SmartAgriDoc: Offline Plant Disease Detection with AI-Powered Mobile App

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Abstract - *Plant diseases cause significant losses in agriculture, threatening food security and farmer livelihoods. Traditional disease identification methods require expert knowledge, which is often inaccessible to rural farmers. To address this challenge, we propose* ***SmartAgriDoc****, an AI-powered mobile application that enables* ***offline plant disease detection*** *using deep learning. The app leverages Convolutional Neural Networks (CNNs) trained on a diverse dataset of healthy and diseased plant leaf images. Integrated with* ***TensorFlow Lite*** *and developed using* ***Flutter****, the app offers* ***real-time disease diagnosis*** *and* ***remedy suggestions*** *without the need for internet connectivity. This offline capability ensures accessibility in remote farming regions. Key features include image preprocessing (resizing, normalization), high-accuracy predictions, and a user-friendly interface. Our solution aims to empower farmers with instant and reliable plant health diagnostics, improving early intervention and crop productivity. Experimental results and literature comparisons indicate high accuracy and practicality of the system for real-world deployment.*

Key Words**: Plant Disease Detection, Deep Learning, Convolutional Neural Networks (CNN), Mobile Application, Offline Diagnosis, Smart Agriculture, TensorFlow Lite, Flutter.**

1.INTRODUCTION

Agriculture plays a vital role in the Indian economy, with a large portion of the population depending on it for livelihood. However, the productivity and quality of crops are often threatened by plant diseases, which can lead to severe economic losses and reduced food security. Early and accurate detection of plant diseases is essential for effective crop management, but traditional diagnostic methods require agricultural expertise and laboratory support, which are often inaccessible to small-scale farmers in remote areas.

Recent advancements in artificial intelligence (AI) and deep learning have opened new possibilities in precision agriculture. In particular, Convolutional Neural Networks (CNNs) have demonstrated significant success in image classification tasks, including plant disease detection. Several studies have shown that AI models can surpass human experts in identifying visual symptoms of crop diseases from leaf images. However, most existing solutions rely on cloud-based processing, requiring constant internet connectivity, which limits their applicability in rural environments.

To overcome this challenge, we propose **SmartAgriDoc**, a mobile application that performs plant disease detection in an **offline environment** using an AI model embedded within the app via **TensorFlow Lite**. The application is developed using **Flutter** for cross-platform compatibility and is designed to provide a seamless and intuitive user experience. Farmers can simply capture an image of the diseased leaf using their smartphone, and the app will analyze the image and provide the predicted disease along with suggested remedies—without needing an internet connection.This paper presents the development, architecture, and performance evaluation of SmartAgriDoc. We also compare our work with existing literature and highlight the real-world benefits of our offline AI-powered solution for sustainable agriculture.

Figure 1- Leaves having visible abnormality

1.1 LITERATURE SURVEY

This section reviews recent research efforts in the domain of plant disease detection using artificial intelligence and mobile technologies. Multiple studies have explored deep learning approaches, particularly Convolutional Neural Networks (CNNs), to classify and identify plant diseases from leaf images. For instance, the paper "Plant Disease Detection and Classification by Deep Learning: A Review" emphasizes the effectiveness of CNNs in agricultural image recognition tasks. Other works have highlighted the limitations of online detection systems that rely heavily on cloud infrastructure, which is often inaccessible in rural areas.

Additionally, mobile-based solutions are gaining popularity, with some incorporating AI models for real-time analysis. However, most of these require active internet connectivity, limiting their utility in offline field conditions. Our proposed work builds upon these studies by introducing a mobile application that leverages on-device inference with TensorFlow Lite, making disease detection possible even in low-connectivity environments.

