PROJECT PHASE - I REPORT

ON

TECHSOW: INTEGRATED CROP AND SOIL HEALTH MONITORING SYSTEM

Submitted by

NIMITHA JOY (SJC20CS096)

to

the APJ Abdul Kalam Technological University

in partial fulfillment of the requirements for the award of the degree

of

Bachelor of Technology

in

Computer Science and Engineering

Department of Computer Science and Engineering

St. Joseph's College of Engineering and Technology, Palai

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Declaration

I undersigned hereby declare that the project report on **"Techsow: Integrated Crop And Soil Health Monitoring System"**, submitted for partial fulfillment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala, is a bonafide work done by me under supervision of **Prof. Divya Sunny**. This submission represents my ideas in my own words and where ideas or words of others have been included, I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

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Place: Choondacherry

Date: 16-11-2023

ST. JOSEPH'S COLLEGE OF ENGINEERING AND TECHNOLOGY, PALAI

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

CERTIFICATE

This is to certify that the report entitled **"TECHSOW: INTEGRATED CROP AND SOIL HEALTH MONITORING SYSTEM"** submitted by **NIMITHA JOY (SJC20CS096)** to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in Computer Science and Engineering is a bonafide record of the project work carried out by them under my guidance and supervision.

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NIMITHA JOY

Abstract

TechSow will represent a holistic approach to crop and soil health monitoring, offering a comprehensive system for farmers to analyze and enhance the well-being of their cultivated crops. Consisting of two integral components—a mobile application and a rover—TechSow will employ advanced technologies to optimize disease detection and soil fertility assessment. The mobile application will serve as a central hub for disease detection, utilizing a smartphone camera to capture crop leaves. Powered by the YOLO V3 machine learning algorithm, the app will provide detailed disease information and suggest natural remedies for prevention. The application will seamlessly integrate with the rover, allowing users to control its movement and receive real-time data on soil conditions.The rover, equipped with NPK and pH sensors, will autonomously navigate the farm using SLAM technology. Its compact design will facilitate easy traversal between crop plots. The acquired NPK and pH values will be processed by the app, which will then compare them against predefined thresholds for selected crops. Recommendations will be provided to address deficiencies, minimize fertilizer usage, and ensure optimal soil health. Additionally, the app will feature a general fertilizer calculator for efficient crop-specific fertilizer requirements.By utilizing TechSow, farmers will be able to make informed decisions to minimize fertilizer usage, promoting sustainable farming practices and maintaining the health of both crops and soil. This integrated monitoring system will contribute to increased agricultural efficiency, reduced environmental impact, and improved overall crop yield. TechSow will stand as a transformative solution, empowering farmers with cutting-edge technology to make informed and sustainable choices in modern agriculture.

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Chapter 1

Introduction

Precision agriculture will stand at the forefront of modern farming, tackling challenges in soil management, crop health monitoring, and decision-making processes. Traditional methods will often lack real-time insights, resulting in suboptimal agricultural practices and reduced yields. To revolutionize this landscape, TechSow will emerge as an innovative solution, integrating sensors and AI-powered analytics.

By harnessing the power of innovative sensors and AI algorithms, TechSow will endeavor to empower farmers with real-time information essential for making informed decisions. The integration of advanced neural network models and user-friendly interfaces will pave the way for a seamless experience, enabling farmers to access precise soil analysis and disease detection with ease. Through TechSow, the convergence of technology and agriculture will seek to redefine farming practices, enabling efficient resource allocation and sustainable agricultural growth, ultimately contributing to heightened productivity and improved yields.

1.1 Problem Statement

Inappropriate fertilizer application methods, common plant diseases, and inadequate soil health procedures present farmers with significant hurdles in maximizing agricultural yields while controlling expenses. The environmental sustainability of conventional farming practices is reduced and expenses rise as a result of the wasteful use of fertilizers. Crop yields are lowered by inaccurate application, which also wastes resources.[2]

Solution: TechSow presents an innovative agricultural monitoring system to address these challenges effectively. Incorporating advanced sensors and AI-driven analytics, the system offers precise soil nutrient analysis and disease detection in real time. By providing accurate insights into soil health and crop conditions, TechSow optimizes farming practices, enabling farmers to make informed decisions promptly. Additionally, the system's intuitive interface and actionable recommendations empower farmers, ensuring sustainable crop management and increased agricultural productivity.

1.2 Objective and Scope

The primary objective of TechSow is to offer a comprehensive and user-friendly solution for precision agricultural management. Some of the key advantages and objectives include:

- **Disease Detection :** By implementing an AI-driven disease detection system capable of analyzing field images to identify and diagnose plant diseases promptly. Early detection aids in minimizing crop losses by enabling swift intervention and targeted treatments, preserving crop yields and overall farm productivity.

- **Soil NPK Content Analysis:** By implementing a comprehensive soil nutrient analysis system to precisely measure and monitor Nitrogen, Phosphorus, and Potassium levels in the soil helps in the accurate assessment of NPK levels, which allows for tailored fertilization strategies, optimizing nutrient balance crucial for improved crop nutrition and growth.

- **Micronutrients Analysis:** Incorporation of an analysis system capable of assessing essential micronutrients (e.g., iron, zinc) in the soil to support overall plant health. Identifying micronutrient deficiencies facilitates targeted supplementation, ensuring balanced soil fertility and promoting healthier plant development.

- **Soil PH analysis:** A soil pH analysis mechanism, for accurately measuring soil acidity or alkalinity. Understanding soil pH facilitates the creation of optimal growing conditions, aiding nutrient uptake and supporting healthy crop growth.

- **Fertilizer Recommendation System:** Establishing an intelligent system interpreting soil nutrient analysis to generate personalized fertilizer recommendations.

Tailored fertilizer guidance optimizes nutrient management, reduces waste, and promotes sustainable farming practices by maximizing resource efficiency while supporting crop growth.

TechSow aims to be the comprehensive solution for agricultural needs and beyond. Developing an affordable, intelligent prototype is crucial in a rapidly evolving landscape where AI-driven precision agriculture tools are expected to transform farming practices, becoming increasingly indispensable for farmers in various applications.

Chapter 2

Literature Survey

In this literature survey, research papers were studied to understand the current state of the technology and its potential applications. The papers discussed various algorithms for disease detection, rover control, and types of soil, crops, and their requirements.

2.1 Literature Referenced

- **The KITTI Vision Benchmark Suite: A Comprehensive Set of Benchmarks for Autonomous Driving**
  This paper[1] discusses the challenges and opportunities of developing visual recognition systems for autonomous driving, and introduces the KITTI (Karlsruhe Institute of Technology and Toyota Technological Institute) Vision Benchmark Suite as a platform for pushing the performance of state-of-the-art algorithms in real-world scenarios.This platform includes high-end sensors and cameras, such as a Velodyne laser scanner and high-resolution video cameras, that can capture data from multiple viewpoints, enabling algorithms to reconstruct 3D scenes and detect objects in real-time. The KITTI platform is designed for autonomous driving research and development, but the principles and techniques used in the KITTI benchmarks can be applied to smaller-scale robotics projects such as small rovers. However, it is important to adapt the algorithms and sensors to the specific requirements and constraints of the target platform, such as size, weight, power consumption, and environmental conditions.The KITTI Vision Benchmark Suite includes tasks related to obstacle

detection, such as 3D object detection and visual odometry/SLAM. These tasks involve detecting and tracking objects in cluttered real-world scenarios, which is a critical component of autonomous driving systems. The benchmarks are designed to push the performance of state-of-the-art algorithms in obstacle detection and reduce the bias of established datasets that are taken in controlled environments.

