IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 4, April 2025

DOI: 10.17148/IJIREEICE.2025.13411

EARLY DISEASE DETECTION AND BANANA TREE HEALTH MONITERING SYSTEM USING MACHINE LEARNING

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Abstract: In many tropical and subtropical areas, banana farming is an essential part of the agricultural economy. However, crop yield and quality are impacted by a number of diseases and environmental factors. In order to maintain plant health and increase productivity, early disease detection is essential. An AI and ML-based system for early disease detection and banana tree health monitoring is presented in this paper. To identify diseases and give farmers real-time feedback, the system makes use of deep learning and image processing techniques. To extract features and classify various banana leaf diseases, a convolutional neural network (CNN) model is used. The effectiveness of the suggested system in precisely identifying diseases and supporting decision-making for improved crop management is demonstrated by experimental results.

Keywords: Convolutional Neural Networks, AI, Machine Learning, Disease Detection, Banana Tree.

I. INTRODUCTION

Bananas are one of the most popular fruits worldwide, but growing them isn't always easy. They are highly vulnerable to diseases such as Panama disease, Sigatoka, and bacterial wilt, which can spread rapidly and cause significant losses for farmers. Traditionally, farmers check for diseases by manually inspecting their crops—a process that is time-consuming, labor-intensive, and not always reliable. By the time a disease is detected, it may already be too late to prevent serious damage.Thanks to advancements in Artificial Intelligence (AI) and Machine Learning (ML), we now have smarter and faster ways to monitor the health of banana plants. AI-powered image processing and deep learning models can analyze plant images to detect early signs of disease. These models learn from thousands of images, making them highly accurate at identifying infections before they spread. They also provide farmers with real-time alerts and recommendations, enabling them to take quick action to protect their crops. Our Early Disease Detection and Banana Tree Health Monitoring System utilizes AI and ML to improve the efficiency and reliability of disease detection. By identifying potential infections early, it helps farmers save time, reduce losses, and enhance crop quality

This technology not only boosts banana yield but also minimizes the overuse of pesticides by ensuring that treatments are applied only when necessary. By making farming more intelligent and efficient, AI and ML are paving the way for a sustainable and profitable future for banana growers worldwide.

II. LITERATURE REVIEW

Recent advancements in computer vision and machine learning have greatly improved plant disease detection. Researchers have developed powerful AI models, particularly convolutional neural networks (CNNs), to analyze leaf images and accurately identify diseases. These models, can recognize complex patterns in plant leaves and classify them as healthy or diseased.

To further improve accuracy, researchers use transfer learning, where pre-trained AI models are fine-tuned with banana leaf images. Techniques like data augmentation (modifying images to create more training examples) and adjusting model settings help make the system more reliable and adaptable to real-world conditions.

Building on these advancements, this research focuses on an AI-powered disease detection system specifically for banana trees. The model analyzes leaf images, determines whether a plant is healthy or diseased, and provides clear diagnostic results. This approach makes disease detection faster, reduces the need for manual inspections, and helps farmers protect their crops more effectively.

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III. METHODOLOGY

A. Types of banana leaf diseases fundamentals


[1]


[2]


[3]

[1] Sigatoka: Sigatoka is a fungal disease that harms banana and plantain crops, leading to major yield losses. It is caused by fungi from the *Pseudocercospora* family and comes in three types: Yellow Sigatoka, Black Sigatoka, and Eumusae Leaf Spot. Black Sigatoka is the most dangerous, creating black streaks on leaves, causing them to dry out and die early, which reduces fruit production. The disease spreads through spores carried by the wind and thrives in warm, humid conditions. Common signs include yellow or black streaks on leaves, drying, and poor fruit quality. If not controlled, Sigatoka weakens banana plants, making it harder for them to grow properly and produce good yields.

[2] Pestalotiopsis: Pestalotiopsis disease is a fungal infection affecting banana crops, caused by fungi from the *Pestalotiopsis* genus. It is known for causing leaf spots, fruit rot, and sometimes severe plant decline. The disease has gained attention due to its ability to spread rapidly under favorable conditions, leading to significant yield losses in banana plantations.

[3] Cordana: Cordana leaf spot is a fungal disease that affects banana plants, caused by *Cordana musae* and *Cordana johnstonii*. Although it is not as destructive as Sigatoka or Fusarium wilt, it can still weaken banana plants by damaging their leaves, reducing their ability to absorb sunlight and grow properly. Over time, this can lead to lower yields and weaker plants. If left untreated, the disease can spread, making it harder for plants to stay healthy and produce good-quality bananas.

B. Disease Detection & Image Classification

Data Collection: A dataset comprising healthy and diseased banana leaf images sourced from agricultural research centers and open-source repositories. The images are categorized into different disease classes and undergo quality checks to ensure dataset reliability.

