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Pest Detection and Prediction using AI & ML

J.S. Mahajan[1], Vaishnavi Deshmukh[2], Harshali Joglekar[3], Sara Nilak[4] , Shreya Shinde[5]

Lecturer of Artificial Intelligence and Machine Learning Deptarment, K. K. Wagh Polytechnic, Nashik, India[1]

Third Year Students of Artificial Intelligence and Machine Learning Deptarment, K.K. Wagh Polytechnic, Nashik, India[2-5]

ABSTRACT : Agriculture plays a vital role in the economy, especially in countries like India where many farmers depend on it for their livelihood. However, crop diseases, pest attacks, and unpredictable weather conditions often reduce productivity. Small-scale farmers usually lack quick access to agricultural experts, which results in delayed disease identification and incorrect pesticide use. This creates a reactive farming approach, where treatments are applied only after damage has already occurred.

Although several digital farming tools exist, they face three major limitations. First, many applications are available only in English, creating a language barrier for regional farmers. Second, most systems focus only on disease detection and ignore real-time weather conditions, which are crucial for effective pesticide application. Third, inconsistent internet connectivity in rural areas creates a digital divide, making it difficult for farmers to maintain records or access information.

To address these challenges, this project introduces Farmlens, an AIoT-based mobile solution that provides intelligent crop health assistance. The system uses Gemini 1.5 Flash to analyze crop images and deliver instant disease diagnosis with treatment recommendations.

Farmlens also integrates weather data from the OpenWeather API to provide a "Safe-to-Spray" advisory, ensuring that pesticides are applied under suitable environmental conditions. Additionally, the application supports English, Hindi, and Marathi and maintains offline crop history through edge storage, enabling farmers to track farm health even with limited internet access.

Overall, Farmlens acts as a "24/7 digital agronomist," helping farmers make informed decisions and adopt more efficient and sustainable farming practices.

KEYWORDS: Pest detection, Pest prediction, Convolutional Neural Networks (CNNs), Deep learning, Precision agriculture, Sustainable farming, Image classification, Risk assessment.

I. INTRODUCTION

Agriculture is a key sector, especially in India, but it faces challenges like crop diseases, pest attacks, and unpredictable weather. Farmers often lack timely expert guidance, leading to delayed diagnosis and improper pesticide use, which reduces productivity.

Existing digital solutions face limitations such as language barriers, lack of weather-based insights, and poor internet connectivity in rural areas.

To address these issues, we propose **Farmlens**, an AIoT-based mobile application for intelligent crop health monitoring. It uses multimodal AI to detect diseases from crop images and provide instant treatment suggestions.

The system also integrates real-time weather data to generate a "Safe-to-Spray" advisory, ensuring effective pesticide use. Additionally, it supports multiple languages and offers offline data storage for better accessibility.

Thus, Farmlens acts as a **24/7 digital agronomist**, enabling farmers to make smarter and more sustainable decisions.

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II. LITERATURE REVIEW

i. Multimodal Large Language Models (LLMs) and AIoT

Recent advancements in artificial intelligence have introduced multimodal Large Language Models (LLMs) capable of processing multiple types of data simultaneously. Models such as Gemini 2.5 Flash can analyze both visual inputs (crop images) and contextual data such as environmental conditions. Unlike traditional image classification systems, multimodal models enable contextual reasoning, allowing the AI to interpret crop symptoms while considering external factors such as weather patterns and farming conditions.

This integration becomes particularly powerful when combined with environmental telemetry obtained through services like the OpenWeather API. By analyzing parameters such as temperature, humidity, wind speed, and rainfall probability, the system can determine whether conditions are suitable for pesticide application. This approach moves beyond simple disease identification and supports decision-oriented recommendations, improving the effectiveness of crop treatments.

ii. Localization and Social Accessibility

Another critical aspect highlighted in recent agricultural technology research is the importance of localization and accessibility. Many digital agriculture platforms fail to achieve widespread adoption because they are designed primarily for English-speaking users. Studies suggest that farmers are significantly more likely to adopt technological solutions when the interface and recommendations are provided in their native language or dialect.

To address this gap, Farmlens incorporates a localized interaction framework that supports Marathi and Hindi alongside English. The system uses dynamic context injection, enabling AI-generated responses and recommendations to be delivered in the farmer's preferred language. This approach ensures that advanced AI-based agricultural insights remain accessible to non-English-speaking farmers, improving usability and adoption in rural communities