- **Image Data Augmentation for Indian Brinjal Plant Disease Detection**
  This paper[2] presents a novel approach to generate a high-quality dataset for Indian Brinjal plant using image data augmentation techniques. The dataset contains 39,010 images for training and 1356 images for validation, which can be used to build deep learning models for disease detection and prediction. The authors highlight the importance of having a good quality dataset for building accurate models and discuss the limitations of using datasets from different geographical locations. The paper also discusses the merits and demerits of various data augmentation techniques used in this research. Overall, this study contributes to the field of computer science and engineering by providing a comprehensive dataset and exploring the potential of image data augmentation for improving the accuracy of disease detection models.

- **Improved Deep Learning for Early Turmeric Disease Detection**
  This paper[3] proposes an improved deep learning algorithm for the early detection of major diseases in turmeric plants. The proposed algorithm, called IY3TM, is based on the YOLOV3-Tiny model and includes two convolutional layers of 3x3 and 1x1 to improve feature propagation and reuse. The algorithm is trained on a dataset of 1,600 images of turmeric leaves captured at different times and under different illumination conditions. The dataset is augmented using Cycle-GAN to improve detection accuracy. The experimental results show that the IY3TM model outperforms other deep learning models, including YOLO-V2, YOLO-V3, YOLOV3-tiny, and faster RCNN with VGG-16, in terms of F1 score, detection speed, and AUC values. The proposed algorithm can accurately detect major turmeric diseases, including leaf spot, leaf blight, and rhizome rot, at an early stage, preventing production loss and crop failure. The proposed algorithm can be extended to other vital diseases in turmeric leaf and other important crops. Overall, the proposed IY3TM model is a

promising approach for the early detection of major diseases in turmeric plants.

- **Plant Disease Identification Using a Novel Convolutional Neural Network**

  This study[4] introduces an innovative CNN model, drawing inspiration from Inception and residual connections, for efficient plant disease classification. The model incorporates depthwise separable convolution, reducing computational costs by 70% and enabling faster training compared to standard CNNs. Results demonstrate superior performance, achieving testing accuracies of 99.39%, 99.66%, and 76.59% on Plantvillage, Rice, and Cassava datasets, respectively. The model outperforms previous studies, especially on imbalanced datasets. Future research aims to extend the model's application to weed detection and pest identification, exploring its performance across diverse plant disease datasets, image varieties, and geographical regions. The integration of clustering-based unsupervised techniques for disease identification is identified as a promising avenue. This comprehensive approach highlights the proposed model's potential in advancing plant disease identification and addressing broader agricultural challenges."

- **Navigation System of the Autonomous Agricultural Robot - BoniRob**

  The paper[5] delves into the navigation system of the autonomous agricultural robot "BoniRob," emphasizing a four-layered software architecture: drivers, reactive, semantic, and planning layers. In the drivers layer, modules handle sensor data, interfacing with BoniRob's drive control. The reactive layer processes data for ground and row detection, localization, and mapping. The semantic layer classifies environments using a probabilistic state automaton. The planning layer manages the application state machine and configuration, coordinating data flow and activating driving skills. Sensors, including a 3D MEMS lidar and inertial sensor unit, enhance navigation, with the lidar's resilience to sunlight being a notable advantage. The system's flexibility accommodates changes in navigation classes and applications while maintaining the overall software architecture. In essence, BoniRob's navigation employs sensor data processing, detection, localization, and mapping techniques, ensuring adaptability and robust autonomous operation in agricultural settings

- **Detection of NPK nutrients of soil using Optical Transducer**

  The developed optical transducer, comprising LEDs, a photodiode, and an Arduino microcontroller, proves effective in detecting Nitrogen (N), Phosphorus (P), and Potassium (K) in soil. By leveraging absorption light of each nutrient, the transducer determines NPK values through LEDs emitting wavelengths tailored to nutrient absorption bands. The Arduino microcontroller facilitates data acquisition, converting transducer output into digital display readings. Testing on diverse soil samples demonstrates the system's capability to assess NPK content as High, Medium, or Low. The inferred conclusion from this paper [6] is that this cost-effective and efficient optical transducer offers a valuable tool for gauging nutrient deficiencies in soil, aiding in precision fertilization. The system's potential impact includes improving soil fertility, optimizing fertilizer use, and contributing to enhanced crop quality and quantity while minimizing environmental repercussions.

- **Soil type classification and estimation of soil properties using support vector machines**

  The paper[7] explores the application of Support Vector Machines (SVM) in predicting soil properties and classifying soil types based on chemical and physical properties. SVM outperforms linear regression models for estimating physical properties and pH when using only chemical data inputs, especially when these inputs are not strongly correlated to the property being estimated. In soil type classification, SVM performs similarly to other methods but gains an advantage with a small number of training samples per soil type. The study emphasizes the efficiency of SVM in small data sets, contrasting with its common application in large-scale observations. The paper concludes by comparing classification methods using cross-validation protocols and highlighting the potential of Logistic Regression and Linear SVM for automating soil type classification tasks with satisfactory accuracy.

2.2 Existing Solutions

2.2.1 Plantix

Plantix [8] helps farmers diagnose and treat crop problems, improve productivity and provide farmer knowledge. The app claims to diagnose pest damages, plant diseases and nutrient deficiencies affecting crops and offers corresponding treatment measures. Users can participate in the online community where they find scientists, farmers and plant experts to discuss plant health issues. Farmers can access local weather, get good agricultural advice throughout the season and receive disease alerts once a disease is spreading in their surrounding.

