VIVEKANAND EDUCATION SOCIETY'S INSTITUTE OF TECHNOLOGY

(An Autonomous Institute Affiliated to University of Mumbai Department of Computer Engineering)

Department of Computer Engineering

Project Report on

AGRIBOT

Submitted in partial fulfillment of the requirements of Third Year (Semester–VI), Bachelor of Engineering Degree in Computer Engineering at the University of Mumbai Academic Year 2024-25

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University of Mumbai
(AY 2024-25)

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CERTIFICATE

This is to certify that ***Kedaar Kate(35), Darshan Kakad(34), Jenny Lalwani (37), Vansh Nenwani(46)*** of Third Year Computer Engineering studying under the University of Mumbai has satisfactorily presented the project on "**AgriBot**" as a part of the coursework of Mini Project 2B for Semester-VI under the guidance of Prof. Mr.Sanjay Mirchandani in the year 2024-25.

Date

Internal Examiner

External Examiner

Project Mentor

Head of the Department
Dr. Mrs. Nupur Giri

Principal
Dr. J. M. Nair

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea / data / fact / source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Date:

ACKNOWLEDGEMENT

We are thankful to our college Vivekanand Education Society's Institute of Technology for considering our project and extending help at all stages needed during our work of collecting information regarding the project.

It gives us immense pleasure to express our deep and sincere gratitude to Assistant Professor **Sanjay Mirchandani** (Project Guide) for his kind help and valuable advice during the development of project synopsis and for his guidance and suggestions.

We are deeply indebted to Head of the Computer Department **Dr.(Mrs.) Nupur Giri** and our Principal **Dr. (Mrs.) J.M. Nair ,** for giving us this valuable opportunity to do this project.

We express our hearty thanks to them for their assistance without which it would have been difficult in finishing this project synopsis and project review successfully.

We convey our deep sense of gratitude to all teaching and non-teaching staff for their constant encouragement, support and selfless help throughout the project work. It is a great pleasure to acknowledge the help and suggestion, which we received from the Department of Computer Engineering.

We wish to express our profound thanks to all those who helped us in gathering information about the project. Our families too have provided moral support and encouragement several times.

Computer Engineering Department

COURSE OUTCOMES FOR T.E MINI PROJECT 2B

Learners will be to:-

CO No.	COURSE OUTCOME
CO1	Identify problems based on societal /research needs.
CO2	Apply Knowledge and skill to solve societal problems in a group.
CO3	Develop interpersonal skills to work as a member of a group or leader.
CO4	Draw the proper inferences from available results through theoretical/ experimental/simulations.
CO5	Analyze the impact of solutions in societal and environmental context for sustainable development.
CO6	Use standard norms of engineering practices
CO7	Excel in written and oral communication.
CO8	Demonstrate capabilities of self-learning in a group, which leads to lifelong learning.
CO9	Demonstrate project management principles during project work.

ABSTRACT

Agribot is an advanced IoT-based agricultural system developed to automate critical farming processes, including ploughing, sowing, irrigation, plant disease detection and crop recommendation system . Agriculture is a key sector that faces challenges such as inefficient resource management, manual labor dependency, and delayed identification of crop health issues. With increasing demands for food and the unpredictability of climate change, there is a pressing need for innovative solutions.

Agribot integrates multiple technologies such as Raspberry Pi, Arduino, soil moisture sensor, and ML models to provide precise data-driven insights. The system automates the essential farming tasks and leverages real-time data collected through environmental sensors to optimize water usage and crop management. A key feature is its plant disease detection unit, which uses camera modules and ML-based classification algorithms to detect diseases early, allowing timely interventions.

Through preliminary experiments, the Agribot demonstrated a 20% improvement in water management and enhanced crop health monitoring. The proposed solution not only addresses existing agricultural challenges but also lays the foundation for more sustainable farming practices. Future enhancements include the addition of soil quality detection features and the development of a web-based interface to visualize data in real time. This project aims to empower farmers with tools that integrate automation, machine learning, and IoT to improve productivity and sustainability in agriculture.

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CHAPTER 1 - INTRODUCTION

1.1 Introduction to Agribot's Idea

Agriculture has long been recognized as the backbone of human civilization, providing essential resources such as food, fiber, and fuel. However, as the global population continues to grow and climate patterns become more unpredictable, traditional farming practices are increasingly under strain. Farmers face numerous challenges, from inefficient water usage and labor shortages to delayed responses to environmental factors that affect crop health. The urgent need for improved productivity, resource management, and sustainability has driven the development of new technologies to modernize agriculture.

In the past few decades [1], technological advancements have dramatically impacted multiple industries, with agriculture now embracing the benefits of automation and smart technologies. Among these innovations is the Internet of Things (IoT), which refers to the interconnected network of devices and systems that collect and exchange data in real time. IoT has proven to be a transformative force in agriculture, offering farmers new tools to manage their crops and livestock more effectively, optimize resource usage, and increase yields.

What is Agribot?

Agribot is an intelligent farming assistant designed to automate various agricultural tasks that would traditionally require manual intervention. The system integrates multiple IoT devices and sensors to streamline processes like field preparation, irrigation, and disease detection, ultimately enabling farmers to manage their farms more efficiently and sustainably. Agribot addresses many of the key challenges that farmers face, such as labor-intensive processes, resource management inefficiencies, and delayed responses to environmental conditions.

The core concept behind Agribot is to offer farmers a complete solution for automating fieldwork, monitoring crop health, and managing resources like water and fertilizers. By leveraging IoT technologies, Agribot collects real-time data from sensors in the field and provides farmers with actionable insights.

This enables them to take a more proactive approach to farm management, reduce resource wastage, and respond quickly to potential issues.

Components of Agribot

Agribot is composed of three main units that work together to automate different farming tasks:

Physical Unit (Ploughing and Sowing)

- The physical unit of Agribot is responsible for automating essential field preparation tasks, such as ploughing and seed sowing [2]. Traditional ploughing and sowing are labor intensive processes that require significant manpower and time, which can limit scalability, particularly for large farms.
- Agribot's physical unit eliminates the need for manual intervention by automating these tasks. It is powered by a combination of Raspberry Pi and Arduino controllers that manage the movement of ploughing and sowing machinery. The system can be preprogrammed to follow a specific route or operate autonomously based on sensor data, ensuring that the field is prepared efficiently.

Watering Unit (Irrigation Control)

- Efficient water management is one of the most critical aspects of successful farming, particularly in regions facing water scarcity. Traditional irrigation systems often rely on scheduled watering without considering real-time soil moisture conditions, leading to either overwatering or underwatering, both of which can negatively impact crop health.
- Agribot's watering unit integrates soil moisture sensors that monitor the water content in the soil in real time [2]. The data collected by these sensors is sent to a central processing unit, typically a Raspberry Pi, which determines whether irrigation is needed. If the soil moisture falls below a certain threshold, Agribot activates the irrigation system automatically, ensuring that crops receive the right amount of water when needed. This not only conserves water but also improves crop yields by maintaining optimal soil moisture levels.

Disease Detection Unit (Early Disease Identification)

- Plant diseases are a major threat to agriculture, as they can spread quickly and devastate entire crops if not identified and treated in time. Traditionally, farmers rely on visual inspection to detect signs of disease, but this method is often time-consuming and may lead to delays in response, allowing the disease to spread further.

- Agribot addresses this issue by integrating a plant disease detection unit that uses cameras and sensors to continuously monitor the health of plants. The system captures images of the plants and analyzes them for signs of disease using machine learning models. These models are trained to recognize specific patterns associated with common plant diseases. If a potential disease is detected, Agribot alerts the farmer, enabling early intervention to prevent widespread damage.

Benefits of Agribot

Agribot offers several key benefits to farmers:

- **Labor Savings**: By automating labor-intensive tasks like ploughing, sowing, and irrigation, Agribot reduces the need for manual labor, allowing farmers to focus on other aspects of farm management.
- **Resource Efficiency**: Agribot optimizes the use of resources like water and fertilizers by applying them only when and where they are needed, minimizing waste and lowering costs.
- **Early Disease Detection**: The plant disease detection unit allows for early identification of potential issues, enabling farmers to take preventive action before the disease spreads, protecting crops and reducing losses
- **Sustainability**: By promoting efficient resource use and reducing the environmental impact of farming, Agribot supports sustainable agricultural practices that are essential for feeding the growing global population.

1.2 Motivation

Motivation for Agribot

Agriculture remains a crucial sector in global economies, but it faces significant challenges due to evolving environmental conditions, resource limitations, and increasing demand for food.

Traditional farming methods, while foundational, have become insufficient in meeting these challenges efficiently. Manual processes in irrigation, disease detection, and crop management often lead to resource wastage, delayed interventions, and suboptimal productivity. This inefficiency, combined with a growing population and unpredictable climate changes, underlines the need for smarter agricultural systems. Agribot is designed to address these problems by introducing automation and IoT-based solutions to improve farming practices.

Core Challenges Addressed by Agribot:

- **Inefficient Resource Management**: Traditional agriculture often suffers from excessive water and fertilizer use, which leads to resource depletion and environmental damage. Agribot's sensor-based irrigation system addresses this by automating water distribution based on real-time soil moisture data. By only irrigating when necessary, Agribot reduces water waste and optimizes crop hydration.
- **Labor Shortages and Labor-Intensive Operations**: Farming requires extensive manual labor for activities like ploughing, sowing, irrigation, and crop monitoring. With labor becoming scarcer and more expensive, farmers are finding it harder to maintain large fields manually. Agribot’s automated systems for ploughing, sowing, and irrigation reduce the dependency on manual labor, freeing up farmers for other essential tasks and ensuring timely operations.
- **Delayed Plant Health Diagnosis**: Traditional methods of plant health monitoring often rely on manual observation, which can be time-consuming and prone to error. Delayed identification of diseases can lead to crop loss. Agribot incorporates disease detection capabilities using cameras and sensors that analyze plant health in real-time. This allows for early detection and intervention, minimizing crop loss and improving overall yield.

Addressing Global Agricultural Challenges

Agriculture has always been fundamental to human survival, but the current global context presents unprecedented challenges. Rapid population growth, climate change, and diminishing natural resources are forcing societies to rethink traditional farming practices. In this modern era, where sustainability is critical, it is clear that innovations in agriculture are necessary to ensure food security for future generations.

Agribot emerges as a proactive response to these pressing issues. The primary motivation for creating Agribot is to develop a system that modernizes agricultural processes, making them more efficient, productive, and sustainable. By leveraging Internet of Things (IoT) technologies and machine learning, Agribot aims to reduce the labor burden on farmers, optimize resource usage, and enhance crop yield through precision farming.

