needed to record and process sensor values, the interval between the identification of sensor data and the delivery of results, the correctness and consistency of the results. By compiling and analysing the data gathered, we also enhanced the algorithm and employed several approaches. Particularly, we used parameter optimization and hyperparameter tunings to improve the algorithm's accuracy. The gathering of sensor data is the project's soul, hence algorithm correctness and consistency are crucial. In order to enhance both hardware and software, other additional characteristics, such as power consumption and connection speed, were also taken into account during experimentation.

5.3.1 Procedural Workflow

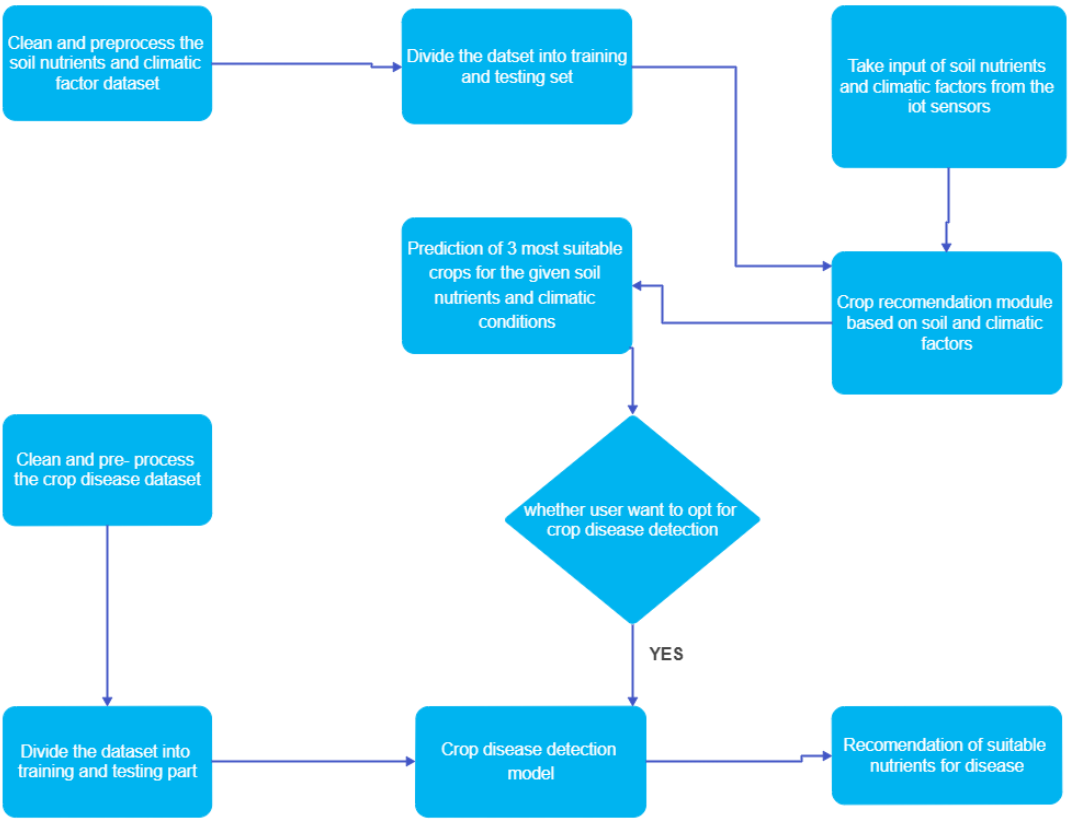


Figure 5.3.1.1 Procedural Workflow

We have successfully built a hardware model which is able to collect readings from the soil used in farms. The analysis from these reading is used to suggest the correct crops and agricultural practices for the farm which can increase the productivity of the farmland. All this work is carried out using machine learning models and this can assist the farmers in short as well as long term. Further we have also successfully trained a machine learning model which can detect various plant diseases based upon the images uploaded by the farmer in our webapp. Our team's IKAT prototype is a very limited version of what could be created in a production facility using more advanced technology.