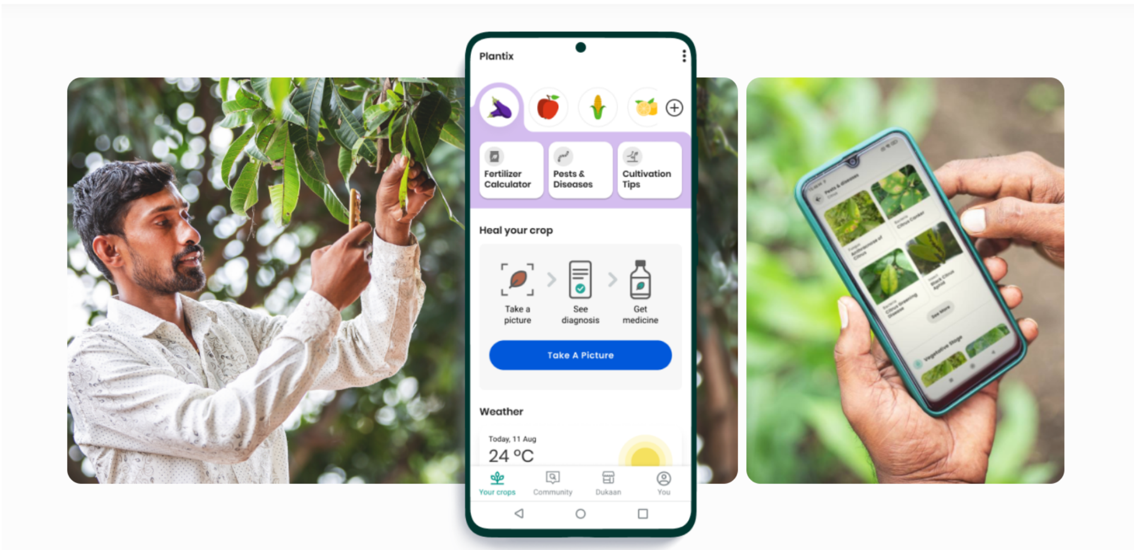

Figure 2.1: UI of Plantix App

Chapter 3

Requirement Analysis

3.1 On-site assessment

In the initial phase of our project, requirements were collected from a farmer in Wayala, highlighting the imperative for precision agriculture in modern farming. A comprehensive understanding was sought by engaging with an Agriculture graduate. The project's scope was refined to focus on a fixed area, specifically targeting poly farms and modern agricultural practices.

To further delineate our objectives, specific tasks were identified. These included meetings with conventional farmers, conducting soil testing at Kozha farm, exploring modern farming techniques such as poly house and rain shelters, implementing fertigation, considering rooftop farming, and conducting an in-depth study of soil types. Additionally, the assessment of student NPK levels for various crops and understanding soil characteristics emerged as pivotal tasks in our requirements analysis.

However, certain limitations were identified during this analysis. The implementation of our project on a large scale farm proved challenging, considering the prevalent practice of crop rotation and the reluctance of conventional farmers to regularly check NPK and pH levels. The non-uniform climate in Kerala and the diverse terrain with varying soil types further posed challenges. Acknowledging these limitations, we concluded that our project would be most effective in poly farms and modern agricultural settings, focusing on a specific area with different crops. It was emphasized that farmers adopting this technology should maintain crops without discrimination.

Considering the farmers' point of view, it was revealed that approximately 80% of them did not regularly check soil moisture or NPK levels. The prevailing practice of mixing nutrients only when the soil is dry after a harvest was highlighted. Notably, in Kerala, large-scale farms suitable for this project were found to be scarce. Farmers were identified as needing a solid understanding of both crops and soil types, demanding accurate and deterministic results rather than probabilistic ones. The emphasis was placed on precision agriculture, checking soil acidity, and advocating for a focus on soil fertility. Additionally, the recommendation was made to concentrate on one crop or plantation, discouraging crop rotation in favor of stability. The farmers' preference for mixed cropping, driven by the availability of alternative options for selling in case of crop failure, was also taken into account in the project requirements.

3.2 Software requirements

3.2.1 Functional Requirements :

Capture high-resolution crop leaf images using the device's camera.

The module should integrate with the smartphone camera to capture clear and high-resolution images of crop leaves. It should ensure optimal image quality and preprocessing to ensure accurate disease detection.

Enhance and segment crop leaf images for further analysis.

The module should perform image enhancement techniques, such as noise reduction and contrast adjustment, to prepare the images for further analysis. It should segment the leaf region from the background to isolate the affected area for disease identification.

Utilize a pre-trained machine learning model for disease detection.

The module should utilize a pre-trained machine learning model, such as YOLO v3, to analyze the segmented leaf region and identify potential diseases. The model should classify the detected objects based on their characteristics and patterns.

Provide accurate and timely disease detection for various plant diseases

The module should provide accurate and timely disease detection for a wide range of plant diseases. It should associate the identified diseases with relevant information and recommendations for treatment or preventative measures.

Display disease detection results and recommendations within the mobile application.

The module should integrate with the mobile application's user interface to display the captured image, disease detection results, and recommendations. It should provide a clear and intuitive interface for farmers to easily access and interpret disease detection information.

Allow users to select the specific crop they are cultivating.

The module should present a user interface that allows farmers to select the specific crop they are cultivating. It should provide a comprehensive list of commonly cultivated crops, ensuring that farmers can easily find the relevant crop information.

Retrieve NPK values from an integrated database based on the selected crop.

Upon crop selection, the module should retrieve the corresponding NPK (Nitrogen, Phosphorus, Potassium) values from an integrated database. It should ensure that the retrieved NPK values are accurate and reflect the recommended nutrient requirements for the selected crop.

Allow users to enter the cultivated area in hectares or acres.

The module should provide an input field for farmers to enter the cultivated area in hectares or acres. It should validate the input to ensure that the area is specified in a valid format and within a reasonable range.

Calculate the required amount of fertilizer for each nutrient component (N, P, K) based on the selected crop's NPK values and cultivated area.

Based on the selected crop's NPK values and the cultivated area, the module should calculate the required amount of fertilizer for each nutrient component (N, P, K). It should employ formulas and algorithms that consider the crop's nutrient demand and the cultivated area to determine the appropriate fertilizer quantities.

Present the calculated fertilizer requirements in a clear and understandable format.

The module should present the calculated fertilizer requirements in a clear and understandable format, including the quantity of each fertilizer type (urea, DAP, MOP, etc.) needed. It should provide farmers with specific recommendations on how and when to apply the calculated fertilizer amounts.

Integrate seamlessly with the TechSow mobile application's user interface.

The rover should integrate seamlessly with the TechSow mobile application's user interface, ensuring a smooth user experience. It should provide a user-friendly interface that is easy to navigate and understand, even for farmers with limited technical expertise.

3.2.2 Non - Functional Requirements

Performance

- Real-time image processing and disease detection for efficient crop monitoring.
- Minimize image processing latency to ensure timely disease identification.
- Efficient fertilizer calculations for various crops and cultivated areas.
- Timely generation of fertilizer recommendations.
- Seamless communication between the mobile application and the rover.
- Real-time transmission of sensor data and control signals.
- Responsive rover movement control for effective navigation.
- Efficient processing of sensor data for micronutrient estimation.
- Timely generation of micronutrient deficiency identification.
- Efficient fertilizer recommendation generation based on soil nutrient analysis.
- Timely provision of fertilizer recommendations for optimal crop nutrition.

Reliability

- Accurate disease detection with minimal false positives or false negatives.
- Robustness to varying image quality and lighting conditions.
- Accurate fertilizer calculations based on established agricultural guidelines.
- Consideration of soil conditions and crop nutrient requirements.
- Secure and stable communication link for uninterrupted remote control.
- Accurate and reliable sensor data acquisition.
- Robustness to environmental factors and potential interference.
- Accurate micronutrient estimation based on established soil science principles.
- Consideration of soil pH and NPK values for micronutrient assessment.
- Accurate fertilizer recommendations based on established agricultural guidelines.
- Consideration of crop nutrient requirements and soil conditions.