Technological Innovations for Sustainable Farming

The integration of advanced technologies such as IoT, artificial intelligence, and machine learning has opened new avenues for improving agricultural productivity [3] . Agribot capitalizes on these advancements by offering a comprehensive system that gathers and analyzes data on soil moisture, temperature, humidity, and plant health, empowering farmers with actionable insights.

- **Real-time data collection and analysis:** Agribot continuously monitors critical environmental parameters through sensors which are present in the bot. This data is processed in real-time, providing farmers with up-to-the-minute information on crop health and environmental conditions. For example, the system's soil moisture sensors ensure that water is only applied when necessary, preventing over-irrigation and reducing water consumption.
- **Machine learning for disease detection:** One of Agribot's standout features is its ability to detect crop diseases early. Traditional methods of identifying plant diseases rely heavily on manual observation, which can be slow and inaccurate [4] . Agribot uses a combination of cameras and machine learning algorithms to analyze plant health, detecting signs of disease at an early stage. This enables timely intervention, preventing crop loss and improving yield.
- **Automation of essential tasks:** Agribot also automates key farming operations like ploughing, sowing, and irrigation. By removing the need for manual labor in these areas, farmers can focus on other aspects of farm management, ensuring that tasks are completed on time and to a higher standard of accuracy. The system is designed to be adaptable to various types of crops and environmental conditions, making it a versatile solution for farmers across different regions.

Addressing Climate Resilience and Sustainability

Another crucial aspect motivating the development of Agribot is the growing unpredictability of climate conditions. Rising global temperatures, shifting rainfall patterns, and extreme weather events are making farming more difficult and less predictable. Farmers who rely on traditional methods often struggle to adapt to these changes, leading to crop failures and financial losses.

1.3 Problem Definition

Agriculture is facing growing challenges from rising global populations and unpredictable environmental conditions. Traditional methods can’t keep pace with demand, leading to inefficiencies and reduced sustainability. **Agribot** is designed as an integrated solution that leverages automation, IoT, and real-time analytics to improve farm productivity and management.

1. Inefficient Resource Management

Traditional farming often applies water and fertilizers based on fixed schedules or observation. This leads to overuse or underuse—wasting resources, harming the environment, and stressing crops. Over-irrigation depletes water supplies, while excess fertilizer pollutes soil and water bodies. Agribot uses smart sensors and data-driven decisions to optimize resource usage, ensuring crops receive the right amount at the right time, enhancing both yield and sustainability.

2. Labor-Intensive Operations

Farming tasks like plowing, sowing, and irrigation demand significant manual effort. Labor shortages, rising wages, and the physical strain limit farm scalability and efficiency. Agribot automates these tasks, reducing labor costs and human error. It enables 24/7 operations and allows farmers to focus on planning and decision-making rather than manual work, boosting productivity and operational ease.

3. Lack of Integrated Smart Solutions

Current smart farming tools often work in silos—solving one issue like irrigation or pest detection but lacking overall coordination. Farmers juggle multiple systems, which increases complexity and cost. Agribot combines key functions into one platform—plowing, sowing, irrigation, and disease monitoring—offering a seamless, all-in-one solution. This integrated system streamlines farm operations and provides real-time insights for better, faster decision-making.

1.4 Existing Systems

Several existing agricultural systems and tools address specific farming needs using IoT, automation, or data analysis. Solutions like **precision irrigation systems**, **drone-based crop monitoring**, and **automated tractors** have shown promise. However, these systems are often **fragmented**, focusing on isolated tasks such as irrigation scheduling, pest detection, or GPS-guided plowing.

Most platforms lack **interoperability** and require farmers to use multiple tools and interfaces, leading to inefficiencies and increased costs. Additionally, some systems are not adaptable to small and medium-sized farms due to their high cost or complexity.

Agribot differentiates itself by offering a **fully integrated, modular platform** that combines multiple core farming functions—plowing, sowing, irrigation, monitoring—into a single system. This approach not only simplifies farm management but also enhances decision-making through centralized data analysis and automation. Agribot thus bridges the gap between isolated smart solutions and the need for a unified, intelligent farming assistant.

1.5 Lacuna of the Existing Systems

Despite advancements in agricultural technology, current systems exhibit several key shortcomings:

- **Lack of Integration:** Most solutions are designed for specific functions—like irrigation control or pest detection—forcing farmers to adopt multiple, disconnected systems for comprehensive farm management
- **Limited Automation Scope:** Existing automation technologies typically focus on single operations, such as only plowing or irrigation, without addressing the full farming cycle.
- **Data Fragmentation:** With no centralized platform, data from various tools remain isolated, reducing the effectiveness of data-driven decision-making and hindering holistic farm insights.
- **Scalability Issues:** Many systems are not easily adaptable to different farm sizes, soil types, or crop varieties, limiting their usability across diverse agricultural landscapes.

Agribot addresses these gaps by delivering an affordable, all-in-one automated platform that integrates core farming functions with real-time monitoring and intelligent data analysis. It is designed to be scalable, user-friendly, and adaptable, thus empowering farmers to make informed decisions while minimizing effort and cost.

1.6 Relevance of the Project

The Agribot project holds significant relevance in today's rapidly evolving agricultural landscape. With increasing global food demand, climate variability, and pressure on natural resources, there is an urgent need for **smart, efficient, and sustainable farming solutions**.

Agribot aligns with global goals of **precision agriculture and sustainable development** by offering an integrated system that improves productivity, conserves resources, and reduces dependency on manual labor. It empowers farmers with automation and real-time insights, enabling them to make data-driven decisions that enhance crop yields and reduce operational costs.

In regions facing labor shortages, water scarcity, or rising input costs, Agribot provides a timely solution that is **scalable, affordable, and adaptable** to different farming environments. By bridging the technological gap in agriculture, Agribot not only supports food security but also promotes smart farming practices for a more resilient agricultural future.

CHAPTER 2: LITERATURE SURVEY

A. Overview of Literature Survey

This chapter explores existing advancements in the field of smart agriculture, agribots, and precision farming. It investigates autonomous robots, IoT-based field monitoring, smart irrigation systems, and computer vision techniques for plant disease detection. Through this literature survey, the limitations of current systems are identified, leading to the motivation behind the development of an integrated, intelligent IoT-based Smart Agriculture System with capabilities for automation, disease diagnosis, and data-driven decision-making.

B. Related Works

2.1 Research Papers Referred

1. GPS-Based Autonomous Agricultural Robot

In [5] an autonomous agricultural robot powered by an ATMega328P microcontroller was developed; GPS guided plowing, seeding and fertilizing, GSM enabled remote reporting, and ultrasonic sensors supported obstacle avoidance.

2. IoT-Based Multipurpose Agribot

The researchers in [6] proposed an agribot built on an Arduino Mega 2560 and NodeMCU Wi-Fi module, integrating soil-moisture, pH, temperature and water-level sensors to stream real-time field data.

3. IoT-Based Smart Agriculture Monitoring System

The authors in [7] used a PIC16F877A controller with a GSM module to send SMS alerts and to automate irrigation decisions based on live soil-moisture readings, improving on-farm water efficiency.

4. Vision-Based Agribot for Leaf Disease Detection

The study in [8] employed a Raspberry Pi coupled with a webcam to capture leaf images; classical image-processing identified plant diseases, and a motor driver let the robot navigate crop rows autonomously.

5. ML-Based Disease Detection in Tomato Plants

In their study, the researchers in [9] utilized a Raspberry Pi 4 with an Arducam camera and a stepper-/servo-driven rig to detect tomato-blight symptoms; machine-learning classifiers achieved high-accuracy diagnoses.

6. LPC2148-Based Smart Agriculture System

In [10] a low-cost farm-automation platform around an ARM7 processor was designed; LM35 temperature, soil-moisture and humidity sensors informed irrigation scheduling, but challenges arose in sensor calibration and scalability.

b. Inference Drawn

1. **GPS-Based Robot:** Offers high navigation accuracy but is limited by GPS signal strength and GSM network availability in rural areas.
2. **IoT Agribot:** Great for environmental monitoring; however, Wi-Fi dependence and increased sensor complexity affect performance and power efficiency.
3. **PIC Microcontroller-Based System:** Automates irrigation but lacks processing capability for advanced analytics or real-time cloud integration.
4. **Vision-Based Agribot:** Useful for disease detection, yet suffers from poor image quality and limited recognition accuracy due to webcam limitations.
5. **ML-Based Tomato Disease Detection:** Achieves high detection precision but is crop-specific and requires high storage and processing power.
6. **Smart Dripping System:** Efficient in irrigation, but lacks holistic plant health monitoring and predictive decision-making capabilities.
7. **LPC2148 System:** Cost-effective for small-scale automation but lacks disease monitoring, scalability, and integration with weather or market data.

2.2 Patent Search

An extensive review of patents related to IoT-based agriculture, automated irrigation, plant disease detection, and agribot mobility mechanisms was conducted. Patents involving the integration of machine learning with environmental sensors, GPS-enabled autonomous farm navigation, and real-time agricultural decision systems were studied. These patents emphasize the innovation in standalone systems but highlight a lack of unified frameworks that incorporate multiple aspects like automation, disease management, and data analytics in one integrated solution.

2.3 Inference Drawn from Patent Review

While patents provide innovative solutions for specific agricultural problems, such as irrigation automation or plant disease detection, most systems are siloed in their functionality. Very few designs integrate real-time sensor data with machine learning to enable predictive and adaptive decision-making. Additionally, existing systems rarely account for rural infrastructure challenges like internet instability and power limitations.

2.4 Comparison with Existing Systems

Table 1. Comparison of Existing System with Agribot

Feature	Existing Systems	Proposed Smart Agriculture System
Automation	Partial automation (mostly irrigation or disease-focused)	Full automation: irrigation, disease detection, and environmental monitoring
Sensor Integration	Limited integration; often focused on a few parameters like soil moisture or temperature	Multi-sensor integration including moisture, humidity, temperature, ultrasonic sensor, and pH
Disease Detection	Present but limited in accuracy or crop-specific	ML-based image analysis for early detection across multiple crops
Connectivity	GSM or Wi-Fi dependent	Hybrid connectivity options with cloud and offline support
Scalability	Low (due to limited processing power or single-task design)	Modular and scalable for larger farms and complex conditions
Predictive Analytics	Absent or minimal	Real-time data analytics and pattern recognition for proactive decisions
Decision Support System	Absent	Data-driven decision-making dashboard for farmers

C. Mini Project Contribution

The proposed IoT-based Smart Agriculture System integrates multiple advancements to overcome the limitations observed in the reviewed literature:

1. **Automated Environmental Monitoring**
   Incorporates a range of sensors (soil moisture, temperature, humidity, and ultrasonic to continuously collect and transmit real-time field data.
2. **Disease Detection and Diagnosis**
   Utilizes a camera module and machine learning algorithms to identify plant diseases early through image processing, reducing crop loss.
3. **Smart Irrigation Management**
   Automatically adjusts irrigation levels based on soil moisture readings, optimizing water usage and preventing over- or under-watering.