5.3.2 Algorithmic Approaches Used

In order train the plant disease detection system various algorithms were applied such as Convolutional Neural Network (CNN), Extreme gradient boosting and K-Nearest Neighbor (KNN). Following are the pseudocodes of the algorithms:

```
def call_existing_code(layer_dropoutRate, layer_filter, layer_neurons):
    model = Sequential()
    model.add(Conv2D(layer_filter[0], (3, 3), activation = 'relu', padding = "same", input_shape = (64, 64, 3)))
    model.add(MaxPooling2D(pool_size = (3, 3)))
    model.add(Dropout(layer_dropoutRate[0]))
    model.add(Conv2D(layer_filter[1], (3, 3), activation = 'relu', padding = "same"))
    model.add(Conv2D(layer_filter[1], (3, 3), activation = 'relu', padding = "same"))
    model.add(MaxPooling2D(pool_size = (2, 2)))
    model.add(Dropout(layer_dropoutRate[1]))
    model.add(Conv2D(layer_filter[2], (3, 3), activation = 'relu', padding = "same"))
    model.add(Conv2D(layer_filter[2], (3, 3), activation = 'relu', padding = "same"))
    model.add(MaxPooling2D(pool_size = (2, 2)))
    model.add(Dropout(layer_dropoutRate[2]))
    model.add(Flatten())
    model.add(Dense(layer_neurons, activation = 'relu', ))
    model.add(Dropout(layer_dropoutRate[3]))
    model.add(Dense(15, activation = 'softmax'))
    model.compile(optimizer = 'adam', loss = 'categorical_crossentropy',
                  metrics = ['accuracy'])
    return model
```

In the code of convolutional neural network we have applied hyperparameter tunning, in which we have test the algorithm by varying the layer dropout rate and number of neurons, in order to achieve the best results. Also we applied data augmentation i.e before the images are passed to the neural network various transformations are applied to the images. And the above model is trained on the GPU.

```
import xgboost as xgb
```

```
x_train = x_train.reshape(x_train.shape[0], -1)
classifier = xgb.XGBClassifier(tree_method = 'gpu_hist',
                               predictor = 'gpu_predictor')
model = classifier.fit(x_train, y_train)
```

```
from tensorflow.keras.applications.vgg16 import VGG16
```

```
vgg_model = VGG16(input_shape = (64, 64, 3), weights = 'imagenet', include_top = False)
for layers in vgg_model.layers:
    layers.trainable = False
```

```
x_train = vgg_model.predict(x_train)
x_train = x_train.reshape(x_train.shape[0], -1)
```

```
classifier = xgb.XGBClassifier(tree_method = 'gpu_hist',
                               predictor = 'gpu_predictor')
model = classifier.fit(x_train, y_train)
```

In the above code we have applied extreme gradient boosting (xgboost), trained on the GPU's for faster results. Further we also applied VGG16 for feature extraction and then using its output, trained the xgboost model.

```
from cuml.neighbors import KNeighborsClassifier
cuda_knn_model = KNeighborsClassifier(n_neighbors = 100)
cuda_knn_model.fit(x_train, y_train)
y_prediction = cuda_knn_model.predict(x_test)
```

In an attempt to achieve better results we have also trained KNN (K-Nearest Neighbour) using RAPIDS library. Training of this model has been done on the GPU.

