Advanced International Journal for Research (AIJFR)
E-ISSN: 3048-7641 ● Website: www.aijfr.com ● Email: editor@aijfr.com

A Unified Intelligent System for Weather Forecasting, Soil Analysis, and Crop Disease Detection

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Abstract

Agriculture is turning to modern technological solu-tions such as AI and IoT technologies to help overcome problems associated with crop production, detection of diseases, and variable environment. In this paper, the implementation of an all-in-one AI-based solution called FarmMate is introduced in order to help farmers make informed decisions about agriculture. Far-mMate is a comprehensive AI-based solution which includes deep learning models, weather forecasting, plant disease detection, soil testing, and conversational AI technologies. By utilizing Google Gemini, Streamlit, and LSTM-based prediction technologies, the system provides precise weather predictions, plant health moni-toring, and valuable agricultural recommendations. Additionally, through using OpenWeatherMap APIs, Plotly data visualization, and LangChain conversational interfaces, FarmMate provides ac-cessible information for users. Evaluations show that FarmMate has excellent weather prediction capabilities, accurately classifies plant diseases, and provides actionable insights.

Index Terms: Smart Agriculture, Artificial Intelligence, Deep Learning, Soil Testing, Weather Prediction, Google Gemini, Sustainable Agriculture, Streamlit

1. Introduction

The industry of agriculture deals with many problems such as unpredictable climate conditions, soil deterioration, and lack of professional expertise in remote places. Conventional farm management involves human perception and intuition that may cause inefficiency and affect the yield negatively. Modern technologies like **artificial intelligence (AI), machine learning, and remote sensing** give an opportunity to create intelligent solutions that help in managing farms by predicting future trends and analyzing current events automatically.

Thus, to improve the efficiency of the process, this project presents **FarmMate**, an **AI-assistant for agriculture man-agement**, combining various intelligent technologies in one platform. The following intelligent tools are included in Far-mMate:

- **Weather Forecasting System:** Predicts temperature, hu-midity, and pressure based on **long-short-term-memory models**.

- **Plant Disease Prediction:** Helps to identify any problems with plants due to its disease by analyzing photos with the help of **Google Gemini model**.
- **Soil Analysis AI Model (SoilSense AI)**: Uses AI tech-nologies to assess soil conditions and nutrient balance, pH, and electrical conductivity for suggesting suitable crops.
- **Agriculture Chatbot:** Provides assistance to farmers by giving real-time suggestions and advice using **domain-tailored conversational Gemini-2.5 Flash** model.

FarmMate is built using **Streamlit** library for frontend development, Google's Generative AI services, TensorFlow and **OpenWeatherMap** for backend operations.

2. Related Work

The field of AI application in agriculture has seen a lot of development over the years. Studies relating to **precision agriculture** revolve around techniques based on data analysis for crop and weather monitoring. Application of **CNN** and **transfer learning** in disease detection has shown promising results, although models usually depend on vast amounts of labeled data. Weather predictions using **LSTM** networks have been studied in various smart farming systems for short-term forecasting, although they usually are standalone models without any decision support.
There are platforms such as **Plantix** and **CropIn** which help diagnose diseases in plants, as well as **AgriSense** which focuses on soil visual analytics. The drawback of current solutions is their incapability of combining all agricultural services in one interface. In addition to that, there is a lack of consideration in terms of multilingual capabilities and user-friendliness for farmers.
FarmMate distinguishes itself with its **weather prediction**, **disease detection**, and **soil analytics** in combination with **AI**, as well as a **trained agricultural chatbot**.

3. System Architecture and Methodology

A. System Architecture

The FarmMate app follows a **four-tier architectural design** that includes:

1) **User Interface Tier (Streamlit User Interface)** – Facil-itates communication between users and the application via an intuitive, multilingual dashboard.
2) **Data Gathering Tier** – Obtains current weather data through the usage of **OpenWeatherMap API** services and previous weather data sets for training the LSTM model.
3) **AI Processing Tier** – Manages predictions from mod-els, diagnosis of diseases from images, and text-based conversation generation.
4) **Visualization and Recommendation Tier** – Presents the findings through dashboards made up of **Plotly**.