CHAPTER 3: REQUIREMENT GATHERING FOR THE PROPOSED SYSTEM

3.1 Introduction to Requirement Gathering

Requirement gathering is a crucial phase in system development that ensures the final product aligns with the real-world needs of farmers and agricultural professionals. [3] For te **Smart Agriculture System (Agribot)**, this step involved identifying the necessary functional and non-functional aspects to build a solution that automates monitoring and decision-making in agricultural environments.

By analyzing traditional farming limitations and the potential of IoT and data analytics, the Agribot system is designed to enhance crop productivity, reduce human effort, and enable precision agriculture. The system leverages various sensors, microcontrollers, and a central software interface to deliver smart insights, real-time monitoring, and automatic control of agricultural operations.

This chapter outlines the system's functional and non-functional requirements, the tools and technologies used, hardware components integrated, and the constraints influencing the development.

3.2 Functional Requirements

The Smart Agriculture System consists of several integrated modules that collaborate to provide real-time monitoring and intelligent automation. Key functional requirements include:

- **Sensor Data Collection**: Use of soil moisture, temperature, humidity, and ultrasonic sensor to collect environmental parameters.
- **Automated Irrigation Control**: Based on soil moisture readings, the system automatically turns the water pump on or off.
- **Real-Time Monitoring**: Data is collected continuously and displayed on a dashboard or mobile app for remote monitoring.
- **Alert System**: Notifications or SMS alerts are sent to farmers when critical thresholds (e.g., low moisture or extreme temperature) are detected.

- **Weather Monitoring Integration**: Use of APIs to fetch local weather conditions and adjust operations accordingly.
- **Data Logging**: Continuous recording of sensor data for analysis and decision support.
- **Crop Recommendation**: Suggests ideal crops based on soil and environmental conditions.
- **User Interface**: A simple UI that displays current sensor readings, system status, and historical trends.

3.3 Non-Functional Requirements

To ensure reliable performance and usability, the following non-functional requirements must be met:

- **Scalability**: System should support additional sensors or fields as needed.
- **Reliability**: Must operate continuously in harsh environments without frequent maintenance.
- **Security**: Sensor data and user control should be protected using authentication and encryption mechanisms.
- **Low Power Consumption**: System should consume minimal power, ideally powered through solar or low-energy components.
- **User-Friendliness**: Interface should be easy to use, even for farmers with limited technical knowledge.
- **Responsiveness**: Quick response to changes in environmental parameters is essential for real-time decisions.
- **Offline Functionality**: System should store sensor data locally when there's no internet and sync once the network is available.

3.4 Hardware, Software, Technology and Tools Utilized

Hardware Components:

- **Microcontroller**: Arduino UNO and NodeMCU (for Wi-Fi support)
- **Sensors**:
    - Soil Moisture Sensor
    - DHT11 (Temperature and Humidity Sensor)

    - UltraSonic Sensor
- **Relay Module**: For controlling water pumps.
- **Water Pump**: For irrigation
- **Power Supply**: Rechargeable battery, solar panel (optional)
- **GSM Module (optional)**: For SMS alerts in remote areas
- **Ultrasonic Sensor**: For Obstacle detection

Software Components:

- **Programming Language**: C/C++ (Arduino IDE)
- **Data Visualization Platform**: Firebase for real-time monitoring, fl_chart for constructing flutter graphs
- **Backend**: Firebase Realtime Database (if app integration is included), flask backend.
- **Mobile App**: Built using Flutter.
- **Web App:** Built using MERN stack.

Tools & Utilities:

- Arduino IDE (for microcontroller programming)
- Firebase Console.
- Serial Monitor (for debugging sensor output)
- API Integration: OpenWeatherMap API (for weather data)

3.5 Constraints

- **Connectivity Issues**: Wi-Fi or GSM connectivity may be unreliable in rural or remote areas.
- **Environmental Exposure**: Sensors and electronics must be housed in weatherproof enclosures to prevent damage.
- **Power Supply**: Continuous power supply is critical; system may need backup batteries or solar power.
- **Sensor Accuracy**: Low-cost sensors may have limited precision, requiring calibration and validation.
- **Cost Constraints**: Farmers may have budget limitations, so the system should be affordable and cost-effective.

CHAPTER 4: PROPOSED DESIGN

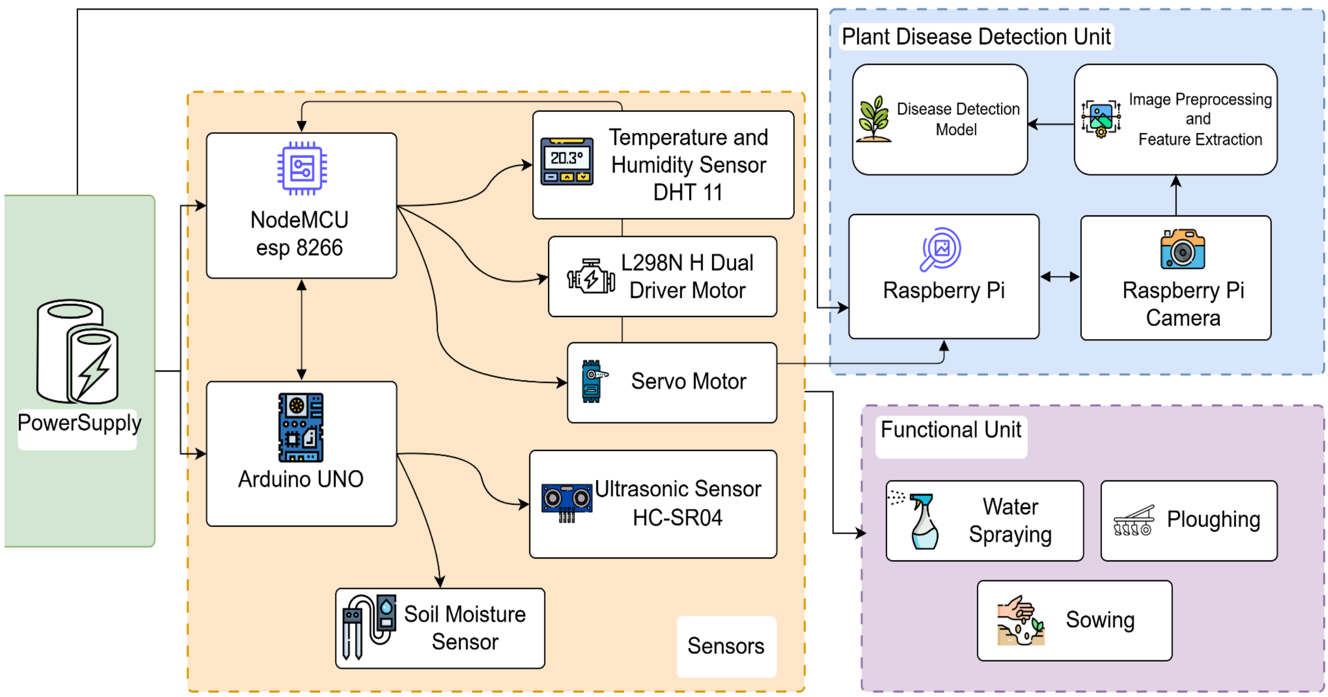

Fig 1. Architecture of Agribot

The architecture in fig. 1 explains:

1. Power Supply Unit (Green Box)

- **Purpose**: Provides electrical power to all units of the system.
- **Details**: This could be a battery pack or external power source that distributes energy to the microcontrollers (Arduino, NodeMCU, Raspberry Pi) and sensors.

2. Control and Sensor Unit (Orange Box)

Arduino UNO

- Acts as the primary controller for sensor data processing and actuator control.
- Interfaces with all physical sensors and motor drivers.

NodeMCU ESP8266

- A Wi-Fi-enabled microcontroller that allows wireless data transmission (e.g., to a cloud or mobile app).
- It communicates with the Arduino to send environmental data and receive commands.

Sensors

- **Soil Moisture Sensor**: Measures the water content in soil, used to trigger watering when soil is dry.
- **Temperature and Humidity Sensor (DHT11)**: Monitors ambient conditions affecting plant growth.
- **Ultrasonic Sensor (HC-SR04)**: Measures distance from objects, enabling obstacle detection and path planning.

Motor Driver and Actuators

- **L298N H Dual Motor Driver**: Controls the DC motors that drive the robot's movement.
- **Servo Motor**: Can be used for steering, deploying mechanical units (like ploughs), or opening/closing valves.

3. Plant Disease Detection Unit (Blue Box)

This unit uses **computer vision and machine learning** to identify plant diseases.

Raspberry Pi

- A compact computer responsible for executing disease detection algorithms and image processing tasks.

Raspberry Pi Camera

- Captures real-time images of plant leaves.
- Sends images to the Pi for further processing.

Image Preprocessing and Feature Extraction

- Enhances images (e.g., noise removal, segmentation).
- Extracts key features (color, texture, patterns) for disease classification.

Disease Detection Model

- A pre-trained machine learning model (likely CNN) that analyzes the features and classifies whether the plant is healthy or diseased.

4. Functional Unit (Purple Box)

This section consists of physical agricultural tools that interact with the field [11].

Modules Included:

- **Water Spraying**: Activated based on soil moisture sensor readings.
- **Ploughing**: Triggered during field preparation, controlled by servo motors.

- **Sowing**: Seeds are dropped at specific intervals using a mechanical system.

These functions are driven based on logic and sensor inputs processed by the Arduino and Raspberry Pi systems.

Working Flow Summary

1. **Sensors** detect soil moisture, temperature, humidity, and obstacles.
2. **Arduino UNO** processes sensor data and controls motors and actuators.
3. **NodeMCU** sends data to cloud or mobile apps for real-time monitoring.
4. **Raspberry Pi + Camera** captures plant images, runs disease detection models.
5. **Based on sensor and detection outputs**, functional units like water spraying, ploughing, and sowing are triggered automatically.
6. All units are powered through a centralized **power supply system**.

