VISVESVARAYA TECHNOLOGICAL UNIVERSITY

BELAGAVI, KARNATAKA

A Project Phase - 2 Report on

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"SvayaKT - An E-Agriculture Ecosystem"

Submitted in the partial fulfilment for the requirements for the conferment of degree of

BACHELOR OF ENGINEERING

in

INFORMATION SCIENCE AND ENGINEERING

By

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2021-2022

BMS INSTITUTE OF TECHNOLOGY & MANAGEMENT

YELAHANKA, BENGALURU-560064

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CERTIFICATE

This is to certify that the Project Phase - 2 entitled **"SvayaKT - An E-Agriculture Ecosystem"** is a bonafide work carried out by **Mr. Adarsh Hiremath (1BY18IS004), Mr. Ananth D (1BY18IS024), and Mr. Karan Venkatesh Upamanyu (1BY18IS057)** in partial fulfilment for the award of **Bachelor of Engineering Degree in Information Science and Engineering** of the Visvesvaraya Technological University, Belagavi during the year 2021-22. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in this report. The Project Phase - 2 report has been approved as it satisfies the academic requirements with respect to Project Phase - 2 work for the B.E Degree.

Signature of the Guide	**Signature of the Coordinator**
Dr. Pushpa S K	Dr. Geeta Patil
Signature of the HOD	**Signature of the Principal**
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EXTERNAL EXAMINERS

Name of the Examiners	Signature with Date
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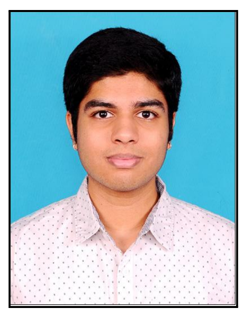
DECLARATION

We, hereby declare that the project titled “SvayaKT - An E-Agriculture Ecosystem” is a record of original project phase - 2 work undertaken for the award of the degree Bachelor of Engineering in Information Science and Engineering of the Visvesvaraya Technological University, Belagavi during the year 2021- 2022. We have completed this project phase - 2 work under the guidance of **Dr. Pushpa S K, Professor & HOD.**

I also declare that this project report has not been submitted for the award of any degree, diploma, associate ship, fellowship or other title anywhere else.

Photo			
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ABSTRACT

58% of India's population relies on agriculture to earn their living. In view of this, farmers contribute most to the Indian economy among many other professions. While technology evolves, the agricultural sector still follows ad-hoc procedures and is yet to be digitised. Starting from sowing seeds, maintenance of the crops and timely watering of the crops are some of the essential tasks among many others. This paves way for technology to help and support farmers to perform their tasks smartly and help them focus on tasks that require human intervention.

Technologies like IoT, AI/ML, and Server-End technologies can essentially help in creating a pipeline of streamlined processes that are reliable and convenient to farmers. These technologies help build an ecosystem of smart processes which ultimately makes farming an easier occupation and less prone to risks.

We have built an android application and a front end application that enables farmers and other users to go through the different stats of the sensors on the field. The android application enables the farmers to remotely monitor the statuses of different factors such as the amount of Nitrogen, Phosphorus, and Potassium in the soil, the humidity in the air, moisture in the soil among other factors. The app is also capable of performing disease detection for tomato and potato plants. The front end application that we have built represents real time values for the temperature and also predicts the prices of tomatoes and potatoes based on the values present on the dataset.

INDEX

LIST OF FIGURES AND TABLES

CHAPTER 1
INTRODUCTION

vCHAPTER 1

INTRODUCTION

1.1 Preamble

The concept of the Internet of Things (IoT) describes how a network of different physical objects that are embedded with sensors, software, and other technologies work together for the purpose of connecting and exchanging data with other devices and systems over the internet.

There are a variety of existing systems which try to implement sections of the proposed module of implementation. These models do not enable remote control of different components while also being able to monitor the values of the different chemicals on the fields.

1.2 Motivation

During our research, we found out that even though a few IoT solutions exist for smart farming, a vast majority of farmers tend to not rely on them. There are several reasons for this, including the expenses of installing and maintaining such systems, lack of technical know-how to operate some IoT-based devices, the fact that most farmers are used to primitive methods and unwilling to change them, etc.

We also found out that most of the IoT solutions that farmers use and rely on are actually not remotely operable. They require on-premise human intervention in order to produce results to the expected extent.

This motivated us to build an android application and a front end application that will enable farmers and other users to be able to view the information of the statuses of the sensors and the status of the market for certain products. We have already built an android application that is capable of performing disease prediction among tomatoes and potatoes. The remaining functionalities that we had planned to build will contribute to the agriculture ecosystem.

1.3 Existing System

Currently, there are a lot of systems present in the world that already bring about automatic seeding. While these systems are effective, they are not efficient enough. Seeding happens at the start of every season to grow a particular crop. Each crop has its differences in terms of soil conditions, moisture content, and nutrient necessity. Some crops would require seeding at a more frequent rate as compared to others.

In such scenarios, these automatic seeding machines may render useless once the seeding is done for a particular crop. After that duration, it just remains idle with nothing else to do. There are a lot of systems that deal with measuring soil quality, moisture content, and other conditions. But, all these systems work in silo i.e. Independently. This is a major cause of inefficiency.

1.4 Problem Statement

To devise a system where it is possible to "*implement various swappable modules in place within the machine to make it more efficient and effective. Alongside, integrate robust applications which would help end users in integrating, controlling and processing the data.* "

Currently, in the agriculture sector, there are a lot of machines available to perform tasks independently. But, these machines are limited to a particular purpose only. For example, consider an automatic seeding machine. This machine is used only during the seeding season of a particular crop, after which it does not have any such work. In such a scenario, this machine would be used maybe thrice a year. As much as this is an effective way of seeding, it can be used for a lot more functionalities. The same machine can also be used to monitor soil and plant conditions by attaching a few swappable modules to it. This ensures that the machine is used efficiently and effectively. The system needs to have functionalities such as seeding, measuring soil moisture content for irrigation assistance and imaging for plant disease prediction. The system should work remotely over the cloud.

1.5 Proposed System

Our proposed system tries to provide precision farming utilities using the latest technologies. Precision farming utilities include incorporating IoT sensors to get readings of metrics such as soil moisture level, temperature, NPK (Nitrogen-Phosphorus-Potassium) levels, soil oxygen level, etc. These readings are made remotely accessible to the farmer.

Our proposed system does the following-

- Store sensor data on GraphCMS
- Create a browser-based dashboard web-application using Next.JS and React.JS
- Create another dashboard for Android mobile phones
- User can remotely access sensor data and metrics and receive alerts
- Query data more efficiently using GraphQL
- Predict market prices and market arrival of crops using past data and train a model using which the future prices and arrival could be predicted.
- The data collected from the sensors could be used to train a DL model using the time forecasting techniques to predict future variabilities.

1.6 Scope of the Project

The project primarily is concerned in addressing the problems faced by different stakeholders in the sectors of the agricultural sector, primarily the farmers who account to be the first set of interacting with the agricultural fields. The project tries to establish robust systems in both the categories of hardware and software related development. The aim of this project ranges from the very beginning of ploughing the field to get the field ready for the crop cultivation. The main concentration has been on the pipeline of work starting from the sowing of the seeds into the ground to the harvesting of those crops.

But there is also a continuation to this process of transferring these yields onto the markets. In establishing all these, a sturdy system is tried to set up for a streamlined and smooth process, which could become a bolstering point in making the concept a reality. The device grading used are IP68 industrial norms followed, which are most suitable for such farming environmental use. The project presents the system in two parts: precision farming utilities and a multipurpose farming robot.

Precision farming utilities include incorporating IoT sensors to get readings of metrics such as soil moisture level, temperature, NPK (Nitrogen-Phosphorus-Potassium) levels, soil oxygen level etc. These readings are made remotely accessible to the farmer.

We have seen a seed sowing machine in the existing systems section. However, seeding is done at most a few times a year and the device stays unused the rest of the time. This has inspired us to build a Multipurpose

Farming Robot. It has a fixed chassis that is IoT operated, the necessary IoT/hardware components, and the ability to work together with a number of separate modules that are built for various purposes.

1.7 Objectives

The system we are trying to build will help streamline and automate a few of the agricultural processes to help farmers and reduce the need for them to be on-site at all times. Reduction of costs incurred in traditional IoT-based precision farming by requiring fewer sensing units.

The branches of the proposal include:

- Precision farming utilities
- Two dashboards
- Remote access to metrics
- Market predictions using Machine Learning
- Improved efficiency in data transfer

CHAPTER 2
LITERATURE SURVEY

CHAPTER 2

LITERATURE SURVEY

2.1 Research Papers

- **Automatic Seed Sowing Robot (IRJET Apr 2019)**

- Published by Vidya Yedave, Punam Bhosale, Jyoti Shinde, Prof. Jagdish Hallur from SVERI's College of Engineering

In this paper, they talk about Agriculture is one of the most vital aspects of human life. It serves as the foundation of our country's economic structure. We concentrated on seed sowing operations in this research and attempted to tackle the problem. We employed battery-powered wheels with a built-in dc motor in the seed sowing machine system, and an Arduino Uno to operate the entire system. It detects the level of stored seed and notifies with an LED when the seeds are empty.

When an obstruction appears in front of the machine or diverts the course, the seed sowing machine can readily identify the obstacle using an infrared sensor. Seeds fall down from this seed drum with each turn of the revolving wheel, allowing the seed planter process to proceed smoothly and without waste. When the system machine reaches the end of its life cycle, an alert is generated or an LED is illuminated. This system comes with everything you need to work productively.

The suggested approach comprises a system that offers quick soil loosening, seed planting, and autonomous robot movement. The RF module is used to drive the robot forward, backward, left, and right in manual mode. The power supply for the system is provided by a 12v battery. The motor drivers are controlled using an Arduino Uno. In robot applications, a DC motor is employed. For controlling two motors, we may utilize the L293D driver motor. Two motors are controlled in both directions by the L293D motor driver. The motors which are on the left and right sides are used to drive the motor in the left to the right direction. The mechanical system for loosening the soil and seed planting.

In conclusion, seeds fall from this seed drum with each entire turn of the revolving wheel, and the seed planter process proceeds smoothly and without seed waste. The seeds fall into the seed chamber through the seed storage tank while the sowing disc rotates in the seed chamber. Seed buckets gather seeds from the chamber and sow them in the ground at the proper depth using a plow. In addition, if an obstruction occurs in front of the seed sowing machine, the IR sensor will detect it and sound the buzzer.

- **Solar Operated Automatic Seed Sowing Machine (IJAAST Feb 2015)**
  - Published by Swetha S., Shreeharsha G.H. from Acharya Institute of Technology and Karavali Institution of Technology respectively.

The true power needed for machine equipment is determined by its resistance to movement. Even now, 98 percent of modern devices in our nation use fossil fuels to power internal combustion engines or external combustion engines. This has resulted in extensive air, water, and noise pollution, as well as a possible energy crisis in the not-too-distant future. The current approach to this project is to design a machine that uses solar energy to drive the robotic machine in order to cut operating costs and time for digging and seed sowing operations.

Solar panels are utilised in this machine to absorb solar energy, which is then turned into electrical energy, which is then used to charge a 12V battery, which then provides the necessary power to a shunt wound DC motor. This energy is then sent to the DC motor, which drives the wheels. In order to reduce labour reliance, further, infrared sensors are employed to operate robots in the field. The area is defined by four post sensors, and the robot detects the track length and pitches to travel from line to line. The seed sowing and digging robot will travel over various ground contours, digging, planting seed, and watering the land after shutting.

As we all know, almost 70% of the population of our nation lives in villages, and their primary source of income is agriculture. As a result, the main goal of this project, the Solar operated automatic seed sowing machine is to use non-conventional energy sources to complete duties such as excavating, seed sowing, water pouring, and fertilising. As a result, solar-powered automated seed sowing machines will benefit farmers in distant regions of the nation where fuel is scarce. They may also carry out their usual agriculture activities while saving fuel to a greater extent. At the same time, harnessing solar energy can help to minimise pollution in the environment. This helps conserve money as well as avoid using fossil fuels.

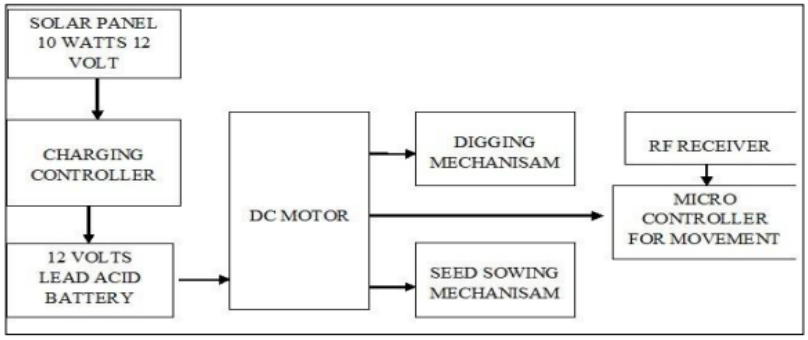

Fig. 2.1.1: Seeding machine architecture

- **Design and Development of Automatic Operated Seeds Sowing Machine (IJRITCC Feb 2017)**

  \- *Published by Kunal A. Dhande, Omkar R. Sahu, Megha S. Bawane, Achal A. Jiwane from Datta Meghe Institute of Engineering, Technology & Research (DMIETR) at Wardha.*

The realm of agriculture is so vast, advanced technology in the processes of planting, cropping, and cutting are required. This technological breakthrough will have no effect on soil quality and will boost agricultural yield efficiency. During the seeding process, seeds and fertiliser are fed to the plants. Farmers are currently dealing with a serious labour shortage. We illustrate the simple way of seed planting. In this study, we replace a difficult gear system with a hall effect sensor for easier and less expensive seed sowing, as well as to eliminate the need for manpower.

For seed sowing at a specific distance, the Hall Effect sensor converts rotation into the distance. There also exists an adjustable method for seeding at various distances. Sowing may be done row by row using this equipment, and the spacing will be maintained. As a result, this equipment saves them time and money by increasing the efficiency and precision of the seed sowing process while lowering labour costs.
Seed sowing equipment that is innovative has a significant impact on agriculture. We can save more time during the sowing process and save labour costs by using this unique seed sowing equipment concept. It's very useful for small-scale farmers. After weighing the pros and cons of various seed sowing methods and current machine constraints, it was determined that the solar-powered seed sowing machine can maintain row spacing and manage seed rate.

- **Design and fabrication of smart seed sowing robot (Elsevier July 2020)**

- Published by Pankaj Kumar, G. Ashok from S R Engineering College, Ananthasagar, Warangal.

There is a demand in agriculture for technology that is easier to understand, adopt, and utilise for farmers. In the agriculture business, equipment that demands less human work and time, as well as lower installation costs, is critical. A seed sowing robot is a technology that assists farmers in spreading seeds in the appropriate spot, saving them time and money. One of the most important aspects of farming is seed sowing. It requires a significant amount of time and human labour. The goal of this project is to develop and build a smart seed sowing robot for the aforementioned duty.

One robotic arm is used to sow seeds from the seeds container in this smart robot. To acquire the appropriate positions for the robot arm, the mobile application is used to operate it. After all of the locations are established, the arm automatically sows the seed after the switch is turned on. The robot's wheel may also be operated via the smartphone app. As a result, this method uses a well-built mechanical mechanism to entirely automate the seed planting procedure. This robot saves time and money by reducing the effort and overall cost of planting seeds.

All of the components of this smart seed sowing robot are created and built in-house with the goal of providing hands-on instruction in the manufacture of various components utilising 3D printing technology and IoT components. CAD software PTC Creo 3.0 was used to design all of the components. Furthermore, this study attempted to develop an automated method of seed planting in the field. The seeds were sown in a certain order according to the distinct rows and columns designated on the field, resulting in proper seed germination. Using robots helps spread seeds automatically minimising labour requirements.

