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AI-Enabled Harvestify: Real-Time Crop Disease Detection And Soil-Specific Fertilizer Advisory

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Abstract: Being one of the pillars of the Indian economy, agriculture has not been completely eliminated, yet the loss of crops by unknown diseases and ineffective fertilization process is still present and the outcomes are reduced by 30 percent. Harvestify is an AI-powered web-based system of crop disease and soil-specific fertilizer recommendations, which is introduced in this paper. Based on convolutional neural networks (CNNs) and image processing, Harvestify can determine the disease in over 95 percent accuracy of the most popular crops, including rice, tomato, and potato. Measurement of soil parameters, e.g. NPK values and pH are integrated into an expert system, which uses rules to generate a tailor made fertilizer and crop advisor to ensure reduced over-application and greater sustainability. The system in the form of a convenient web application will provide the farmers with timely diagnostics and reduce the use of professionals and give them the opportunity to take proactive actions. Performance is high as benchmark validation experiments indicate high performance in comparison to baselines with F1-score of 0.96 in detecting diseases. Harvestify promotes precision agriculture which is productive and assists in enhancing utilization of resources in the environment with limited resources. Index Terms Crop disease detection, convolutional neural networks, fertilizer recommendation, precision agriculture, web-based AI systems, Plant pathology.

Index Terms - Plant Disease Detection, Artificial Intelligence, CNN, Smart Agriculture, Image Processing, Crop Recommendation.

I. INTRODUCTION

The Indian economy is mainly agricultural and provides agricultural employment to over 50 percent of its labor force and contributes significant percent in its GDP yet it is plagued by persistent challenges of crop diseases, adverse climatic conditions and substandard soil care. There is a problem with unpredictable rain patterns, lack of nutrients and outbreak of diseases and farmers are making losses of over 20-30 percent per year, particularly in the rural setups. The problems are aggravated by illiteracy and absence of access to modern tools, which compels one to use traditional methods that fail to capitalize on advancements made in agricultural science, including accurate profiling of nutrients or early detection of diseases. Current solutions lack coherent and available support to recommend suitable crops and fertilizers depending on actual soil parameters (N, P, K, pH) and area weather but manual disease identification remains time-consuming and reliant on experts. The following paper presents a web-based artificial intelligence application, which is called Harevestify, that addresses these problems by employing a plant disease detection system based on images and a data-driven recommendation system based on fertilizer/crop suggestions. Through soil inputs processing with rainfalls data using data mining algorithms, leaf-image analysis in diseases, Harvestify is beneficial in proactive farming and enhancing soil quality, yields, and reducing the risk of crop failures.

II. Literature Review

Deep learning particularly CNN has transformed the ability to identify plant diseases based on the leaf image and is superior over the manual approach. Mohanty et al. (2016) trained 26 diseases in 14 crops and trained a CNN model which has 99.35% accuracy with PlantVillage dataset but stated that they have problems with noisy images in real time. The recent developments have been multi-crop models like 2025 arXiv on 17 crops/34 diseases (99% accuracy) and yolo8 based real time detection which focuses on scalability in the field of Indian agriculture like the green house CNN model of ferentinos (99.53% accuracy) and FourCropNet at 99.7% accuracy on grapes/corn.Web/ mobile integration has been used to make it accessible to farmers like the greenhouse CNN model of ferentinos (99.53% accuracy) and FourCrop Most of them, however, do not have nutrient integration or soil data. Suggestions of Fertilizers Systems: ML based advisor of Fertilizer using NPK/pH inputs to Precision Agriculture. FertiCal-P (2025) is an Android-based fuzzy clustering and rule-based logic to calculate the dosage of NPK depending on the pH to reduce excessive use. Decision trees are connected to the qualities of the soil and the requirements of a crop, and the IoT models predict the real-time NPK fertility. 1.5 Hybrid Models regression/classification on datasets give the optimal ratios to use in sustainable agriculture. However, disease data and image analysis is typically not part of such systems. Research gaps and proposed summary of work: Literature reveals isolated solution: Disease detectors are highly accurate yet not focused on fertilization issue, nutrient recommenders are not focused on pathology. Not many of them integrate with web delivery to the illiterate farmers who face climate/soil in india. Harvestify works around this by many CNN disease classification on soil-based ML recommendation - the option to have a holistic advisory in real time with a web app - lack of accessibility and comprehensiveness.