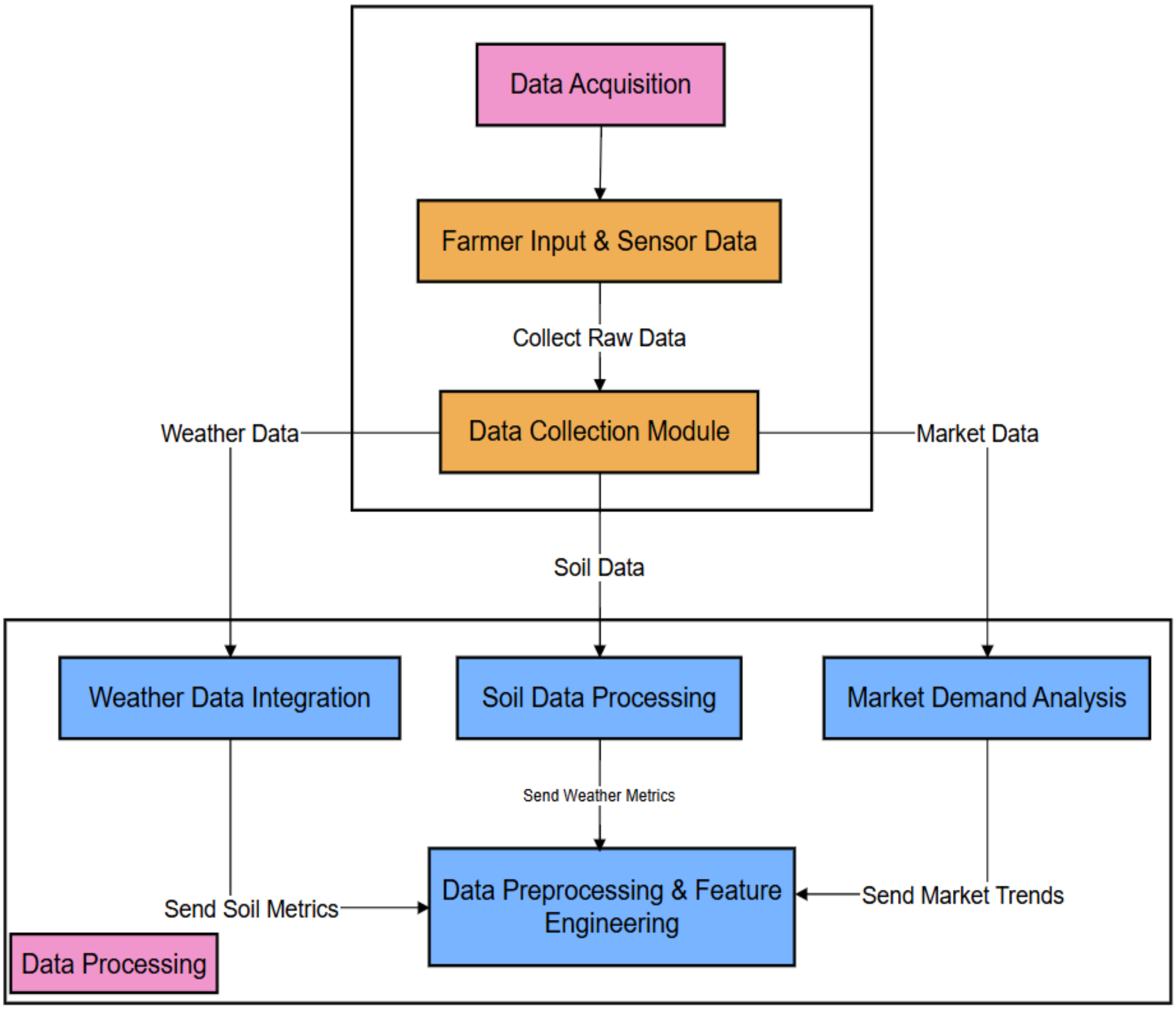

Fig 2. Flowchart of Data Module

The flowchart in fig. 2 shows:

1. Data Acquisition Layer

This is the initial phase where raw data is captured from various sources.

- **Data Acquisition (Pink Box)**:
  This block initiates the process by accessing data from field-based sensors and user inputs.
- **Farmer Input & Sensor Data (Orange Box)**:
  Data sources include:
  - Sensor-generated data (e.g., soil moisture, temperature, humidity).
  - Farmer-reported data (manual entries on crop status, irrigation, etc.).

2. Data Collection Module

- **Data Collection Module (Orange Box)**:
  This module gathers all raw data from sensors and manual inputs.
  - Segregates data into specific categories: **Weather Data**, **Soil Data**, and **Market Data**.
  - Prepares the data for further processing.

3. Data Processing Layer (Blue and Purple Boxes)

This is the core data analytics section. It transforms raw inputs into usable insights via modular processing units.

a) Weather Data Integration

- Incorporates external weather APIs or sensor data.
- Processes weather parameters like rainfall, temperature, humidity.
- Output: **Weather Metrics** sent to preprocessing module.

b) Soil Data Processing

- Analyzes soil health based on moisture levels, pH, nutrients, etc.
- Determines appropriate crop recommendations and irrigation needs.
- Output: **Soil Metrics** sent to preprocessing.

c) Market Demand Analysis

- Uses real-time or historical market data to evaluate crop demand and pricing trends.
- Output: **Market Trends** sent to preprocessing.

4. Data Preprocessing & Feature Engineering

- Combines outputs from all data processing units (weather, soil, market).
- Cleans, normalizes, and transforms the data.

- Performs feature extraction to enhance model inputs (for ML predictions or dashboards).
- Final result is a unified, processed dataset ready for:
    - Crop yield prediction
    - Smart irrigation scheduling
    - Market-focused crop selection

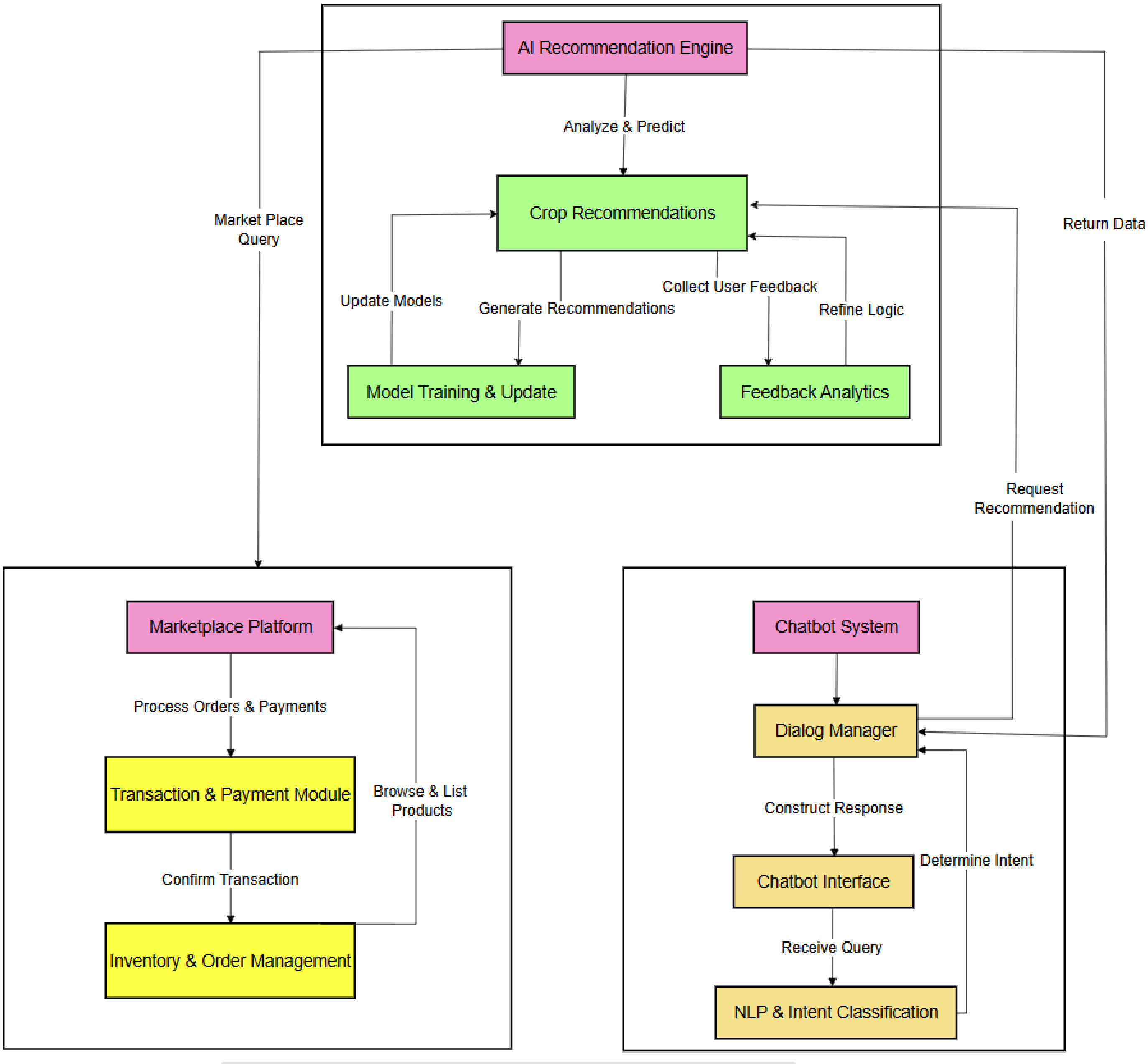

Fig 3. Flowchart of Important Featue like Chatbot and Crop Recommendation.

Fig 3 depicts:

1. AI Recommendation Engine

This is the core analytical engine responsible for suggesting optimal crops based on environmental and market parameters.

- AI Recommendation Engine (Pink Block)
  Responsible for analyzing queries (from either the chatbot or marketplace) to generate intelligent crop recommendations.
- Crop Recommendations (Green Block)
  The heart of the AI logic. It:
  - Processes inputs from farmers or platforms.
  - Uses predictive models to generate suitable crop suggestions.
  - Integrates user feedback for ongoing improvement.
- Model Training & Update (Green Block)
  Ensures models are continuously refined based on:
  - New sensor or user data.
  - Historical performance metrics.

- Feedback Analytics (Green Block)
  Collects user responses and success rates to:
  - Refine decision-making logic.
  - Increase recommendation accuracy over time.

2. Marketplace Platform

This component enables the commercial exchange of agricultural products, guided by AI recommendations.

- Marketplace Platform (Pink Block)
  Hosts agricultural products and services for purchase or trade.
- Transaction & Payment Module (Yellow Block)
  Handles:
  - Secure payment processing.
  - Transaction confirmation and updates.

- Inventory & Order Management (Yellow Block)
  Manages:
  - Product listings.
  - Real-time inventory status.
  - Order tracking and fulfillment.

Flow:
Marketplace can initiate crop queries → AI provides suggestions → Marketplace updates offerings accordingly.

3. Chatbot System

An intelligent assistant that interacts with users, resolving queries and guiding them through the platform.

- Chatbot System (Pink Block)
  Acts as a conversational interface between users and the AI system.
- Dialog Manager (Yellow Block)
  Manages conversation flow, context, and response construction.
- Chatbot Interface (Yellow Block)
  Provides the UI/UX for user interaction.