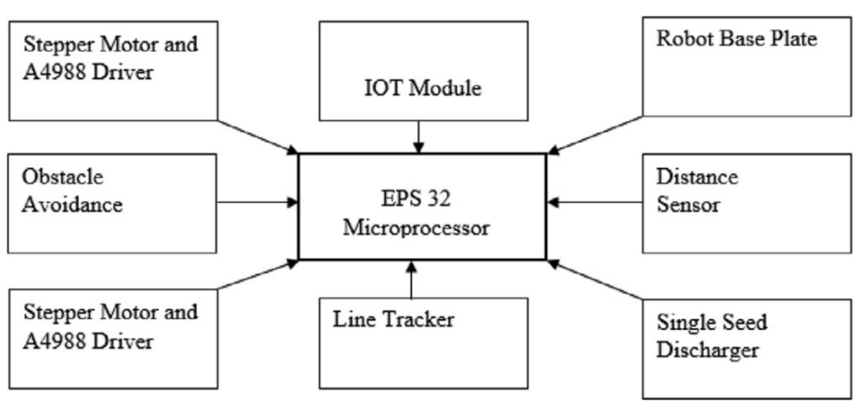

Fig. 2.1.2: Smart seeding robot

- **Design And Development Of Application-Specific Drone Machine For Seed Sowing (IRJET May 2018)**
- Published by Sunil Karbharee Diwate, Vilas N. Nitnaware, Kartik Argulwar from Dr.D Y Patil School of Engineering, Ambi, Pune.

Agricultural robotics aims to achieve more than only the application of robotics technology to farming. Most agricultural vehicles that are utilised for weed identification, pesticide dissemination, terrain levelling, irrigation, and other tasks are currently staffed. Because information about the environment may be autonomously gathered and the vehicle can then perform its mission accordingly, the autonomous performance of such vehicles would allow for continuous field surveillance. So, in this project, we'll be utilising the following keywords to describe a drone vehicle.

Drone farming is a difficult undertaking due to many reasons. It will form the foundation of the proposed system. Drones, like human beings, are more concerned with perfect task completion. It also makes effective use of existing resources, such as seeds, to ensure that there is minimal waste and that the work is completed in the shortest time possible. A manual switch is used to regulate the action of seed sowing, as indicated in Figure 1. When the power is turned on, the drone goes into idle mode and does nothing until an order is provided to him. As soon as I was told to drone, I did so. It will carry out the specific task specified in the application.

They discuss an architecture based on unmanned aerial vehicles (UAVs) that may be used to build a control loop for agricultural applications in which UAVs are in charge of seed planting in the farm in this study. The application procedure is guided by the input received from the wireless sensor network (WSN). The goal of this effort is to allow for brief control loop delays so that the seed sowing UAV can process data from the sensors.
They test an algorithm that adjusts the UAV path in response to variations in wind speed and direction. We can also assess the relation between the number of communication messages exchanged between the UAVs and the seed wastage.

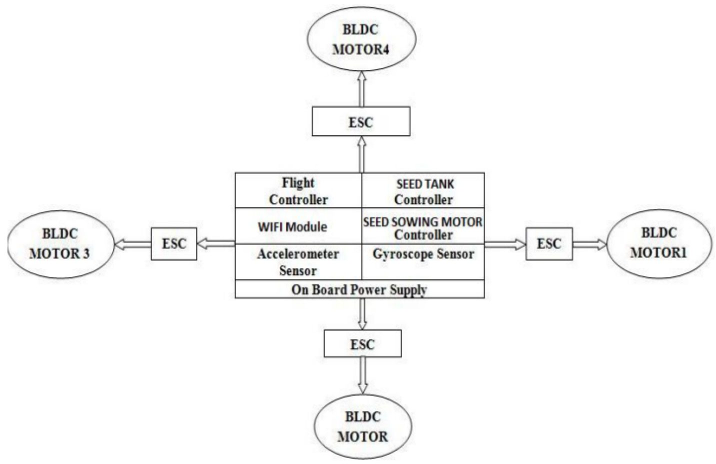

Fig. 2.1.3: Drone for farming architecture

- **Payload Manipulation for Seed Sowing Unmanned Aerial Vehicle through interface with Pixhawk Flight Controller (ICISC Sep 2020)**

  - Published by D.Yamunathangam, J.Shanmathi, R.Caviya, G.Saranya from Kumaraguru College of Technology at Coimbatore.

Unmanned Aerial Vehicles (UAVs) have been increasingly popular in agricultural and forest management in recent years. In forestry applications, UAVs play a critical role in forest conservation and protection. UAVs are utilised to automate farming chores and boost yield output, especially in precision agriculture. Seed-sowing unmanned aerial vehicles are concerned with identifying desired waypoints and the weight they can carry while flying. This concept proposes a seed sowing quadcopter payload capable of scattering seeds in woods and places on the edge of a road.

Furthermore, using the Mission planner, waypoints are specified in target fields and relayed to the Pixhawk Flight Controller. The seed dispenser is controlled by the Pixhawk, which is connected to the UAV and manages the flow of seeds to the required places. As a consequence, the seed sowing quadcopter is developed and tested in a semi-automated mode, reducing manual labour substantially.

The Pixhawk module transforms the quadcopter into a full-featured personal drone with the aid of ArduPilot Mega (APM) Firmware.

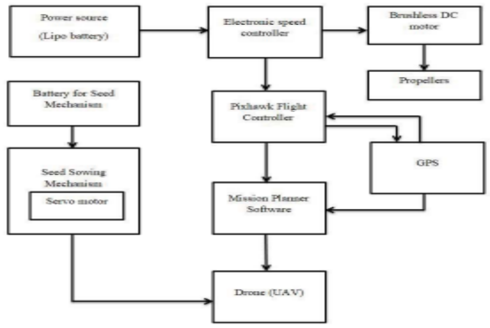

Fig. 2.1.4: Unmanned vehicle architecture

The following procedures are needed to link the mission planner software with the Pixhawk module:

a. Install

b. Connect

c. Update firmware

d. Calibrate

e. Create GPS waypoints

In forest regions, the Unmanned Aerial Vehicle interfaced with the flight controller and mission planner serves as an environmentally beneficial system. The suggested drone aids in the sowing of seeds in less densely forested areas. Unmanned aerial vehicles (UAVs) can be used for roadside planting to achieve a more effective planting pattern. UAVs such as these can plant billions of trees on their own.

- **A sustainable agricultural system using IoT (IEEE Apr 2017)**

  - Published by Ramya Venkatesan and Anandhi Tamilvanan

Internet of Things (IoT) has a lot of applications in the agricultural sector and using IoT will help farmers do their activities in the most efficient way. The system proposed here ensures that remote monitoring of the fields can be done. It also suggests the use of sensors, software, and gadgets that enable live video streaming of the agricultural field from the server itself. This is done using the Raspberry Pi camera module. The paper also talks about monitoring the temperature of the environment, humidity, and soil moisture. The paper also recommends automatic irrigation based on the levels of water in the soil. The data collected from the different sensors in IoT are analysed and accordingly, measures or steps are taken and the information is passed to the field owners or farmers so that they can take preventive measures when required.

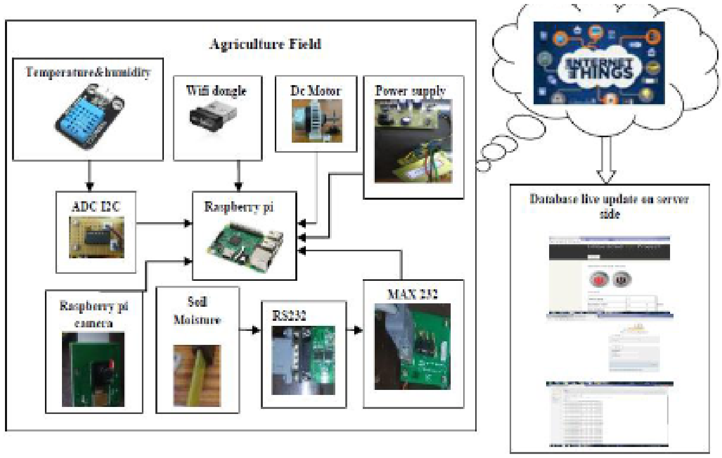

Fig. 2.1.5: Overall architecture of smart farming

The paper also talks about the use of IoT and wireless sensor networks to decrease the efforts that farmers put in when it comes to monitoring the fields and taking preventive measures. Through the proposed system, farmers can remotely monitor the fields and accordingly activate the required machines based on the sensor data and irrigate the fields, add fertilisers to the soil, and so on.

- **Automated irrigation with advanced seed germination and pest control (TIAR 2017)**

  - Published by Arvind G, Arvind. G, Athira. V.G, Haripriya. H, Akshaya, Rani. R, Aravind.S. Department of Computer Science and Engineering, Easwari Engineering College

The paper states that Agriculture contains multiple phases like sowing seeds, irrigation, weeding, etc. To date, most procedures have been manual and this paper recommends systems to help automate some phases of agricultural processes. The paper suggests the use of Ubiquitous computing which also goes by the name Nomadic computing and the use of sensors that are a part of the Internet of Things phase. The paper also discusses the use of data analytics to help measure the humidity and moisture levels where the data coming from the sensors is stored on an online database. The paper proposes a system that uses this data to check for the moisture content in the soil. If the moisture content is lower than the expected threshold value, the irrigation systems on the fields get activated to irrigate the fields. The paper says that the existing systems are all manual. What this means is that the systems require manual inputs so that the functionalities on the fields can get activated. The proposed system in the paper ensures that integrations are using the concept of IoT. The proposed system in the paper also talks about pest control which is a part of the system where different environmentally safe methods are used to get rid of the pests on the fields.

- **Smart Farming – IoT in Agriculture (ICIRCA Jul 2018)**

  - Published by Rahul Dagar, Subhranil Som, Sunil Kumar Khatri, Amity Institute of Information Technology, Amit University Uttar Pradesh, Noida, India

The paper talks about how the Internet of Things (IoT) is a revolutionary technology that will help improve the future of agriculture and connectivity in different areas of technology. This paper in particular talks about the use of IoT in agriculture and states that IoT can be used to enhance crop management, and improve resource management. The paper discusses the use of IoT to help in increasing both the quality and the quantity of the crops. The paper also discusses different sensors like Temperature sensors, Humidity and moisture sensors, pH sensors, and the use of NPK Sensors. The paper talks about the use of existing systems where users who are the farmers are not using the best means to do farming. There are a lot of lapses in farming that are practiced by farmers around the world. It also suggests ways that the systems can be improved. The proposed model suggested in this paper talks about the use of different IoT sensors that measure a variety of data. This data is then recorded on an online server. The paper also states that the server can take the desired actions based on the data coming into the server.

- **IOT Based Smart Agriculture System (WISPNET Mar 2018)**

  - Published by G. Sushanth and S. Sujatha, Department of ECE, Christ University, Bangalore, India

The paper talks about smart agriculture and how it is an emerging concept where it is dependent on the sensors in IoT or Internet of Things. The paper talks about a system that comprises technologies like Wireless Sensor Networks (WSN), Arduino, and IoT. It also states that monitoring the environmental conditions is a major factor in deciding when the farming needs to be done. The paper proposes a system where conditions like temperature, humidity, moisture, and movement of animals are monitored. These factors are considered to be important because they are capable of destroying the crops. The system suggested here sends an alert through SMS to the farmer's smartphone via Wifi, 3G, or 4G. The WSN used here makes use of a duplex communication link that enables the farmers to remotely monitor and control different processes. For example, the farmer can control irrigation of the crops and can also inspect the data being gathered by the sensors remotely through the android application suggested in the proposed system.

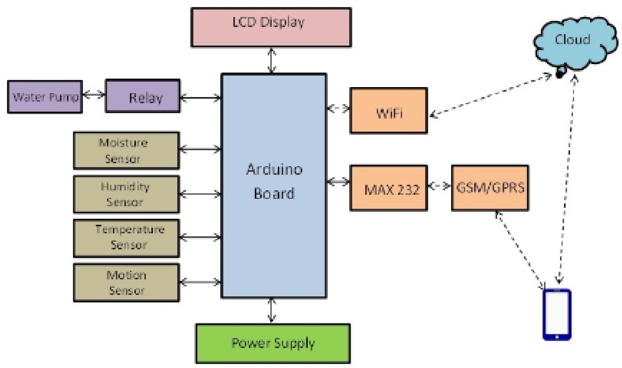

Fig. 2.1.6: Hardware Block diagram

2.2 Summary

The research papers enclosed above talk about the different concepts and systems that can be used to enable smart farming but each of these systems that are proposed have certain drawbacks that need to be addressed. Some systems may seem innovative but may not be financially viable while some systems may not be efficient enough to be deployed on a large scale basis. It is in view of this that there are a lot of systems in place to ensure that we can measure the performance of the system and accordingly make changes to the system so that the farmers get benefitted from the systems that are being proposed in the research papers.

2.3 Patent Search

- **Seeder (KR20130037993A)**

  A seeder is supplied that includes a wheel that sprays seed and a wheel with a seeding needle that forms a seeding furrow. A seeder consists of a first wheel with a seeding needle formed in the outer periphery to the radial direction; a second wheel that rotates according to the trace of the first wheel and sprays seeds into the seeding furrow formed by the seeding needle through a hole formed in an outer periphery when the first wheel rotates; and a third wheel rotating according to the trace of the first wheel and spraying seed in the seeding furrow formed; and support that holds the first wheel's and second wheel's shafts together. The second wheel is wider than the first. The second wheel's outer perimeter is shaped to be inclined in one direction.

- **Seeding Machine (JP5828148B2)**

The present invention pertains to the seeding machine that includes a seeding device and a groove-producing tool mounted on a machine frame that supports front and rear wheels on opposing sides, and more specifically to a height-setting configuration of a seeding device feeding outlet.

Traditionally in a sowing machine, there is a sowing apparatus and a groove-creating tool mounted on a machine frame that supports a front wheel and a rear wheel, the sowing apparatus is mounted practically horizontally, and the groove-producing tool is mounted below the sowing apparatus. A guiding member, such as a cylindrical body, connects the seeds supplied from the feeding outlet to the groove forming tool and the feeding outlet provided in the seeding device's feeding part.

It is known how to make it fall into the sowing | grooving groove | channel grooved by the grooving tool (for example, see patent document 1). Seeds are not dispersed in the middle of dropping with this approach, and sowing precision is enhanced.

- **Planter with seed delivery apparatus (CA2939497C)**

A number of row units are included in an agricultural implement. One or more seed metres are included in the row units for receiving, singulating, and discharging seed to the ground in order to achieve chosen seed spacing. Seed delivery systems are included to assist in conveying seed from the seed metre to the ground in a regulated manner to reduce skips and manage seed spacing, which can be depending on the implement's ground speed as it passes across the field.

The seed delivery systems may manage the seed's transit to a furrow in the field such that it travels at zero or near-zero relative velocity, causing the seed to move very little once positioned in the furrow.

- **Sowing machine and method of operating seeder with controlled separate metering devices (RU2595425C2)**

The idea concerns a planter that employs separate seed meter motor drives in each row-unit. Each seed meter drive motor is controlled by a motor controller. Each row seed meter may be started, paused, and operated at a different rate than the others. Meters may be controlled before planting to fill them and guarantee that they are primed and ready to start dropping seed as soon as the planter starts planting seed. When a seed delivery system is used with each meter to carry seed from the meter to the soil, the delivery system is also primed with seed before the planter's motor, which is controlled by the control system, is started.

- **YOLO target detection method using OpenCL (RU2407269C2)**

A seed tube for an agricultural seeding machine includes a side wall with a continuous, relatively smooth surface facing the seed and a sensor containing a transmitter situated next to the outer side of the side wall in a first embodiment. At least a portion of the side wall is composed of a material that is essentially transparent to the transmitter in this situation. A transmitter is set up to identify individual seeds passing through the seeding tube through a transparent material. The sole difference between the second and first variants of the vas deferens is that it has front and back walls that form a hollow interior chamber. One of the walls is constructed in the same manner as the previously stated side wall. A seed meter and a seed tube, comparable to the previous iteration of the seed tube, are included in the agricultural equipment.

- **Tyne with seed metering device (AU2014100073A4)**

The bottom end of the curved or vertical tyne shank features a seeding boot and a digging point for a cultivating machine tyne. A seed measuring device is 5 installed on the back of the tyne shank and has an outlet that is operationally coupled to but ideally separated from the seeding boot inlet. The seed metering device's seed-intake is either attached to a seed hopper or reservoir installed on the tyne shank, or it receives seeds from the cultivating machine's seed supply via air pressure. The seed measuring apparatus should be protected against tyne shank shocks and vibrations. A cultivating machine should include one or more toolbars, each having a plurality of the tynes, organised in such a way that seeds can be planted at equal spacings in evenly spaced rows.

- **A kind of agricultural planting seeder (CN209403014U)**

The utility model shows a variety of agricultural planting seeders, including fuselage, seeder, compact wheel, plough, and chain. The top side of the fuselage has a handle, the middle position of the fuselage has a sowing machine support attached, the top position of the bracket has a fertiliser box, at the lower end of the fertiliser box is a fertiliser hole and the Seeding box is installed to the right of the fertiliser box.