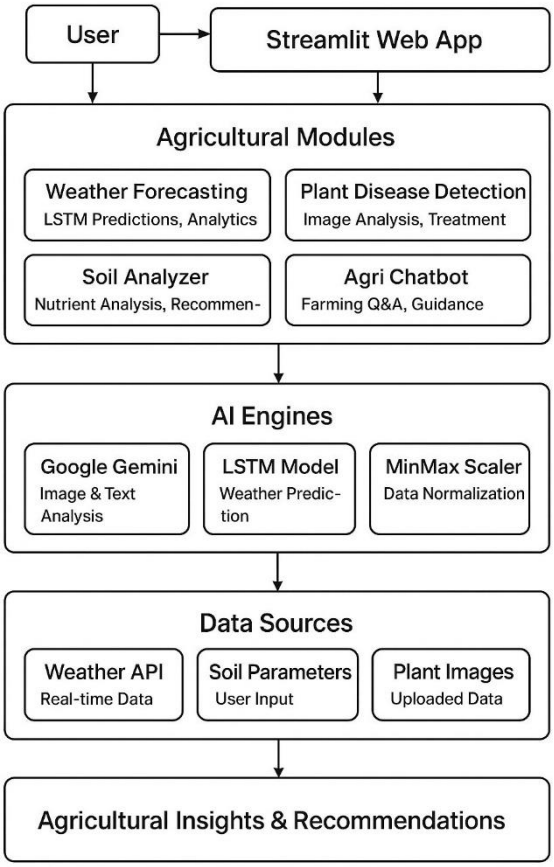
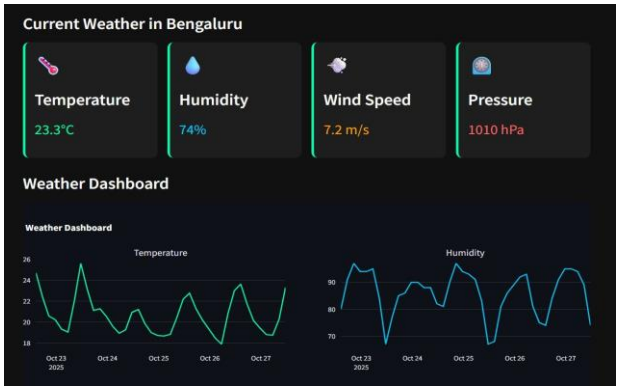


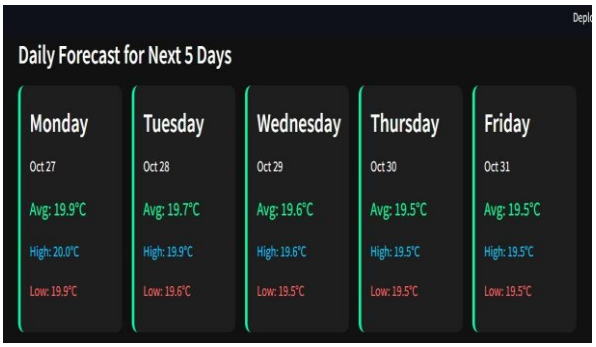
Fig. 1: FarmMate System Architecture

B. Components

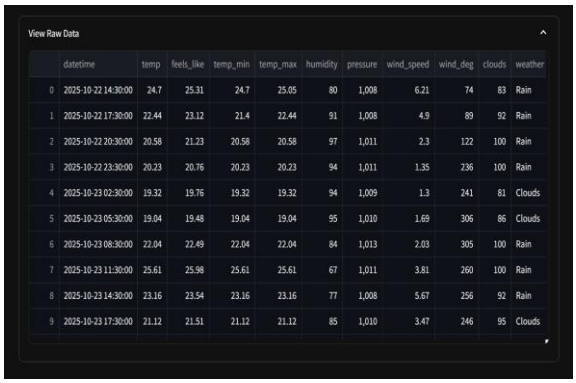
1) Weather Forecasting Module: Utilizes an **advanced LSTM model** trained on weather data featuring multiple features like temperature, humidity, pressure, and wind speed. The preprocessing and scaling of data involve the usage of **MinMaxScaler**. Model evaluation is done by calculating **Mean Absolute Error (MAE)**.