5.3.3 Project Deployment

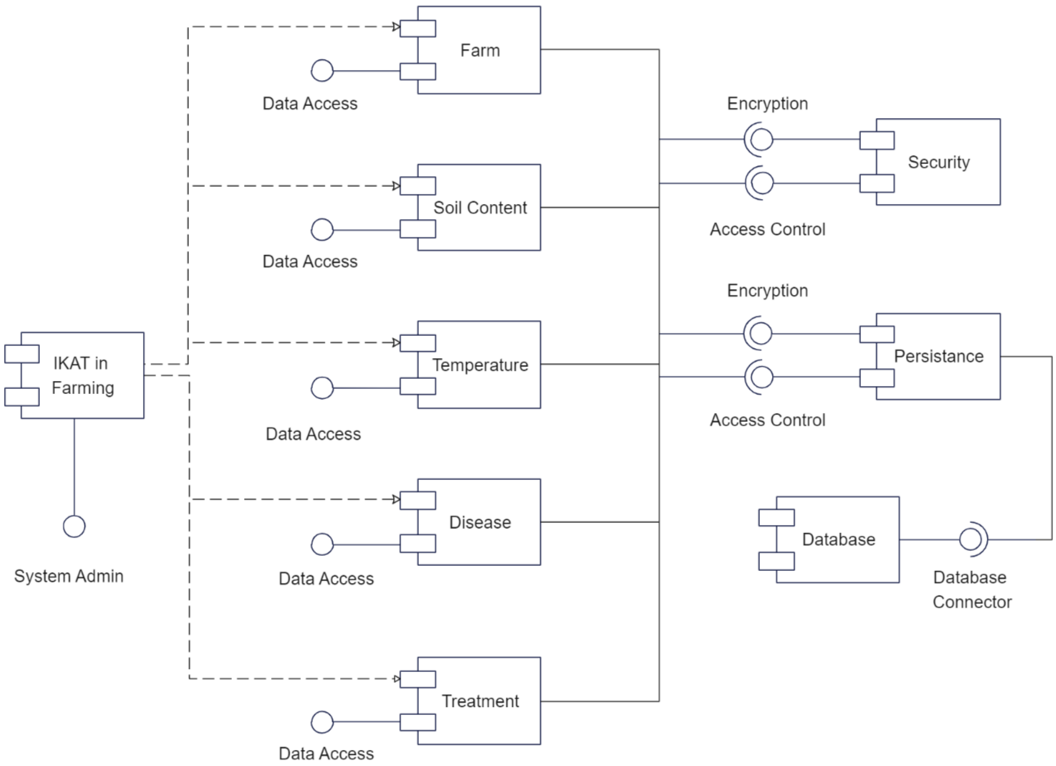


Figure 5.3.3.1 Component Diagram of IKAT in Farming

5.4 Testing Process -

5.4.1 Test Plan

The test plan includes procedures for the website and the hardware model i.e., how to test each module and what are the test cases for all the modules.

5.4.2 Features to be tested

Different features that needs to be tested are:-

- Testing all the sensors and nodeMCU
- Testing the working of the web app
- Testing the crop prediction model and gathering of data by the hardware
- Testing the disease detection model and image upload features on the webapp

5.4.3 Test Strategy

To achieve high efficiency and accuracy from the web app, the hardware and the machine learning models, the best strategy available was unit testing. It was preferred because it increases confidence in changing and maintaining code. Moreover, a bug obtained at the time of unit testing can be easily corrected in comparison to the bugs obtained at higher levels. White Box Testing Method made the code efficient, reusable and reliable. The machine learning model and the webapp was tested again and again to find bugs and to increase the accuracy. Further the hardware model and various sensors were tested manually.

5.4.4 Test Techniques

For the testing purpose we tried various machine learning and artificial intelligence algorithms like KNN, CNN, linear regression, random forest etc to find the best accuracy for our machine learning models. We tested our website for various corner cases through various devices like mobile, computer and laptop. Our hardware sensors were tested manually for efficiency and defectiveness.

5.4.5 Test Cases and Results

Table 4: Test Case T01

<table>
<tr><td colspan="4">Project Name: IKAT Farming</td></tr>
<tr><td colspan="2">Test Case ID: T01</td><td colspan="2">Test By: Amritpal Singh</td></tr>
<tr><td colspan="2">Test Priority (Low/ Medium/ High): High</td><td colspan="2">Test Designed Date: 30 Aug 2022</td></tr>
<tr><td colspan="2">Test Title: Crop Prediction</td><td colspan="2">Test Execution Date: 30 Aug 2022</td></tr>
<tr><td>Step No.</td><td>Test Steps</td><td>Expected Result</td><td>Status (Pass/ Fail)</td></tr>
<tr><td>1</td><td>Click on the Crop Prediction from top of menu bar next to Home</td><td rowspan="2">The best suitable crop name will be shown as result</td><td rowspan="2">Pass</td></tr>
<tr><td>2</td><td>Fill the results obtained from sensors and click on Get Predictions</td></tr>
</table>

Table 5: Test Case T02

Project Name: IKAT Farming			
Test Case ID: T02		Test By: Karan Singh Pathania	
Test Priority (Low/ Medium/ High): High		Test Designed Date: 15 Sept 2022	
Test Title: responsiveness of website		Test Execution Date: 15 Sept 2022	
Step No.	**Test Steps**	**Expected Result**	**Status (Pass/ Fail)**
1	Open the webapp on laptops of various dimensions	The website came out to be completely oriented on all devices Pass	Pass
2	Using various devices like PC or mobiles to open the webapp		

Table 6: Test Case T03

Project Name: IKAT Farming			
Test Case ID: T03		Test By: Tarunvir Singh	
Test Priority (Low/ Medium/ High): High		Test Designed Date: 20 Sept 2022	
Test Title: Plant Disease Detection.		Test Execution Date: 20 Sept 2022	
Step No.	**Test Steps**	**Expected Result**	**Status (Pass/ Fail)**
1	Click on the upload image button on the website.	The name of the disease should be shown or else healthy	Pass
2	Choose the leaf image for detection		