The bracket and turn Fastener is installed, and the purpose is adjusted to ditching depth. The bracket is fixed inboard, and it is connected to the plough by a turn Fastener. The height and position of the plough can be adjusted by turning the Fastener in operation, making it easier to control seed burying depth and improving work quality and efficiency.

- **Gnss and optical guidance and machine control (US20160252909A1)**

A global navigation satellite sensor system (GNSS) and gyroscope control system for vehicle steering control consists of a GNSS receiver and antennas at a predetermined spacing to calculate the heading, pitch, and roll angles of the vehicle based on carrier phase position discrepancies. The system additionally has a control system that can create a steering command for a vehicle steering system in response to input from the vehicle's position, heading, and at least one of its roll and pitch. In order to establish vehicle location, velocity, rate-of-turn, attitude, and other operational parameters, the system comprises gyroscopes for determining system attitude change with respect to various axes. Optical sensors and cameras can be used to analyse the relative orientations and attitudes of motive and functioning components. Multiple cars can be guided in relation to one another using the method.

Here, embodiment is a sensor system for vehicle steering control that consists of a number of GNSSs with antennas and receivers spaced at fixed intervals to calculate the position, speed, and at least one of the heading (slew), pitch, and roll angles of the vehicle using carrier phase corrected real time kinematic (RTK) position differences. Because the antennas move as the vehicle drives depending on an offset to the ground and the roll angle, the roll angle makes it easier to repair lateral motion-induced location problems. The system further comprises a control system able to provide a steering command for a vehicle steering system based on the vehicle location, heading, and at least one of roll, pitch, and yaw.

- **Integrated multi-sensor control system and method (USRE47648E1)**

A global navigation satellite system (GNSS) sensor unit with a receiver and an antenna is part of a GNSS integrated multi-sensor guiding system for a vehicle assembly. Vehicle dynamic data is produced by an inertial measurement unit (IMU) and combined with the GNSS unit's output. The outputs of the sensor suite are sent into a controller with a processor, which then computes steering solutions that are used by the actuators in the vehicle, including an automated steering control unit attached to the steering, to guide the vehicle. The processor is programmed to construct a variety of behaviour-based automatons that include self-operating entities in the guiding system. These self-operating entities carry out their assigned behaviours utilising data produced from one or more sensor units. Also revealed is a multi-sensor vehicle steering technique with GNSS integration.

A procedure for offering exact and precise vehicle placement guidance and control with automated steering capabilities is disclosed here. The current invention makes use of a number of distinct sensors that, when GNSS signals are weak, can act as temporary, trustworthy navigation devices and that, when GNSS signals are strong, can be calibrated. Multiple vehicles can work together utilising autonomous job delegation and control thanks to this precise positional information collecting. A flexible system is proposed that uses proportional hydraulic control with cutting-edge GNSS positional systems to provide a number of accurate steering tasks for a range of activities.

- **Precision farming system for applying product to a field (US6877675B2)**

The dispensing units for the product are equipped with control valves that can lower the flow rate of the product through specific dispensing units to zero. This control system is disclosed for an agricultural implement, such as an agricultural sprayer, used to dispense a product to the ground. Overapplication of the substance to the ground may be significantly reduced by managing the flow rate through the dispensing machines. In alternate implementations of the invention, the control mechanism can get information about where the product needs to be applied to the ground from a remote source, like a central controller or another device working in the field. A prescription map may also be used independently of or in addition to controlling the product's application. It is preferred that each dispensing unit has a control valve that may be operated in conjunction with the control system. This allows for the independent control of each dispensing unit to deliver a varied flow rate of the product to the ground.

A control system for regulating the dispensing of agricultural crop supplies to a field eliminates the drawbacks and restrictions of the previous art. The purpose of the current invention is to create a control system for the application of agricultural goods that helps avoid missing applications or applying products twice to the same spots in a field. The ability to direct a user of a crop product applicator to suitable areas for the dispensing of crop products based on information regarding whether those locations have previously received applications of a crop product is a feature of the invention.

2.4 Summary

The patented products enclosed above detail about the different concepts and systems that have been developed have qualified precision farming but each of these systems that are proposed have certain drawbacks that need to be addressed. Most of the systems that have been listed are systems that are secluded from integration possibility from any other type of systems that are available. But still they cumulatively provide a definitive foundational system for the different systems which are proposed later. These systems could be made us of in the form of building blocks for the further advancement and enhancement for the future systems.

CHAPTER 3

SYSTEM REQUIREMENT SPECIFICATIONS

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3.1 Functional and Non-Functional Requirements

Functional Requirements:

- **Sensing:** The sensors should be able to get readings and send them over to the dashboard for visualisation.
- **Manoeuvring:** The robot should be capable of moving comfortably on mud.
- **Connectivity:** The IoT sensors and the dashboard system should be connected over a network for data exchange.
- **Robustness:** The robot should be robust enough to handle movements in the fields without damaging itself.

Non-Functional Requirements:

- **Usability:** The robot should be able to monitor the conditions of the soil and should work effectively.
- **Reliability:** The readings gathered by the robot must be accurate and reliable which in turn helps farmers understand the crop situation.
- **Performance**: The system should be consistently responsive and with a good performance.
- **Efficiency:** The system should work efficiently while gathering data and perform seeding accurately as well.

3.2 Software Requirements

- Operating System - Windows 8 or above.
- Arduino IDE
- Text Editor - PyCharm Community Edition

3.3 Interface Specifications

There are 2 main user interfaces- one web-based interface and one mobile application.

Web Interface-

The web-based interface, which can be opened on a computer's browser, looks like so-

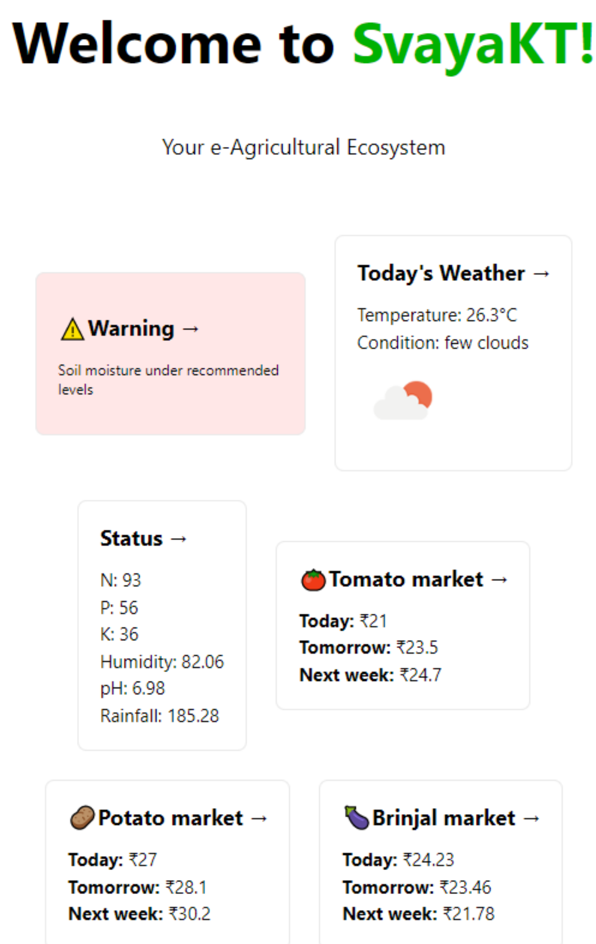

Fig. 3.4.1: Web Interface 1

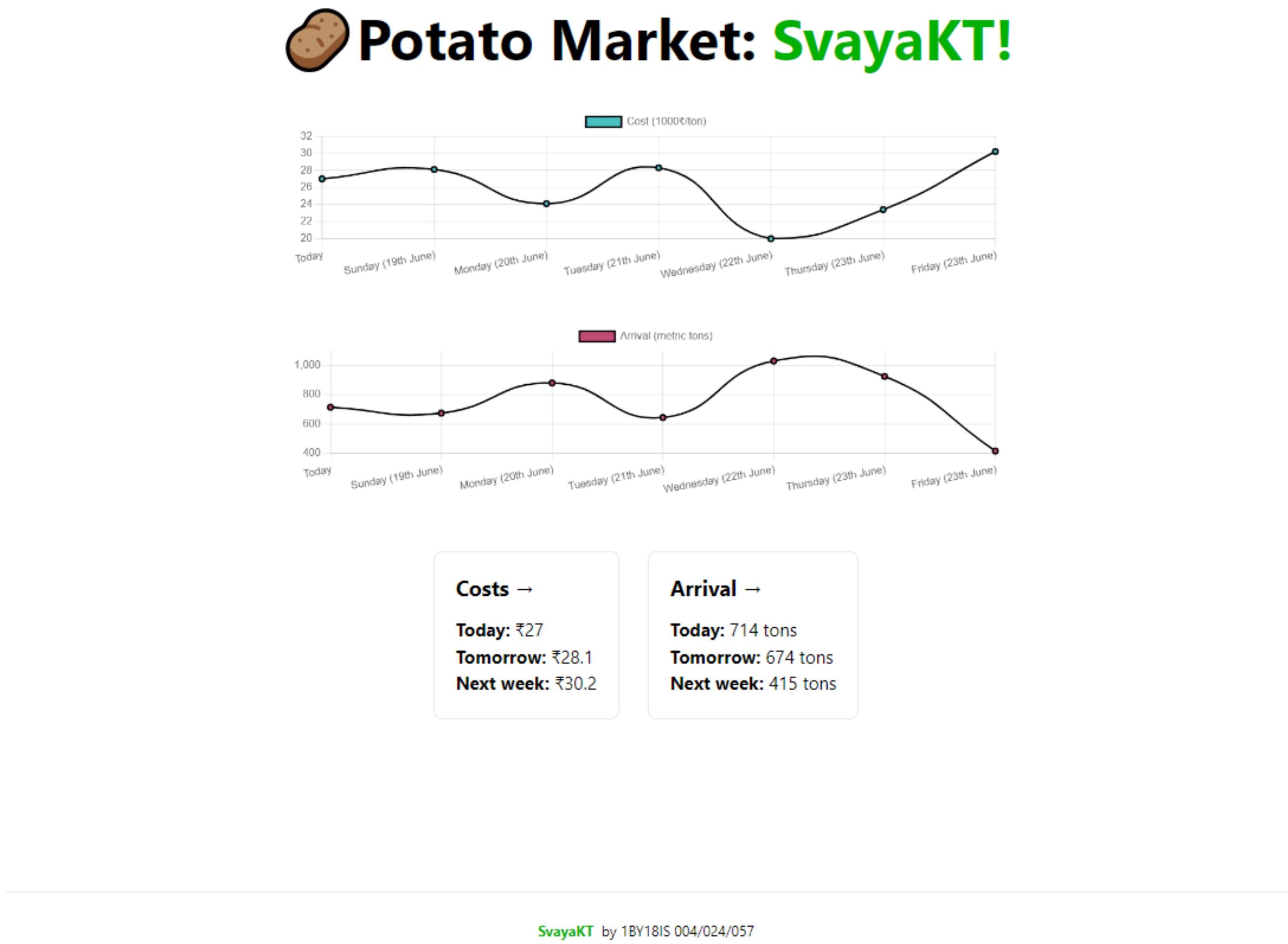

Fig. 3.4.2: Web Interface 2

The data and functionality provided through it is as follows-

1. Weather condition
2. Abnormal status alerts
3. Sensor measurements (queried from GraphCMS)
4. Market price predictions (for the current day, the next day, and one week from the current day)
5. Market price prediction graphs
6. Market arrival prediction graphs