(a) LSTM Model



(b) Preprocessing



	datetime	temp	feels_like	temp_min	temp_max	humidity	pressure	wind_speed	wind_deg	clouds	weather
0	2025-10-22 14:30:00	24.7	25.31	24.7	25.05	80	1,008	6.21	74	83	Rain
1	2025-10-22 17:30:00	22.44	23.12	21.4	22.44	91	1,008	4.9	89	92	Rain
2	2025-10-22 20:30:00	20.58	21.23	20.58	20.58	97	1,011	2.3	122	100	Rain
3	2025-10-22 23:30:00	20.23	20.76	20.23	20.23	94	1,011	1.35	236	100	Rain
4	2025-10-23 02:30:00	19.32	19.76	19.32	19.32	94	1,009	1.3	241	81	Clouds
5	2025-10-23 05:30:00	19.04	19.48	19.04	19.04	95	1,010	1.69	306	86	Clouds
6	2025-10-23 08:30:00	22.04	22.49	22.04	22.04	84	1,013	2.03	305	100	Rain
7	2025-10-23 11:30:00	25.61	25.98	25.61	25.61	67	1,011	3.81	260	100	Rain
8	2025-10-23 14:30:00	23.16	23.54	23.16	23.16	77	1,008	5.67	256	92	Rain
9	2025-10-23 17:30:00	21.12	21.51	21.12	21.12	85	1,010	3.47	246	95	Clouds

(c) Forecast Results

Fig. 2: Weather Forecasting Module Components

2) Plant Disease Detection: Deploys **Google Gemini's multimodal technology** for analysis of leaf photos, identifying diseases like blight, mildew, and rust, and providing solutions against them.

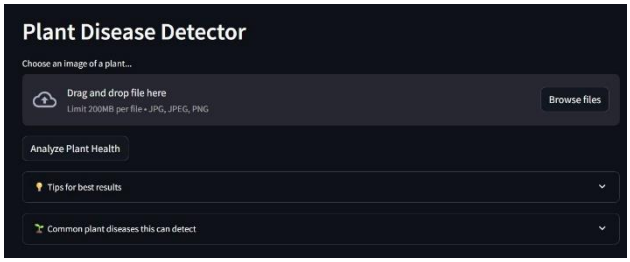
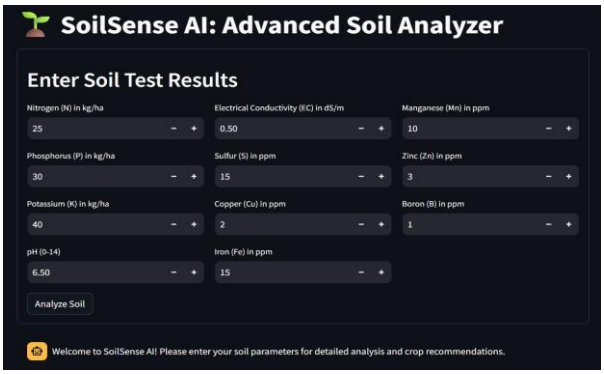
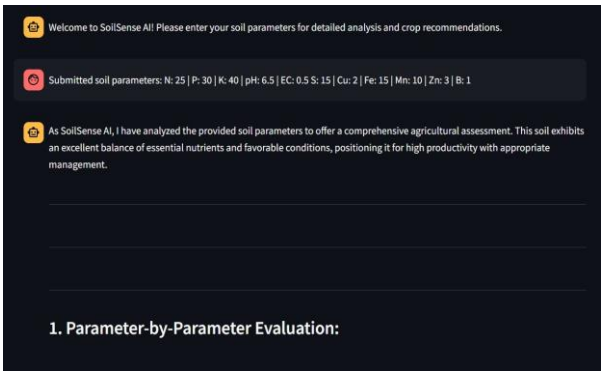