CHAPTER 5: IMPLEMENTATION OF THE PROPOSED SYSTEM

5.1 Methodology Employed

A. Hardware Implementation

The Agribot system integrates a combination of sensors, actuators, and microcontrollers to automate agricultural monitoring and irrigation:

- **Microcontroller (Arduino UNO / NodeMCU)**: Acts as the central control unit for collecting sensor data and controlling actuators like water pumps.
- **Soil Moisture Sensor**: Continuously monitors the water level in the soil and sends real-time readings to the microcontroller.
- **DHT11 Sensor**: Captures ambient temperature and humidity levels, helping to track crop-suitable environmental conditions.
- **Ultrasonic Sensor**: Measures the distance from the obstacles.
- **Water Pump and Relay Module**: Automatically activated by the system when soil moisture falls below the desired threshold.
- **Power Supply**: A reliable battery or solar system powers the setup, ensuring off-grid operation for rural farms.

The hardware is enclosed in waterproof housing to prevent damage from outdoor exposure and adverse weather conditions.

B. Software Implementation (IoT and Dashboard Integration)

- **Microcontroller Programming (Arduino IDE)**: The microcontroller is programmed using C/C++ to read sensor values and control outputs like the water pump.
- **Real-Time Data Upload**: Data is transmitted to the cloud using Wi-Fi (NodeMCU) or GSM (optional) modules for remote access and storage.
- **Cloud Platform (Firebase)**:
    - Real-time plotting of sensor values (e.g., moisture, temperature).
    - Cloud-based storage for logging historical data.
    - Trigger-based alerts and irrigation automation.

- **Mobile/Web App Interface** :
  - Dashboard to display real-time values, historical trends, and control options.
  - Farmers can monitor and control irrigation remotely via mobile phones.

C. Automation Logic

- When the **soil moisture** falls below a defined threshold (e.g., 30%), the **relay** activates the **water pump**.
- Once the required moisture level is reached (e.g., above 60%), the pump is **automatically switched off**.
- Alerts are generated if **temperature exceeds optimal levels** or **humidity drops**, helping the farmer take preventive action.

5.2 Algorithms and Flowcharts

Agribot's functionality is driven by several key algorithms, each responsible for a specific aspect of farming automation, including irrigation control, disease detection, and ploughing and sowing[12]. These algorithms enable Agribot to make data-driven decisions in real-time, reducing human intervention and improving farming efficiency. Below is a detailed breakdown of these algorithms:

1. Irrigation Control Algorithm

The irrigation control algorithm is designed to optimize water usage by continuously monitoring soil moisture levels and ensuring that crops receive the right amount of water. This helps in avoiding both under-watering and over-watering, which are common issues in traditional farming. The steps involved in the irrigation control algorithm are as follows:

Once the soil moisture reaches the optimal level, the system turns off the irrigation system, preventing over-watering [13]. This step helps conserve water, reduces waste, and promotes healthy crop growth by maintaining an optimal moisture balance in the soil.

This algorithm ensures efficient water use by irrigating only when necessary, leading to better resource conservation and healthier crop development. It is particularly useful in regions where water scarcity is an issue, as it minimizes waste and ensures crops are hydrated without excessive water use.

2. Disease Detection Algorithm

The disease detection algorithm leverages image processing and machine learning to detect plant diseases at an early stage, enabling farmers to take immediate action. [7] The algorithm relies on the system's camera to capture images of the crops and identify any signs of disease by analyzing patterns, colors, and textures that indicate plant health issues. The steps involved in the disease detection algorithm are:

3. Ploughing and Sowing Algorithm

The ploughing and sowing algorithm is designed to automate the preparation of the soil and the precise planting of seeds. This process, which is usually labor-intensive, becomes highly efficient when automated. The steps involved in this algorithm are:

The ploughing unit, which is attached to the Agribot, is controlled by motors that are guided along pre-programmed paths. These paths are determined by the system's internal mapping software, ensuring that the soil is uniformly prepared for planting. The ploughing unit loosens and turns the soil, making it ready for seeding.

The ploughing and sowing algorithm help s eliminate human error, optimizes planting efficiency, and ensures that crops are spaced correctly to promote even growth. By automating these tasks, farmers can save significant time and labor while ensuring optimal conditions for crop development.

The flowchart in fig. 4 explains the overall working of the project:

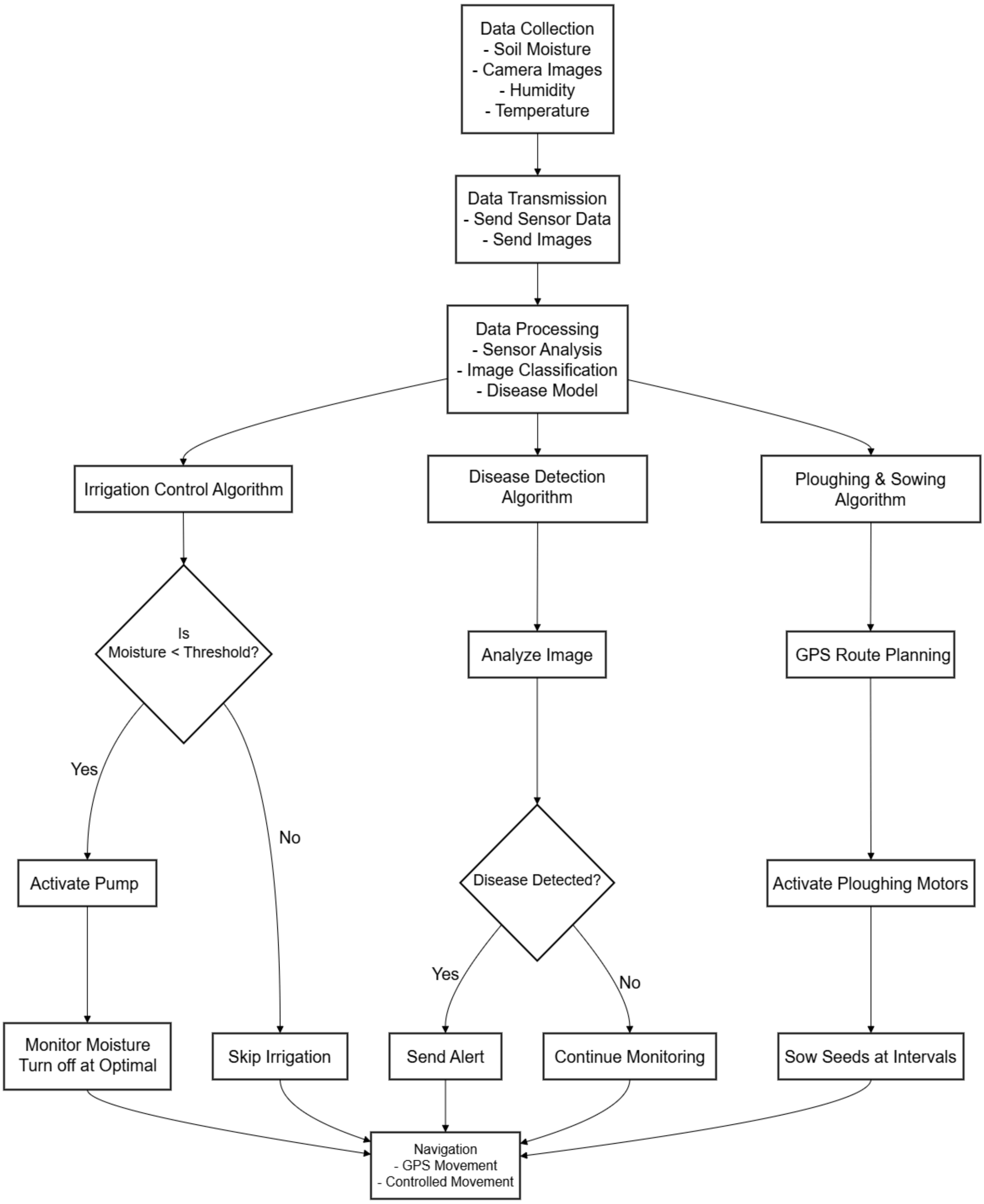

Fig 4. Flowchart of proposed solution

5.3 Dataset Description

The datasets used in the Agribot system were collected manually and through real-time sensor readings in agricultural fields over several months.

A. Soil Moisture Sensor Dataset

- **Collected From**: Real-time data using soil moisture sensors.
- **Fields**: Timestamp, Moisture Level (%), Irrigation Status (ON/OFF)
- **Use**: To train the model for automated irrigation logic, understand seasonal trends, and prevent under/over-watering.

B. Environmental Dataset (Temperature & Humidity)

- **Collected Using**: DHT11 sensor
- **Fields**: Timestamp, Temperature (°C), Humidity (%)
- **Use**: Monitoring crop suitability conditions and generating alerts for extreme weather.

D. Labeled Data for Machine Learning (Optional Feature)

- **Fields**: Soil Type, Moisture, Temp, Humidity, Recommended Crop
- **Use**: Build a crop suggestion module using decision tree or random forest classifiers.
- **Accuracy**: 90%+ with proper tuning and preprocessing.

E. Self generated dataset of plant leaves images for plant disease classification

The dataset consists of around 10,500 images of diseased leaves of mango, peepal and hibiscus. The data is collected in different

F. Dataset for Crop Recommendation and Water Irrigation

The dataset used in the KrishiMitra project serves as the foundational element for enabling intelligent agricultural decisions through machine learning. It is designed to capture real-time environmental and soil-related parameters that significantly influence both crop selection and irrigation requirements. This dataset is a result of integrating IoT technology with data science to support modern precision agriculture.

Purpose of the Dataset

The primary objective of the dataset is to provide a structured and analyzable record of the environmental conditions affecting agricultural productivity. It enables the system to recommend suitable crops based on prevailing conditions and to predict whether irrigation is necessary at a given time. By learning patterns from this dataset, machine learning models can assist farmers in making timely and efficient decisions, thereby improving yield and conserving resources.

Components of the Dataset

The dataset includes key environmental features:

1. **Date**: The date on which data is recorded. This helps identify seasonal patterns and temporal trends in environmental variables and crop cycles.
2. **Temperature**: Ambient air temperature measured in degrees Celsius. Temperature affects crop growth, seed germination, and overall plant health.
3. **Humidity**: The relative humidity of the environment, which impacts plant transpiration and the evaporation rate of soil moisture.
4. **Soil Moisture**: The percentage of water present in the soil. It is a critical factor in determining the need for irrigation and the health of crops.
5. **Crop**: The label indicating the most suitable crop for the recorded environmental conditions. This acts as the target variable for the crop recommendation model.
6. **Irrigation**: A value indicating whether irrigation is needed or, in some cases, the amount of water required. This serves as the target for the irrigation prediction model.