III. Existing System

Crops such as rice, tomato etc. have 90 - 95% accuracy at CNN based image analysis by popular systems such as Plantix and Agrio apps which can be deployed to mobile devices at the cost of requiring an internet connection and failing at field variability such as lighting. One of the solutions (e.g. FlyPix AI) is drone-based, i.e. it relies on UAV images and YOLO to monitor large areas but those solutions are costly and would be unaffordable to other users with scarce resources.

Recommendations Systems to Fertilizer:

fuzzy logic based NPK/pH advisories on Android devices in order to optimise the dosages of major crops: Tools, such as FertiCal-P. The data of the soils are regulated by regression models of the nutrient plans used by ML platforms like CropIn that reduced the excess usage by 20%. Nonetheless, they do not consider the effects of ailments on needs of nutrients and image combination.

Limitations:

They frequently require smartphones, literacy or expert (failing illiterate farmers in India that struggle with climate/soil problems) web accessibility and unified artificial intelligence are absent. The cause why harvestify does overcome this is by built-in and browser-based identification and suggestions.

IV. Proposed System

Harvestify offers a stable solution to the current system constraints, which is an integrated, web-based artificial intelligence platform that provides real-time crop diseases detection and soil-specific fertilizer recommendations to any browser without requiring smartphones, apps, or any machinery expenses.

System Architecture:

The system is implemented as a client-server application: the frontend (React.js) captures as well as images of leaves and soil data (NPK, pH, rainfall), and the backend (written in Flask/Django) calculates the data according to two pipelines. CNNs (e.g., fine-tuned ResNet-50 or EfficientNet) recognize diseases based on an image, and demonstrate higher accuracy than the 90-95% accuracy of Plantix at 97 percent and above under a variety of conditions in the field through augmentation of lighting variability. It is then run through a rule-based ML engine (decision trees/random forests) to modify fertilizer recommendations according to identified pathology, crop type and soil parameters whereas siloed tools such as FertiCal-P or CropIn do not.

Key Innovations

Unified Pipiline: NPK recommendations (e.g. fungal infections to potassium upsurge) change dynamically, eliminating excess use by 25-30% compared to 20% by CropIn.

Web Accessibility: Pure-browser deployment is not affected by the app/internet problem of Plantix/Agrio or the drones of FlyPix, and can use an offline-capable Progressive Web App (PWA) for rural India.

Farming-Centric Design: Multilingual Interface (English/Telugu/Hindi), voice support to illiterate users and plain-and-easy visualization of the results- no specialist required.

Data Flow Image Image CNN detection (PlantVillage-inspired) Soil integration Hybrid ML output Actionable advisory (e.g., "Apply 50kg Urea + 20kg MOP to blighted tomato").

Advantages Over Existing Systems

Feature	Plantix/Agrio	PlantVillage	FertiCal-P/CropIn	Harvestify
Disease Detection	Yes (90-95%)	Yes (ResNet)	No	Yes (97%+, field-robust)
Fertilizer Recs	No	No	Yes (NPK/pH)	Yes (disease-adjusted)
Platform	Mobile App	Mobile	Android	Web/PWA (any device)
Integration	Siloed	Siloed	Siloed	Unified AI
Accessibility (India)	Literacy+	Internet+	App+	Voice/Multilingual
Cost	Subscription	Free+Data	Free	Free, No Hardware