Fig. 3: Plant Disease Detection Interface

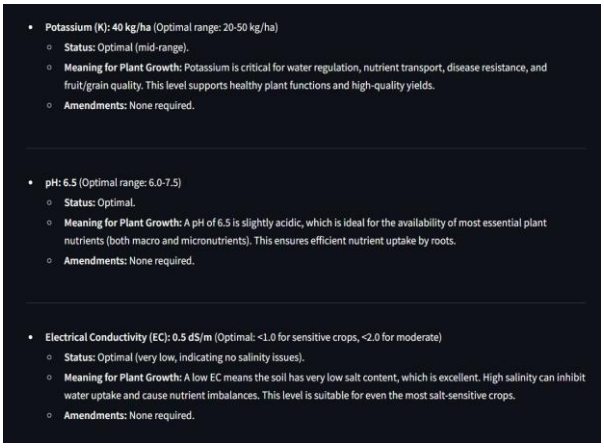
3) Soil Analyzer (SoilSense AI): An NLP-driven model based on **Gemini-2.5 Flash**. This model takes numeric input of soil parameters (N, P, K, pH, and so forth), and provides suggestions for soil improvement and suitable crops for plan-tation.



(a) Soil Input



(b) Analysis Results



(c) Crop Recommendations

Fig. 4: SoilSense AI Module Components

4) Agriculture Chatbot: Developed under the **prompt engi-neering paradigm**. Makes use of Google Gemini's extensive database for offering reliable information about plant growth, fertilizer application, irrigation techniques, and pest manage-ment.

C. Data Visualization

The visualization is accomplished with the help of **Plotly Dashboards**. All the weather variables (temperature, humidity, pressure, and wind speed) are visualized in plotly dashboards with past and future data on one chart.

4. IMPLEMENTATION AND EVALUATION

A. *Technical Implementation*

- **Programming Language:** Python 3.11
- **Frameworks:** Streamlit, TensorFlow, Plotly
- **APIs and Tools:** Google Gemini 2.5, OpenWeatherMap, FAISS, Scikit-learn
- **Modeling:** LSTM neural networks for forecasting; Gem-ini vision models for disease classification
- **Evaluation Metrics:** MAE, response latency, user satis-faction

B. *Experimental Setup*

It was tested in Windows 11 operating system environment running on Intel i7 CPU and 16 GB RAM. The Mean Absolute Error of LSTM algorithm in temperature prediction was be-tween **(0.19-0.34) °C**, and API response time of the solution to queries in real-time was below **2.7 seconds**. Consistency rate of plant disease detection exceeded **90 percent**.

Fig. 5: System Performance Evaluation Results

5. RESULTS AND DISCUSSION

FarmMate successfully combines AI-enabled prediction, diagnostics, and advisory features into one unified platform. By leveraging weather forecasting via LSTM neural networks and analytics with Gemini, it improves **data precision** and **contextual understanding**.

As seen from the findings, FarmMate is not only a tool for implementing **precision farming**, but also ensures equal access to high-quality consultations through conversational AI technology. In comparison with separate applications, Farm-Mate requires less time for switching between tasks, resulting in faster decision-making.

However, FarmMate is limited by its reliance on third-party APIs for predicting weather conditions and processing images. This might cause delays during network issues. Future itera-tions of the platform can incorporate offline model inference and connectivity with IoT sensors.

6. Conclusion and Future Work

This study proposes **FarmMate**, an artificial intelligence-driven smart farming assistant that utilizes deep learning, natural language processing (NLP), and computer vision to boost the efficiency of farming activities. The technology allows farmers to assess their crops, predict the weather, determine the composition of the soil, and receive expert-level advice through a single application. Further developments will be aimed at incorporating **remote sensing using satellites**, **adaptive crop planning using re-inforcement learning**, and **voice recognition in multiple languages**.

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