Security

– Protection of sensitive crop data and user information.

– Implementation of secure communication protocols for data exchange.

Usability

– Intuitive and user-friendly interface for easy operation.

– Clear and concise presentation of disease detection results and recommendations.

– Simple and straightforward interface for crop selection and area input.

– Clear and understandable presentation of fertilizer recommendations.

– Intuitive and user-friendly interface for rover control and sensor data monitoring.

– Clear visualization of sensor data and rover status.

– Clear and understandable presentation of micronutrient analysis results.

– Recommendations for micronutrient supplementation tailored to specific soil conditions.

– Clear and understandable presentation of fertilizer recommendations.

– Specific recommendations for fertilizer type, quantity, and application timing.

3.3 Hardware Requirements

3.3.1 Smartphone with high-resolution camera

– Capture high-resolution crop leaf images with sufficient clarity for disease detection.

– Ensure adequate lighting conditions for optimal image quality.

– Provide sufficient processing power for real-time image processing and machine learning model execution.

3.3.2 Smartphone with adequate processing power and storage

- Provide sufficient processing power to handle fertilizer calculations and database interactions.
- Offer adequate storage capacity to store crop NPK data and fertilizer recommendations.
- Ensure a user-friendly interface for inputting crop selection and cultivated area.
- Provide sufficient processing power to handle fertilizer calculation algorithms.
- Offer adequate storage capacity to store crop NPK data and fertilizer recommendations.
- Ensure a user-friendly interface for displaying fertilizer recommendations.

3.3.3 Rover with communication module, sensors, and control system

- Establish a secure and reliable connection with the TechSow mobile application.
- Transmit pH and NPK sensor data to the TechSow mobile application.
- Support appropriate communication protocols, such as Wi-Fi or Bluetooth, for data exchange.
- Ensure sufficient range for remote rover control within the farm.
- pH sensor: Accurately measure soil pH levels.
- NPK sensors: Precisely measure soil nitrogen, phosphorus, and potassium levels.
- Provide real-time sensor data transmission to the rover's communication module.
- Receive and interpret control signals from the TechSow mobile application.
- Effectively control the rover's movement, including forward, backward, left, and right maneuvers.
- Implement safety mechanisms to prevent collisions or hazardous movements.

3.4 Module Description

3.4.1 Image Processing for Disease Detection

This module provides real-time disease detection capabilities for the TechSow mobile application. It utilizes image processing techniques and machine learning models to analyze crop leaf images captured using the device's camera and identify potential diseases.

Functionalities

- Image Capture:
  The module integrates with the smartphone camera to capture clear and high-resolution images of crop leaves. It ensures optimal image quality and preprocessing to ensure accurate disease detection.

- Image Processing:
  The module performs image enhancement techniques, such as noise reduction and contrast adjustment, to prepare the images for further analysis. It segments the leaf region from the background to isolate the affected area for disease identification.

- Machine Learning Model Integration:
  The module utilizes a pre-trained machine learning model, such as YOLO v3, to analyze the segmented leaf region and identify potential diseases. The model classifies the detected objects based on their characteristics and patterns.

- Disease Detection and Diagnosis:
  The module provides accurate and timely disease detection for a wide range of plant diseases. It associates the identified diseases with relevant information and recommendations for treatment or preventative measures.

– User Interface Integration:

The module integrates with the mobile application's user interface to display the captured image, disease detection results, and recommendations. It provides a clear and intuitive interface for farmers to easily access and interpret disease detection information.

3.4.2 Fertilizer Calculator

This module provides a user-friendly interface for calculating the appropriate fertilizer requirements for different crops and their cultivated areas. It assists farmers in optimizing fertilizer usage, promoting sustainable agricultural practices, and enhancing crop yield.

Functionalities

– Crop Selection:

The module presents a user interface that allows farmers to select the specific crop they are cultivating. It provides a comprehensive list of commonly cultivated crops, ensuring that farmers can easily find the relevant crop information.

– NPK Retrieval:

Upon crop selection, the module retrieves the corresponding NPK (Nitrogen, Phosphorus, Potassium) values from an integrated database. It ensures that the retrieved NPK values are accurate and reflect the recommended nutrient requirements for the selected crop.

– Area Input:

The module provides an input field for farmers to enter the cultivated area in hectares or acres. It validates the input to ensure that the area is specified in a valid format and within a reasonable range.

– Fertilizer Calculation:

Based on the selected crop's NPK values and the cultivated area, the module calculates the required amount of fertilizer for each nutrient component (N, P, K). It employs formulas and algorithms that consider the crop's nutrient demand and the cultivated area to determine the appropriate fertilizer quantities.

- Recommendation Output:

  The module presents the calculated fertilizer requirements in a clear and understandable format, including the quantity of each fertilizer type (urea, DAP, MOP, etc.) needed. It provides farmers with specific recommendations on how and when to apply the calculated fertilizer amounts.

- User Interface Integration:

  The module integrates seamlessly with the TechSow mobile application's user interface, ensuring a smooth user experience. It provides a user-friendly interface that is easy to navigate and understand, even for farmers with limited technical expertise.

3.4.3 Rover Control

This module establishes seamless communication between the TechSow mobile application and the rover, enabling remote control of the rover's movement and real-time data acquisition from its sensors. It provides farmers with the ability to monitor and manage the rover's operations directly from their mobile devices.

Functionalities

- Rover Connection:

  The module establishes a secure connection between the mobile application and the rover using appropriate communication protocols, such as Wi-Fi or Bluetooth. It ensures reliable and consistent communication, enabling real-time data exchange and control signals.

- Rover Movement Control:

  The module provides a user interface within the mobile application that allows farmers to control the rover's movement. It includes controls for forward, backward, left, and right movements, enabling farmers to navigate the rover within the farm.

- Sensor Data Acquisition:

  The module receives real-time data from the rover's sensors, including pH and NPK values. It processes the sensor data to ensure accuracy and consistency, providing farmers with reliable information about soil conditions.

- Data Display:

  The module presents the acquired sensor data in a clear and understandable format within the mobile application. It displays real-time pH and NPK values, enabling farmers to monitor soil conditions and make informed decisions regarding fertilizer application.

- User Interface Integration:

  The module seamlessly integrates with the TechSow mobile application's user interface, providing a unified platform for rover control and sensor data monitoring. It ensures a user-friendly interface that is easy to navigate and understand, allowing farmers to easily control the rover and access sensor data.

3.4.4 Soil Micronutrient Measurement

This module extracts and analyzes soil micronutrient levels based on the pH and NPK values obtained from the rover's sensors. It provides farmers with insights into the overall soil health and enables them to take preventive measures to maintain optimal soil conditions.

