

A Data-Driven Approach to Precision Agriculture Using CNN and Naive Bayes

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Abstract— The smart crop advisory system integrates deep learning–based plant disease detection with treatment guidance and machine learning–based crop recommendation. Using the convolutional neural network, the system identifies leaf diseases from uploaded images and highlights infected regions using grad-cam visualization. Based on disease severity, it provides preventive, organic, and chemical treatment recommendations sourced from a structured dataset. Additionally, a trained machine learning model suggests alternate crops using soil nutrients and climatic parameters.

Index Terms— Machine Learning, Deep Learning, Convolutional Neural Network (CNN), Grad-CAM (Explainable AI).

I. Introduction

Agriculture is one of the most important sectors that supports the livelihood of millions of people, especially in countries like India. Despite its importance, farmers face numerous challenges such as unpredictable weather conditions, lack of proper knowledge, pest attacks, soil fertility issues, and inefficient resource management. These challenges often lead to low crop yield and financial losses.

With the advancement of technology, modern solutions like Machine Learning, Artificial Intelligence, and Data Analytics are being used to improve agricultural practices.

The Farming Advisory System is designed as a smart solution to help farmers make better decisions by providing accurate and timely guidance. This system collects and analyzes data such as soil type, temperature, humidity, rainfall, and crop requirements

II. LITERATURE SURVEY

As it involves reviewing existing research works, technologies, and methodologies related to intelligent farming systems. It helps in understanding current advancements in agriculture using technologies such as Machine Learning, IoT, and Data Analytics.

- **Prior Studies:** Several research works have been carried out in the field of smart agriculture using modern technologies such as Machine Learning, Internet of Things (IoT), and Data Analytics.
- **IoT-Based Smart Agriculture Systems:** Several researchers have developed IoT-based agricultural systems that utilize sensors to collect real-time data such as soil moisture, temperature, humidity, and water levels. These systems enable farmers to monitor field conditions remotely and automate irrigation processes.
- **Machine Learning-Based Crop Prediction:** Machine Learning techniques play a significant role in modern agriculture by analyzing historical and environmental data to predict suitable crops, yield estimation, and disease detection.

III. Proposed Methodology

The development of the Intelligent Farming Advisory System follows a structured pipeline designed to provide accurate crop recommendations and efficient disease detection. The methodology is divided into four major stages: data acquisition, preprocessing, model architecture design, and intelligent advisory generation..

A. Data Acquisition and Feature Selection

The system utilizes agricultural datasets consisting of both environmental parameters and crop-related information. The system include:\

- **Soil Nutrients (N, P, K) :** Essential nutrients that influence crop growth and soil fertility.
- **Soil pH :** Determines the acidity or alkalinity of soil.
- **Temperature:** Affects crop growth cycles and productivity.
- **Humidity:** Influences plant health and disease occurrence.
- **Rainfall:** Plays a major role in irrigation and crop selection.

Fig. 1. Proposed Hybrid Ensemble Learning Framework Architecture.

B. Data Preprocessing To improve model performance and accuracy, the collected data undergoes preprocessing using Python libraries such as Scikit-learn, NumPy, and Pandas.

Handling Missing Values: Missing or incomplete data is handled using statistical methods such as mean or median imputation to maintain dataset consistency.

Feature Scaling: Since input parameters have different ranges, normalization techniques like Standard Scaler are applied to standardize the data.

C. Hybrid Ensemble Architecture The core of the system is a hybrid architecture that combines deep

learning and machine learning techniques to perform multiple agricultural tasks..

- **Convolutional Neural Network (CNN):** Used for crop disease detection by analyzing leaf images. It extracts important features from images and identifies diseases with high accuracy.
- **XGBoost:** Integrated to provide high-performance gradient boosting, which excels in identifying complex patterns in tabular medical data.