Mobile Application-

Here are some screenshots of the mobile application-

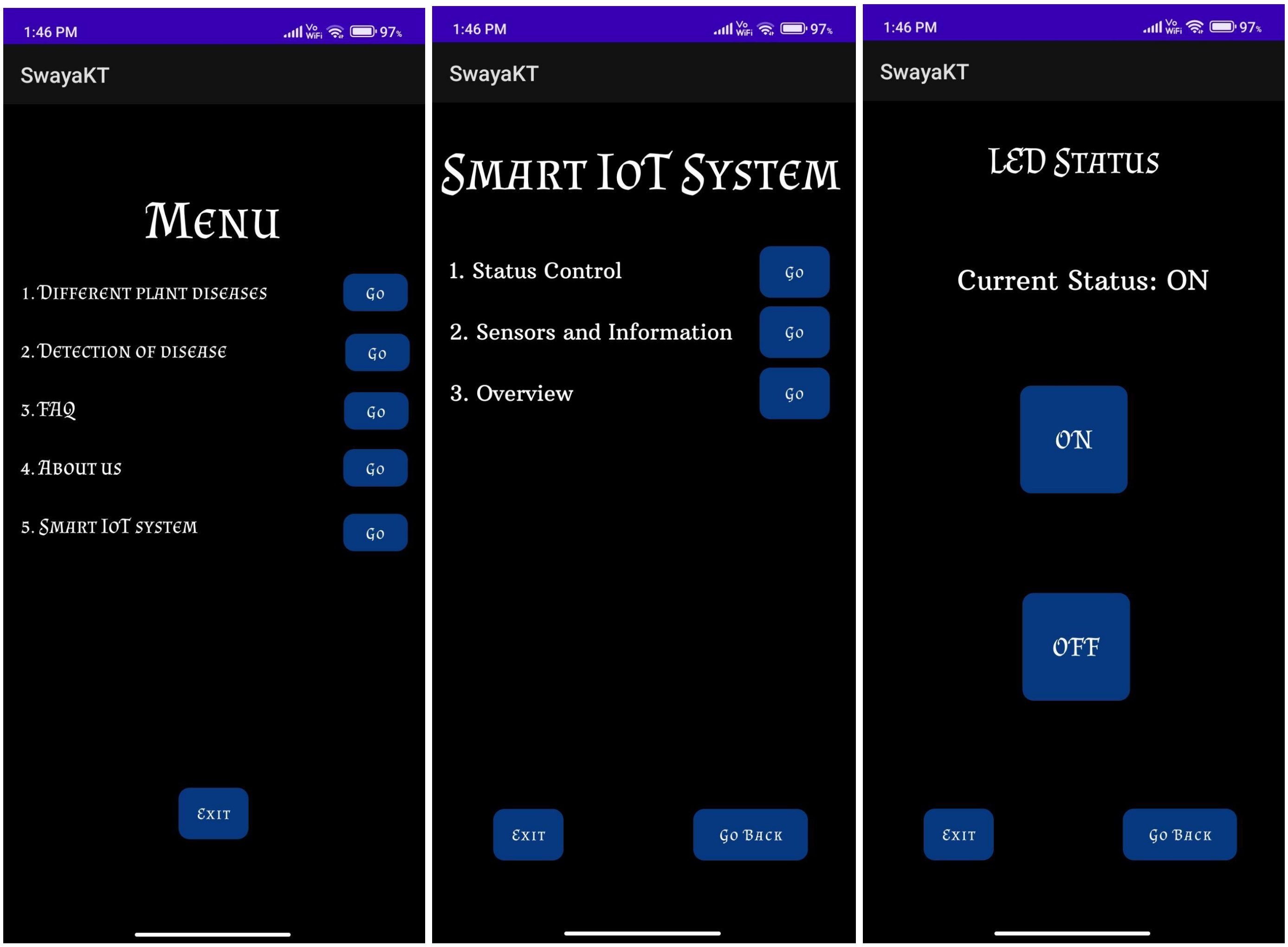

Fig. 3.4.3: Android app 1

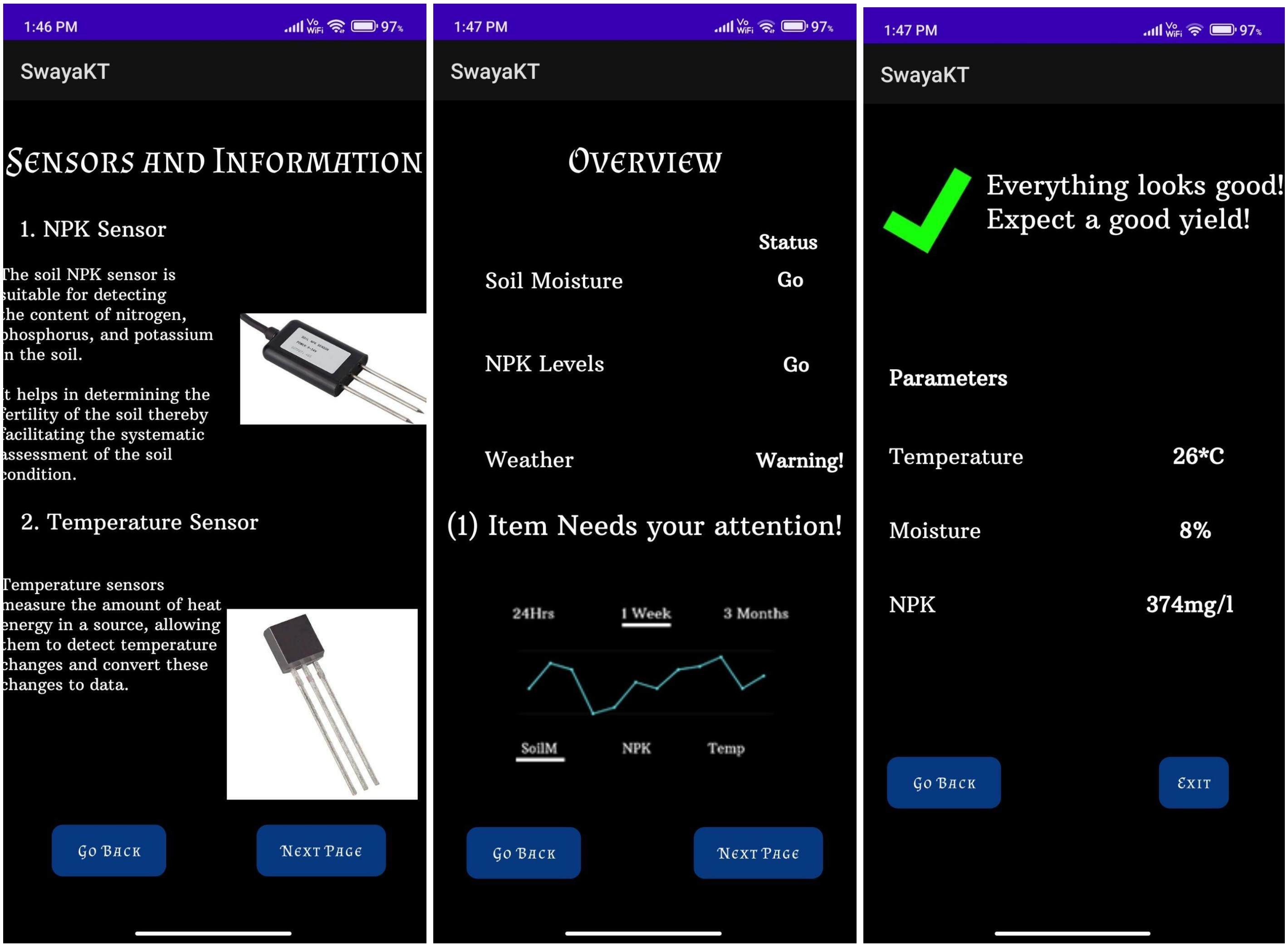

Fig. 3.4.4: Android app 2

The data and functionality provided through it is as follows-

1. Plant disease detection
2. List of detectable plant disease
3. Frequently Asked Questions
4. About us
5. Smart IoT System functionality and data, including-
    a. A brief description
    b. LED Status check
    c. Information about sensors used

d. Weather data
e. Sensor status alerts
f. Alerts and warnings
g. Graph of how sensor readings have changed
h. Expected parameters

3.4 User Requirements

The following are the user requirements being met by our system-

- Read weather condition
- Get abnormal status alerts
- Remotely read sensor measurements
- Market predictions (price and arrival)
- Predict plant diseases
- Read about plant diseases
- Read about IoT sensors
- LED check to ensure connectivity

3.5 Use Case Diagram

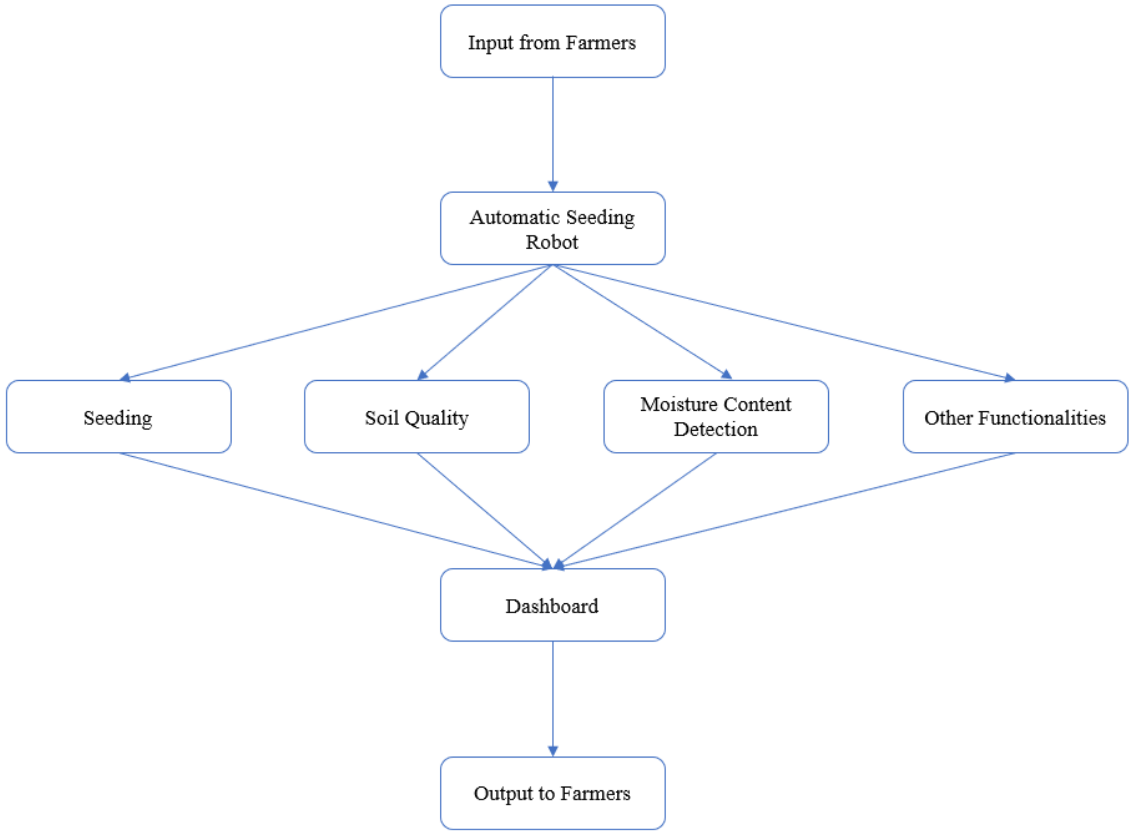

Fig. 3.5: Use Case Diagram

CHAPTER 4
DESIGN AND IMPLEMENTATION

CHAPTER 4
DESIGN AND IMPLEMENTATION

4.1 System Architecture

The system architecture comprises a variety of components. The system comprises both the hardware parts and the software part. The hardware part of the project comprises the sensors. The software part of the project comprises graphcms, firebase, and Machine Learning that is used to perform analysis. The same is showcased on an android app.

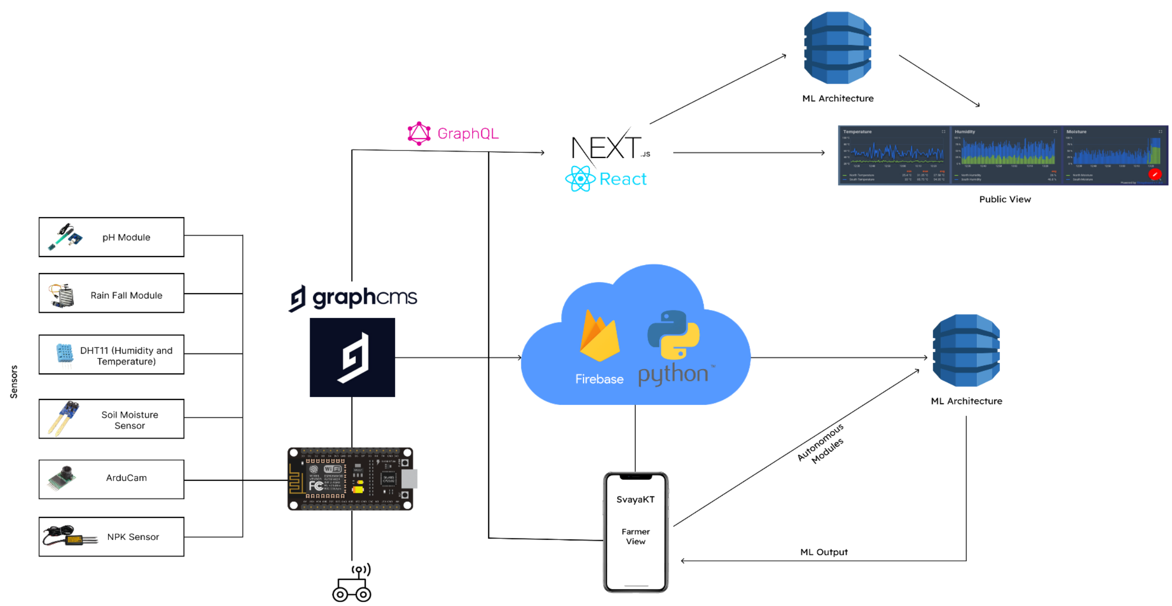

Fig. 4.1.1: Overall system architecture

The first part of the diagram comprises different sensors such as pH sensors, rainfall sensors, DHT11 sensors, soil moisture sensors, NPK sensors, and Arducam. The following diagram represents the entire system architecture.

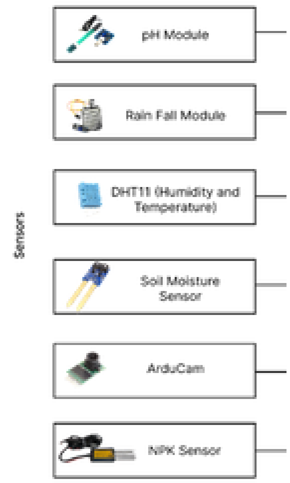

Fig. 4.1.2: Sensors

The pH value of the soil is essential to determine if the soil is suitable for growing crops. The pH sensors shown here measure the pH value of the soil. The rainfall module, DHT11 sensors, and soil moisture sensors are used to determine the water content in the soil. If the moisture content is less than a threshold value, then the smart irrigation system or existing irrigation systems on the fields get activated.

The Arducam is there in the architecture to check for the diseases in plants and if there are any diseases, then the farmer is informed the same. Every type of soil requires sufficient levels of Nitrogen, Phosphorus, and Potassium to be able to grow crops successfully. The NPK sensor is used to measure the levels of these 3 components and the data being gathered is sent to the database.

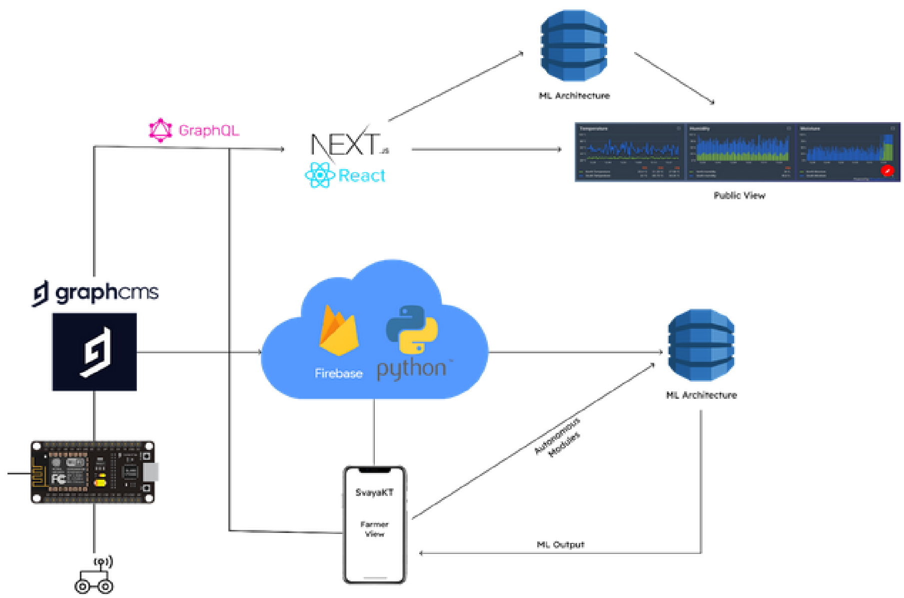

Fig. 4.1.3: Software components

The software components include a NodeMCU, the NodeMCU is a wifi module that will be used to communicate with the smart robots so that the processes and different functionalities can be done. The graphcms is used to store the incoming data from the sensors. The data from the database is queried using GraphQL and the same is showcased using the website that we have built using React. We have also built an android application that performs plant disease prediction and can be used to remotely control the different sensors on the fields.

The Machine Learning models we have proposed and used are spoken about in the next section. The algorithms help determine if the soil conditions are proper for farmers to grow their crops or not. This will in turn affect the profitability of the farmers.

4.2 Algorithm/Pseudocode

The algorithms used in the models are as follows:

- Long short-term memory (LSTM)

- Double Temporal Convolutional Networks
- Gradient Tree Boosting
- Convolutional Neural Network
- Wide and Deep Network

Long short-term memory (LSTM)

- Long short-term memory (LSTM) is an artificial neural network used in the fields of artificial intelligence and deep learning.
- LSTM has feedback connections. Such a recurrent neural network can process not only single data points (such as images), but also entire sequences of data (such as speech or video).
- A common LSTM unit is composed of a cell, an input gate, an output gate and a forget gate.
- The cell remembers values over arbitrary time intervals and the three gates regulate the flow of information into and out of the cell.
- LSTM networks are well-suited to classifying, processing and making predictions based on time series data, since there can be lags of unknown duration between important events in a time series.

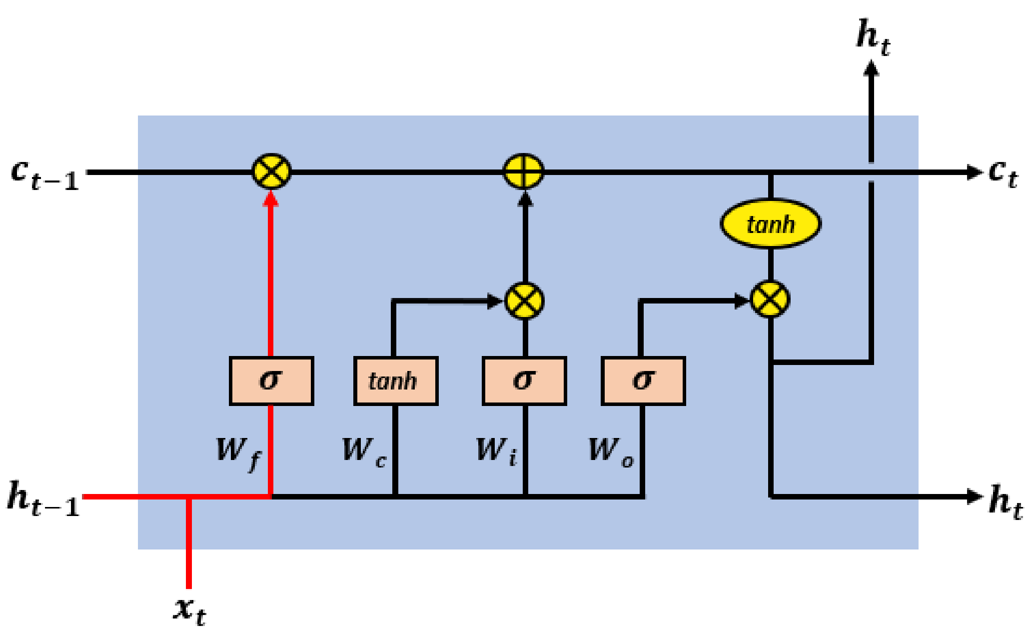

Fig. 4.2.1: LSTM

Pseudocode

Initialization: Initialize the population $S_i^{t=0} = \{s_{1,i}^t, s_{2,i}^t, \ldots, s_{D,i}^t\}$, $i = 1, \ldots, Np$ *which each individual uniformly distributed in the range*$[s^{low}, s^{high}]$

While the termination criteria is not met

For each individual, target vector, in the population NP

Mutation: Select three individual from the population randomly and generate a donor vector v_i^t using the following mutation equation:

$v_{j,i}^t = s_{j,p}^t + F_i * (s_{j,r}^t + s_{j,q}^t)$

Crossover: Compute the trial vector for the *i*th target vector $u_{j,i}^{t+1}$:

$$u_{j,i}^t = \begin{cases} v_{i,j}^t & if \;\; r_i \leq c_r \; or \; j = J_{rand} \\ s_{i,j}^t & otherwise \end{cases}$$

Selection: Apply LSTM classifier as fitness function *f* and evaluate s_i^t and u_i^t:

If $f(s_i^t) \leq f(u_i^t)$ *then* $s_i^{t+1} = u_i^t$

Else $s_i^{t+1} = s_i^t$

End For

End While

Fig. 4.2.2: LSTM Pseudocode

Double Temporal convolutional network (Double - TCN)

- Temporal convolutional network (TCN) is a framework which employs casual convolutions and dilations so that it is adaptive for sequential data with its temporality and large receptive fields.
- A 1D convolutional network takes as input a 3-dimensional tensor and also outputs a 3-dimensional tensor.
- The convolutions in the architecture are causal(there is no information leakage) from future to past. The architecture can take a sequence of any length and map it to an output sequence of the same length, just as with Recurrent Neural Networks.
- A double TCN is used where as one is used to study the location features whereas the other one is used for studying the humidity feature
- Advantages include: Parallelism, Flexible Receptive Field Size, Stable Gradients and Low Memory Requirement for Training.