Functionalities

- pH and NPK Analysis:

  The module analyzes the pH and NPK values received from the rover sensors, identifying potential imbalances or deficiencies. It compares the measured values against predefined soil nutrient reference ranges to assess the overall soil health.

- Micronutrient Determination:

  Based on the pH and NPK analysis, the module estimates the levels of micronutrients, such as calcium, magnesium, sulfur, and iron, in the soil. It employs soil nutrient equations and empirical relationships to derive these estimates.

- Micronutrient Deficiency Identification:

  The module identifies potential micronutrient deficiencies based on the estimated micronutrient levels and soil reference ranges. It provides farmers with clear indications of which micronutrients are lacking in the soil.

- Recommendations for Micronutrient Supplementation:

  The module recommends appropriate measures for micronutrient supplementation to address any identified deficiencies. It suggests suitable organic or inorganic sources of micronutrients, taking into account soil pH and crop requirements.

- Data Visualization:

  The module presents the analyzed soil micronutrient data in a clear and understandable format within the mobile application. It includes charts, graphs, and tables to effectively visualize the micronutrient levels and identify trends.

– User Interface Integration:

The module seamlessly integrates with the TechSow mobile application's user interface, providing a unified platform for soil micronutrient monitoring and analysis. It ensures a user-friendly interface that is easy to navigate and understand, allowing farmers to easily access micronutrient data and recommendations.

3.4.5 Fertilizer Recommendation

This module provides farmers with tailored fertilizer recommendations based on the analyzed NPK values obtained from the rover's sensors. It recommends specific fertilizers and quantities to address any identified nutrient deficiencies, optimizing fertilizer usage and promoting sustainable agricultural practices.

Functionalities:

– NPK Deficiency Analysis:

The module analyzes the NPK values received from the rover sensors and compares them to predefined soil nutrient reference ranges. It identifies potential nutrient deficiencies, focusing on nitrogen (N), phosphorus (P), and potassium (K).

– Fertilizer Recommendation Generation:

Based on the identified nutrient deficiencies, the module generates specific fertilizer recommendations. It suggests appropriate fertilizers, such as urea, DAP (Diammonium Phosphate), and MOP (Muriate of Potash), to address the deficiencies.

– Fertilizer Quantity Calculation:

The module calculates the required quantities of each recommended fertilizer based on the crop type, cultivated area, and severity of nutrient deficiencies. It employs formulas and algorithms that consider crop nutrient requirements and soil conditions to determine the optimal fertilizer quantities.

- Application Timing Recommendations:
  The module provides recommendations for the timing of fertilizer application, ensuring optimal nutrient uptake by the crops. It considers crop growth stages, soil conditions, and weather patterns to suggest appropriate application timings.

- Data Presentation:
  The module presents the fertilizer recommendations in a clear and understandable format within the mobile application. It includes fertilizer type, quantity, and application timing recommendations, along with explanations of the rationale behind the recommendations.

- User Interface Integration:
  The module seamlessly integrates with the TechSow mobile application's user interface, providing a unified platform for fertilizer recommendation generation and access. It ensures a user-friendly interface that is easy to navigate and understand, allowing farmers to easily access and implement fertilizer recommendations.

3.5 Technology Stack

1. Codebase : Flutter - Flutter serves as the codebase for TechSow, providing a robust framework for developing cross-platform mobile applications. Its single codebase allows for seamless deployment on multiple platforms like Android and iOS.

2. Backend : FireBase - Firebase, a comprehensive mobile and web development platform by Google, powers TechSow's backend. It offers features like real-time database, authentication, hosting, and cloud functions, enabling efficient data storage, retrieval, and user authentication for the application.

3. Tensorflow - TensorFlow, an open-source machine learning framework, plays a crucial role in TechSow's AI-driven functionalities. It supports building and training machine learning models for various tasks such as disease detection, soil analysis, and predictive analytics.

4. Kaggle - Kaggle, a popular platform for data science and machine learning, provides datasets crucial for training and testing machine learning models within TechSow. These datasets might include agricultural data, soil characteristics, crop health indicators, etc. The disease-affected images of the crops are available in Kaggle.

5. Yolo V3 Tiny - YOLO (You Only Look Once) V3 Tiny is an object detection model that TechSow utilizes specifically for disease detection in plants. This model enables real-time detection of diseases in agricultural produce, ensuring prompt identification and management.

Chapter 4

System Design

4.1 Use Case Diagram

The Use Case Diagram outlines how users interact with various functionalities provided by TechSow, covering aspects like soil analysis, disease detection, connectivity, and fertilizer recommendation system. The use case diagram is shown in Figure 4.1.

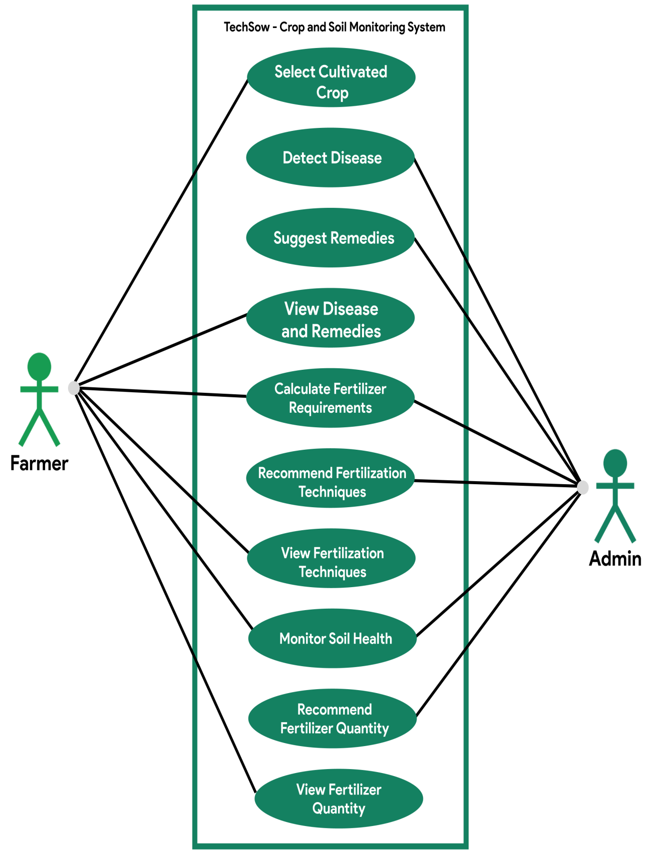

Figure 4.1: Use case diagram for TechSow

4.2 Activity Diagram

The activity diagram visually represents the flow of activities or actions within the TechSow system. For TechSow, the activity diagram could illustrate the sequence of actions involved in analyzing soil and managing crop health. The activity diagram for TechSow is given below in Figure 4.2.

After authentication and completing soil analysis, it proceeds to the soil fertilizer recommendation from the input from the rover. Depending on the outcome of disease detection, TechSow generates a disease report on the crop.