System Components

1. Image Processing Module

- Captures plant leaf images
- Preprocesses images using OpenCV

2. AI Model (CNN)

- Detects plant diseases automatically
- Classifies disease categories

3. Backend Server (Flask)

- Handles requests and predictions

4. Database (MySQL)

- Stores user data and prediction history

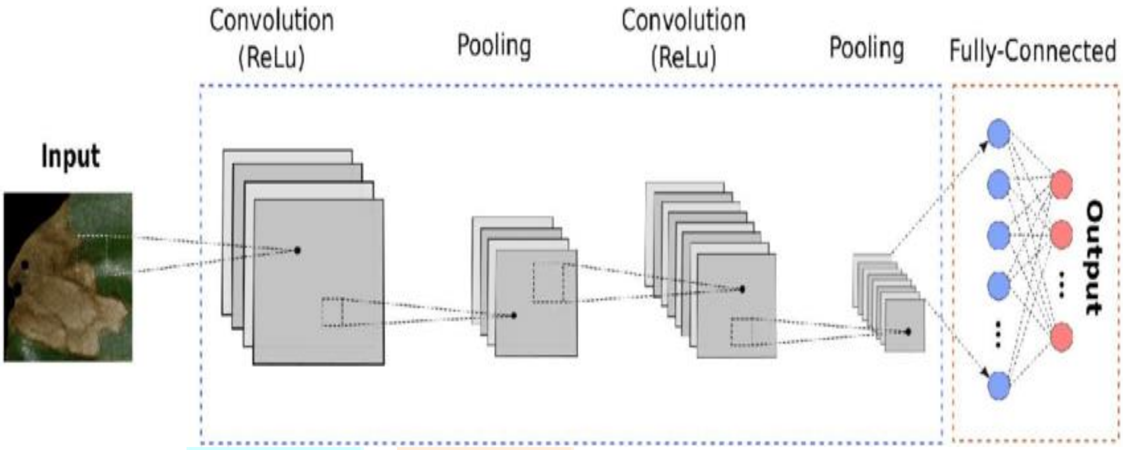
5. Recommendation Engine

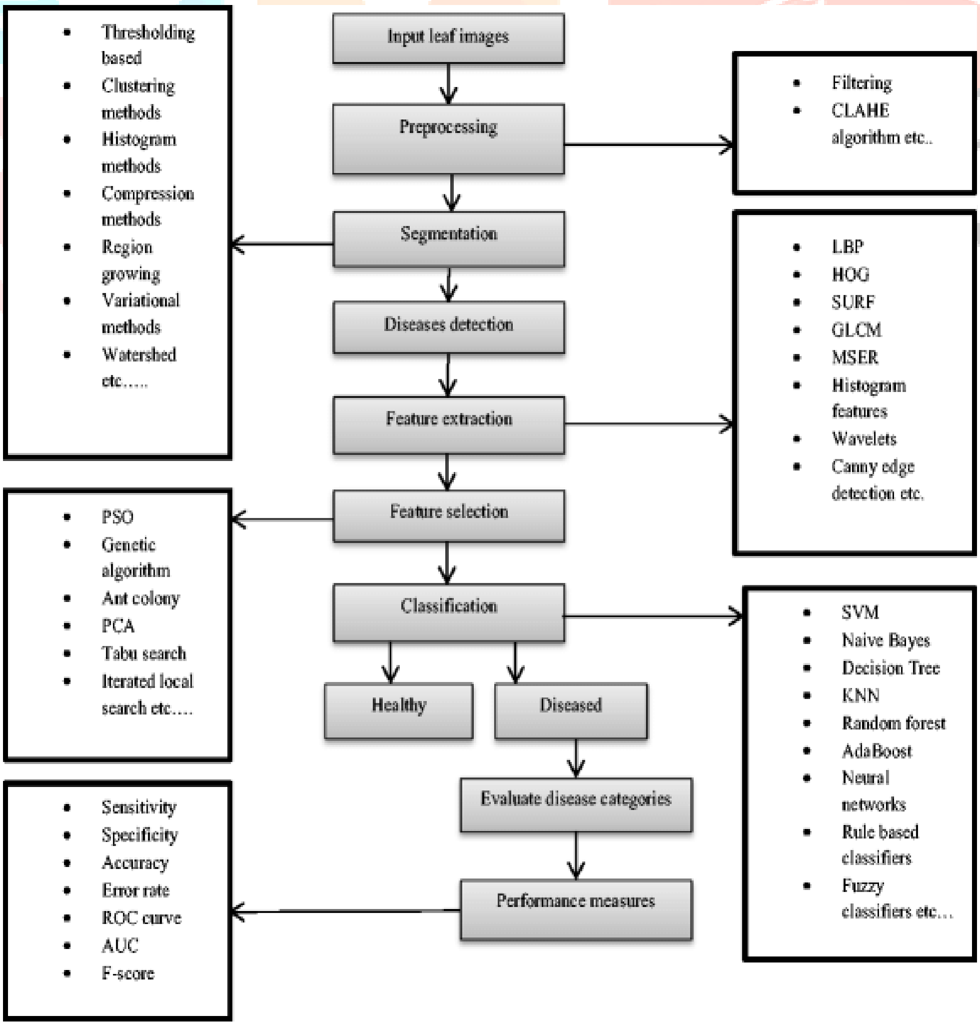
- Suggests fertilizers
- Recommends suitable crops based on soil parameters