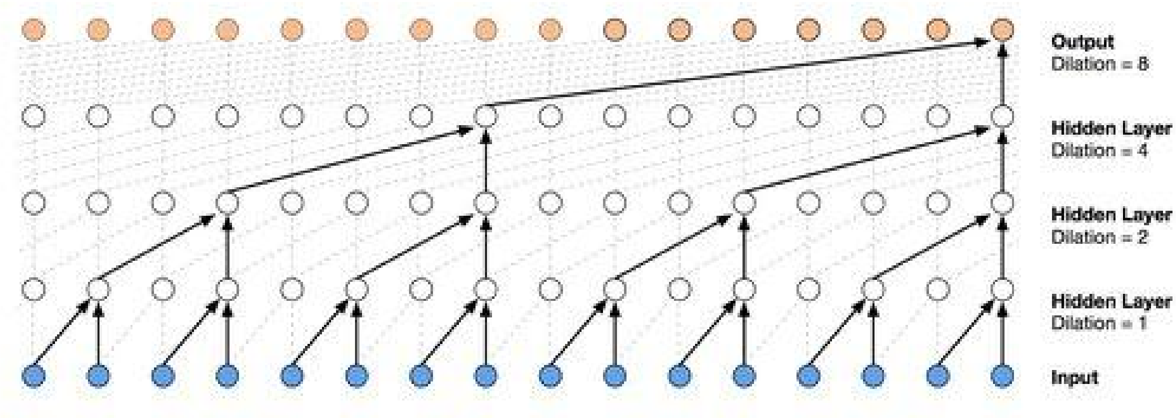

Fig. 4.2.3: Double - TCN

GRADIENT TREE BOOSTING (GTB)

- Gradient boosting is a machine learning technique used in regression and classification tasks.
- It gives a prediction model in the form of an ensemble of weak prediction models, which are typically decision trees.
- When a decision tree is the weak learner, the resulting algorithm is called gradient-boosted trees; it usually outperforms random forest.
- A gradient-boosted trees model is built in a stage-wise fashion as in other boosting methods, but it generalises the other methods by allowing optimization of an arbitrary differentiable loss function.
- For the moisture a hard predictive model would result in an unexpected result prediction.

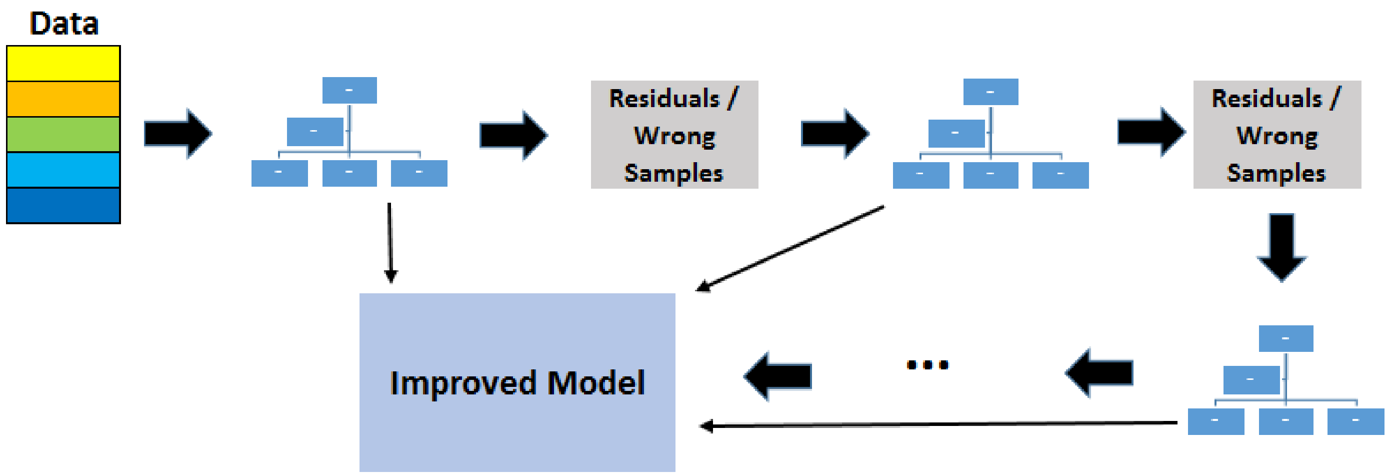

Fig. 4.2.4: GTB

PseudoCode

1. Initialize the observation weights $w_i = 1/N,\ i = 1, 2, \ldots, N$.
2. For $m = 1$ to M:
   (a) Fit a classifier $G_m(x)$ to the training data using weights w_i.
   (b) Compute
   $$\text{err}_m = \frac{\sum_{i=1}^{N} w_i I(y_i \neq G_m(x_i))}{\sum_{i=1}^{N} w_i}.$$
   (c) Compute $\alpha_m = \log((1 - \text{err}_m)/\text{err}_m)$.
   (d) Set $w_i \leftarrow w_i \cdot \exp[\alpha_m \cdot I(y_i \neq G_m(x_i))],\ i = 1, 2, \ldots, N$.
3. Output $G(x) = \text{sign}\left[\sum_{m=1}^{M} \alpha_m G_m(x)\right]$.

Fig. 4.2.5: GTB Pseudocode

Convolutional neural network (CNN)

- In deep learning, a convolutional neural network (CNN, or ConvNet) is a class of artificial neural network (ANN), most commonly applied to analyse visual imagery.

- CNNs are also known as Shift Invariant or Space Invariant Artificial Neural Networks (SIANN), based on the shared-weight architecture of the convolution kernels or filters that slide along input features and provide translation-equivariant responses known as feature maps.
- Extraction of features from the image to observe some patterns in the dataset.
- Filters are being made use of in a ConvNet, which help us exploit the spatial locality of a particular image by enforcing a local connectivity pattern between neurons.

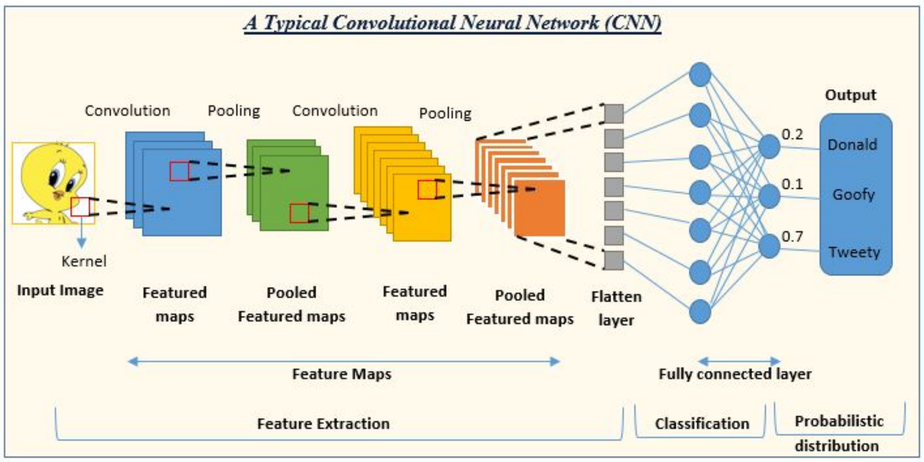

Fig. 4.2.6: CNN

WIDE AND DEEP LEARNING

- Wide & Deep jointly trains wide linear models and deep neural networks to combine the benefits of memorization and generalisation for real-world recommender systems. This means the wide
- The deep component is a feed-forward neural network. The deep and wide components are combined using a weighted sum of their output log odds as the prediction.
- This is then fed to a logistic loss function for joint training, which is done by back-propagating the gradients from the output to both the wide and deep part of the model simultaneously using mini-batch stochastic optimization.
- It's useful for generic large-scale regression and classification problems with sparse inputs (categorical features with a large number of possible feature values), such as recommender systems, search, and ranking problems.

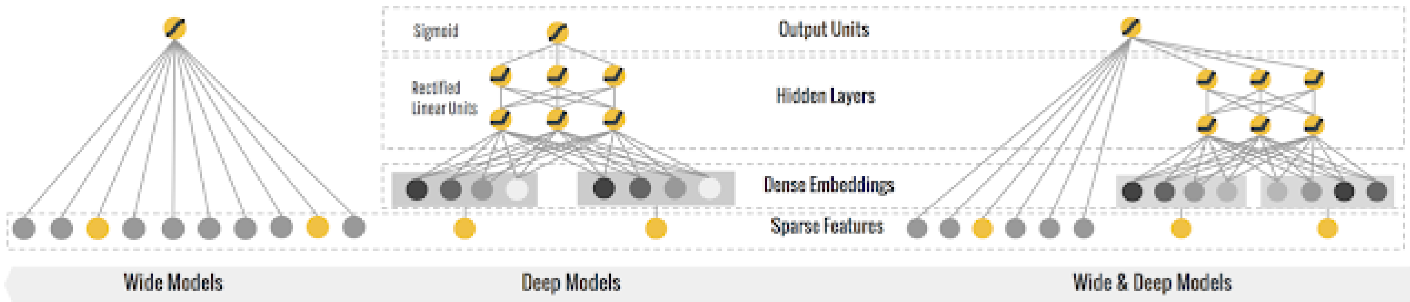

Fig. 4.2.7: Wide and Deep Learning

4.2.1 Analysis and Design

- The algorithms listed above have been used in developing the most robust and active models to predict the best results for the data that are being collected.
- The LSTM algorithm is being used to implement the prediction of temperature of the surrounding farmland. They include a 'memory cell' that can maintain information in memory for long periods of time. This helps in containing the data and propagating it in the long term.
- TCN or the Temporal Convolutional Networks have been detrimental in the prediction of time series data, which include data like humidity data. The humidity data could be better predicted to fulfil the water vapour availability in air. TCN, a framework which employs casual convolutions and dilations so that it is adaptive for sequential data with its temporality and large receptive fields.
- Double TCN would help in propagating and convoluting the network structure further and ease the operation of implementation. As the variation in the humidity read would be differing through the day, double TCN would bolster in the apt prediction.
- GTB or Gradient Tree Boosting method is used provides a large range of flexibility, which could be optimised on different loss techniques. Providing several hyperparameters for tuning. This would be really helpful in performing soil moisture detection as it would help in accurate decision making of the most appropriate measure of moisture of the field ground, there would exist a lot of difference in the measure through the field. It also provides predictive accuracy that cannot be trumped.
- Convolutional neural networks play an important role in performing image analysis and identification of features from those images to the fulfilment of the requirement. They automatically detect the important features without any human supervision. They tend to bolster the entire process of computer

supervision to the complete requirement. They would be really helpful to detect plant diseases.

- Finally the Wide and the Deep network have been a novel and a pristine method in the course of development in the coming times, which has made a lot of headway. The possesses the features of memorization and generalisation, which would be highly required for the prediction of future price and arrival. It also provides a time series forecasting method of predicting the values for a next fixed number of days, based on the requirement mentioned.
- The above decision has been carried out based on the algorithms that have been developed with the most satisfactory results that were obtained. But these decisions were made and based on the comparison of similar working algorithms that were also tested in the same process.
- For the temperature the model LSTM was done in comparison with the GRU (Gated recurrent units in RNN) and Hidden Markov model (HMM) models, which also provided similar levels of results .
- For the Humidity the model Double TCN was done in comparison with the single TCN model, which also provided similar levels of results .
- For the temperature the model LSTM was done in comparison with the GRU (Gated recurrent units in RNN) and Hidden Markov model (HMM) models, which also provided similar levels of results .
- For the soil moisture the model GTB was done in comparison with theRandom forests model, which also provided similar levels of results .
- For the temperature the Wide and Deep model was done in comparison with the Attention-LSTM model, which also provided similar levels of results .

4.3 Class Diagram

The class diagram, in our case, would apply to the schema of the database we have implemented using our database provider, GraphCMS.

The classes of data (called ‘Models of the Schema’ in GraphCMS) we have implemented are-

- Daily Records of Sensor data
- NodeMCU units
- Sensors

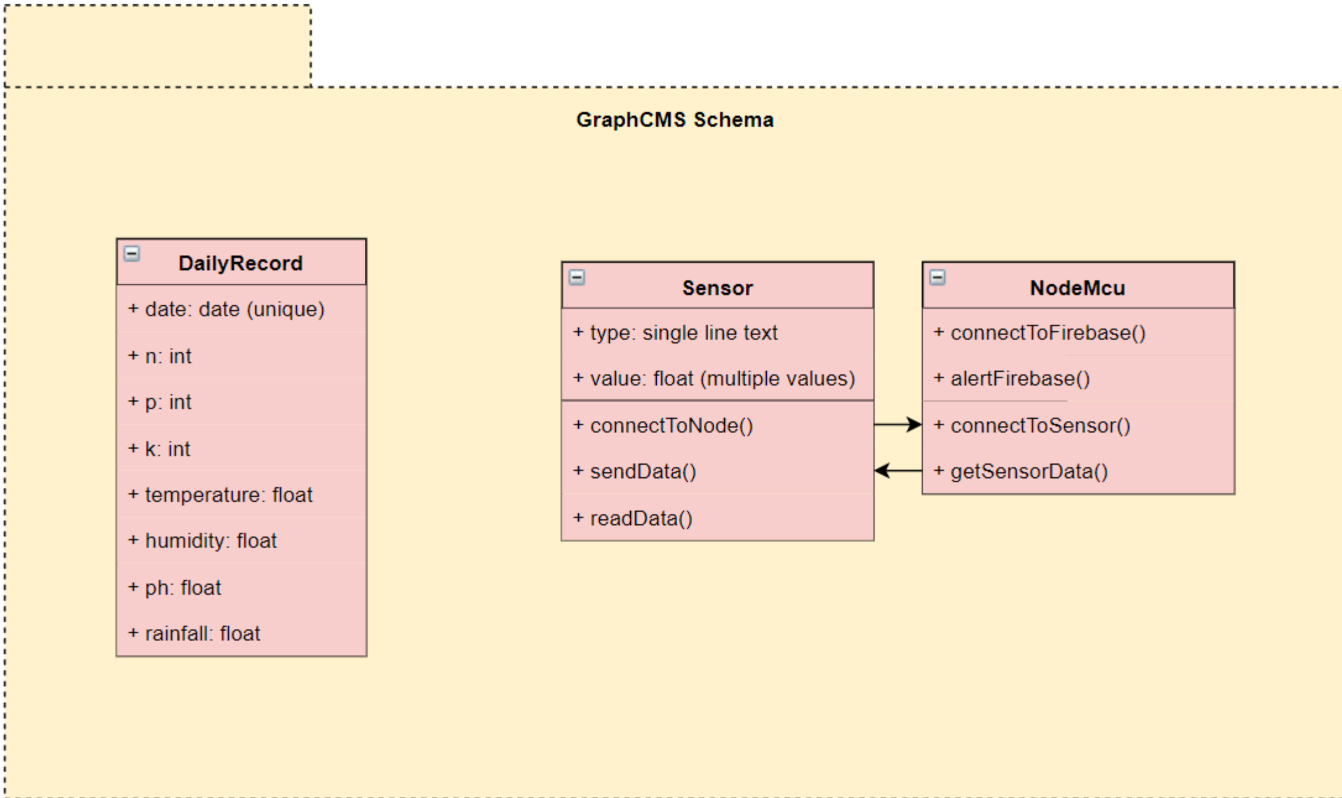

Fig. 4.3.1: Class Diagram showing GraphCMS Schema

4.4 Implementation

First, we will discuss how we have implemented the GraphCMS database for the first part of our implementation section.