Table 7: Test Case T04

<table>
<tr><td colspan="4">Project Name: IKAT Farming</td></tr>
<tr><td colspan="2">Test Case ID: T04</td><td colspan="2">Test By: Inderpal Singh</td></tr>
<tr><td colspan="2">Test Priority (Low/ Medium/ High): High</td><td colspan="2">Test Designed Date: 15 Sept 2022</td></tr>
<tr><td colspan="2">Test Title: Check the live readings.</td><td colspan="2">Test Execution Date: 15 Sept 2022</td></tr>
<tr><th>Step No.</th><th>Test Steps</th><th>Expected Result</th><th>Status (Pass/ Fail)</th></tr>
<tr><td>1</td><td>Click on the current readings on the home screen.</td><td rowspan="2">The current readings should update as we click the refresh button.
Pass</td><td rowspan="2">Pass</td></tr>
<tr><td>2</td><td>Changing the actuators value</td></tr>
</table>

5.4.6 Test Results

The number of test cases created were 4. The test cases executed were 4. The number of test cases passed, failed and pending are 4, 0, 0 respectively. Cause Effect testing was used to test the code as it increases confidence in changing and maintaining the code.

5.5 Results and Discussions

Our system has been designed to detect the values of actuators and use machine learning models to predict crop and plant diseases. By our experiments we find that we able to achieve all the demands precisely and accurately. All of the major objectives have been completely achieved.

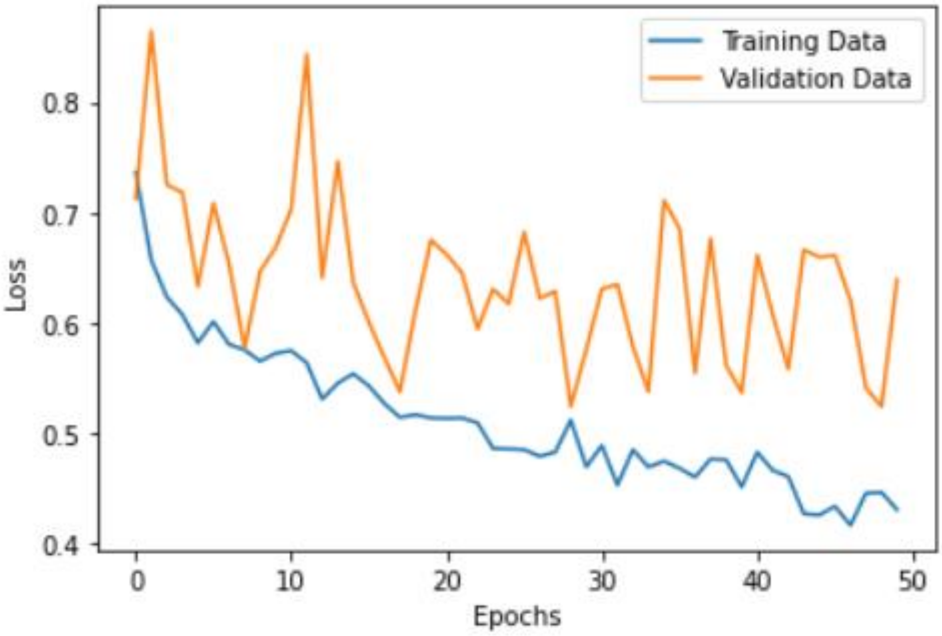


Figure 5.5.1 Graph showing variation of Loss with epochs for training and validation data