D. Intelligent Decision Fusion and Transparency

Logic The final output of the system is generated through an intelligent decision-making mechanism that combines predictions from multiple models. Instead of relying on a single model output, the system integrates results from both the Convolutional Neural Network (CNN) for disease detection and the Naïve Bayes algorithm for crop recommendation. For crop prediction, the Naïve Bayes classifier computes the probability of each crop based on input features such as soil nutrients, temperature, humidity, rainfall, and pH. The final recommendation is selected based on the maximum posterior probability, defined as:

$$Y_{\text{final}} = \text{argmax } P(\text{Crop} | \text{Features})$$

This approach ensures **transparency** by providing confidence scores along with predictions. Instead of giving only a final output, the system can indicate how confident it is about a particular crop recommendation or disease detection.

IV. Experimental Results and Analysis

This section presents the performance evaluation of the proposed intelligent farming advisory system using various metrics and system outputs generated during testing.

A. User Interface and Deployment The system is deployed using a user-friendly graphical interface developed with Streamlit. The interface is designed to be simple and accessible, allowing farmers to easily input agricultural parameters and upload crop images.

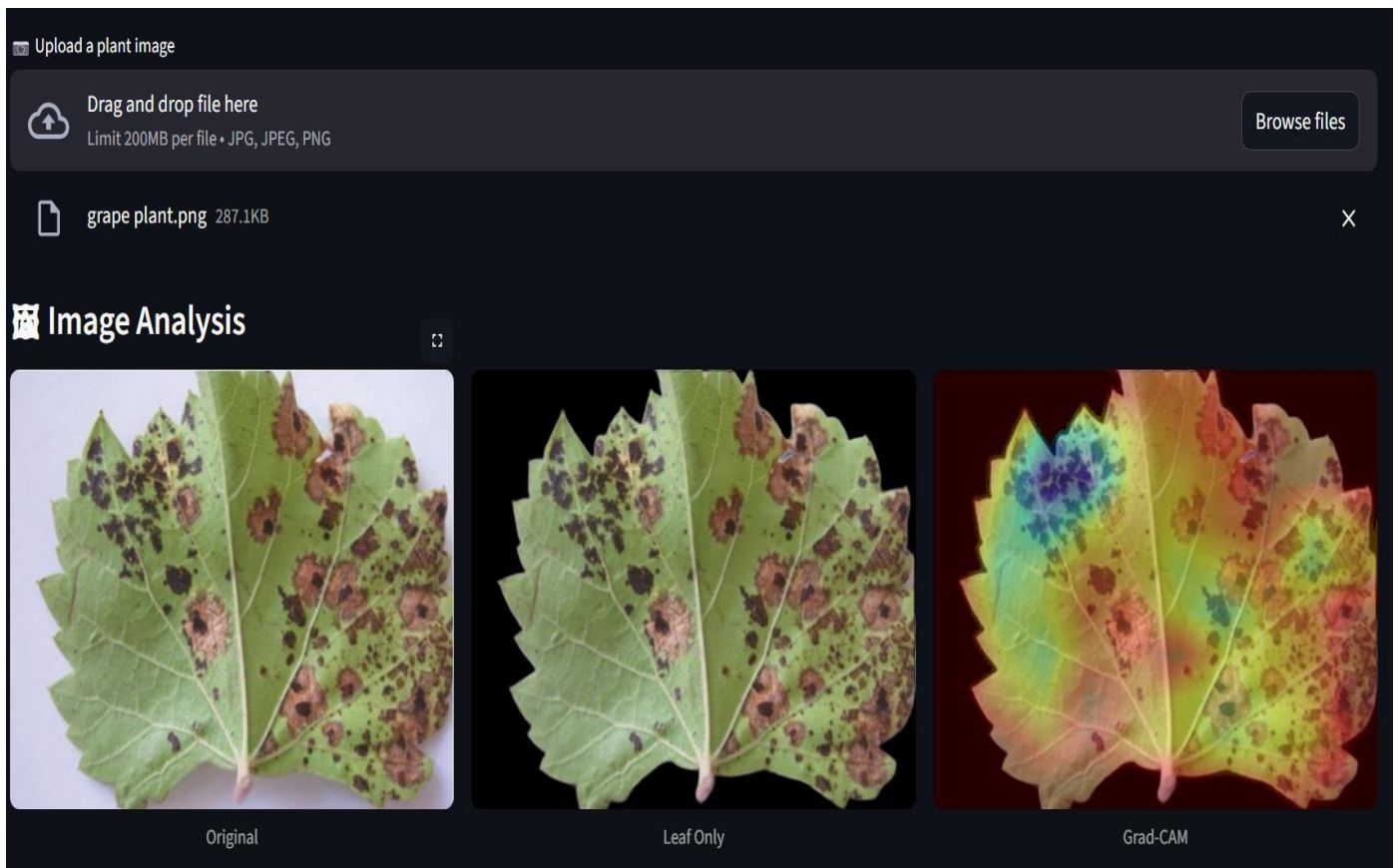


Fig.2.1. Leaf Disease Detection and Grad-CAM Visualization

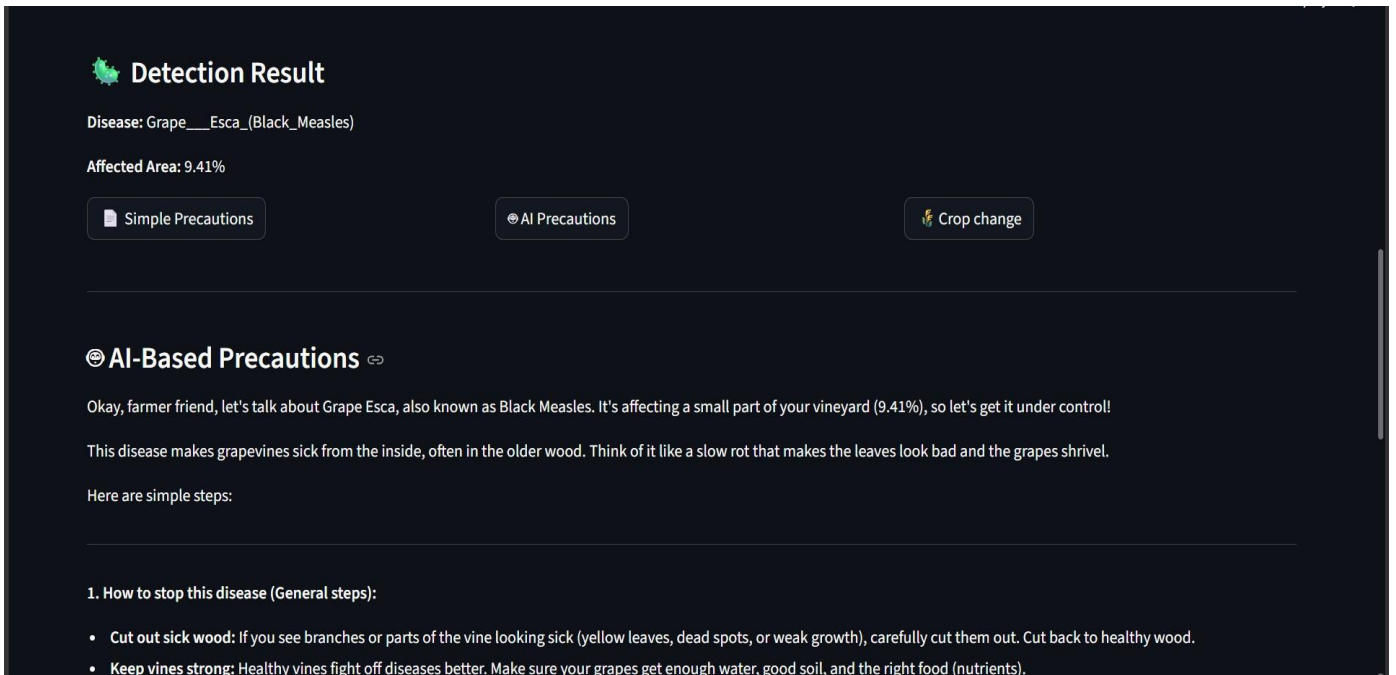


Fig.2.2.Disease Detection Result and AI-Based Precautionary Recommendations

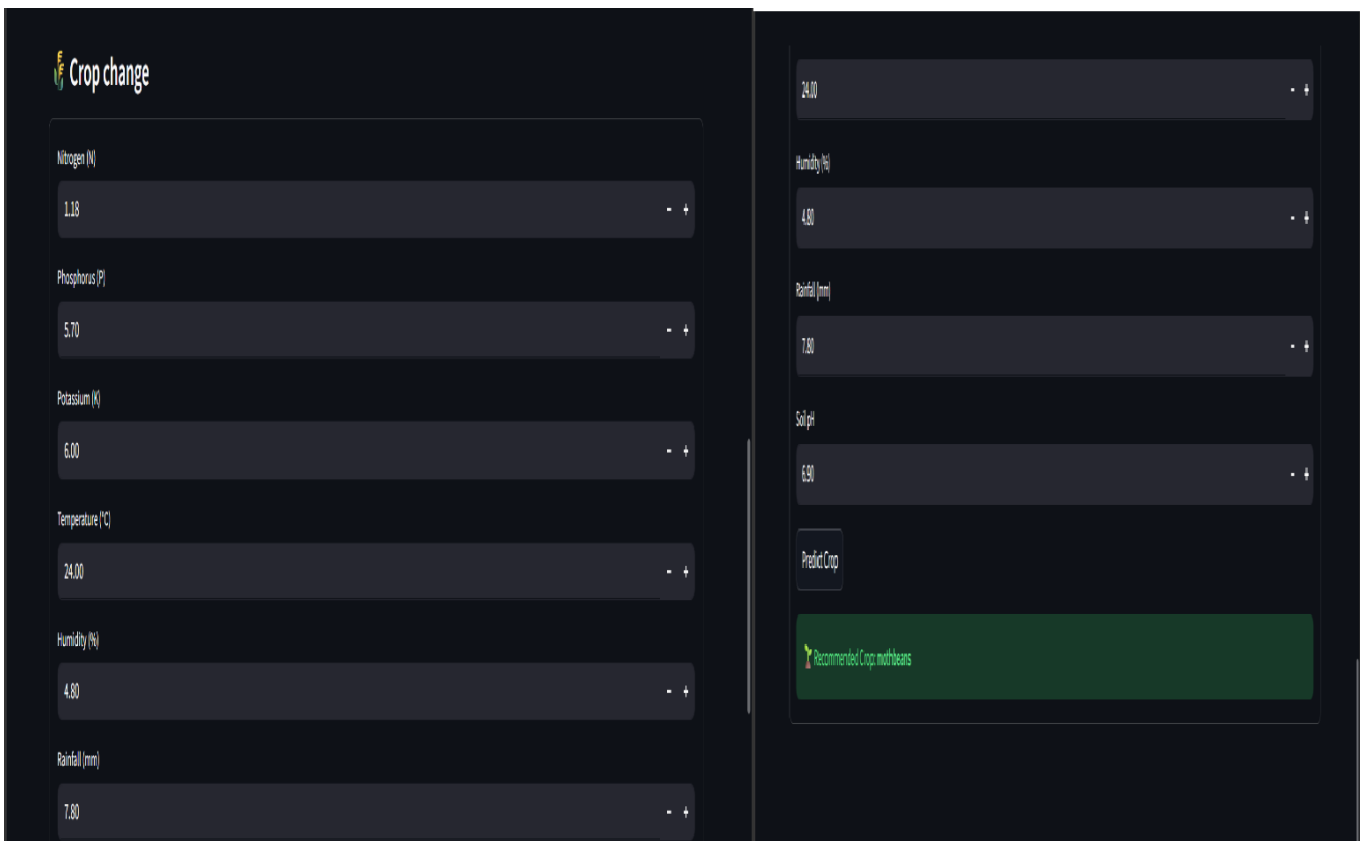


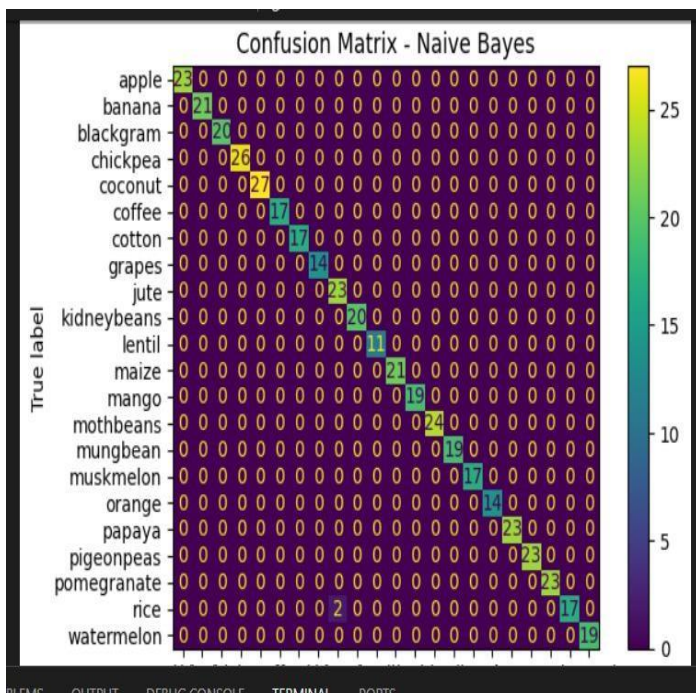