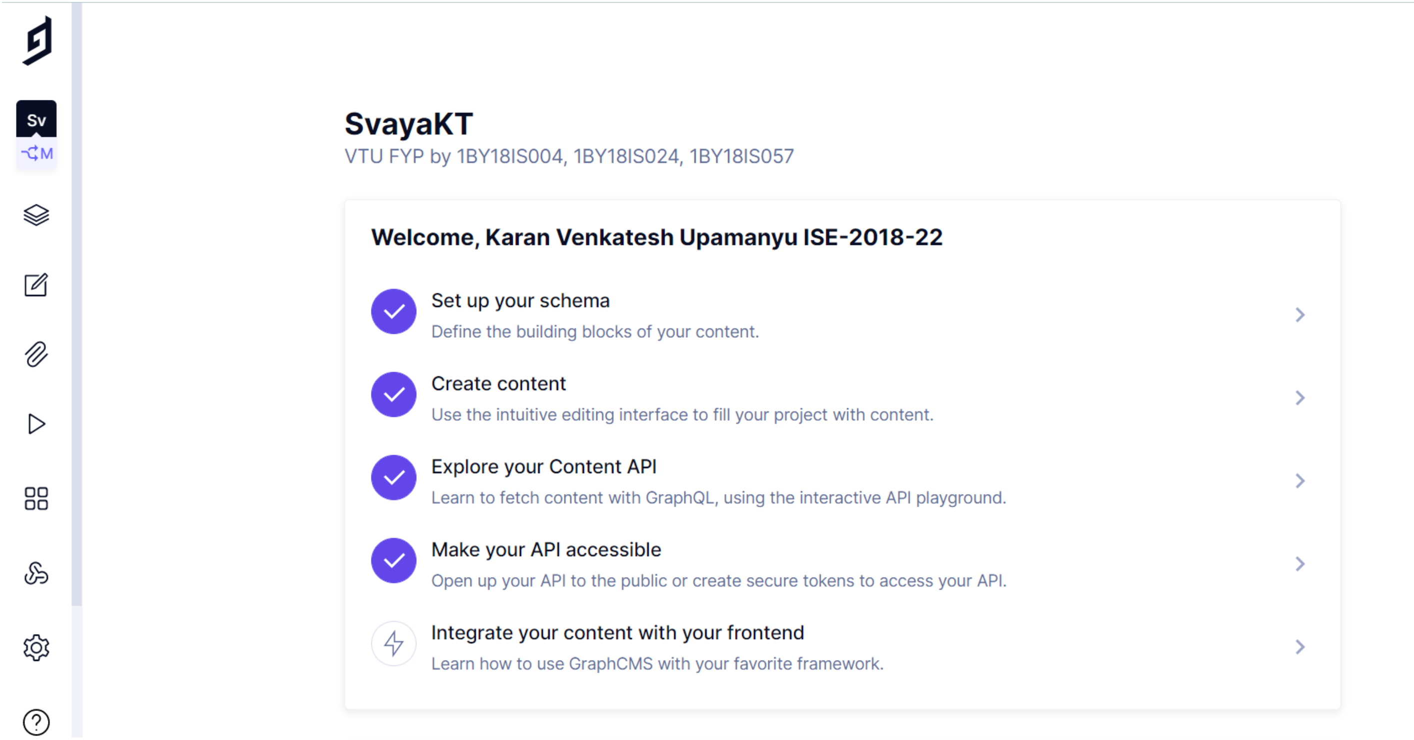

Fig. 4.4.1: GraphCMS Dashboard

This is the GraphCMS dashboard page that we see once we create our GraphCMS project.

Each GraphCMS project has a 'Schema' that it uses to store its data. The schema refers to the rules we can enforce onto our database so that all data added to it adheres to these rules. Each 'Record', or piece of data added to our database, is added taking the schema into account to be that record's blueprint.

Here are some of the schemas we have created-

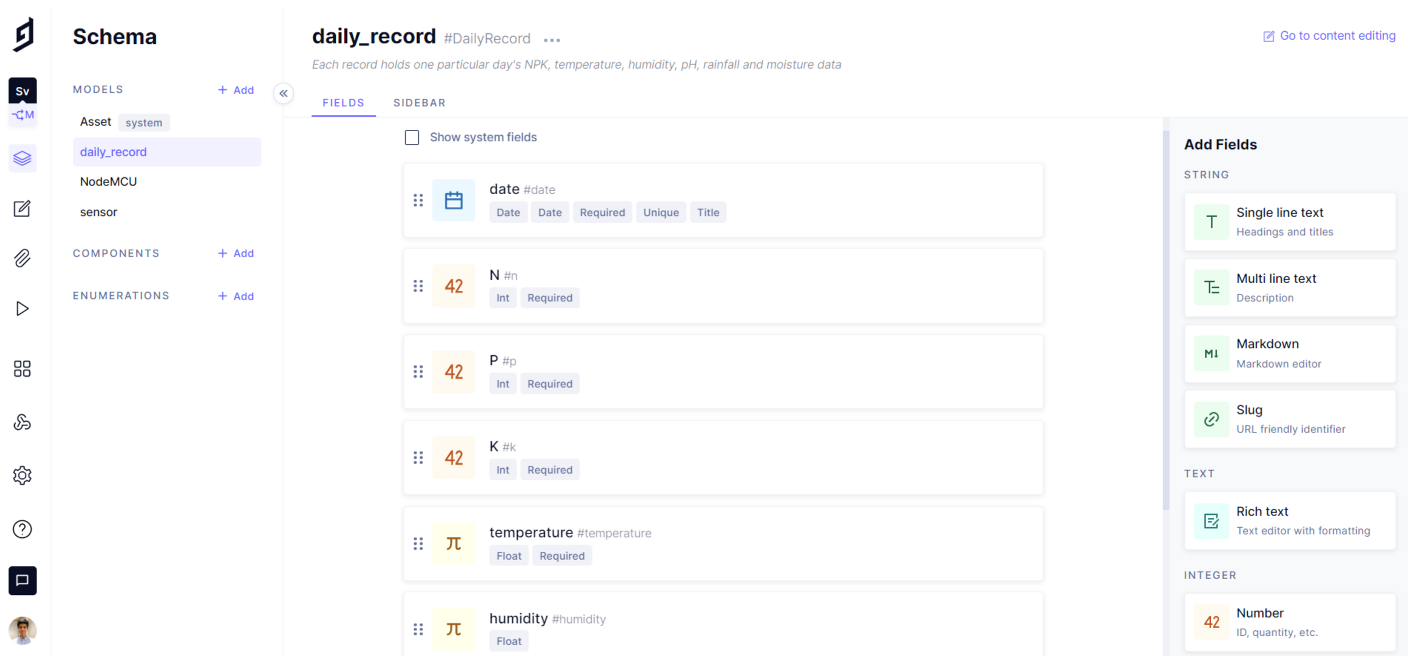

Fig. 4.4.2: GraphCMS #DailyRecord Schema

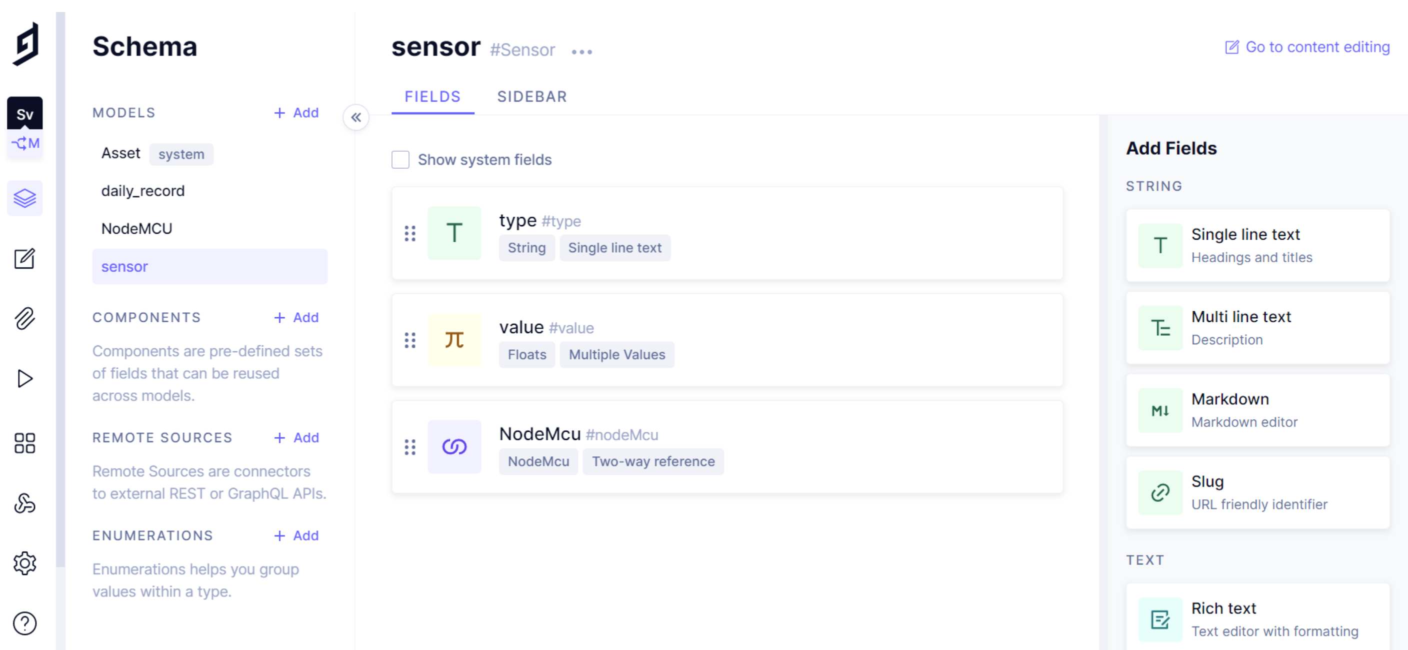

Fig. 4.4.3: GraphCMS #Sensor Schema

We have created a schema #DailyRecord that stores historic values of sensor-read data for a given date.

We have also created another schema called #Sensor. All types of sensor fall under the same schema, differentiated by the “type” attribute. The schema can handle multiple values through the “value” attribute.

We have established A 2-way reference relationship between #Sensor and the schema for NodeMCUs’, #NodeMcu, as shown below-

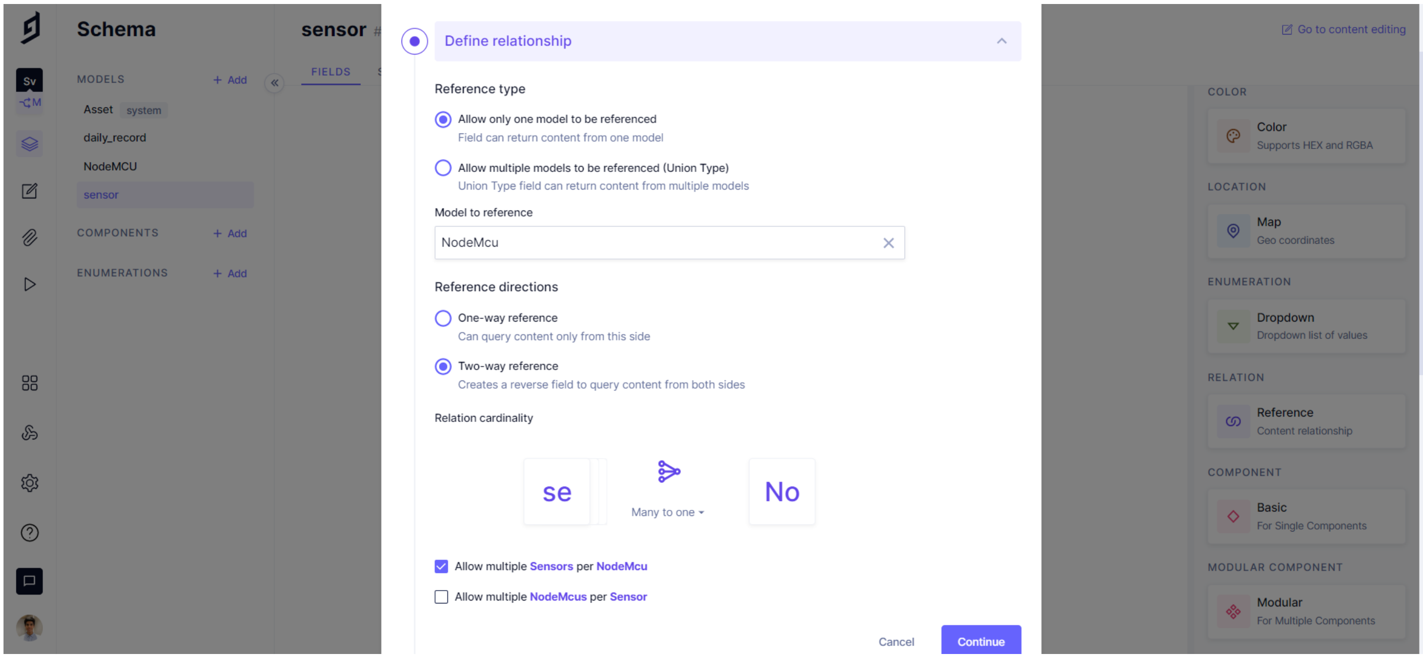

Fig. 4.4.4: GraphCMS two-way relationship between NodeMCU and Sensors

As we can see in the above picture, there exists a two-way reference, which means that-

- Given a sensor, we can tell which NodeMCU it belongs to
- Given a NodeMCU, we can tell which sensors belong to it

This reference model makes all sorts of queries especially easier.

We use GraphQL as our query language. GraphQL is an open-source data query and manipulation language for APIs, and a runtime for fulfilling queries with existing data.

Using GraphCMS’ Query Playground option, we can try running some sample queries like so-

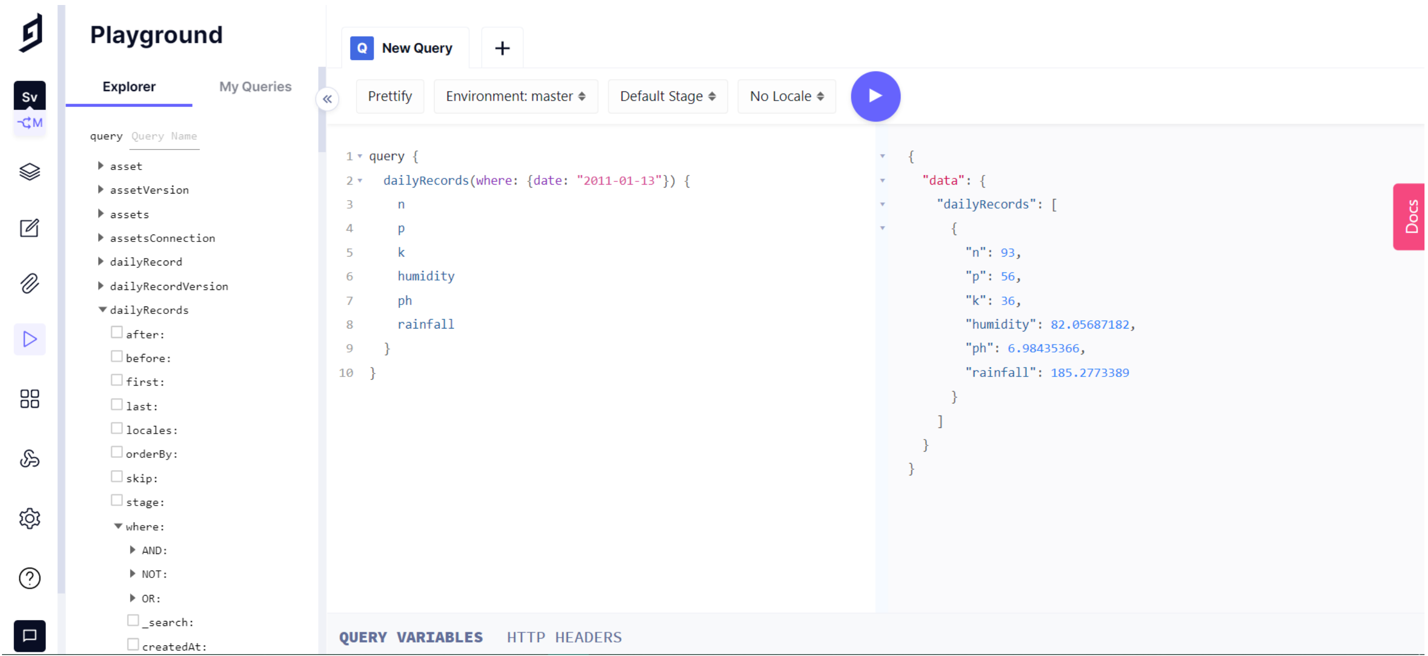

Fig. 4.4.5: GraphCMS Query Playground

These queries are later used in our Next.JS / React.JS application, we will look into that next.