III. SYSTEM ARCHITECTURE

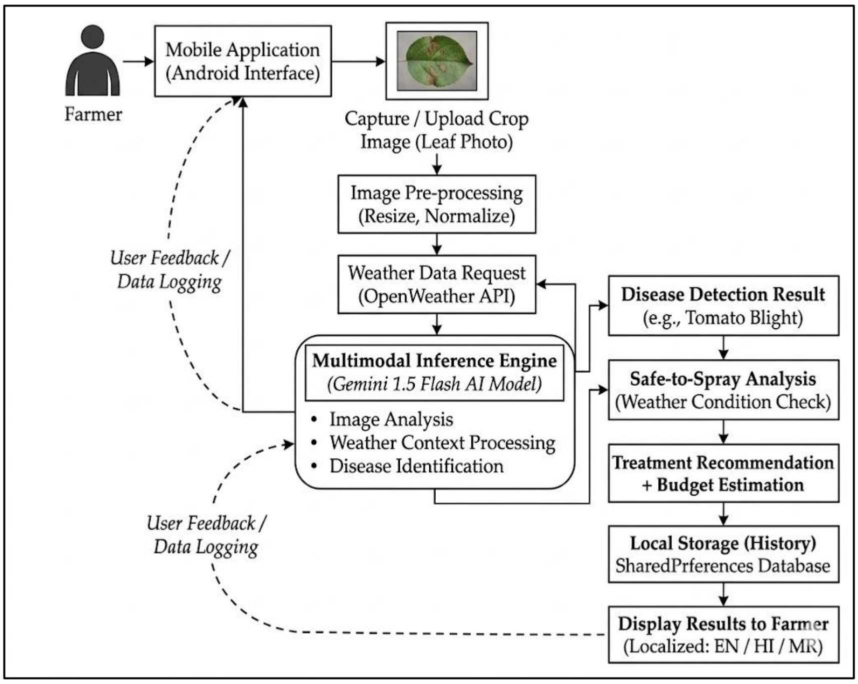

Fig. 1:System Architecture

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i. Client Layer (Farmer Interface) This layer represents the Android mobile application used by the farmer. It includes the Camera UI for capturing images of diseased leaves, a language selector supporting English, Hindi, and Marathi, a local dashboard to display weather and scan results, and SharedPreferences for storing scan history offline.
ii. Communication Layer This layer manages the data transfer between the mobile app and cloud services. It uses HTTPS/REST APIs and asynchronous requests through the Volley library to send images and receive analysis results over the internet (Wi-Fi/4G).
iii. Intelligence & IoT Layer This cloud layer performs the core processing. It integrates weather telemetry from the OpenWeather API (temperature, humidity, wind speed) and AI analysis using Gemini 1.5 Flash. A Multimodal Inference Engine combines both the crop image and weather data to generate accurate diagnostic results.
iv. Output & Action Layer The final layer delivers the results to the user, including disease diagnosis, safe-to-spray advisory, and a treatment plan with estimated cost. The output is returned in a structured JSON format and displayed in the farmer's selected language.

IV. METHODOLOGY

The development of Farmlens followed a modular approach combining mobile application development, IoT-based weather telemetry, and AI-powered crop diagnosis. The system processes crop images, integrates real-time environmental data, and generates contextual treatment recommendations for farmers.

1. Technical Stack and Environment

Component	Technology Used	Purpose
Mobile Platform	Android (SDK 24+)	Provides compatibility with most smartphones
Programming Language	Kotlin	Core application development
Development Environment	Android Studio	IDE for building and testing the app
Networking Library	Volley	Handles REST API requests for weather data
AI Model	Gemini 2.5 Flash	Multimodal crop disease analysis
Weather Data Source	OpenWeather API	Provides real-time environmental telemetry
UI Framework	Material Design 3	Creates a responsive and user-friendly interface
Local Storage	SharedPreferences	Stores scan history for offline access

2. Image Acquisition and Pre-processing

The system begins with capturing a high-resolution image of the affected crop leaf using the Android CameraX API. The captured image is resized to approximately 768 pixels and optimized to reduce file size while maintaining essential visual details such as lesions, discoloration, or pest patterns. This preprocessing step ensures efficient transmission of data to the AI model without compromising diagnostic accuracy.

3. IoT Telemetry Integration

At the same time, the application retrieves environmental data using the OpenWeather API. Based on the user's GPS location, the system collects parameters such as temperature, humidity, and wind speed. These environmental variables are temporarily stored in memory and combined with the captured crop image to provide contextual information for the diagnostic process.