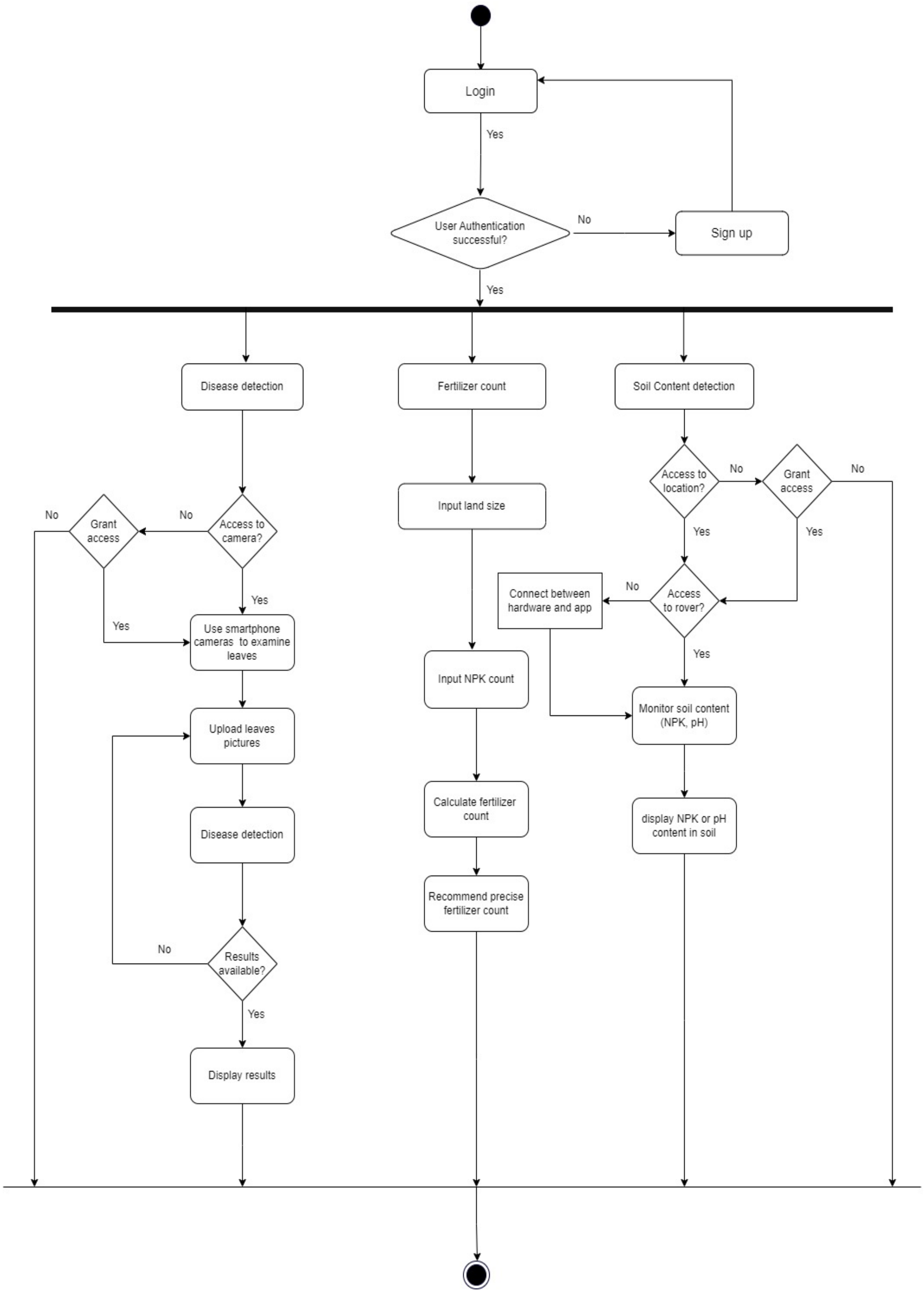

Figure 4.2: Activity Diagram for TechSow

4.3 Sequence Diagram

The TechSow project's sequence diagram, depicted in Figure 4.3 using Unified Modeling Language (UML), outlines interactions between key modules: Farmer, TechSow, Camera, AI module, and Rover. The farmer selects the crop, and for disease detection, the camera captures images processed by the AI module. Simultaneously, the rover provides NPK and pH values, which the app compares with thresholds to offer fertilizer recommendations, optimizing soil conditions for the chosen crop. This concise representation illustrates the dynamic collaboration among modules for efficient crop management in TechSow.

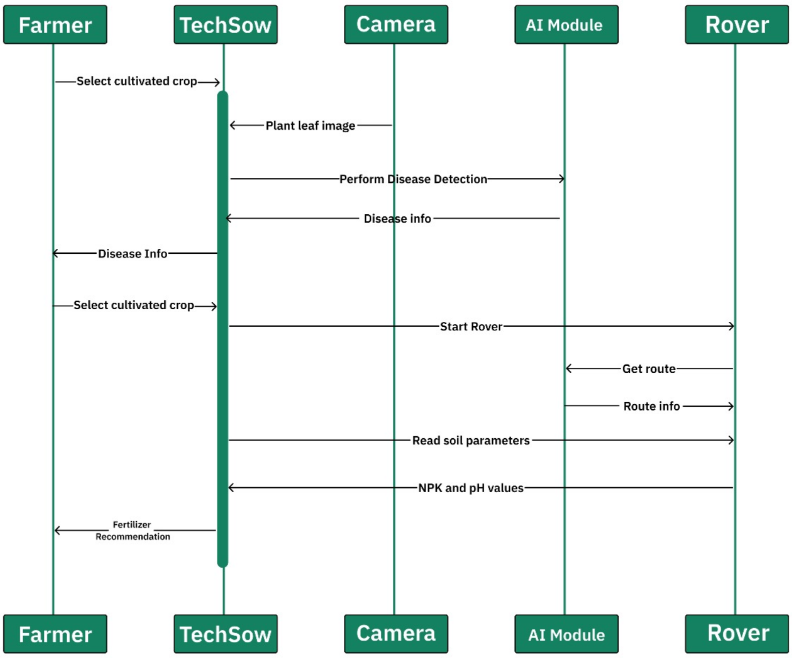

Figure 4.3: Sequence diagram for TechSow

4.4 Schema Diagram

The schema diagram for the TechSow project depicts a relational database model consisting of multiple tables.The "Crops" table is identified by a primary key, Crop ID, and correlates with the "Land" and "Farmer" tables, where Farmer ID serves as the primary key. Additionally, there are tables such as FertilizerRecommendation, DiseaseDetectionInput, PredictionResult,Fertilizers,ImageData, CropsDiseaseDetection, DiseaseInfo, and TrainingData, each designed to fulfill specific data storage and retrieval functions within the crop and soil health monitoring system. The interconnectivity of these tables is established through primary and foreign key relationships, ensuring data integrity and facilitating efficient querying and analysis for tasks like disease detection, fertilizer recommendation, and crop management in the TechSow platform.