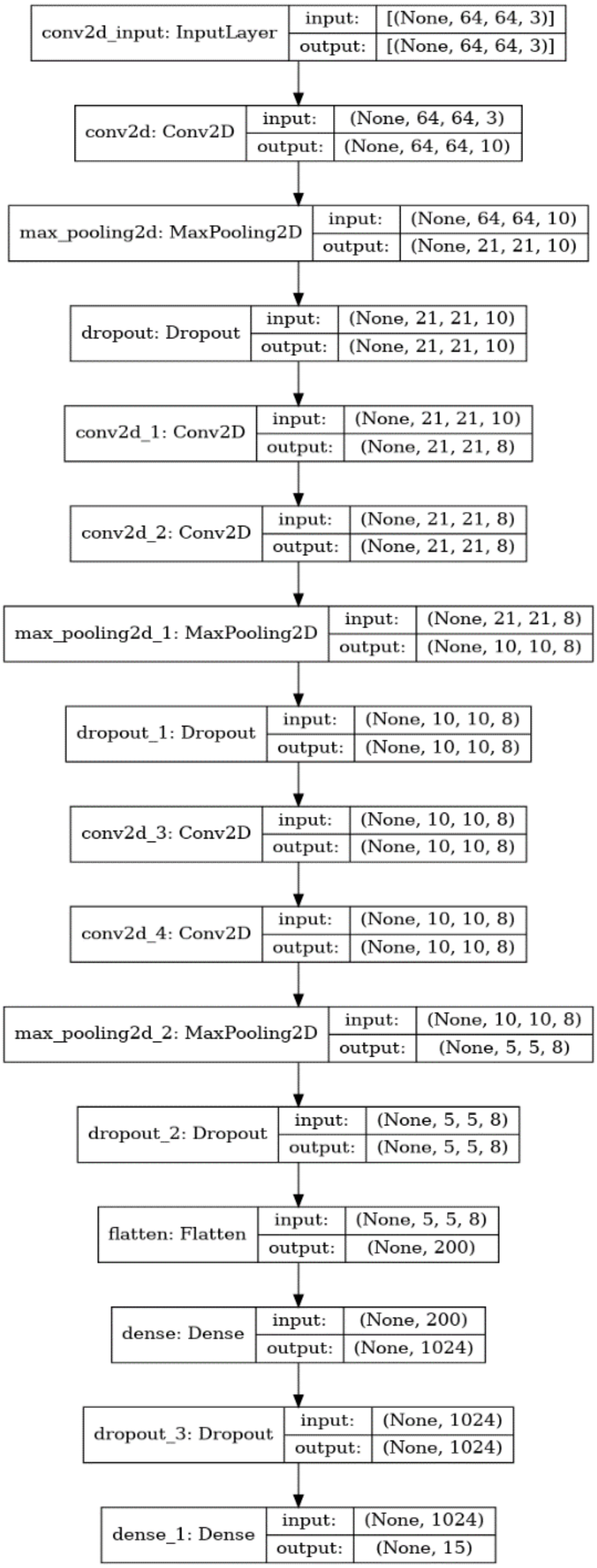


Figure 5.5.2 Architecture of Convolutional Neural Network model

Using VGG-16 and AlexNet, studies on plant disease identification demonstrated high accuracies of 97.29% and 97.49%, respectively. Additionally, in other research, a CNN with a transfer learning technique was used to identify leaf disease sets. Automatic feature extraction was carried out by directly processing the raw images. With transfer learning, this CNN approach had a high accuracy of 99.18%. In our work we have applied algorithms like CNN, Xgboost and KNN, among all of them using xgboost we achieved an accuracy of 93.12%, which was trained on GPU's for faster processing and giving a scope to increase image dataset for better results.

5.6 Inferences Drawn

The following are inferences drawn:

1. Computer technology is still not used in agricultural purposes. It is in its early stages. These technologies can be used to properly exploit this field.
2. Arduino can be used in various Internet of Things Systems, in majorly in any field if system requirements match properly.
3. Low power computing boards like Raspberry Pi can be used to solve a lot of complex daily life problems with help from powerful servers.
4. Web apps have brought internet to doorstep which can be exploited to provide simple solutions to complex daily life problems.

5.7 Validation of Objectives

The main objective was to develop a holistic solution catering the needs of the Indian based Farmers. We are successfully able to get data from our sensors apply machine learning models and recommend crop to farmers. Further we are able to detect plant diseases based on the images uploaded by the farmers on our webapp.

Table 8: Validation of Objectives

S. No	Objectives	Status
1	Building the web app and deploying the machine learning models on it.	Successful
2	Crop Recommendation based on the values obtained from the sensors.	Successful
3	Detecting plant diseases from the images uploaded on the webapp	Successful
4	Hardware Model collecting all the sensor values correctly.	Successful

6.1 Conclusion

Integrated Knowledge & AI Technology in farming is a holistic solution for the problems faced by the farmers of developing nations like India. It is a cost-effective way of smart farming which can assist the farmer and can increase the productivity of the farmland. We as a team our trying to build a hardware and a software service to assist the farmers. Farmers can use our hardware model to analyse the various parameters regarding their crops like temperature, moisture, humidity, Ph values etc. Now this information once passed from our machine learning model can suggest the right crop and farming techniques for the farmers to increase the productivity of their land. Further we are trying to implement a system where farmer can upload the images of their crop and unwanted crops or crop diseases can be detected. Also, it is often observed that most of the fruits or vegetables that come in the market are unripe. Due to this farmer get paid lees for the hard work that they have put during the whole season. We are also trying to develop a system where we can detect whether the crop has ripped or not. This project can undergo further research to improve the functionality of device and its applicable areas.