For building the web-based dashboard, we have used Next.JS with React.JS.

React.JS is a free and open-source front-end JavaScript library for building user interfaces based on UI components. Next.js is an open-source web development framework built on top of Node.js enabling React-based web applications functionalities such as server-side rendering and generating static websites.

Given below is a code snippet where we're querying for the present day's data from GraphCMS using GraphQL-

```
import {GraphQLClient, gql} from 'graphql-request'

const graphcms = new GraphQLClient(`https://api-ap-sou

let myDate = new Date()
var today = myDate.toISOString().split('T')[0]

const QUERY = gql`
{
  dailyRecords(where: {date: "${today}"}) {
    date
    n
    p
    k
    humidity
    ph
    rainfall
  }
}`

export async function getStaticProps() {
  const posts = await graphcms.request(QUERY);
  return {
    props: {
      posts
    },
    revalidate: 30
  };
}

export default function Home( {posts} ) {
```

Fig. 4.4.6: Sending GraphQL requests to GraphCMS database using Next.JS application

Then, the retrieved data can be displayed on our dashboard like so-

```
<div className={styles.card}>
  <h2>Status &rarr;</h2>
  <p>N: {posts.dailyRecords[0].n}</p>
  <p>P: {posts.dailyRecords[0].p}</p>
  <p>K: {posts.dailyRecords[0].k}</p>
  <p>Humidity: {posts.dailyRecords[0].humidity}</p>
  <p>pH: {posts.dailyRecords[0].ph}</p>
  <p>Rainfall: {posts.dailyRecords[0].rainfall}</p>
</div>
```

Fig. 4.4.7: Displaying the data retrieved using GraphQL from GraphCMS

This code makes our frontend look like this-

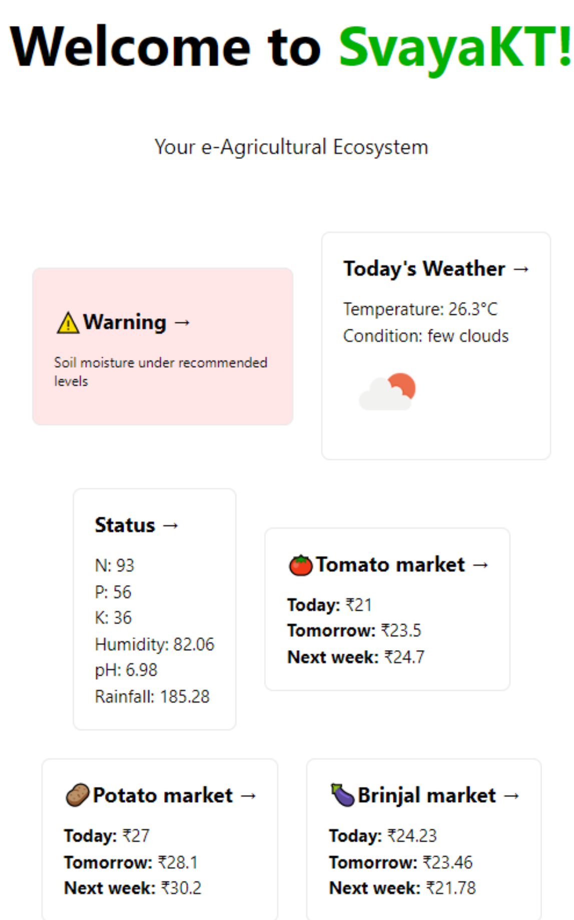

Fig. 4.4.8: Frontend 1 (Dashboard)

Similarly, we make even simpler API calls (i.e., GET requests) to Algorithmia like we did for GraphCMS to fetch prediction data that the model prepares (separately), and display them along with the graphs. We only fetch the data itself, the graphs are built using Chart.js library.

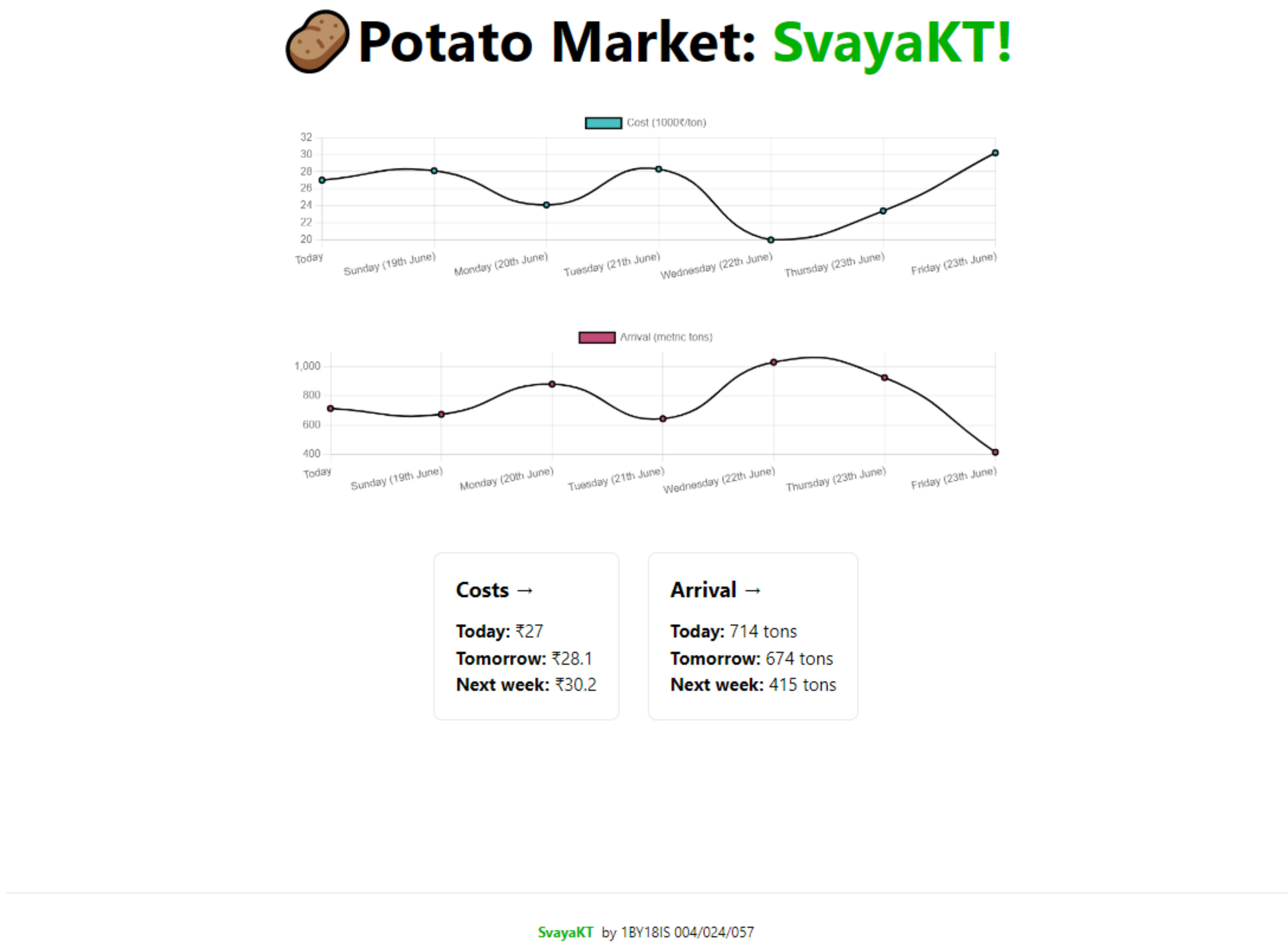

Fig. 4.4.9: Frontend 2 (Predictions)

Heya

The android app we have built comprises 2 main sections. The first part of the app is about disease prediction. The app has an inbuilt option where users can upload the pictures of different leaves of 2 plants in particular. The app is capable of predicting diseases in potato and tomato plants.

The overall system architecture of the app is as follows:

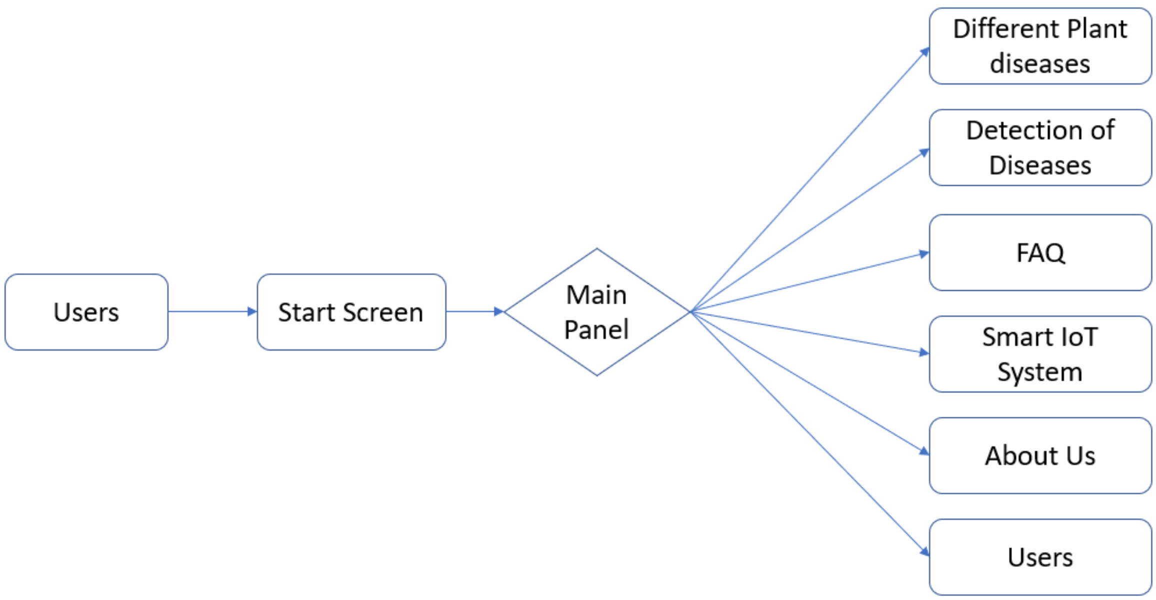

Fig. 4.4.10: Component Design

Users can gain information of different plant diseases by navigating to the different plant diseases tab.

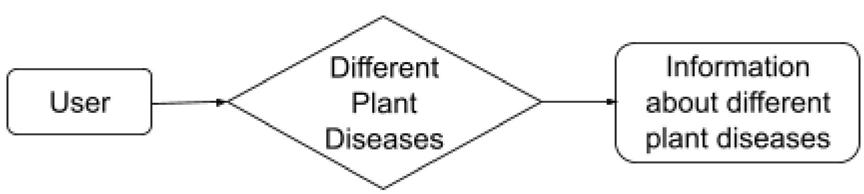

Fig. 4.4.11: Different Plant Disease Design

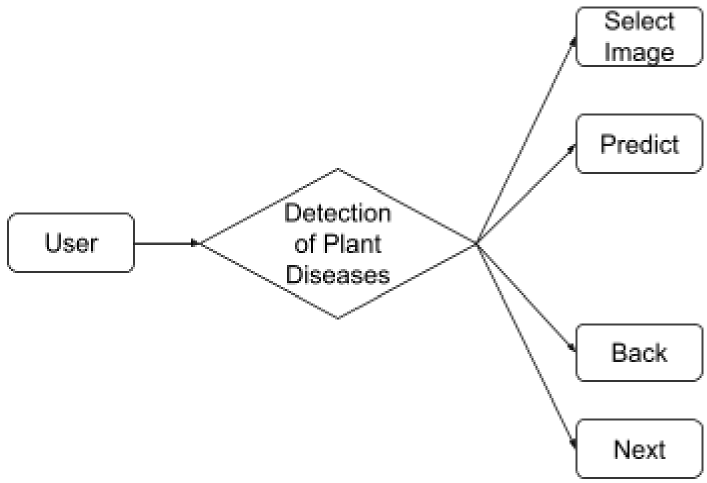

Fig. 4.4.12: Detection of Plant Disease Design

There is a screen for prediction activity. There are 4 buttons here-

Select image: Lets the user select an image from their gallery to predict the disease

Predict: Based on the selected image, a prediction is made

Back: Takes user back to the main menu

Next: Takes the user to a page with more information on the predicted disease.

We have also built a simple, scrollable FAQ page with general information about food wastage statistics, simple guidelines everyone can follow to help society, and such.

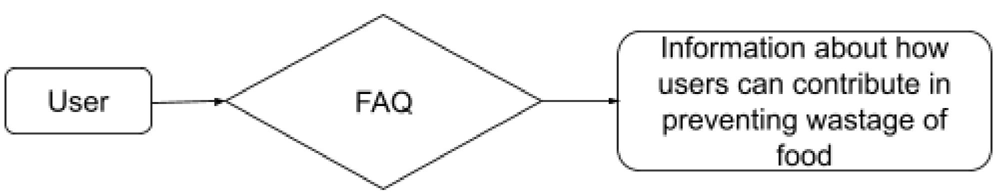

Fig. 4.4.13: FAQ Design

The smart IoT tab leads the users to another page where they can avail information about different sensors and can also remotely activate certain sensors from the android app.

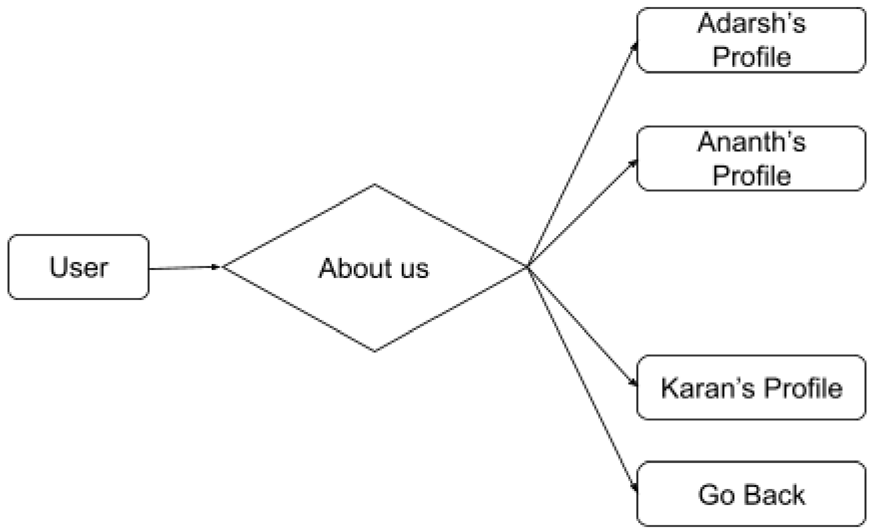

Fig. 4.4.14: About us Design

The about us page gives a general introduction to the 3 members of the team and our college. There are 3 more pages that contain our respective individual profiles along with links to get in touch with us.

CHAPTER 5
TESTING AND VALIDATION

CHAPTER 5

TESTING AND VALIDATION

5.1 Unit Testing

SI.No.	Test Case	Input	Actual Output	Expected Output	Is Actual output the same as expected output?
1	Select Image	On click of the Select image button	It leads to the image picker panel	Image picker panel is opened	Yes
2	Back Button	Back button is pressed	It goes back to the menu screen	Menu screen appears	Yes
3	Predict Button	Predict button is chosen	Based on which image is selected a prediction is delivered	Prediction is done	Yes
4	Info Button	Info button is chosen	The details of the disease are displayed	Details are displayed	Yes
5	FAQ Screen	List of all the FAQs	Displays all FAQs that are available	Displays FAQ	Yes
6	About Us Screen	List of all the available details about the project	Lists all the available details about the project	Lists information about the project	Yes

7	Adarsh Hiremath Profile	The Profile Button is selected	The profile details are displayed	Details are displayed	Yes
8	Ananth D Profile	The Profile Button is selected	The profile details are displayed	Details are displayed	Yes
9	Karan Venkatesh Upamanyu Profile	The Profile Button is selected	The profile details are displayed	Details are displayed	Yes

Table 5.1: Unit Testing

5.2 System Testing

SI.No.	Test Case	Input	Actual Output	Expected Output	Is Actual output the same as expected output?
1	Different Plant Diseases	The Go button of the Different Plant Diseases	It is redirected to the Plant Diseases list page	It redirects to the plant diseases page	Yes
2	Detection of Diseases	The Go button of the Detection of Diseases	It is redirected to the Prediction page	Goes to the prediction page	Yes
3	Smart IoT System	The Go button leads to the sensor related data	It goes to the Abstract page	Goes to the abstract page	Yes

4	FAQ	The Go of button of the FAQ	It is redirected to the FAQ page	Goes to the FAQ page	Yes
5	About Us	The Go button of the About Us	It is redirected to the About Us page	Goes to the About Us page	Yes
6	Exit Button	Exit button is chosen.	The Application exits normally.	Application ends	Yes

Table 5.2: System Testing

CHAPTER 6
RESULTS AND DISCUSSION

CHAPTER 6

RESULTS AND DISCUSSION

The system comprises both the front end application and the android app that we have built so that they can easily be integrated into the entire architecture that we have proposed in the system architecture.