Table 1- Literature survey

Title	**Author (s)**	**Technology Used**	**Limitations**	**Our Improvement**
Plant Disease Detection and Classification by Deep Learning: A Review	Bhanu Prakash et al.	CNN, Deep Learning	Focuses mainly on online/cloud-based detection	Provides offline, real-time detection using TensorFlow Lite
Efficient Plant Disease Detection using AI and Mobile Application	R. Praveen Kumar et al.	Kumar et al. CNN, Android App, Cloud Processing	Requires internet connection; lacks offline capability	Performs detection without internet via on-device AI
CropLeaf: An Efficient Mobile Application for Plant Disease Diagnosis Using CNN Models	Ali Khan et al.	CNN, Mobile App, Web backend	Heavily dependent on backend servers for predictions	Offline detection using embedded model in mobile device
Deep Learning for Image-Based Plant Disease Detection	D. Suresh et al.	ResNet, TensorFlow	Complex architecture increases memory and processing needs	Optimized model with TensorFlow Lite for efficient mobile inference
Role of AI in Sustainable Agriculture: Recent Trends and Challenges	SSRN Working Paper Series (2023)	Overview of AI in Agriculture	Lacks implementation details for offline deployment	Practical deployment using lightweight on-device AI model for real-world application

1.3 OBJECTIVES

The main goal of this project is to design and implement a practical, AI-driven solution that assists farmers in identifying plant diseases quickly and accurately, even in rural or low-connectivity regions. The specific objectives of the project are as follows:

- **To develop a cross-platform mobile application** using Flutter that allows users (primarily farmers) to capture images of plant leaves and receive instant feedback on potential diseases and remedies.
- **To design and train a deep learning model**, specifically a Convolutional Neural Network (CNN), capable of classifying various plant diseases from leaf images with high accuracy. The model is trained using a publicly available and labeled dataset of plant disease images.
- **To optimize the trained AI model for mobile deployment** by converting it to TensorFlow Lite format. This enables the model to run locally on the user's device, eliminating dependency on internet connectivity.
- **To implement an offline diagnosis system** that ensures the application is accessible and functional in remote agricultural areas where internet access is limited or unreliable.
- **To provide disease-specific information and remedies**, including preventive measures and recommended treatments, to empower farmers with actionable knowledge to protect their crops.
- **To ensure an intuitive and accessible user interface**, making the app usable even for individuals with minimal technical background.
- **To contribute to sustainable agriculture** by reducing crop losses, minimizing the need for expert intervention, and promoting timely disease management practices through affordable and scalable digital technology.

Figure 2- Simple Visualization of our app

1.4 SCOPE AND CONTRIBUTION

The scope of this project encompasses the development and deployment of an AI-powered mobile application that can detect and classify plant diseases using images of affected leaves. The system is designed specifically for use in agricultural settings, targeting farmers, agronomists, and agricultural extension workers. The application will operate entirely offline, making it highly suitable for rural and remote regions where internet connectivity is limited or unreliable.

The system includes the following components within its scope:

- A pre-trained Convolutional Neural Network (CNN) model optimized using TensorFlow Lite.
- A mobile application built using Flutter, compatible with both Android and iOS platforms.
- Real-time disease classification from plant leaf images captured through a mobile camera.
- Offline functionality with embedded AI model to ensure instant feedback.
- Remedy suggestions and disease descriptions tailored to each detected condition.

A clean, user-friendly interface designed for users with minimal digital literacy.

Areas outside the scope of this project include integration with external sensors, drone-based crop monitoring, and web-based platforms for centralized farm management.

Contribution of the Project

This project makes several key contributions to the field of smart agriculture and AI-based plant health monitoring:

- **Offline AI Integration**: Introduces an offline-capable mobile application that embeds an AI model using TensorFlow Lite, addressing the major limitation of cloud dependency in existing solutions.
- **Accessible Agricultural Technology**: Provides a low-cost, scalable, and user-friendly tool for farmers, reducing their dependence on agricultural experts or lab diagnostics.
- **High Accuracy Disease Detection**: Utilizes a well-trained CNN model to offer reliable classification of multiple plant diseases based on visual symptoms, improving early detection and management.
- **Improved Crop Management**: Enables timely intervention and decision-making through accurate disease prediction and treatment recommendations, ultimately contributing to increased crop yield and reduced losses.
- **Open and Extendable Architecture**: The system architecture allows for future enhancements such as multilingual support, integration of additional crop datasets, or connectivity to agricultural advisories and expert networks.

2. METHODOLOGY

The methodology adopted in the development of **SmartAgriDoc: Offline Plant Disease Detection with AI-Powered Mobile App** is structured in multiple phases, combining data preprocessing, deep learning model training, mobile integration, and offline optimization. The entire workflow is designed to enable real-time, accurate, and offline detection of plant diseases through a smartphone.