6.2 Environmental / Social / Economic Benefits

Environmental: The second, larger-scale benefit of targeting inputs-in spatial, temporal and quantitative terms-concerns environmental impacts. The most important environmental factors on a particular location are sun, air, soil and water. Of the four, water and soil quality and quantity are the most controllable by humans through time and labour. Though sunlight & air are available in abundance, crops and plants also depend on soil nutrients and the availability of freshwater. When farmers are involved in various stages of farming, sometimes, unknowingly they remove some of these nutrients from the soil. In future, Internet based farming can significantly reduce the amount of nutrient and other crop inputs used for boosting the yields, as natural inputs would be sufficient. Smart farming focuses on replenishing the soil quality while minimizing the use of unnecessary synthetic resources. Our system will help in saving water and not degrading the quality of soil due to over irrigation.

Economic: The adoption of our technology will result in several benefits for the farmer with regard to the economic outcome of his enterprise. A more efficient use of our product will lead to lower costs and a better quality and production rate. Farmers would be able to get insights about the crop and their land and would be able to increase the productivity. Better planning tools might reduce machine operations. Hence, costs for energy and water can be saved by smart metering.

Social: With technology being so easily available, more and more people could benefit from it as a whole to improve their day to day lives. This would lead to betterment of their life comfort, personal space etc leading to overall better life style. A solution provided like this helps farmers gain their confidence back. Thus, it would have positive social effects in the forthcoming years.

6.3 Reflections

The question we posed for our project was whether a holistic solution can be developed which is able to assist the Indian farmers at a low-cost. We have successfully built a hardware model which is able to collect readings from the soil used in farms. The analysis from these reading is used to suggest the correct crops and agricultural practices for the farm which can increase the productivity of the farmland. All this work is carried out using machine learning models and this can assist the farmers in short as well as long term. Further we have also successfully trained a machine learning model which can detect various plant diseases based upon the images uploaded by the farmer in our webapp. The User Interface of our web app has also been successfully built.

6.4 Future Work Plan

Our primary focus is to train our and implement our machine learning models and to further increase the accuracy of the models which we have implemented.

Our next task is to successfully integrate all these models on our application so that it can be made available for the farmers.

Currently the farmer has to manually upload the images and sensory values on our web app to get the result, but we would like to build a robot – car which could collect all these information's and click images of the farmland and provide the insights about the farm using Internet of Things.

7.1 Challenges Faced

In hardware model various sensors were used to monitor the condition of soil and crops, these sensors sometimes disfunction while taking the measurements. Also we faced difficulties while integrating the hardware model with blynk platform, which was used to show the readings taken through the sensors. While building the crop recommendation system, it was difficult to find the data to train the model as very limited data is available on the internet. The preprocessing was done due to some data inconsistencies present in the dataset used for training the model. Further during the development of plant disease detection model we applied various algorithms in order to find the algorithm giving best results. And in that process we faced the challenge to optimize the parameters in order to achieve the best possible accuracy. Since the training was done on the GPU's, we faced the shortage of GPU memory.

7.2 Relevant Subjects

The Table shows the subjects relevant to the development of the project

Table 9: Subject Code and Subject Name

Subject code	Subject name	Description
UML501	Machine Learning	Used python programming language for ML
UCS663	Conversational AI: Data Science	Used the various ML based models.
UCS503	Software Engineering	Used the software testing techniques.
UCS301	Data Structures	Used the data structures and algorithms in programs
UTA014	Engineering Design Project 2	Used Arduino based coding in NodeMCU

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. Being students of Computer Engineering and Software Engineering and having basic knowledge of Arduino related hardware, the intention was to bring it all together through sharing to develop something meaningful. Sharing knowledge between computational image processing and machine learning made image detection a lot better. The joint strides in website development helped bring life to the project and helped solve the problem of the performance bottleneck. It is a known fact that when knowledge from different domains comes together, it leads to development through multi-disciplinary points of view.

7.4 Peer Assessment Matrix

Peer assessment matrix refers to any of a variety of approaches where we students are required to assess other members of a group on their relative contribution to a project. Our evaluations are in table 10.