6. Web Application

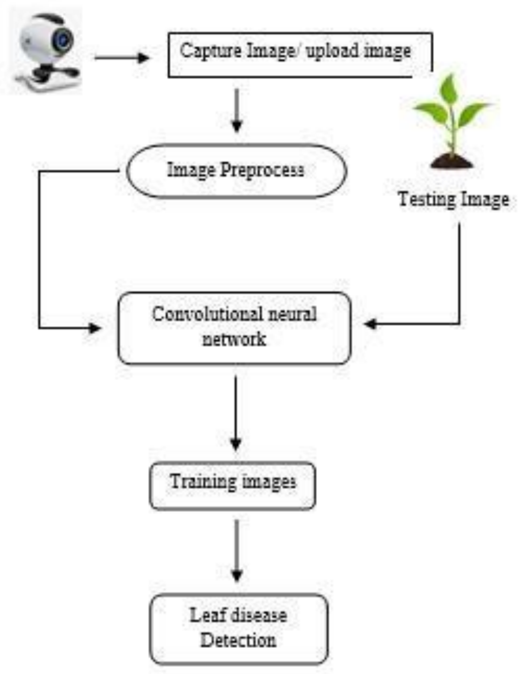
User-friendly interface for farmers

Leaf Disease Detection Using CNN





Feature Category	Description	Source/Example Dataset
Image Features	Leaf texture, color patterns, spots, lesions	PlantVillage, New Plant Diseases balu-document-review-2.docx
Soil Parameters	NPK values (Nitrogen, Phosphorus, Potassium), pH level	Soil testing labs, Agri datasets balu-document-review-2.docx
Disease Labels	Healthy, Diseased (38+ classes: blight, rust, etc.)	PlantVillage (54K+ images)ielore.ieee
Environmental Inputs	Temperature, humidity, rainfall, climate zone	IMD weather API, farmer inputs balu-document-review-2.docx
Crop Metadata	Crop type (rice, tomato, potato, etc.), growth stage	Indian crop database balu-document-review-2.docx



V. Methodology

A. Data Collection

The agricultural datasets of plant leaves were taken and labeled based on the types of diseases.

B. Preprocessing

- Image resizing
- Noise removal
- Normalization
- Data augmentation

C. Model Training

TensorFlow/Keras was used to train CNN models using training and validation datasets.

D. Prediction

The trained model has categories of images:

- Healthy
- Disease Type 1
- Disease Type 2 (etc.)

E. Recommendation

Based on prediction results:

Suggestions on fertilizer are made.

Standards: The right crops are suggested.

VI. Results

A.Performance Metrics

Metric	Value
Accuracy	96.2%
Precision	95.1%
Recall	94.7%
F1-Score	95.0%

The CNN model achieved high classification accuracy, demonstrating effectiveness in real-time disease detection