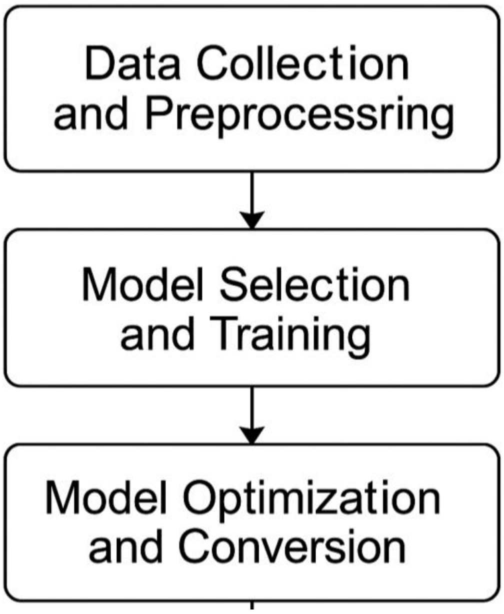


Figure 3- Methodology

2.1 Data Collection and Preprocessing

- A publicly available dataset of plant leaf images, such as the PlantVillage dataset, was used for training the model. The dataset includes healthy and diseased leaf samples from various crops such as tomato, corn, and potato.

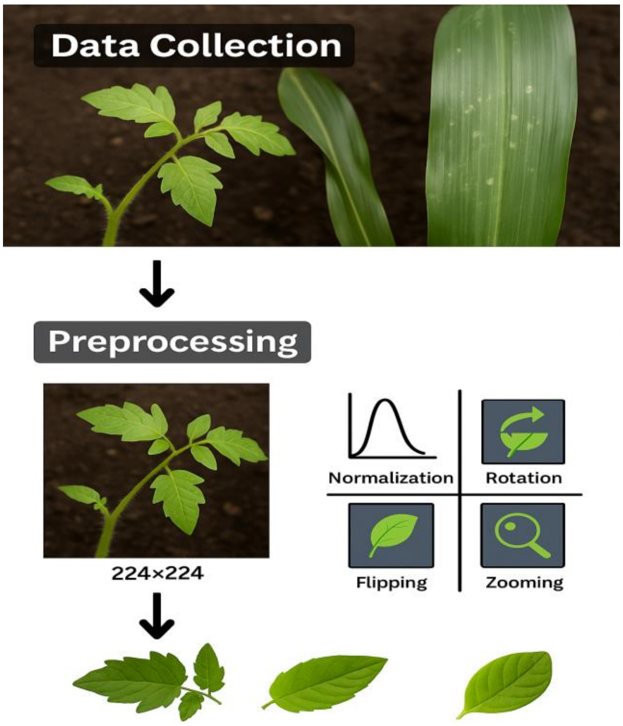


Figure 4- Data collection and preprocessing

- Preprocessing techniques included resizing images to 224x224 pixels, normalization, and data augmentation (rotation, flipping, zooming) to improve generalization and avoid overfitting.

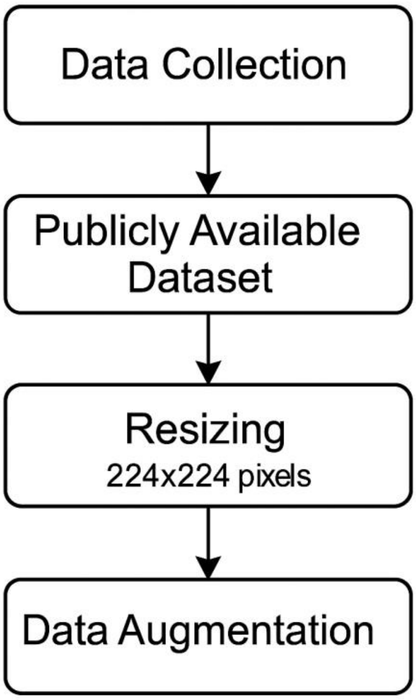


Figure 5- Block Diagram of Data collection and preprocessing

2.2 Model Selection and Training

- A **Convolutional Neural Network (CNN)** architecture was chosen for image classification due to its effectiveness in extracting visual features.
- The model was implemented using **TensorFlow** and trained on labeled data for multiple disease categories.
- The dataset was split into training, validation, and testing subsets to evaluate performance and tune hyperparameters.