Table 10: Peer Assessment Matrix

		Evaluation of			
		Karan Singh Pathania	**Tarunvir Singh**	**Amritpal Singh**	**Inderpal Singh**
Evaluation by:	**Karan Singh Pathania**	5	4	4	5
	Tarunvir Singh	4	5	5	4
	Amritpal Singh	5	4	5	4
	Inderpal Singh	4	5	4	5

7.5 Role Playing and Work Schedule

The following are the role of different team members in the development of the project:

Table 11: Role Playing

Team Member	Role played
Karan Singh Pathania	• Created the Frontend and Backend of website • Connected Database to website • Deployment of ML models
Tarunvir Singh	• Software Requirement Analysis • Implementation of Disease Detection Model • Dataset Collection
Amritpal Singh	• Software Requirement Analysis • Implementation of Crop Recommendation Model • Dataset Collection
Inderpal Singh	• Worked on Arduino IDE • Node MCU Connection with sensors • Linked actuators data on blynk platform

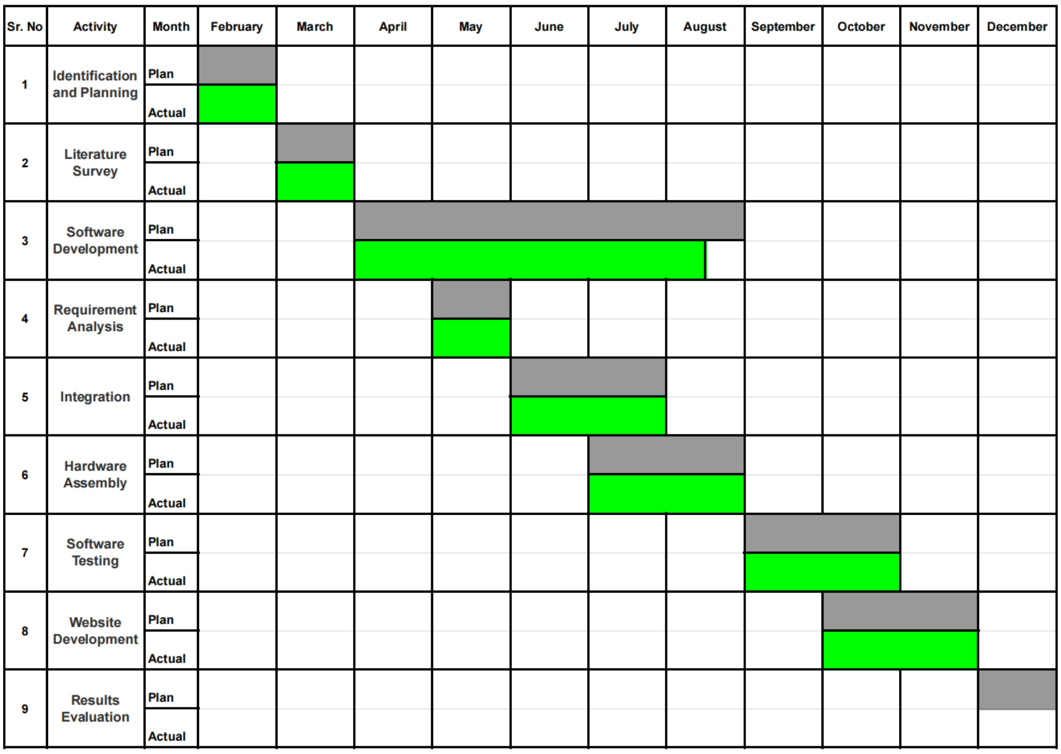
The following are the work schedule with respect to members:

Table 12: Work schedule

	Karan Singh Pathania	Tarunvir Singh	Amritpal Singh	Inderpal Singh
Literature Survey	*	*	*	*
Implementation of IOT sensors				*
Database Connectivity	*			
Website Development	*			
Hardware Requirement Analysis				*
Software Requirement Analysis		*	*	

Crop Recommendation Model			*	
Disease Detection Model		*		
Documentation	*	*	*	*
UML Diagrams	*	*	*	*

The following is the Gantt chart of work schedule:



7.6 Student Outcomes Description and Performance Indicators (A-K Mapping)

Table 13: SO1-SO7 Mapping of the course 'UCS794- Capstone Project'

SO	Student Outcomes Description	Outcomes
A1	Applying mathematical concepts to obtain analytical and numerical solutions.	Used basic principles of physics and mathematics in calculating data points of the model.