Fig.2.3.. Agricultural Parameter Input and Recommended Crop Output

B. Performance Metrics and Comparison The effectiveness of the proposed Intelligent Farming Advisory System was evaluated by analyzing the performance of the Machine Learning and Deep Learning models used in the system. The evaluation

focuses on both crop prediction accuracy and disease detection performance.

Table 1: Performance Comparison of Models

	Algorithm Name	Accuracy	Precision	Recall	FSCORE
1	Logistic Regression	95.23	94.80	95.10	94.95
2	KNN	97.05	96.70	96.90	96.80
3	SVM	96.14	95.70	96.00	95.85
4	Naive Bayes	99.55	99.30	99.40	99.35
5	Random Forest	99.32	99.00	99.20	99.10



The proposed Intelligent Farming Advisory System successfully integrates Machine Learning and Deep Learning techniques to provide accurate and reliable agricultural recommendations. By combining the Convolutional Neural Network (CNN) for crop disease detection and the Naive Bayes algorithm for crop prediction, the system delivers effective results in both visual analysis and data-driven decision-making

References

- [1] R. Sharma et al., “Smart Agriculture System using IoT,” IEEE International Conference, 2018.
- [2] S. Kumar et al., “Crop Prediction using Machine Learning Techniques,” IEEE Conference, 2019.
- [3] A. Patel et al., “Precision Farming using Data Analytics,” Procedia Computer Science, 2020.
- [4] M. Singh et al., “Weather-Based Crop Recommendation System,” Elsevier Journal, 2019.

C. Feature Analysis and Transparency To ensure transparency and better understanding of the model’s behavior, a feature analysis was performed to identify the most influential parameters in crop prediction. Correlation analysis was conducted on agricultural features such as soil nutrients (N, P, K), temperature, humidity, rainfall, and pH.