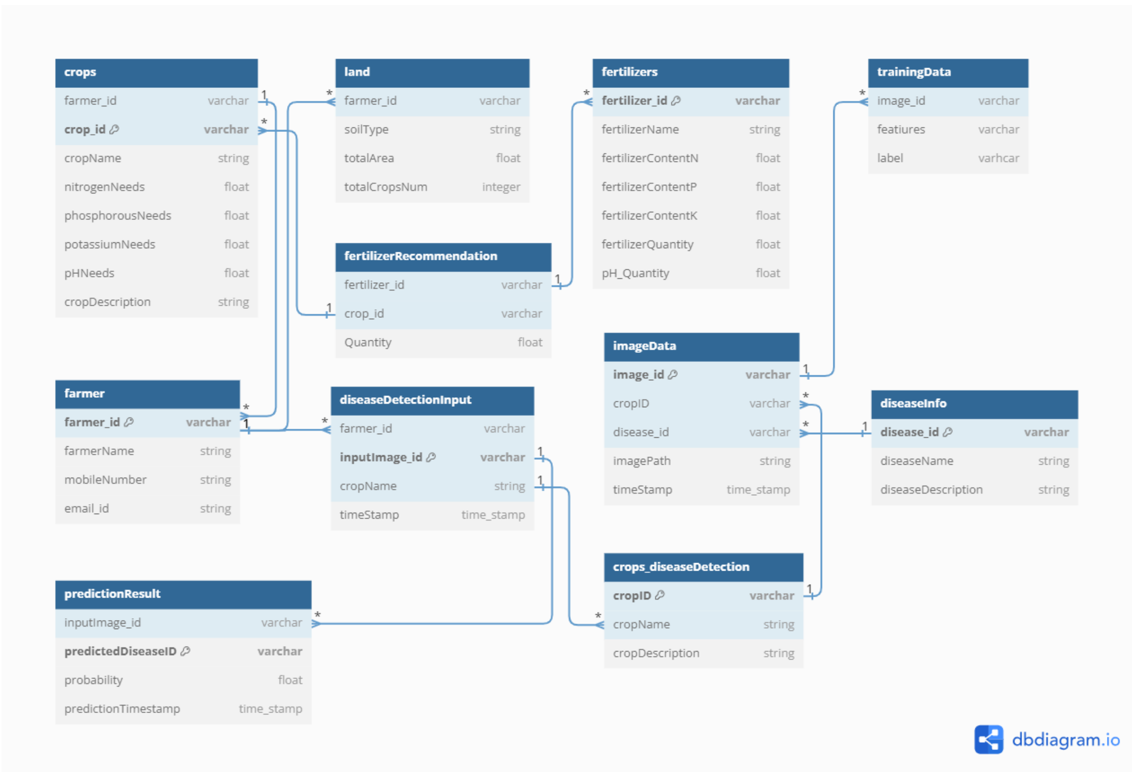

Figure 4.4: Schema diagram for TechSow

4.5 UI Diagram

Figure 4.4 depicts the UI diagram for the TechSow project and illustrates the user interface elements and their connections to facilitate efficient communication between the user and the system. The primary user interactions involve selecting crops, monitoring disease detection, and receiving fertilizer recommendations. The UI elements are designed to provide a user-friendly experience and enable seamless navigation through the various functionalities of the application.

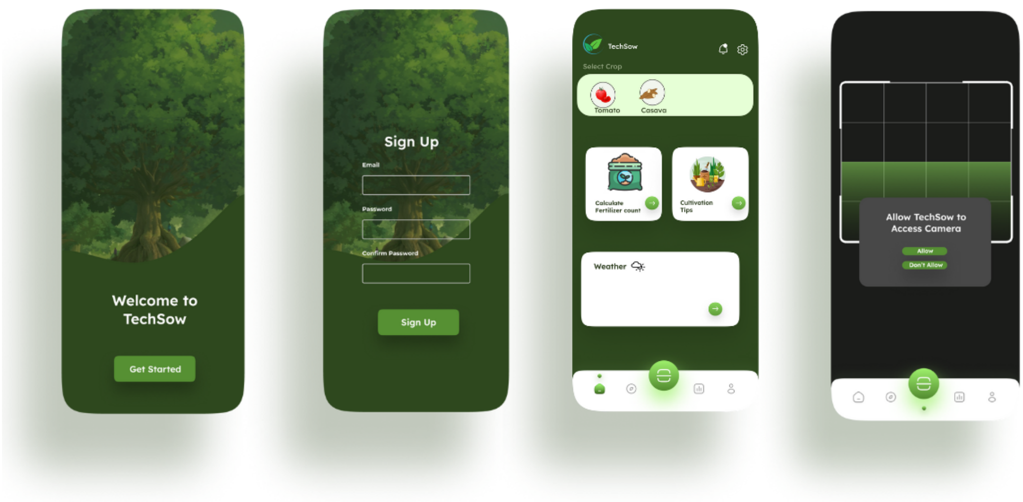

Figure 4.5: UI diagram for TechSow

The UI diagram depicted in Figure 4.5 is designed to illustrate the user interface elements associated with the process of connecting the application to a rover in the context of the TechSow project. The primary goal of this UI is to provide farmers with a seamless and intuitive experience for establishing a connection to the rover and subsequently tracking its real-time movement.