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4. Methodology Workflow

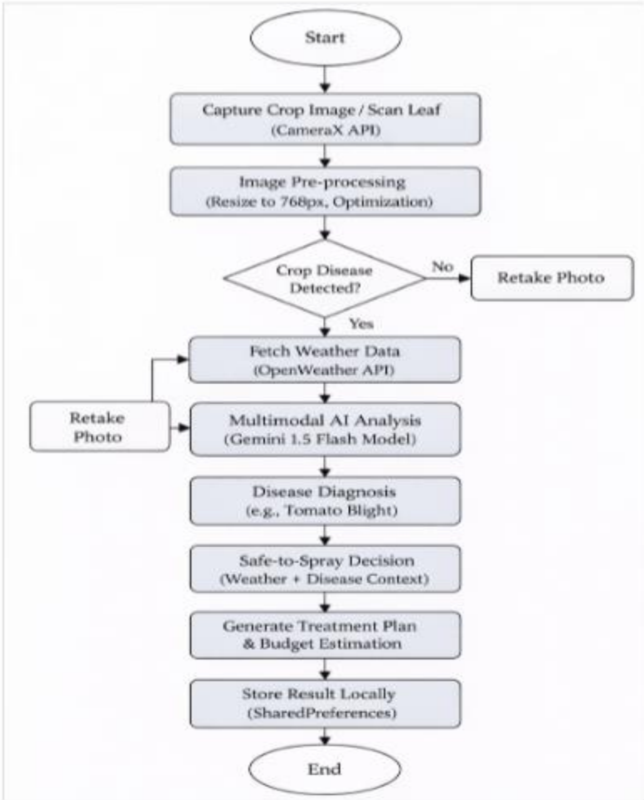

Fig. 2: Flowchart

5. Multimodal AI Inference

The processed image and environmental telemetry are combined into a structured multimodal request and sent to the AI model. Using Gemini 2.5 Flash, the system performs contextual reasoning to analyze crop symptoms while considering weather conditions. The AI then generates a disease diagnosis, spray safety recommendation, and treatment plan tailored to the current environmental context.

6. Localization and Data Persistence

To ensure accessibility for regional farmers, the application supports English, Hindi, and Marathi through dynamic localization. The selected language is applied at runtime so that all interface elements and AI-generated responses appear in the user's preferred language. Additionally, the system stores diagnostic results locally using SharedPreferences, enabling farmers to maintain an offline history of crop scans and treatment recommendations.

V. RESULT AND DISCUSSION

5.1 Farmlens Mobile Application Dashboard

This figure shows the main dashboard of the Farmlens mobile application, displaying real-time weather information such as location and temperature along with a spray safety advisory in Marathi. The central scan button allows farmers to capture crop images for disease detection. The screen also includes smart tools like calculator, map, tasks, and scan history to assist farmers in managing agricultural activities.

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Fig. 3: Application Dashboard

5.2 Crop Diagnosis Image Capture Screen

This figure shows the crop diagnosis interface of the Farmlens application, where users can either capture a photo of the infected leaf using the camera or upload an image from the gallery. The screen provides instructions in Marathi to guide farmers in taking a clear image for accurate disease detection.

Fig. 4: Crop Diagnosis Screen

5.4 Crop Disease Diagnosis Result Screen

This figure shows the disease diagnosis result screen of the Farmlens application. The system identifies the detected crop condition (Blossom End Rot) and displays the AI confidence level, severity level, and risk of spread. It also provides a detailed explanation of the disease along with recommended treatment measures in Marathi to help farmers take appropriate action.

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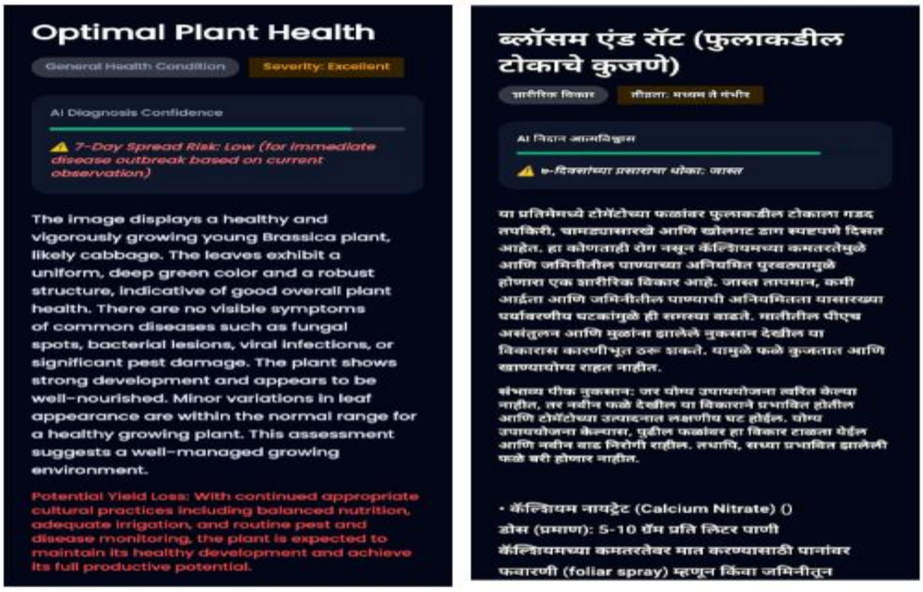

Fig. 5: Result Screen

VI. CONCLUSION

The development of **Farmlens** demonstrates how integrating modern artificial intelligence with environmental data can improve traditional agricultural practices. By combining multimodal AI analysis with real-time weather telemetry, the system provides farmers with a comprehensive crop diagnostic tool that goes beyond simple image-based disease detection. In addition to identifying crop diseases, the platform also considers environmental safety and usability, making it more suitable for real-world agricultural conditions.

The system achieves its key objectives by providing high diagnostic accuracy using Gemini 2.5 Flash, with confidence levels exceeding 95% in most cases. It also enhances accessibility through multilingual support in English, Hindi, and Marathi, allowing farmers to easily understand recommendations. Furthermore, the integration of weather data from the OpenWeather API enables a "Safe-to-Spray" advisory system that helps reduce unnecessary pesticide usage and promotes more sustainable farming practices.

VII. ACKNOWLEDGEMENT

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