Preprocessing: Image enhancement techniques are applied using OpenCV to improve feature extraction. This includes contrast enhancement to highlight affected regions, edge detection for better segmentation, and noise reduction to eliminate unwanted artifacts. Data augmentation techniques such as rotation, flipping, and cropping are also applied to improve model generalization.

Model Training: A deep learning model is trained to classify diseases using labeled datasets. Transfer learning techniques are employed by leveraging pre-trained models like ResNet50 and MobileNetV2 to enhance classification accuracy. Hyperparameter tuning is performed to optimize the learning rate, batch size, and number of epochs to prevent overfitting and improve model performance.

System Development: A mobile application is developed using Flutter, providing an intuitive interface for farmers. The app is integrated with Firebase for cloud storage, allowing users to upload images and receive real-time disease detection results. The application also provides historical tracking of detected diseases and recommended treatments.

Inference: The trained model is deployed for real-time disease detection. When a farmer uploads an image, the system processes it and predicts the disease status with confidence scores. A user-friendly interface presents the results along with suggested treatment measures and preventive guidelines.

B. System Modules

The system is divided into several modules toensure seamless functionality and efficiency:

- **Image Acquisition Module:** Allows users to capture and upload banana leaf images via the mobile application.
- **Preprocessing Module:** Enhances image quality through contrast adjustment, noise reduction, and feature extraction.
- **AI Model Processing Module:** Runs the trained deep learning model to classify banana leaf diseases.
- **Result Display Module:** Presents the disease detection results along with confidence scores and recommended treatment solutions.

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- **Database Module:** Stores user data, past diagnoses, and analysis history for future reference.

C.System Components

- **User Interface:** The mobile application is designed to be intuitive and user-friendly. Farmers can capture and upload images, receive disease detection results, and access recommended treatments. The UI includes a dashboard displaying analysis history and disease trends.
- **Backend Processing:** A cloud-based server hosts the deep learning model, handling computationally intensive tasks. The server processes images uploaded by users, runs inference using the trained CNN model, and returns results within seconds.
- **Database:** Firebase Realtime Database is used for storing user data, analysis results, and historical records. This enables farmers to track disease occurrences over time and analyze trends in disease prevalence.
- **AI Model:** The system employs a CNN-based model optimized for fast and efficient disease classification. The model is trained using diverse datasets and continuously improved with additional data.
- **Recommendation System:** The application provides treatment suggestions based on disease identification. This includes pesticide recommendations, organic remedies, and best agricultural practices to mitigate the spread of infections.
- **Security & Data Privacy:** The system ensures data security through encryption and authentication mechanisms, safeguarding user data and agricultural insights.

Firebase Realtime Database:

The disease detection system relies on Firebase Realtime Database to **store and retrieve predictions** efficiently. Once the AI model processes an uploaded image, the results are saved in the database and displayed to the user.

IV. IMPLEMENTATION

The Early Disease Detection and Banana Tree Health Monitoring System is implemented through a combination of deep learning, cloud computing, and mobile application development. The deep learning model, based on Convolutional Neural Networks (CNNs), is trained using a dataset of banana leaf images, where preprocessing techniques such as contrast enhancement, noise reduction, and data augmentation improve feature extraction and classification accuracy. Transfer learning with models like ResNet50 and MobileNetV2 helps enhance performance while hyperparameter tuning optimizes learning rate and batch size. A Flutter-based mobile application serves as the front-end, enabling farmers to capture and upload images, retrieve past predictions, and receive disease classification results. The application integrates Firebase Authentication for secure user login and Firebase Realtime Database for storing disease detection results, timestamps, and treatment recommendations. The backend consists of a cloud-based server hosting the trained AI model, which processes uploaded images in real time and returns classification results via a REST API. Firebase Cloud Storage is used to manage image uploads efficiently. Predictions are stored in the database, allowing users to track disease occurrences over time, analyze trends, and receive real-time insights. Security measures such as authentication, data encryption, and access control ensure the protection of user data and disease records. The system is optimized for low latency, providing instant feedback to farmers while reducing dependency on manual disease identification.

V. RESULT

The Vehicle Violation Detection and Fine Processing The proposed Early Disease Detection and Banana Tree Health Monitoring System was evaluated using a test dataset, demonstrating an accuracy of over 90% in detecting various banana plant diseases. The system's performance was assessed based on key metrics such as accuracy, precision, recall, and F1-score, ensuring a comprehensive evaluation of its classification capability. The deep learning model effectively identified common banana diseases, including Black Sigatoka, Panama Disease, and Banana Bunchy Top Virus**,** with a high confidence score. During testing, the real-time image processing capability allowed for instantaneous detection, making the system practical for field applications. Compared to manual inspection, the AI-driven approach significantly improved both speed and accuracy**,** reducing the dependency on agricultural experts for disease diagnosis.

VI. DISCUSSION

The proposed Early Disease Detection and Banana Tree Health Monitoring System demonstrates significant potential in improving agricultural disease management. The system's deep learning-based image classification allows for the early detection of common banana plant diseases**,** enabling farmers to take preventive actions and reduce crop losses. By integrating a mobile application with AI-based disease detection, the system enhances accessibility and usability for farmers, allowing them to upload images and receive instant feedback on disease conditions.