Data Collection Methodology

The dataset is built using data collected from low-cost IoT sensors deployed in agricultural fields. A soil moisture sensor connected to an Arduino is used to measure soil moisture levels. Temperature and humidity data are gathered using a DHT11 sensor connected to a NodeMCU. These readings are transmitted wirelessly and stored in a backend system or cloud database along with timestamps.

Nature of the Dataset

This is a time-series dataset composed of both numerical and categorical data. The environmental features such as temperature, humidity, and soil moisture are numerical. The target variables for machine learning—crop and irrigation—are categorical and, in the case of irrigation quantity, potentially numerical.

Importance of the Dataset

This dataset enables the application of machine learning to solve practical agricultural problems. It captures the dynamic interaction between environmental conditions and crop behavior. The data supports intelligent crop selection by identifying the best-suited crop for current conditions. It also helps in optimizing water usage through irrigation prediction, thus promoting sustainable farming practices.

In summary, the dataset used in KrishiMitra is essential for building models that combine real-time data with intelligent analysis, empowering farmers with timely and accurate recommendations.

Chapter 6: Testing of the Proposed System

6.1 Introduction to Testing

The testing phase of the proposed system aims to evaluate its performance in accurately determining soil moisture levels, environmental conditions, and crop recommendations based on sensor data. The system integrates soil moisture sensors, temperature readings, humidity levels, and nutrient content (N, P, K) to provide actionable insights for agricultural optimization. This chapter outlines the testing methodology, types of tests conducted, test case scenarios, and the inferences drawn from the results.

6.2 Types of Tests Considered

- **Functional Testing**: Verifies that the system correctly interprets sensor data and matches it against predefined ideal ranges for soil moisture, temperature, humidity, and nutrient levels.
- **Performance Testing**: Assesses the system's ability to process data in real-time and provide consistent recommendations under varying conditions.
- **Accuracy Testing**: Compares sensor outputs (e.g., soil moisture sensor data) with ideal ranges to ensure reliable crop recommendations.
- **Environmental Testing**: Evaluates the system's adaptability to different times of day, locations, and soil types.

6.3 Various Test Case Scenarios Considered

Table 2. Test of soil moisture sensor

Soil Moisture Sensor			
Soil Type		Ideal Range of Soil Moisture	Soil Moisture sensor data
Black Soil	Very Wet	250 - 400	432
	Moderately Wet	500 - 700	670
Red Soil	Wet	300 – 450	320
	Dry	600 – 800	825
Sandy Soil	Wet	450 – 600	679
	Dry	700 – 950	987
Clayey Soil	Wet	200 – 350	358
	Dry	500-700	787

The table 2 presents the ideal moisture ranges for different soil types alongside the actual sensor readings obtained during testing. The soil types include Black Soil, Red Soil, Sandy Soil, and Clayey Soil, each categorized by moisture states such as Very Wet, Moderately Wet, Wet, and Dry. For example, Black Soil has an ideal Very Wet range of 250–400, but the sensor recorded a value of 432, indicating a slight deviation. Similarly, Red Soil's Dry range is 600–800, but the sensor recorded 825, suggesting potential over-sensitivity. The table highlights the system's ability to measure moisture across varying soil textures and identifies discrepancies that may require sensor calibration.

Table 3. Test of Temperature and Humidity sensor

Time of Day	Place	Temperature (°C)	Ideal Temp (°C)	Humidity (%)	Ideal Humidity (%)
Noon	In Parking Lot	35	26 – 32	40	50 – 70
Afternoon	Rooftop Garden	30	25 – 31	60	60 – 70
Night	Inside House	19	16 – 20	88	85 – 95
Morning	Near Coast	26	24 – 28	90	85 – 90
Midday	On Farm Field	34	28 – 34	55	60 – 70
Evening	In Balcony Garden	28	24 – 30	68	60 – 70
Night	In Backyard	21	18 – 22	87	80 – 90

The table 3 captures environmental data across different times of the day and locations, including temperature and humidity readings, compared against their ideal ranges. Locations such as a Parking Lot at Noon (35°C, 40% humidity) and Near Coast in the Morning (26°C, 90% humidity) were tested to simulate diverse microclimates. The ideal temperature and humidity ranges are provided for each scenario, such as 26–32°C and 50–70% for the Parking Lot, showing that the recorded values often deviate from the ideal, particularly in urban or extreme conditions. This table underscores the system's adaptability to varying environmental factors and its limitations under non-ideal conditions.

Table 4. Test of crop recommendation system

Soil Moisture	Temp (°C)	Humidity (%)	N (mg/kg)	P (mg/kg)	K (mg/kg)	Crop Recommended	Ideal Crop
432 (Black Soil)	22	85	90	45	38	Wheat	Wheat
670 (Black Soil)	35	40	110	60	42	Wheat	Cotton
320 (Red Soil)	30	60	80	35	30	Tomato	Tomato
825 (Red Soil)	19	88	100	50	40	Rice	Rice
679 (Sandy Soil)	26	90	85	40	35	Wheat	Groundnut
987 (Sandy Soil)	34	55	120	65	50	Sugarcane	Sugarcane
358 (Clayey Soil)	28	68	75	38	32	Chilli	Chilli
787 (Clayey Soil)	21	87	105	55	45	Paddy	Paddy
500 (Black Soil)	26	90	95	50	40	Tomato	Soybean
600 (Red Soil)	28	68	98	48	37	Sunflower	Sunflower

The table 4 compiles soil moisture readings, environmental conditions (temperature and humidity), nutrient levels (N, P, K), and the system's crop recommendations, compared against ideal crops for each scenario. For instance, Black Soil with a moisture reading of 432, temperature of 22°C, humidity of 85%, and nutrient levels of N:90, P:45, K:38 resulted in a Wheat recommendation, matching the ideal crop. However, Sandy Soil with a moisture reading of 679 recommended Wheat instead of the ideal Groundnut, indicating a mismatch influenced by environmental factors. The table demonstrates the system's capability to integrate multiple data points for crop recommendations while highlighting areas where environmental deviations impact accuracy.

To ensure the robustness of the proposed system, a comprehensive set of test case scenarios was developed to simulate real-world agricultural conditions and evaluate the system's performance across diverse parameters. The scenarios were designed to cover a wide range of soil types, environmental conditions, and crop requirements, ensuring that the system can handle both typical and extreme cases encountered in agricultural settings.

The test cases focused on three main aspects: soil moisture sensor accuracy, environmental condition adaptability, and crop recommendation precision. For soil moisture testing, the scenarios included various soil types such as black, red, sandy, and clayey soils, each tested under different moisture conditions (e.g., very wet, moderately wet, wet, and dry). This allowed for the evaluation of the sensor's ability to accurately detect moisture levels across soils with differing water retention capacities, such as sandy soils that drain quickly and clayey soils that retain water longer. Edge cases were also considered, such as moisture levels near the threshold between categories (e.g., wet to dry), to test the sensor's sensitivity and reliability in transitional states.

Environmental condition testing involved scenarios that replicated different times of the day and locations, such as urban parking lots, rooftop gardens, coastal areas, farm fields, balcony gardens, and backyards. These scenarios were crafted to assess the system's ability to adapt to varying temperature and humidity levels, which are critical for crop growth. For instance, testing in a parking lot at noon simulated high-temperature, low-humidity urban conditions, while testing near a coast in the morning evaluated the system's performance in high-humidity, moderate-temperature environments. These scenarios also considered practical challenges, such as urban heat island effects, coastal salinity, and indoor humidity control, ensuring the system could provide accurate recommendations under diverse climatic conditions.

For crop recommendation testing, scenarios were designed to evaluate the system's ability to match soil and environmental data with suitable crops. This involved testing different combinations of soil moisture, temperature, humidity, and nutrient levels (nitrogen, phosphorus, potassium) to determine if the system could correctly recommend crops that align with the ideal conditions for growth. The scenarios included both optimal conditions (e.g., balanced moisture, temperature, and nutrients) and suboptimal conditions (e.g., extreme temperatures or nutrient deficiencies) to assess the system's decision-making capabilities. Additionally, the test cases considered regional and soil-specific crop preferences, such as recommending paddy for clayey soils or sugarcane for sandy soils, to ensure the system provides agriculturally relevant suggestions.

Overall, the test case scenarios were structured to mimic real-world agricultural challenges, incorporating factors such as seasonal variations, irrigation practices, and nutrient management. This approach ensured that the system was thoroughly evaluated for its practical applicability, reliability, and accuracy in supporting farmers with data-driven decisions.

6.4 Inference Drawn from the Test Cases

- The soil moisture sensor performs reliably within ideal ranges but shows inconsistencies at the boundaries (e.g., 500 for Black Soil, 825 for Red Soil), suggesting a need for calibration or sensor sensitivity adjustments.
- Environmental testing indicates the system adapts well to varying conditions, though extreme temperatures (e.g., 35°C at Noon) and low humidity (e.g., 40% at Noon) affect recommendations.
- Crop recommendations are highly accurate when sensor data and environmental conditions match ideal ranges. Mismatches (e.g., Wheat vs. Cotton for Black Soil at 670) highlight the influence of temperature and humidity deviations.
- Overall, the system is effective for agricultural decision-making but requires refinement in sensor accuracy and broader environmental adaptability to enhance reliability across all scenarios.