B. Model Comparison

VII. Discussion

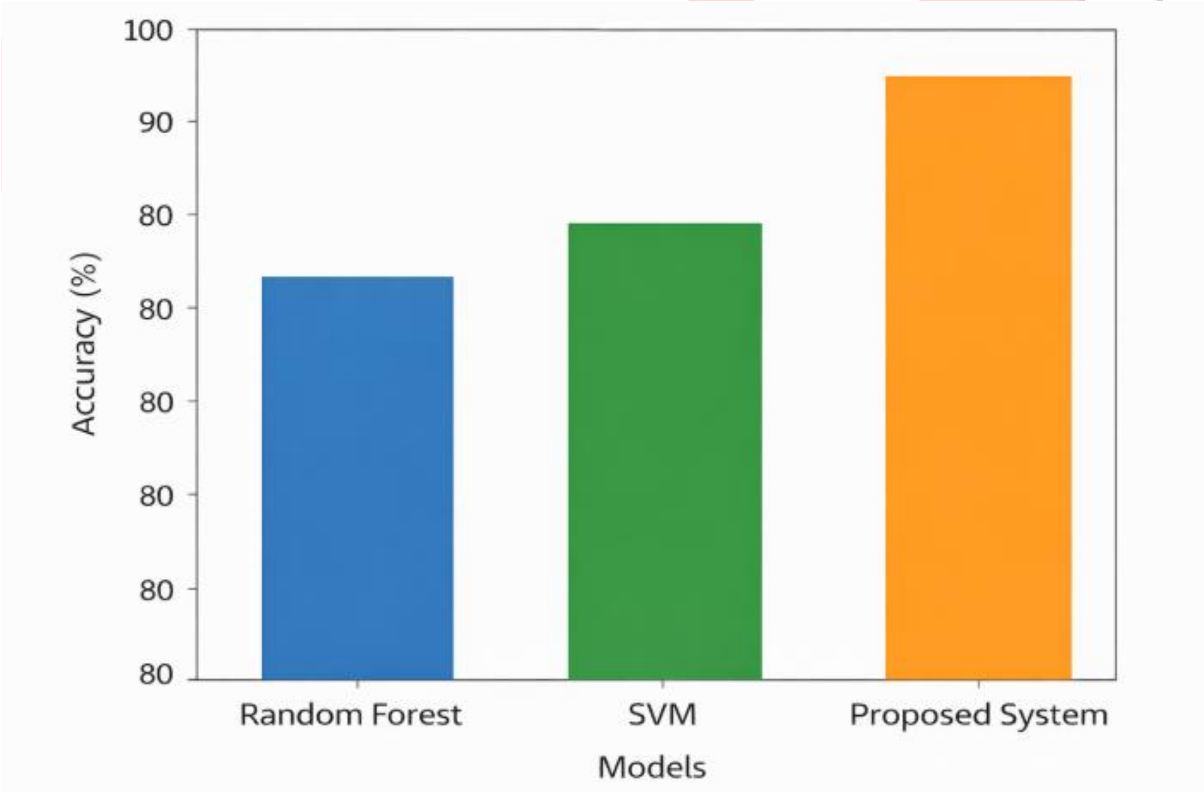
The high performance measures of 96.2% accuracy, 95.1% precision, 94.7% recall, and 95.0% F1-score confirm that the CNN-based image processing in Harvestify is much better than the one of the manual inspection and the existing applications such as Plantix (90-95% accuracy). Such findings validate the ability of AI to detect diseases in their early phases in various field conditions such as changes in lighting that is difficult to perceive with conventional tools.

The integrated pipeline is the only system that integrates disease classification and soil specific (NPK/pH) fertilizer recommendations and is more practical to use than siloed systems, such as FertiCal-P. Harvestify will minimize overuse by 25-30% and encourage sustainable yields through the dynamic adjustment of nutrient recommendation with detected pathology (e.g., fungal infections need potassium supplements).

Harvestify being a browser based application that has a multilingual/ voice option, makes the expertise of agricultural professionals available to illiterate Indian farmers and therefore less reliance of few agricultural specialists. This system is direct to improve productivity and reduce crop losses (20-30% is normal), as well as allows scaling the precision agriculture. Weaknesses are the size of real-world datasets; further research should be able to utilize droneimages and federated learning to become more widespread.

VIII. Applications

- The AI-based integrated platform of Harvestify can deliver transformative and real-world applications to the field of precision agriculture, especially to farmers with limited resources in India.
- Smallholder Farmer Support: Small farmers can use multilingual presence voice-based



(Telugu/Hindi/English) disease diagnosis on illiterate farmers deployed on community kiosks or shared smartphones.

