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AI-Smart Agro Advisor: A Hybrid Deep Learning Based Smart Crop Disease Prediction and Recommendation System

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ABSTRACT: Crop diseases pose a major threat to agricultural productivity, particularly in rural regions where timely expert guidance and reliable internet connectivity are limited. This project presents **AI-Smart Agro Advisor**, a hybrid artificial intelligence–based mobile application designed for **real-time crop disease detection and intelligent crop recommendation**. The system employs dual**-mode architecture** to ensure continuous operation under both offline and online conditions. In offline mode, a **MobileNetV2-based Convolutional Neural Network** optimized using **TensorFlow Lite** performs on-device inference to identify commonly occurring crop diseases from leaf images captured using a smartphone camera. In online mode, the application integrates a **cloud-based deep learning model (ResNet50)** accessed through a RESTful API to enable large-scale detection of crop diseases and pests with higher accuracy. Additionally, crop suitability predictions are generated using **machine learning models** trained on soil parameters and seasonal data. To enhance accessibility, the system incorporates **offline Tamil voice-assisted interaction** implemented using on-device **Text-to-Speech and Speech Recognition** modules. The proposed system aims to reduce crop losses, improve farmer decision-making, and support sustainable agriculture through an efficient, scalable, and farmer-centric smart advisory solution.

KEYWORDS: Deep Learning, MobileNetV2, ResNet50, Convolutional Neural Networks, RESTful API, Text-to-Speech.

I. INTRODUCTION

Agriculture remains one of the most important sectors supporting global food production and rural economies. However, crop diseases continue to pose a major threat to agricultural productivity, leading to substantial reductions in yield and quality. Early detection of plant diseases plays a crucial role in preventing disease spread and enabling farmers to apply appropriate treatments at the right time. Unfortunately, many farmers rely on manual observation or consultation with agricultural experts, which may not always be accessible in rural areas.

Recent advances in artificial intelligence and computer vision have enabled the development of intelligent systems capable of automatically identifying crop diseases using image analysis. Deep learning models, particularly Convolutional Neural Networks (CNNs), have demonstrated significant success in visual recognition tasks and have been widely applied in plant disease detection. These technologies provide an opportunity to develop mobile-based agricultural advisory systems that can support farmers in real-time disease diagnosis.

Despite these advancements, many existing AI-based agricultural systems depend heavily on cloud computing infrastructure. Such solutions require stable internet connectivity and may suffer from latency issues when deployed in

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rural regions. Furthermore, several systems focus primarily on disease classification without providing actionable treatment recommendations or agricultural guidance.

To address these challenges, this research proposes **AI-Smart Agro Advisor**, a hybrid AI-based agricultural advisory platform designed to provide both disease detection and intelligent crop recommendations. The system combines offline deep learning inference on mobile devices with cloud-based AI services, ensuring reliable operation under varying connectivity conditions. By integrating mobile computing, deep learning, and voice-assisted interaction, the system aims to provide farmers with an accessible and practical smart farming assistant.

II. LITERATURE REVIEW

The application of artificial intelligence in agriculture has gained significant attention in recent years. Several research studies have explored the use of machine learning and deep learning techniques for plant disease detection and agricultural decision support.

One of the most widely used datasets in plant disease research is the **PlantVillage dataset**, which contains thousands of labeled images of plant leaves affected by different diseases. Researchers have applied various deep learning architectures such as **AlexNet, VGG16, ResNet, DenseNet, and MobileNet** for plant disease classification tasks.
Among these architectures, **ResNet-based models** have demonstrated high classification accuracy due to their deep residual learning structure. However, these models are computationally intensive and require significant processing power, making them difficult to deploy on mobile devices without optimization.

Lightweight architectures such as **MobileNet and MobileNetV2** have been introduced to address this challenge by reducing computational complexity while maintaining acceptable accuracy. These models are designed specifically for **edge devices and mobile platforms**, enabling real-time inference with limited hardware resources.

Several mobile-based agricultural applications have also been developed to assist farmers in diagnosing crop diseases. However, most of these systems rely entirely on **cloud-based processing**, which increases latency and limits usability in areas with poor internet connectivity.

Another limitation observed in existing solutions is the absence of **integrated agricultural advisory systems**. Many applications provide disease classification results but do not offer treatment recommendations, crop management guidance, or decision-support mechanisms.

Additionally, voice-based interaction systems for agriculture are still limited, particularly those supporting **regional languages such as Tamil**. Voice-assisted advisory systems can significantly improve usability for farmers with limited literacy or technical expertise.

The proposed **AI-Smart Agro Advisor** addresses these limitations by integrating a hybrid AI architecture, crop recommendation engine, and regional language voice support within a single mobile platform.

III. PROPOSED SYSTEM

The proposed **AI-Smart Agro Advisor** is a hybrid intelligent agricultural advisory system designed to provide farmers with real-time disease diagnosis and crop recommendations.

A. Overview of AI-Smart Agro Advisor

The AI-Smart Agro Advisor system is designed as a mobile-based decision-support platform for farmers. The system integrates crop disease detection, crop recommendation mechanisms, and voice-based advisory assistance within a single application environment.