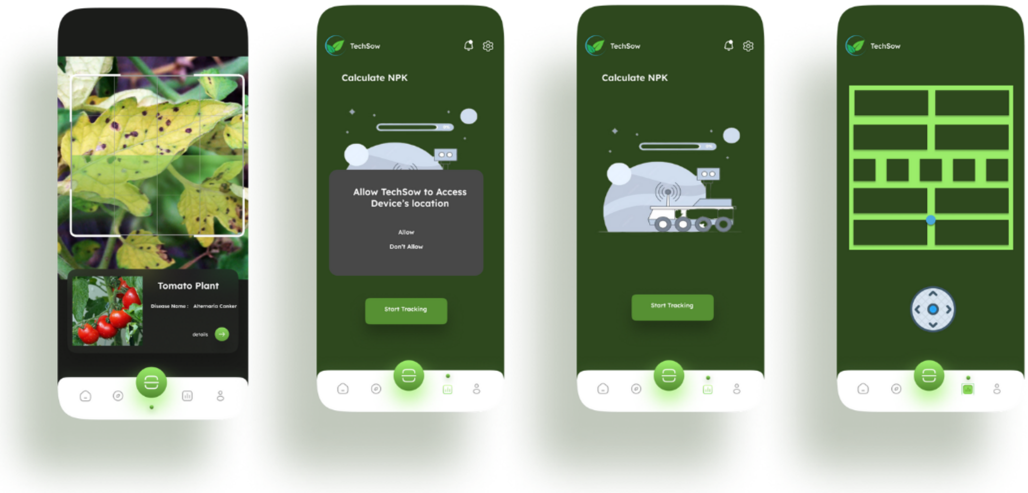

Figure 4.6: UI diagram for TechSow

4.6 Hardware Design

4.6.1 Hardware block diagram

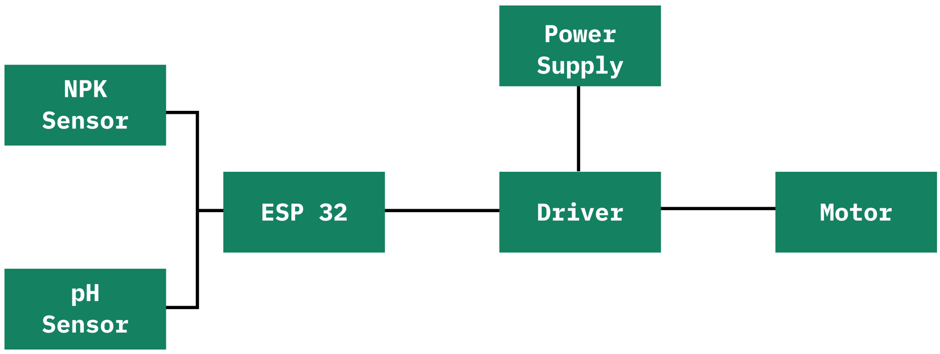

Figure 4.7: Hardware block diagram for TechSow

The rover's hardware block diagram illustrates the interconnected components that enable its operation. The microcontroller serves as the rover's central processing unit, receiving sensor data, interpreting it, and generating control signals. Motor drivers act as intermediaries between the microcontroller and the rover's motors, translating signals into power for movement.Sensors such as pH sensor and NPK sensor reads pH and NPK values of the soil. A communication module facilitates data exchange between the rover and external devices, enabling remote control and monitoring. This well-structured hardware design enables autonomous navigation and remote control capabilities, making the rover a versatile tool for various applications.

4.6.2 Rover Sketch

This is the sketch of the rover we are going to implement, designed to navigate diverse environments and perform various tasks. The rover's operation is orchestrated by a central microcontroller, which receives data from sensors that provide real-time information about its surroundings. Motor drivers translate these signals

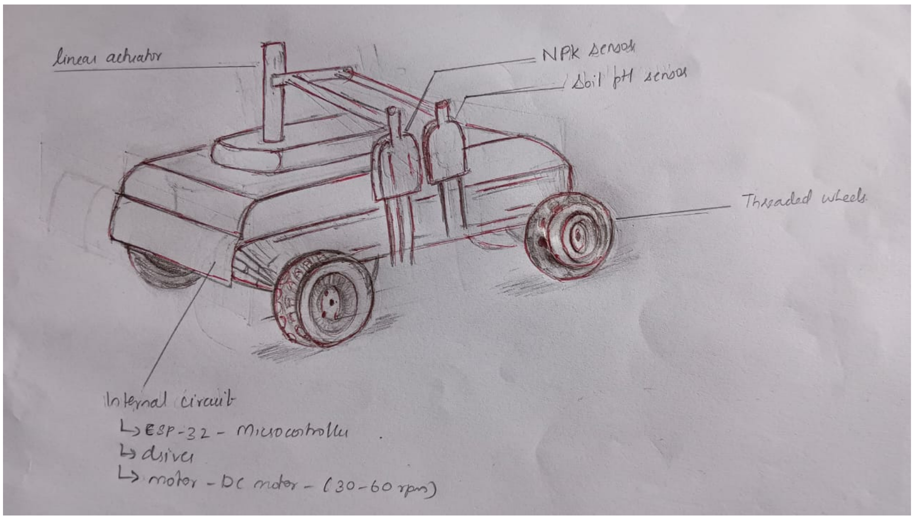

Figure 4.8: Sketch of rover for TechSow

into power, enabling the rover's movement. A communication module facilitates data exchange and remote control, while the rover's power supply ensures continuous operation. This well-structured system empowers the rover to adapt to different conditions and perform tasks as instructed.

4.6.3 Hardware Components

1. NPK Sensor - The NPK (Nitrogen, Phosphorus, Potassium) sensor (Figure 4.9) within TechSow is a vital hardware component designed to measure and analyze the levels of the key nutrients in the soil. It provides real-time data on soil fertility, allowing farmers to make informed decisions regarding fertilizer application and nutrient management. The sensor's accuracy in detecting NPK levels assists in optimizing crop health and improving agricultural productivity by ensuring adequate nutrient supply for plant growth.

Figure 4.9: NPK sensor for TechSow

2. pH Sensor - The pH sensor (Figure 4.10) is responsible for measuring the acidity or alkalinity levels of the soil. It offers precise readings of soil pH, a crucial parameter influencing nutrient availability to plants. By providing accurate pH data, this sensor aids farmers in determining optimal soil conditions for specific crops. It enables adjustments in soil pH levels, ensuring suitable environments for nutrient uptake and fostering healthier plant growth.

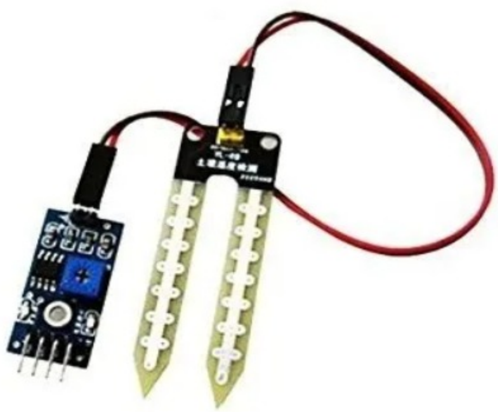

Figure 4.10: pH sensor for TechSow

3. ESP32 Microcontroller - The ESP32 microcontroller (Figure 4.11) serves as the central processing unit in TechSow's hardware setup. It facilitates communication between the sensors (such as NPK and pH sensors), the application interface, and the cloud platform. Its versatility and connectivity features enable seamless data collection, processing, and transmission from the sensors to the application. The ESP32 ensures efficient IoT integration, empowering the system to gather real-time agricultural data for analysis and decision-making.

Figure 4.11: ESP32 Microcontroller

4. DC Motor - The DC (Direct Current) motor shown in Figure 4.12 will play a pivotal role in rover movement and functionality. It enables precise and controlled motion, allowing the rover to navigate through agricultural fields for various tasks such as actuator movement for soil analysis, or other movement along the field. The motor's reliable operation ensures the rover's agility and maneuverability, enabling it to perform designated agricultural operations effectively within the farm environment.

Figure 4.12: DC Motor

Conclusion

Ensuring sustainable agriculture demands a concerted effort to tackle the hurdles confronting farmers in detecting soil nutrient content and identifying crop diseases. Addressing these challenges head-on is not just necessary but pivotal for the future of farming. The integration of innovative technological solutions stands as a beacon of hope in this endeavor, promising a transformative shift in agricultural practices. By leveraging advancements in technology, we can equip farmers with tools and systems that revolutionize how they manage their crops, leading to improved yields while conserving crucial resources. This empowerment through accurate and accessible information becomes the cornerstone for building a resilient and productive agricultural landscape. A future where farmers are armed with the knowledge to make informed decisions not only fosters sustainability but also fosters a symbiotic relationship between technology and agriculture, ensuring a fruitful and sustainable future for generations to come.

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