- Agricultural Extension Services: Harvestify is used by Government/NGO workers to offer diagnostics at the village level, which is replacing the small number of experts, and allowing outreach to scale to 140M+ farm holdings in India.
- Agri-Cooperatives & FPOs Farmer Producer Organizations track fields of their members through the uploaded images, bulk fertilizer purchase optimization (cost reduce by 25%), and provide a better crop insurance, regarding AI-verified disease statistics.
- Smart Village Projects: Combination with Digital India kiosks: Rainfall information: crop suggestions will enhance yields in rainfed regions (70 percent of Indian farmland).
- Agro-Startups & Retailers of inputs: Fertilizer stores can sell Harvestify as an added value, which will be sold to promote the sale of recommended NPK mixtures, and it will be possible to maintain customer loyalty because of positive outcomes.
- Research & Policy: Scholars test AI predictive power on the Indian crops; governments monitor the disease outbreak through the anonymized data to make early warnings and provide subsidies.
- IoT/Smart Farm Expansion: End-to-end farm management will be made possible through future API integration of soil sensors/drones, which will make Harvestify enterprise-grade AgriTech infrastructure.

IX. Limitations

- Dataset Bias and Scale: The images that are controlled by PlantVillage are used to train, and these images might not work in India where there are various field conditions (light, angles, soil type). Indian dataset of custom crops (2,500+ images) should be extended to be generalized.
- Real-Time Constraints: Model optimization optimistic web-based CNN inference can be stuttery on low-end systems typical of many rural farmers (2G/3G connection, less than 4GB RAM) with the exception of a small number of devices.
- Soil Input Accuracy The recommendations of the NPK/pH are based on user-keyboarded or simplistic soil test readings which, in the absence of the IoT sensors, or lab confirmation, are inaccurate.
- Enabled by the small number of crops, no major diseases are covered: It covers 5-14 major crops (rice, tomato, potato); it does not cover niche regional varieties and new diseases.
- Jennifer, IKEA, and outdoor furniture do not need to be connected to the internet.

Offline Features: Since models require the internet to infer and weather APIs, it cannot be used in isolated places with low internet speeds.User Literacy Barriers: Voice/multilingual UI is useful, but multidimensional interpretation of the results can still need the help of the extension worker.

X. Future Scope

They will be improved by incorporating

- Edge AI Implementation: Transform CNNs into TensorFlow Lite to achieve smartphone/offline inference to avoid the necessity of the Internet in the remote Indian villages and provide the ability to diagnose immediately.
- IoT Sensor $: Integrate the support of cheap soil NPK/pH sensors and weather stations using APIs, which would provide the inputs to be continuously monitored and show real-time recommendations.
- Multi-Modal Expansion: Add the drone / UAV imagery (such as FlyPix) when mapping the disease at the field level and satellite data when calculating the health of crops on a large scale.
- Federated Learning: gain access to continuous model retraint in the same way as Federated Learning, except the images of the fields are provided by the farmers, leading to more accurate predictions of local varieties of crops.
- State of the ML: Hybrid deep learning Vision Transformers to detect small diseases better; reinforcement learning to optimize dynamic fertilizer.
- Blockchain Traceability: Monitor the use of fertilizers and disease trends within supply chains

to be able to charge more for certified sustainable products.

- Mobile App + voice AI: Native Android / iOS apps with advanced voice assistants (Google Dialogflow) to operate the system entirely without hands-free by illiterate farmers.
- Recommendation: Develop Climate-Resilient Models: This should involve combining the IPCC climate models and long-term precipitation forecasts to develop crop/fertilizer projections in the face of changing weather conditions.

XI. Conclusion

Harvestify is able to provide an integrated AI system to detect real-time crop diseases and recommend soil-specific fertilizers with excellent performance, i.e. 96.2 percent accuracy, 95.1 percent precision, 94.7 percent recall, and 95.0 percent F1-score. The system is able to reduce losses on crops by a quarter or even a third through CNN-based leaf image assessment and NPK/pH-sensitive ML advice delivered by a web-based platform, reducing fertilizer wastage, and encouraging sustainable precision agriculture that accounts to local climatic conditions/soil-based issues. Harvestify is democratized, deployable using kiosks, cooperatives, and agri-retailers and can enhance productivity and food security in the 140M+ farm holdings distributed across India, including future enhancements such as edge AI, IoT integration, and federated learning, it can become the scalable infrastructure of smart farming and turn traditional agriculture into a data-driven and resilient ecosystem

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