A2	Applying engineering techniques for solving computing problems.	Pretrained models were used and a website was developed which uses some engineering techniques to solve the problem of optimal performance on limited hardware.
B1	Identify the constraints, assumptions and models for the problem.	The product is intended to work in proper environmental conditions. Some constraints were internet dependency, and disease detection.
B2	Analyse and interpret results with respect to assumptions, constraints, and theory.	A suitable model was selected according to the constraints required and the results are recommended correctly for a quite high accuracy.
C1	Design software system to address desired needs in different problem domains.	A website was developed which uses default web app libraries.
C2	Can understand scope and constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, sustainability.	We knew exactly what restrictions would have to be satisfied in order for this project to be finished successfully. The project is intended to be sustainable when it is deployed on web servers.
D1	Fulfill assigned responsibility in multidisciplinary teams.	Each team member contributes effectively to the job at hand and the corresponding deadline. Additionally, each team member often addressed the state of the other's job progress.
D2	Can play different roles as a team player.	No team member has the authority to act as team leader since everyone works well together and can make decisions for the team. The project is completed with full team cooperation.
E1	Identify engineering problems.	The issue is that the present blind assistance devices on the market are either too expensive or too sophisticated.
E2	Develop appropriate models to formulate solutions.	The model includes several images, website, and IOT-related approaches. For efficient results, the solutions were developed at group sessions.
E3	Use analytical and computational methods to obtain solutions	Use databases and libraries available for web development for model training and

		data input.
F1	Showcase professional responsibility while interacting with peers and professional communities.	The meeting was conducted effectively, searching for solutions to problems faced by the team members as well as designing new models for the forthcoming part of the project.
G1	Produce a variety of documents such as laboratory or project reports using appropriate formats.	The idea was presented in front of the panel and the need was conveyed effectively, all the reports needed for the project were made in time and following specific formats as guided by our mentor and the panel.
G2	Deliver well-organized and effective oral presentation.	We gave three presentations for this project involving all the team members, the presentation was done quite professionally following all the norms as well as was conducted in a well-organized manner
I1	Able to explore and utilize resources to enhance self-learning.	We had to learn Web development as well as some advanced concepts of machine learning.
J1	Comprehend the importance of contemporary issues	The main issue which this is project is all about, is to provide a pocket friendly blind assist technology using the latest technologies.
K1	Write code in different programming language	We used Python for the project mainly. We also use JavaScript for designing our website.
K2	Apply different data structures and algorithmic techniques	Various kinds of techniques were needed for the project and algorithmic techniques such as model training and evaluation parameters.
K3	Use software tools necessary for computer engineering domain.	We used VS Code text editor. We used Team Gantt software and many online modelling software for the planning of the project.

7.7 Brief Analytical Assessment

This capstone project assigned made us learn values and facts on academic area as well as psychological level. As we chose a topic we never studied before, it helped us to learn more in Computer Science. Also, it helped us to gain confidence to think about and execute new things to solve various problems of society. Various values such as teamwork, time management etc. were inculcated on a personal level. On the academic level, we got to polish our skills on report writing, poster making, presentation etc., quite well. All the submissions were done before the deadlines without any delay.

Ques 1. What sources of information did your group explore to arrive at the list of possible Project Problems?

Answer: The group was aware to the understanding of the Capstone requirement and some of problems that need to be explored. The data was needed to be gathered and processed. Most of the exploration was achieved via research papers and already established patents on agriculture. Besides three of the team members have an agricultural background so the difficulty for selection of project was minimal.

Ques 2. What analytical, computational and/or experimental methods did your project team use to obtain solutions to the problems in the project?

Answer: The experimental method we adopted was the use of micro-controller values and interprets them to decide among various crops provided in the data set which should be planted to give better yield without any loss or minimum loss as possible.

Ques 3. Did the project demand demonstration of knowledge of fundamentals, scientific and/or engineering principles? If yes, how did you apply?

Answer: In this technical project, we have used the principles of machine learning, computer programming studied in the curriculum. Design principles studied in software engineering helped in arriving at the design solution of the project that comprises of Use Cases, Data Flow Diagram, Component Diagram, ER Diagram, etc.

Ques 4. How did your group shares responsibility and communicate the information of schedule with others in team to coordinate design and

manufacturing dependencies?

Answer: We had the Gantt chart prepared initially and the work was divided in the respective domains and when deadlines approached, we were notified through email notification. We used WhatsApp group to collaborate and communicate for official works. Since major work was software development no such manufacturing dependencies.

Ques 5. What resources did you use to learn new materials not taught in class for the course of the project?

Answer: To comply with the challenging research project a lot of literature background was required, thus we took necessary lecture videos for our specific requirements, read various journals. The implementation part required knowledge of website development, deep learning models and Arduino.

Ques 6. Does the project make you appreciate the need to solve problems in real life using engineering and could the project development make you proficient with development tools and environments?

Answer: The project development is the finest way to solve real life problems and the only way to make our team proficient with software development tools an environment. To bring the bookish knowledge into a real life entity, the only way is project development on real life problems. This project also helped us to learn various new tools which were not taught in our university curriculum.

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