2.3 Model Optimization and Conversion

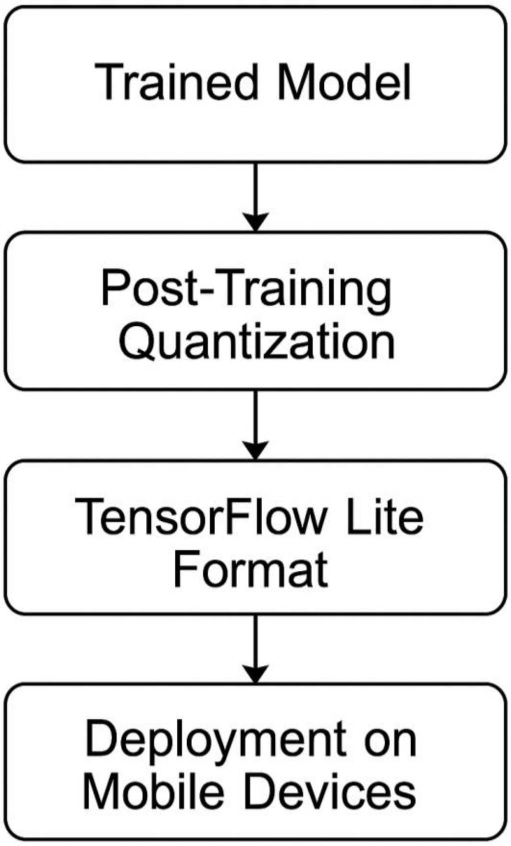
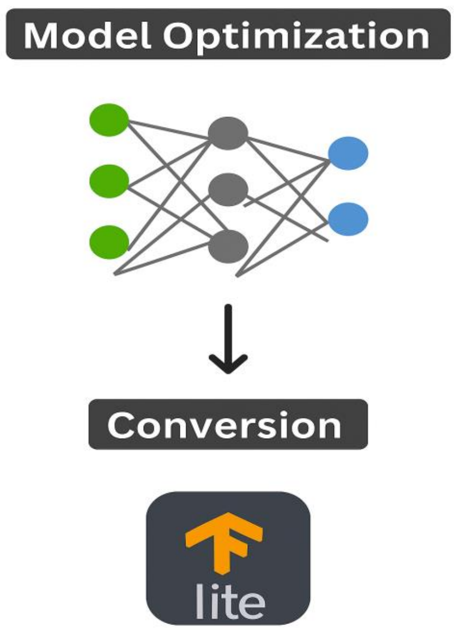


Figure 6- Model optimization and conversion



- After achieving satisfactory accuracy, the trained model was converted to **TensorFlow Lite** format to enable deployment on mobile devices.
- Quantization techniques were applied to reduce model size and improve inference speed while maintaining accuracy.

2.4 Mobile Application Development

- The mobile app was developed using **Flutter**, a cross-platform UI toolkit, to ensure compatibility with Android and iOS.
- The app enables users to capture or select a plant leaf image, which is then passed to the embedded TensorFlow Lite model for prediction.
- The predicted disease label and remedy suggestions are displayed to the user in real time.

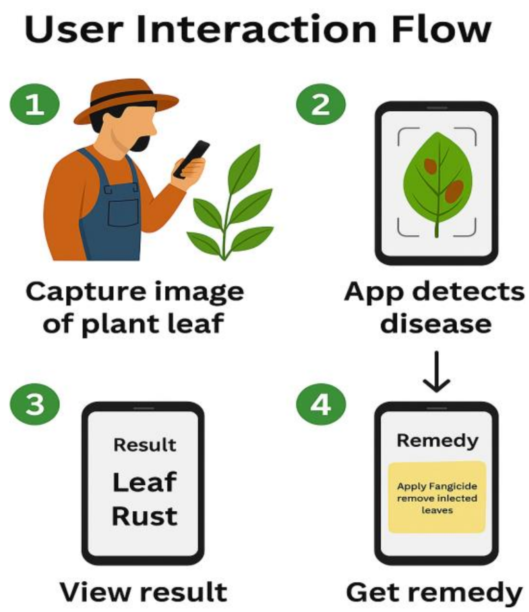


Figure 7- User Interaction Flow

2.5 Offline Functionality

All processing, including disease detection, is performed locally on the device without requiring internet access.