B. Crop Disease Detection Module

The disease detection module analyzes crop leaf images captured through the mobile device camera. The system uses convolutional neural networks to identify disease symptoms by analyzing image features such as color variations, texture patterns, and leaf damage.

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C. Hybrid AI Inference Mechanism

The system implements a hybrid inference architecture that allows disease detection in both offline and online modes. In offline mode, a lightweight **MobileNetV2 model optimized with TensorFlow Lite** performs disease classification directly on the mobile device. In online mode, images are transmitted to a cloud server hosting a **ResNet50 deep learning model** that performs more accurate disease identification.

D. Crop Recommendation Engine

The crop recommendation engine generates treatment and crop advisory suggestions based on detected diseases and environmental parameters. The system evaluates factors such as soil type, seasonal conditions, nutrient levels, and weather data to produce appropriate recommendations for farmers.

E. Voice-Based Farmer Assistance

To improve accessibility, the system integrates offline Tamil voice assistance using an on-device Text-to-Speech engine. This feature allows farmers to receive spoken disease diagnosis results and agricultural recommendations directly through the mobile application.

IV. SYSTEM ARCHITECTURE

A. Mobile Application Layer

The mobile application serves as the primary interface for farmers interacting with the system. Developed using Flutter, the application enables users to capture crop leaf images, view disease detection results, and receive treatment recommendations.

B. Image Processing Module

Captured leaf images are processed through an image preprocessing module that performs resizing, normalization, and formatting operations. These steps ensure compatibility with the deep learning models used for disease classification.

C. Hybrid AI Processing Layer

The hybrid processing layer performs disease detection using two AI models. The MobileNetV2 model performs on-device inference in offline mode, while the ResNet50 model hosted on a cloud server performs high-accuracy classification when internet connectivity is available.

D. Recommendation Engine Layer

The recommendation engine analyzes disease classification results along with environmental parameters such as soil conditions, seasonal data, and weather information. Using rule-based logic, the system generates treatment recommendations and crop advisory guidance.

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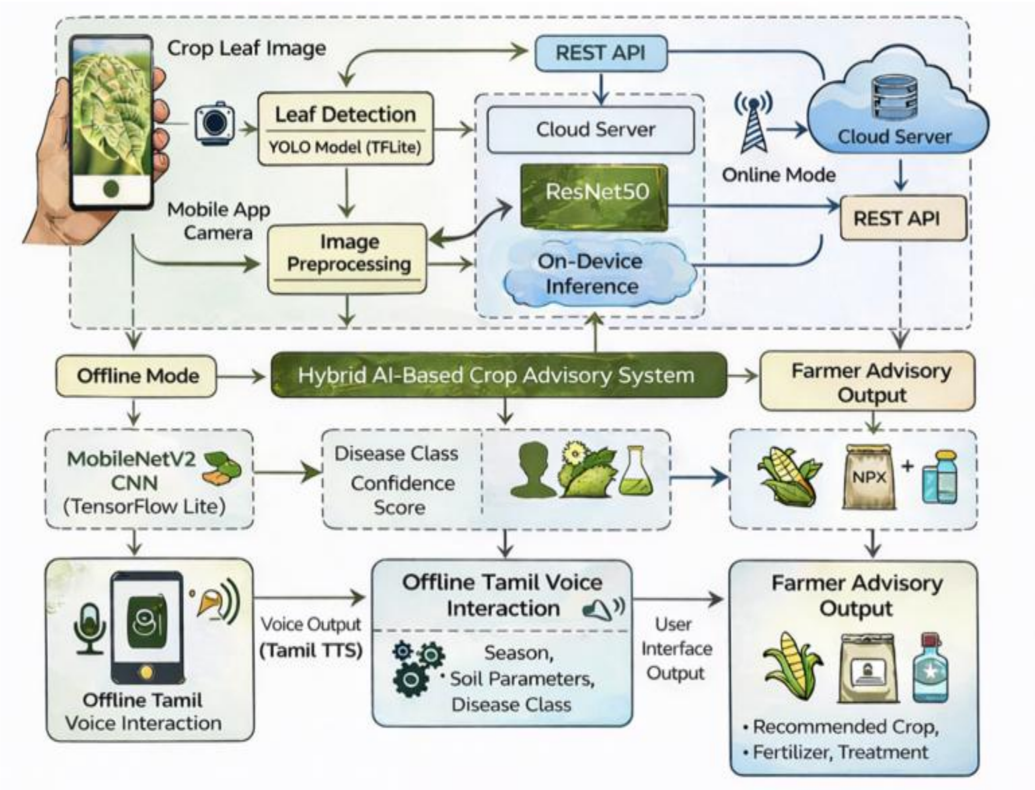

Fig 1: AI-Smart Agro Advisor Architecture

V. IMPLEMENTATION

A. Mobile Application Development

The mobile application was developed using the Flutter framework to provide a responsive and user-friendly interface. Flutter allows cross-platform development and efficient integration with machine learning models and cloud APIs.