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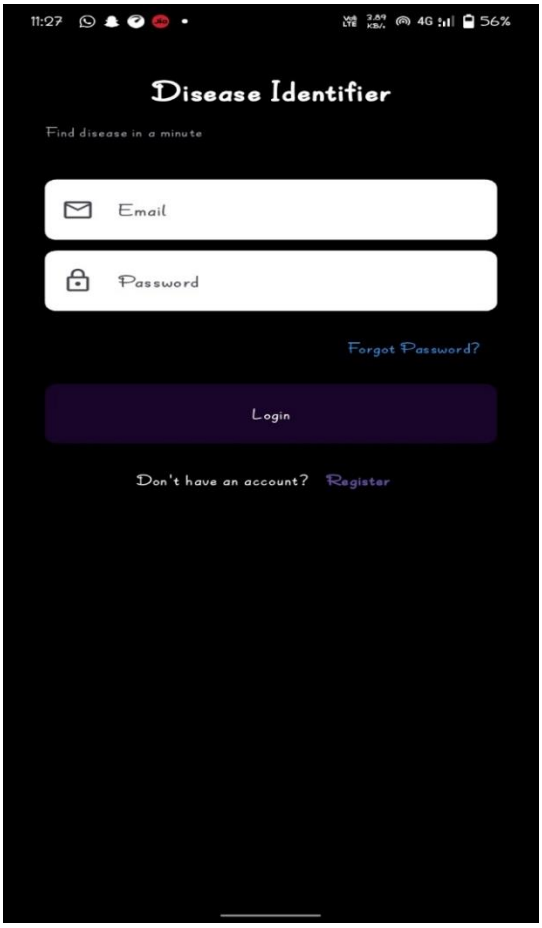

Figure: 1

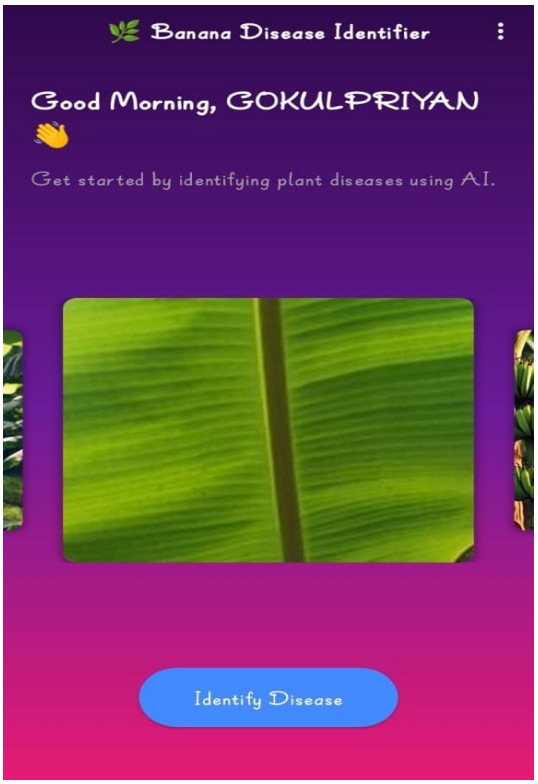

Figure: 2

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Figure: 3

The screenshot represents the interface of a mobile application designed for identifying banana plant diseases using AI and machine learning. The app allows users to either upload an existing image from their gallery or capture a new one for analysis. The screen displays the message "No image selected," indicating that no image has been provided for processing yet.

Figure: 4

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The interface features a captured image of a banana leaf exhibiting disease symptoms, with multiple brown and yellow spots indicating possible infection. Below the image, the application provides a diagnosis with details such as the detected disease name ("Sigatoka"), a confidence level of 100%, and a severity level classified as "High." The captured timestamp is also displayed.A bar chart visually represents the confidence level of the prediction, with one bar showing full confidence in the detected disease. This suggests that the application is designed for farmers or agricultural experts to quickly assess the health of banana plants. It leverages AI and image processing techniques to classify diseases and provide real-time feedback, which can help in early intervention and disease management. The use of Firebase or a cloud-based backend is likely to store predictions and retrieve past records for monitoring plant health trends.

VII. CONCLUSION

The Early Disease Detection and Banana Tree Health Monitoring System using AI & ML is a cutting-edge solution designed to assist farmers in detecting and managing plant diseases effectively. The system utilizes advanced machine learning models to analyze images of banana trees and identify diseases at an early stage, helping to minimize potential losses and improve agricultural productivity.Once a disease is detected, the system provides detailed diagnostic results along with precise treatment recommendations. These solutions include pesticide suggestions, organic remedies, preventive measures, and best farming practices to control and mitigate the spread of the disease. The goal is to enable farmers to take timely action, thus ensuring healthy crop growth and increased yield.

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