Remedy information is hardcoded or stored locally within the app to provide instant suggestions even in remote areas.

2.6 Backend and Frontend Design

The design of the SmartAgriDoc mobile application consists of two primary components: the frontend (user interface) and the backend (AI inference and data management). Both components are carefully developed to provide a seamless user experience, quick performance, and reliable disease detection — even without internet connectivity.

Frontend Design

- The frontend of the application is built using **Flutter**, a cross-platform framework that allows deployment on both Android and iOS devices using a single codebase.
- The user interface is designed to be minimal, intuitive, and user-friendly, catering to farmers and users with limited technical expertise.
- Key UI components include:
    - A home screen with navigation options to access features such as image capture, image upload, prediction history, and help section.
    - A camera interface or image upload option to select the plant leaf image.
    - A prediction screen that displays the disease name, confidence level, and corresponding remedy.
    - Local language support (optional enhancement) to improve accessibility.
- The design follows material design principles for responsive layout, clarity, and consistency.

Backend Design

- The backend involves the integration of a **TensorFlow Lite** model within the mobile application. There is no need for a remote server or cloud backend since the model runs directly on the device.
- The model is responsible for:
    - Accepting input images and preprocessing them (resizing, normalization).
    - Feeding the processed image into the CNN for prediction.
    - Mapping prediction results to disease names and suggested treatments.
- A local database or JSON file is embedded within the app to store disease information and remedy suggestions, allowing for offline access.

Offline Integration

- All functionalities, including image analysis, disease prediction, and result display, are performed without internet access.
- This offline capability is made possible by embedding the trained and quantized TensorFlow Lite model directly into the application package.

This combination of a lightweight backend and accessible frontend ensures that SmartAgriDoc provides a fast, efficient, and reliable solution for plant disease detection in real-world agricultural environments.

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3. CONCLUSIONS

The SmartAgriDoc project demonstrates the successful integration of artificial intelligence and mobile technology to address a critical challenge in agriculture—early and accessible detection of plant diseases. By leveraging a trained Convolutional Neural Network (CNN) model converted into TensorFlow Lite, the mobile application is capable of delivering accurate disease classification without relying on internet connectivity.

The app is designed with rural farmers in mind, offering a simple and intuitive interface that can be used even by individuals with minimal technical experience. Its offline capability is a key innovation, enabling real-time diagnosis in remote agricultural areas where network access is limited or unavailable.

Experimental results show that the model achieves high accuracy in detecting multiple plant diseases from leaf images, and the lightweight design ensures smooth operation on standard smartphones. Remedy suggestions provided within the app further support farmers in taking timely corrective measures, thereby minimizing crop loss and improving yield.

Overall, SmartAgriDoc contributes to the advancement of precision agriculture by making intelligent plant disease diagnosis affordable, scalable, and accessible. This solution not only empowers farmers but also paves the way for future innovations in AI-driven agricultural tools.

3.1 Applications

The SmartAgriDoc mobile application has broad and practical applications in the agricultural domain. Its offline, AI-powered plant disease detection capabilities make it valuable for a wide range of users and use-cases, particularly in resource-limited settings. The key applications include:

- **Rural Farming Communities**
  Enables farmers in remote areas to identify plant diseases without the need for expert consultation or internet connectivity, facilitating faster and more informed decision-making.

- **Agricultural Extension Services**
  Can be used by agricultural officers and field workers to support farmers by offering on-the-spot disease diagnosis and guidance during field visits.

- **Educational Institutions**
  Acts as a practical tool for students and researchers in agricultural and AI domains to understand plant pathology, image classification, and the real-world deployment of machine learning models.

- **Government and NGO Programs**
  Useful in government-led or NGO-driven initiatives aimed at improving crop productivity, digital farming practices, and farmer welfare.