B. Offline Disease Detection Model

Offline disease detection is implemented using a **MobileNetV2 deep learning model converted into TensorFlow Lite format**. This lightweight architecture enables real-time inference directly on mobile devices without requiring internet connectivity.

C. Online Disease Detection System

The online detection module uses a **ResNet50 deep learning model deployed on a cloud server**. Images captured by the mobile application are transmitted to the server through a REST API, and the server returns predicted disease labels and confidence scores.

D. Dataset Preparation and Model Training

The deep learning models were trained using multiple plant disease datasets including the **PlantVillage dataset** and the **Bangladesh Crop and Vegetable Disease Dataset**. These datasets contain labeled images representing more than one hundred crop diseases.

Table 1: Datasets Used for Model Training

Dataset Name	Disease Classes
PlantVillage Dataset	38
Bangladesh Crop and Vegetable Disease Dataset	94

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E. Voice Assistance Implementation

Tamil voice assistance was implemented using the Android Text-to-Speech engine configured with the Tamil language pack. This feature allows the system to provide spoken agricultural recommendations without requiring internet connectivity.

VI. RESULTS AND DISCUSSION

A. Offline Model Performance

The MobileNetV2 model demonstrated efficient performance when deployed on mobile devices. The lightweight architecture allowed real-time disease detection with minimal computational overhead.

Parameter	Value
Model	MobileNetV2
Platform	Mobile Device
Accuracy (%)	94.6
Precision (%)	93.8
Recall (%)	93.2
Average Inference Time	0.8 seconds

Table 2: Offline Model Performance

B. Cloud Model Performance

The cloud-based ResNet50 model achieved higher classification accuracy due to its deeper neural network architecture and larger dataset coverage.

Parameter	Value
Model	ResNet50
Deployment	Cloud Server
Accuracy (%)	97.3
Precision (%)	96.8
Recall (%)	96.4
F1 Score (%)	96.6

Table 3: Cloud Model Performance

C. Hybrid System Efficiency

The hybrid architecture enables the system to dynamically switch between offline and online inference modes based on network availability, ensuring consistent performance in both rural and urban environments.

Feature	Offline Model	Cloud Model
Model Architecture	MobileNetV2	ResNet50
Deployment	Mobile Device	Cloud Server
Internet Requirement	Not Required	Required
Accuracy	94.6%	97.3%
Response Time	Faster	Slightly Slower

Table 4: Hybrid System Efficiency

D. User Interaction and Accessibility

User testing demonstrated that farmers were able to easily capture crop leaf images and obtain disease detection results through the mobile application. The Tamil voice advisory feature significantly improved accessibility for farmers who prefer spoken guidance.

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VII. CONCLUSION

The AI-Smart Agro Advisor system presents a hybrid artificial intelligence–based solution designed to support farmers in crop disease detection and agricultural decision-making. The proposed system integrates mobile-based deep learning models with cloud-based processing and an intelligent recommendation engine to provide accurate and timely advisory services. The lightweight disease detection model based on MobileNetV2 enables real-time crop disease identification directly on mobile devices, while the cloud-based model using ResNet50 enhances prediction accuracy through deeper feature extraction and larger dataset training.

The hybrid architecture ensures reliable operation in both online and offline conditions, making the system suitable for deployment in rural agricultural environments where internet connectivity may be limited. In addition, the integration of voice-based advisory features improves accessibility for farmers who may prefer spoken guidance over textual information.

Overall, the proposed AI-Smart Agro Advisor demonstrates the potential of combining mobile computing, cloud intelligence, and machine learning techniques to develop scalable and user-friendly smart agriculture solutions that can improve crop health monitoring and support informed farming practices.

VIII. FUTURE WORK

A. IoT-Based Soil Monitoring Integration

Future enhancements of the AI-Smart Agro Advisor system may include the integration of Internet of Things (IoT) based soil monitoring devices. Soil sensors can continuously measure important parameters such as soil moisture, temperature, pH level, and nutrient content. By integrating these sensors with the existing system, real-time environmental data can be collected and analyzed to improve the accuracy of crop and fertilizer recommendations.

B. Expansion of Crop Disease Dataset

Another important area for improvement is the expansion of the plant disease training dataset. Although the current system utilizes datasets such as the PlantVillage Dataset, incorporating additional datasets containing more crop varieties and disease classes can significantly enhance the model's ability to generalize across different agricultural conditions. A larger and more diverse dataset will also improve classification accuracy and robustness.

C. Multilingual Voice Assistance

Future versions of the system may also incorporate multilingual voice-based advisory services to support farmers from different linguistic backgrounds. By integrating speech recognition and text-to-speech technologies, the application can deliver agricultural guidance in multiple regional languages. This feature will improve usability and accessibility for farmers who may have limited literacy or prefer spoken interaction.

D. Advanced Agricultural Analytics

The system can further be enhanced by integrating additional machine learning modules for advanced agricultural analytics. These may include crop yield prediction, pest detection, and climate-based crop advisory models. Such capabilities would transform the AI-Smart Agro Advisor into a more comprehensive agricultural decision-support platform capable of assisting farmers throughout the entire crop lifecycle.

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