React Website:

The front end application comprises different functionalities such as the status of Nitrogen, Phosphorus, and Potassium in the soil, the current day's weather, and the pricing chart of tomatoes, and potatoes.

Android:

The android application that was developed comprised 2 parts. The first part consisted of disease prediction using Machine Learning algorithms.

Fig. 6.2.1: Home Page

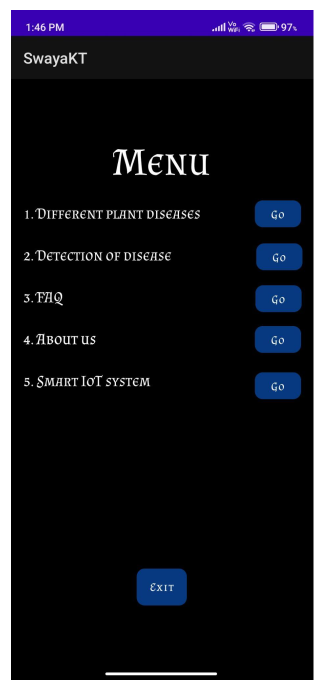

Fig. 6.2.2: Menu Screen

The Detection of the disease and the different plant disease options contains all the functionalities related to plant disease detection.

Fig. 6.2.3: Plant disease list

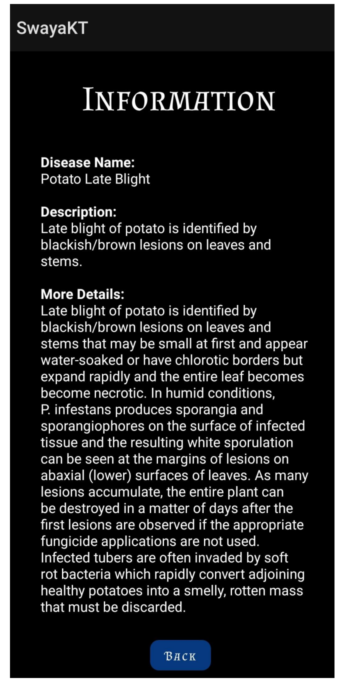

Fig. 6.2.4: Information Screen

Fig. 6.2.5: Disease Prediction Page

Fig. 6.2.6: Potato - Healthy

Fig. 6.2.7: Tomato - Late Blight

Fig. 6.2.8: Tomato - Septoria Leaf Spot

Fig. 6.2.9: Predict Activity Page

Fig. 6.2.10: Information Page 1

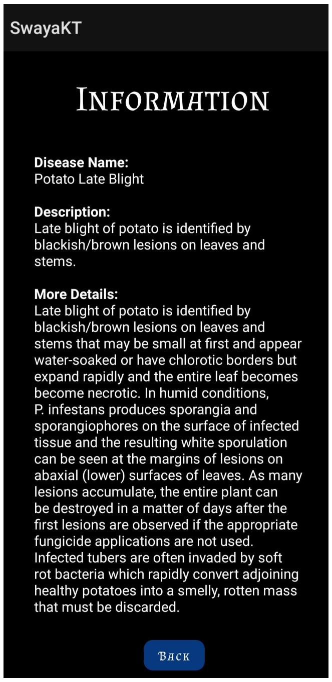

Fig. 6.2.11: Information Page 2

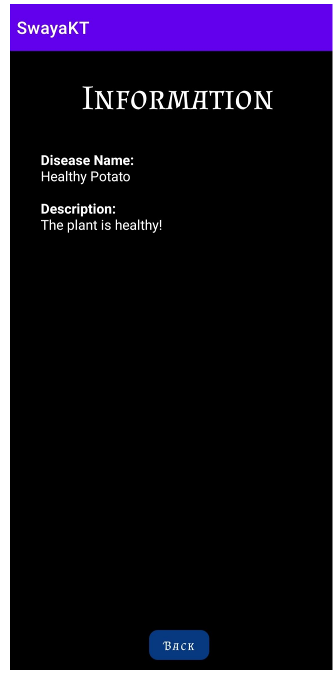

Fig. 6.2.12: Information Page 3

The smart IoT system tab or option contains all the information about the sensors and the overview of the values and the prediction if the soil is good for growing crops.

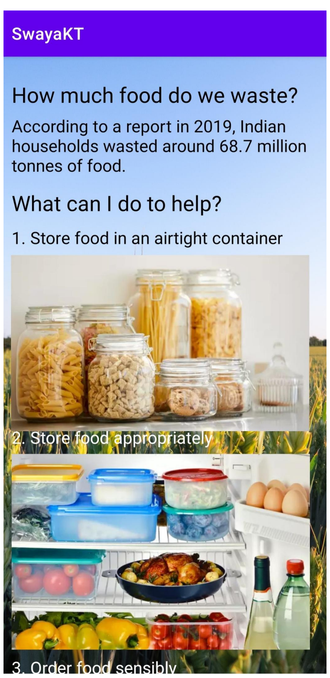

Fig. 6.2.13: FAQ

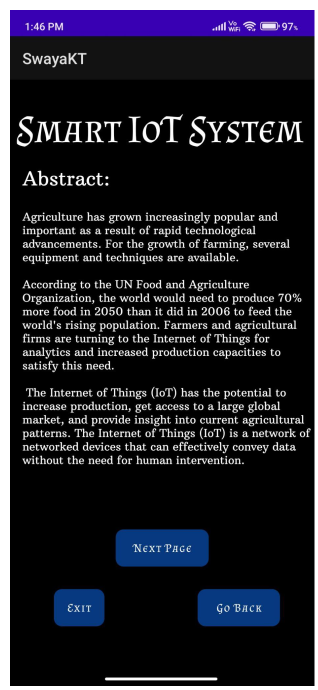

Fig. 6.2.14: Abstract

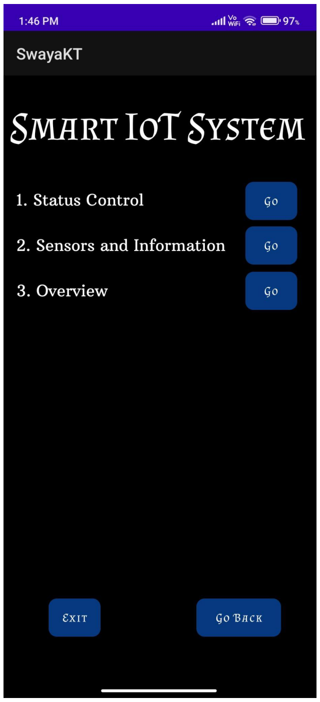

Fig. 6.2.15: Smart IoT System Menu

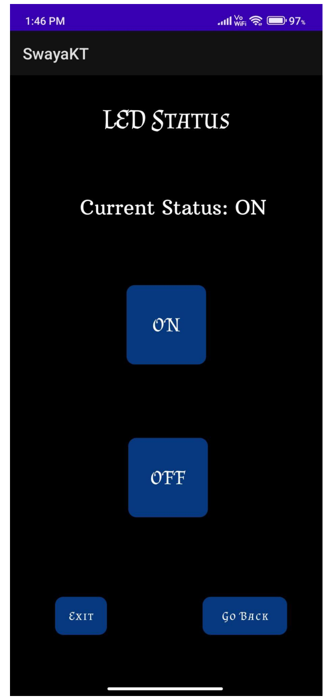

Fig. 6.2.16: LED Status Page

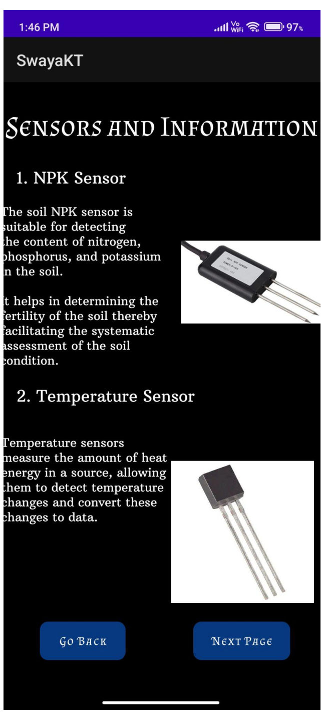

Fig. 6.2.17: Sensor Information 1

Fig. 6.2.18: Sensor Information 2

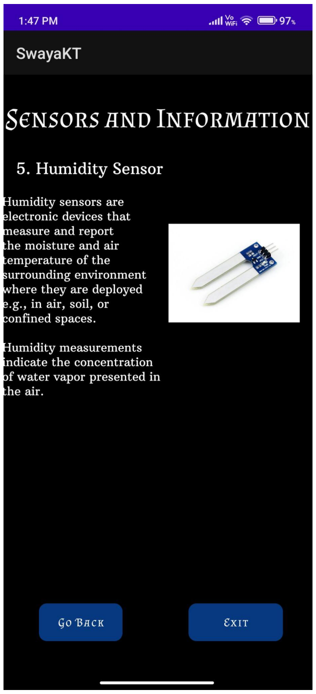

Fig. 6.2.19: Sensor Information 3

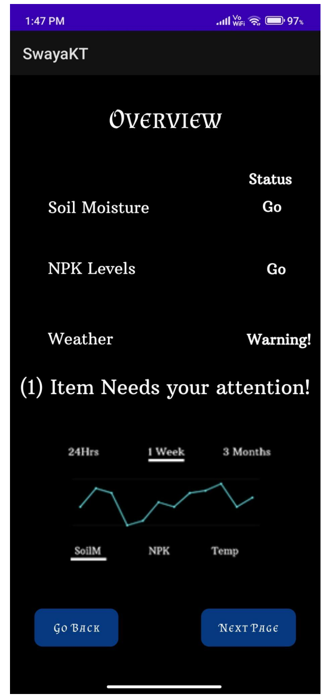

Fig. 6.2.20: Overview 1

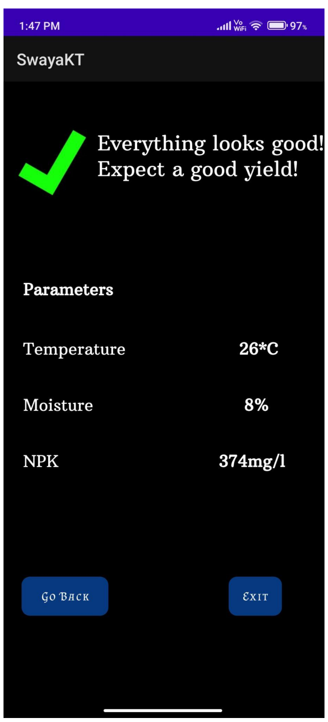

Fig. 6.2.21: Sensor Information 3

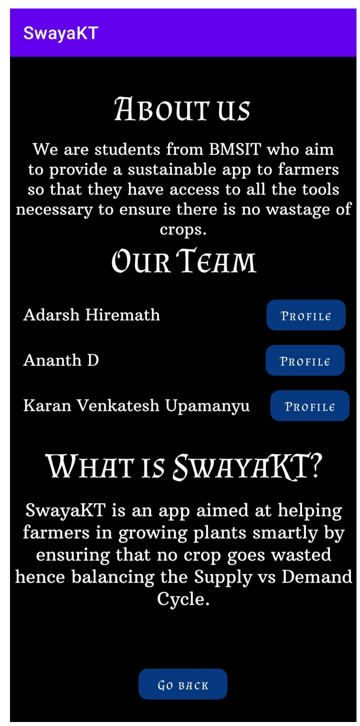

Fig. 6.2.22: About Us

Fig. 6.2.23: Profile 1

Fig. 6.2.24: Profile 2

Fig. 6.2.25: Profile 3

Machine Learning Models:

The models that have been used are implemented in order to prepare the most well connected system that would be helpful in establishing the required requirements. As the architecture consists of ML models at two different levels. One at the farmer's view which would help in modelling and making intelligent decisions in order to make smart decisions. The other for the User's view or the public view, which would model based on the data of the prices and arrival. The different models used have been chosen based on the least RMSE values of the respective models.

Temperature	
Model	**RMSE Value**
GRU	31.4
HMM	26.31
LSTM	**19.7**

The above table depicts the different models used in the decision of a model for Temperature parameter. Among the three, GRU, HMM and LSTM, LSTM provided the least RMSE value of 19.7 for the temperature prediction.

Humidity	
Model	**RMSE Value**
TCN	20.59
Double TCN	**13.88**

The above table depicts the different models used in the decision of a model for Humidity parameter. Among the two, TCN and Double TCN, D-TCN provided the lowest RMSE value of 13.88 for the temperature prediction.

Moisture	
Model	**RMSE Value**
Random Forest	19.45
GTB	**14.87**

The above table depicts the different models used in the decision of a model for Soil Moisture parameter. Among the Random Forest and GTB, GTB provided the least RMSE value of 14.87 for the temperature prediction.

Price and Arrival	
Model	**RMSE Value**
Attention-LSTM	17.45
Wide and Deep	**12.07**

The above table depicts the different models used in the decision of a model for Price and quantity arrival parameters. Among the two Attention-LSTM and, Wide and Deep, where Wide and Deep provided the least RMSE value of 12.07 for the temperature prediction.

CHAPTER 7
CONCLUSION AND FUTURE ENHANCEMENT

CHAPTER 7
CONCLUSION AND FUTURE ENHANCEMENT

7.1 Conclusions

We have built and deployed a mobile application and a react website that enables users who are farmers to interact with the application. The users can view the real time data coming in from the different sensors on the fields and accordingly take the necessary actions. The mobile-based application, that was planned and deployed to change crop data and field information, was the second portion. Large-scale data from the Internet of Things is stored and analysed in this stage. This work made a significant contribution by using data mining with association rules to uncover important information on environmental and climatic effects.

7.2 Limitations

Due to the inaccessibility of the hardware components, we were only able to implement the software side of the project. This is one of the major limitations of the project as the data that we have used in the project is from a dataset where data keeps getting appended daily. This does not resemble real time data coming in from sensors into our system. Due to the lack of funds, we were unable to acquire the components.

While we are trying to solve some of the most prominent problems in the agricultural industry, it goes to say that with the hardware components, we can build an ecosystem that allows a farmer to control most of the farming activities through his smart phone via an app or a website. This reduces the downtime for farmers and also contributes towards efficient farming. In terms of future scope of enhancement, we would like to work on different types of sensors and also include other modules which are showcased in the diagram below.

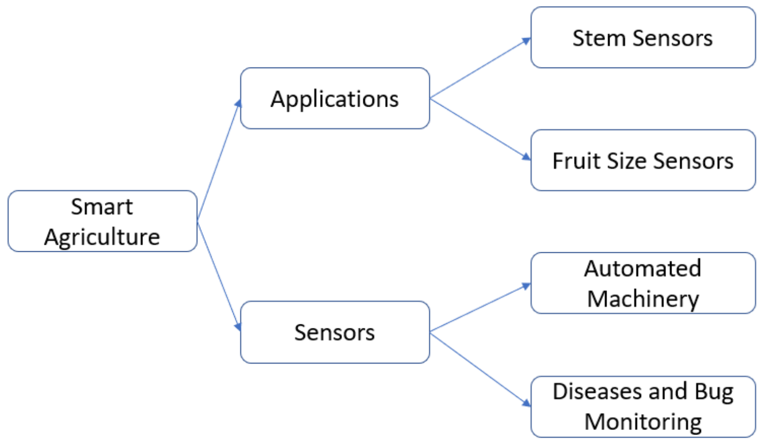

Fig. 7.2: Future Scope

The dataset that has been used is limited by its implementation and its availability by the scope of sensors and the crops from which it can be obtained. From the dataset we can get certain data like the NPK data which cant be directly correlated to the fertiliser regulation by inturn it needs to be done via indirect methods of achieving it.

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APPENDIX A

PLAGIARISM REPORT

B1- SvayaKT Plagiarism Report

ORIGINALITY REPORT

20%	12%	9%	12%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

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