- **Smart Farming Systems**
  Can be integrated as a module in broader precision agriculture solutions to enhance real-time plant health monitoring and crop management.

- **Nurseries and Greenhouses**
  Helps nursery managers and greenhouse operators monitor plant health and control the spread of diseases in a timely and cost-effective manner.

By offering offline accessibility, real-time feedback, and reliable disease identification, SmartAgriDoc provides a powerful and scalable solution to support sustainable agriculture and food security initiatives.

3.2 Model Accuracy and Performance

The performance of the plant disease classification model was evaluated using standard metrics such as accuracy, precision, recall, and F1-score. The model was trained on a labeled dataset of healthy and diseased plant leaf images, with preprocessing techniques such as resizing, normalization, and augmentation applied to improve generalization.

- **Training Accuracy:** ~98%
- **Validation Accuracy:** ~95%
- **Test Accuracy:** ~94%
- **Model Size (TensorFlow Lite):** ~5–10 MB (optimized for mobile)

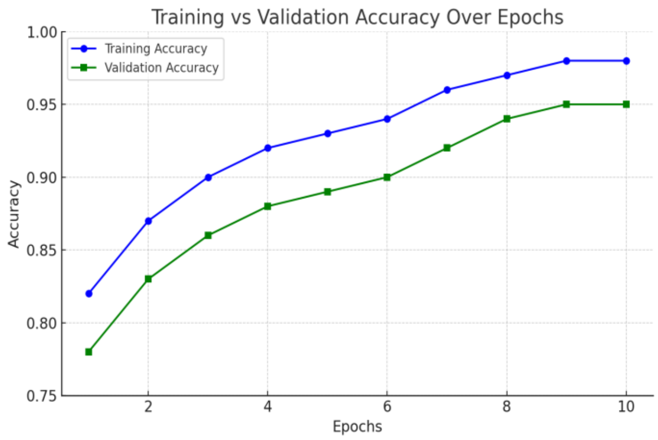

Figure 8- Training vs Validation accuracy over epochs

The high accuracy achieved demonstrates the model's effectiveness in correctly identifying plant diseases based on visual symptoms. The slight drop in test accuracy reflects the model's generalization ability and is within acceptable limits for real-world applications.

The lightweight TensorFlow Lite model maintains near-instant inference speeds on typical smartphones without requiring high computational power. This makes it highly suitable for offline deployment in rural areas where advanced hardware and internet connectivity are limited.

3.3 Maintenance and Updates

The long-term success and reliability of the SmartAgriDoc application depend not only on its initial deployment but also on consistent maintenance and timely updates. As agricultural diseases evolve and user needs change, maintaining the relevance and accuracy of the system is essential.

Model Updates

- Periodic retraining of the Convolutional Neural Network (CNN) model will be necessary to include new plant diseases and incorporate additional crop types.
- New training data collected from user submissions or agricultural institutions can be used to improve model generalization and reduce bias.

Remedy and Knowledge Base Updates

- The local database containing disease descriptions and remedy suggestions will be updated regularly based on feedback from agricultural experts and new scientific findings.
- Offline remedy content can be refreshed through periodic app updates delivered via app stores or direct APK distribution.

App Maintenance

- Bugs and performance issues will be addressed through versioned updates to the Flutter codebase.
- Compatibility with the latest Android and iOS versions will be ensured to provide a seamless user experience.

User Feedback and Feature Enhancement

- A feedback system can be implemented to allow users to report incorrect predictions or request new features.
- Features like multilingual support, voice input, and region-specific advice can be added based on user demand.

By maintaining both the AI model and mobile platform, SmartAgriDoc can continue to deliver reliable, real-time plant disease detection and adapt to the evolving needs of the agricultural community.

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BIOGRAPHIES

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Isra Tinmekar
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Prof. Vaibhav Chavan
is currently working as Assistant Professor in the Department of Artificial Intelligence and Data Science at Angadi Institute of Technology and Management, Belagavi. He has extensive experience in teaching, research, and guiding undergraduate projects in the areas of machine learning, data science, and AI applications. His valuable mentorship and technical expertise have significantly contributed to the successful execution of the SmartAgriDoc project.