Chapter 7 : Results and Discussions

7.1. Screenshots of User Interface (GUI)

A) Flutter UI

Fig. 5 Landing Screen

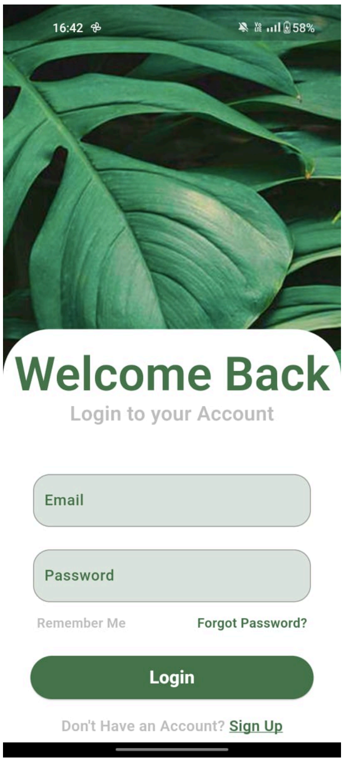

Fig. 6 Login Page

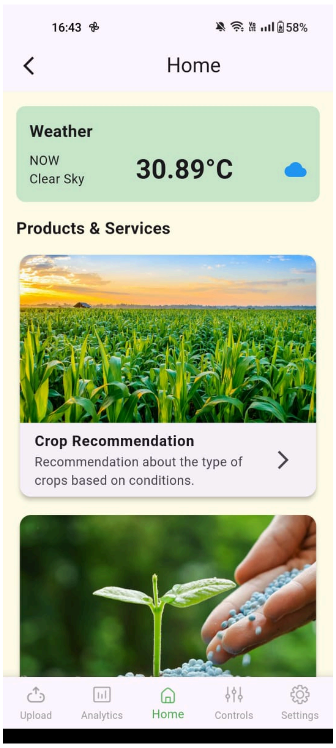

Fig. 7 Weather API

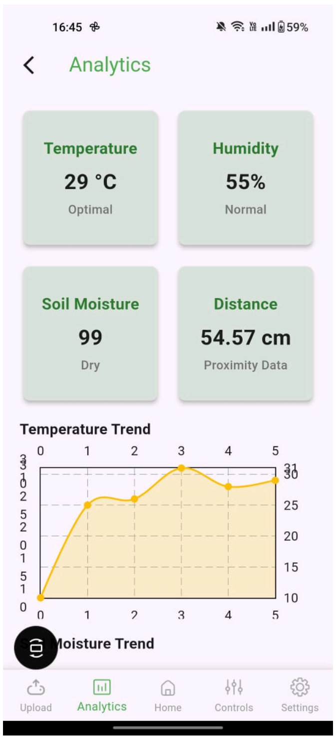

Fig. 8 IoT Data Analysis Page

Fig. 5,6,7,8 shows the splash screen introduces the app with a green, nature-themed background and options to sign in or create an account. The login screen allows users to securely access their accounts with email and password input. The home screen displays current weather and offers crop recommendations based on conditions. The analytics screen presents key agricultural metrics like temperature, humidity, soil moisture, and proximity data with visual trends for informed decision-making and all the data is collected by the sensors present on our AgriBot.

Fig. 9 Disease Detection

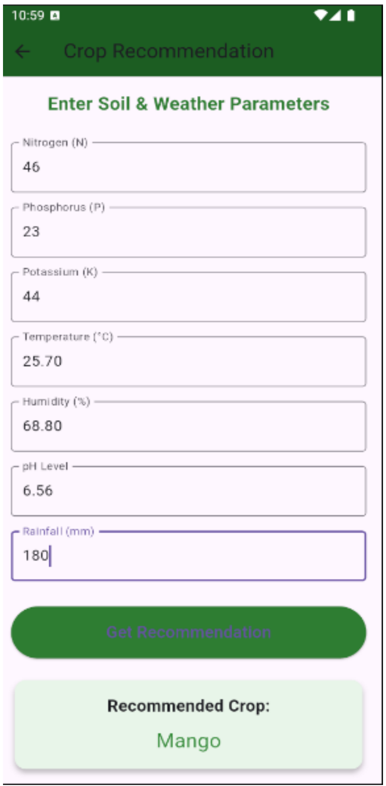

Fig. 10 Crop Recommendation

Fig. 9, 10 shows the leaf disease detection page allows users to upload an image from their camera or gallery, which the app processes to detect and identify any plant diseases, providing a diagnosis. The crop recommendation page takes input such as NPK values, temperature, humidity, and rainfall to recommend the most suitable crops based on environmental conditions.

B) WebUI for the same:

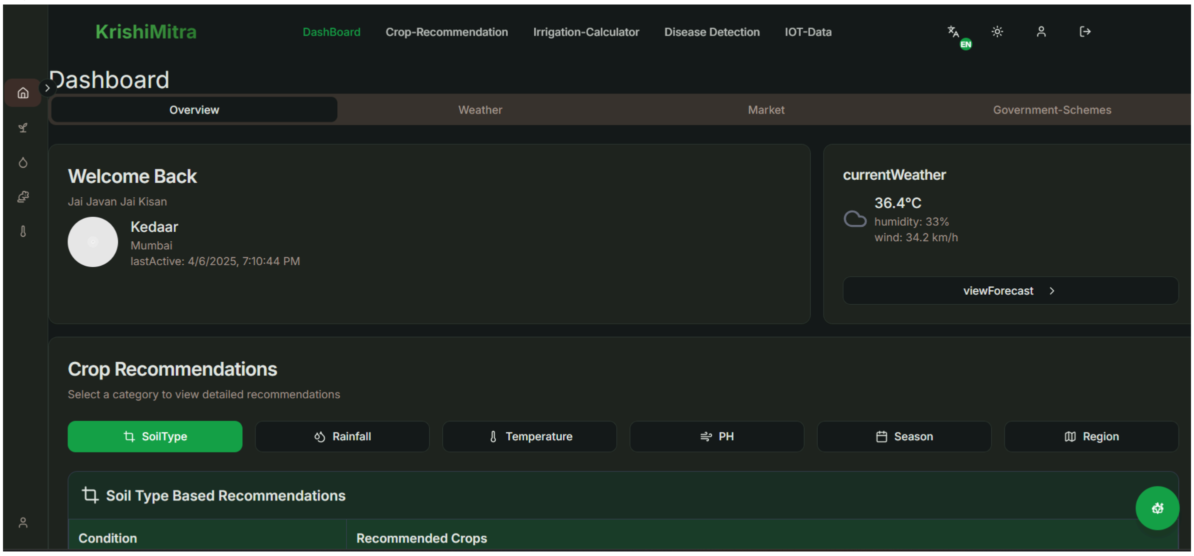

Fig. 11 Dashboard with User name and general information

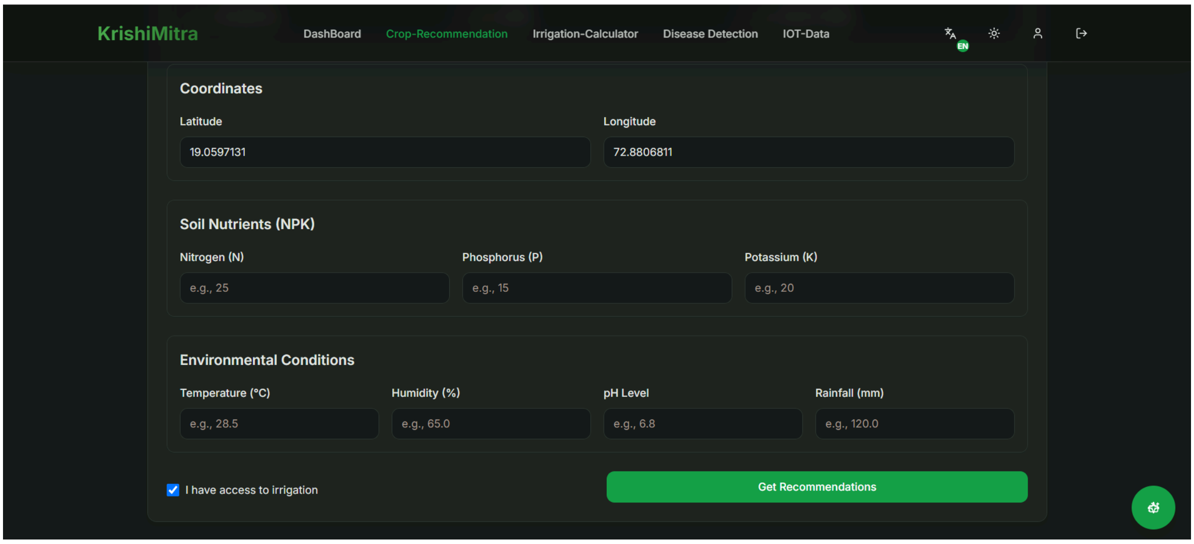

Fig. 12 Crop Recommendation using ML model

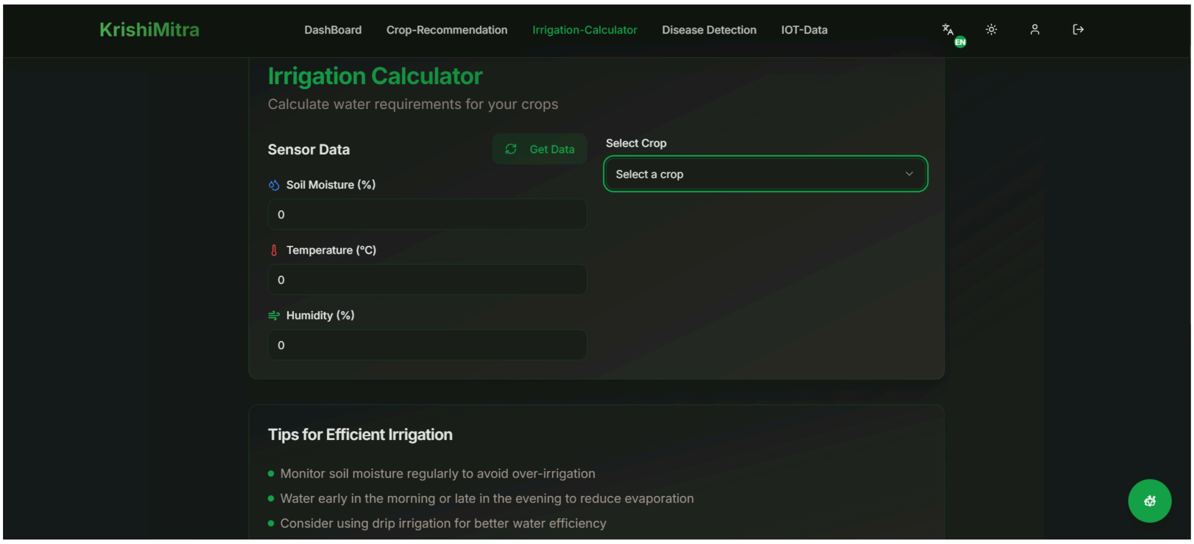

Fig. 13 Irrigation Recommendation using IoT Data

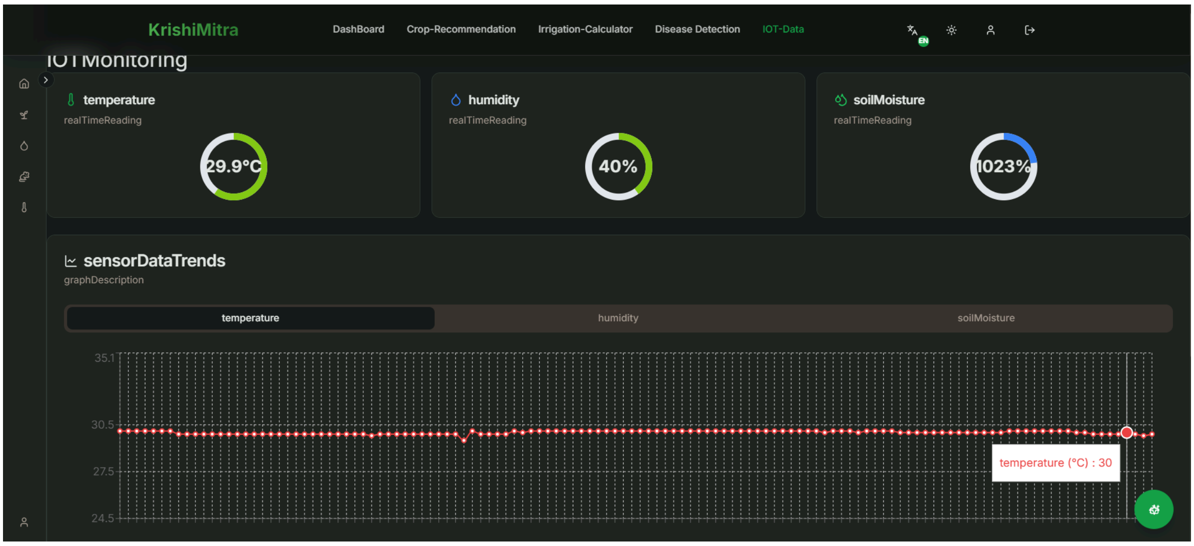

Fig. 14 Display of IoT Data

C) Agribot

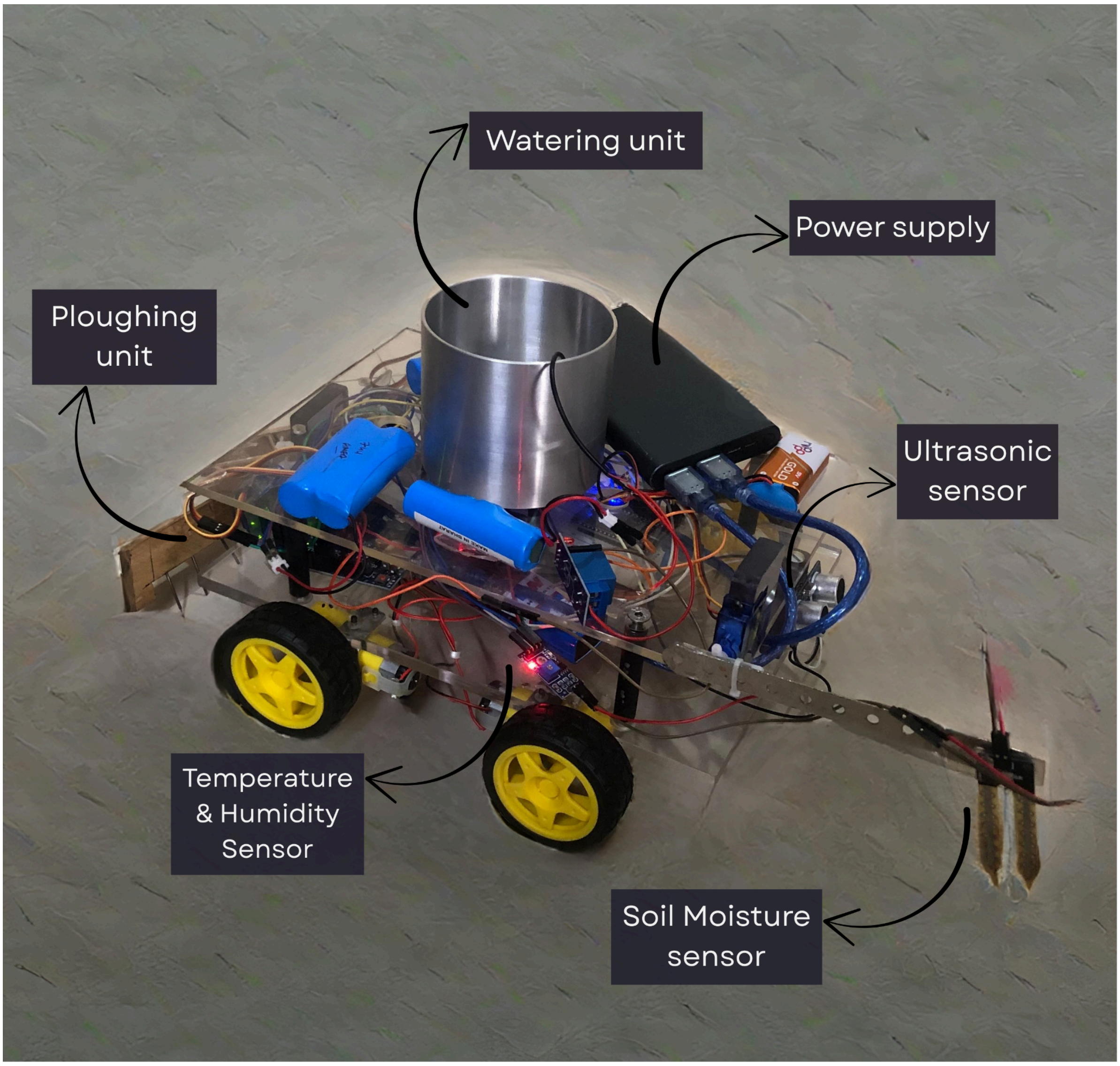

Fig 15. AgriBot

The AgriBot is a multi-functional automated robot designed to assist farmers in various agricultural tasks such as ploughing, watering, and monitoring environmental conditions as shown in fig. 15. The robot integrates multiple sensors and mechanical components to enable autonomous operation and real-time data collection for smart farming applications.

1. Ploughing Unit

The ploughing unit is mounted at the rear of the vehicle and is designed to break up the soil surface, making it suitable for sowing seeds. It resembles a miniature plough blade and is often made of durable metal. This unit helps in turning over the topsoil, burying crop residues, and loosening compacted layers to improve aeration and water retention in the soil. It automates one of the most labor-intensive farming processes, reducing the need for manual labor.

2. Watering Unit

Located centrally on the robot, the watering unit consists of a cylindrical container that holds water. It is connected to a water-dispensing mechanism, which could be a solenoid valve or motorized pump. The unit is triggered based on readings from the soil moisture sensor, ensuring that water is dispensed only when needed. This intelligent watering system promotes water conservation and delivers optimal hydration to plants.

3. Power Supply

The power supply is the energy source for the entire robotic system. It is typically a rechargeable battery pack or power bank securely mounted on the chassis. This component supplies electricity to all modules, including sensors, microcontrollers, and motors. A reliable power supply ensures uninterrupted operation of the robot in the field and supports long working hours without needing frequent recharging.

4. Ultrasonic Sensor

Mounted at the front of the robot, the ultrasonic sensor detects obstacles in the path of the vehicle. It works by emitting ultrasonic waves and measuring the time it takes for the waves to bounce back from an object. Based on this data, the robot can determine the distance to an obstacle and adjust its path to avoid collisions. This feature is essential for autonomous navigation and allows the robot to operate in dynamic field environments.

5. Soil Moisture Sensor

Positioned near the front lower section of the robot, the soil moisture sensor is inserted into the soil to measure its water content. This sensor plays a crucial role in determining whether the soil is dry or adequately moist. The data collected is used to control the watering unit, ensuring efficient use of water and healthy crop growth. It helps prevent both under-watering and over-watering, which can damage plants or waste resources.

6. Temperature and Humidity Sensor

This sensor is typically mounted near the center or side of the chassis and is responsible for monitoring the atmospheric conditions in the field. It measures the ambient temperature and relative humidity. These environmental parameters are vital for understanding plant growth conditions and can be logged for analysis or transmitted to a remote system. This information can help farmers make data-driven decisions regarding crop management.

7. Chassis and Wheel Base

The body of the robot is built on a lightweight but durable chassis that supports all components. It includes a four-wheel base with yellow-rimmed wheels that provide mobility across rough and uneven farmland. The wheels are likely powered by DC motors that allow the robot to move forward, reverse, and turn. The design ensures stability and ease of movement during operation in open fields.

Overall Application

This agricultural robot is a prototype for a smart farming solution aimed at improving efficiency, precision, and sustainability in agriculture. By combining automation with real-time data sensing, it reduces manual effort, conserves water, and supports healthier crop yields. It is suitable for small-scale farms, research, educational purposes, and can be scaled up for larger applications.

CHAPTER 8: CONCLUSION

8.1 Limitations

Despite its promising potential, the current implementation of the Agribot system has certain limitations:

- Sensor Accuracy: Low-cost sensors like DHT11 and basic soil moisture probes can sometimes provide inaccurate or inconsistent readings, which may affect decision-making accuracy.
- Limited Disease Detection Dataset: The image processing model for disease detection may not perform well across all plant types due to a limited and less diverse training dataset.
- Connectivity Dependency: The system's reliance on Wi-Fi or GSM for real-time data transfer can be a challenge in remote areas with poor network coverage.
- Power Supply Constraints: Although battery or solar-powered options are integrated, prolonged operation in unfavorable weather conditions may lead to power insufficiency.
- Fixed Thresholds: Static thresholds for irrigation control (e.g., soil moisture levels) may not generalize well across different soil types or crop varieties without dynamic calibration.
- Limited Autonomy: While irrigation and monitoring are automated, other complex tasks like harvesting or fertilization still require human intervention or additional modules.

8.2 Conclusion

The Agribot system effectively combines hardware components, IoT integration, and intelligent algorithms to enhance agricultural productivity and reduce manual workload. By automating key tasks such as irrigation, disease detection, and sowing, the system provides a comprehensive solution to many challenges faced by farmers, particularly in regions with limited access to modern agricultural tools.

The system's ability to monitor environmental conditions in real time and act autonomously not only improves crop health but also promotes sustainable farming by optimizing water usage and reducing waste. Moreover, the integration of a user-friendly dashboard allows farmers to control and monitor their farms remotely, bridging the technological gap in traditional agriculture.

In conclusion, Agribot represents a significant step toward smart and precision agriculture, offering a scalable and practical solution tailored for both small and large-scale farming operations.

8.3 Future Scope

There is ample room for enhancement and expansion of the Agribot system in future iterations:

- AI-Powered Adaptive Thresholding: Implementation of machine learning models to dynamically adjust irrigation thresholds based on soil type, weather forecasts, and crop requirements.
- Expanded Crop Disease Database: Training the disease detection algorithm on larger, more diverse datasets to improve accuracy and support more plant species.
- Voice-Based User Interface: Adding multilingual voice commands to make the system accessible to farmers who are not tech-savvy.
- Integration with Weather APIs: Incorporating weather forecast data to plan irrigation cycles and pesticide use more effectively.
- Automated Fertilization Module: Integrating a fertilizer dispensing mechanism for precise nutrient delivery.
- Drone Integration: Using drones for large-area surveillance, pest detection, and aerial imaging to enhance field coverage and monitoring.
- Blockchain for Crop Data Security: Applying blockchain technology to ensure secure and tamper-proof records of crop health and yield predictions.

By addressing current limitations and expanding functionality, Agribot can evolve into a fully autonomous smart farming assistant that empowers farmers with data-driven insights and reliable automation.

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