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ORIGINAL ARTICLE

Deep Learning-Driven Mango Leaf Disease Identification and Management System

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Abstract

Leaf diseases pose a serious difficulty challenge in the management of mango growers and may cause significant yield loss if diagnosis is delayed. In this paper, we describe a novel deep learning-based approach for the classification of diseases in mango leaves using images. The method proposed takes advantage of a pretrained MobileNetV2 model to predict whether a leaf image is healthy or belongs to one of its diseased classes, including Anthracnose, Bacterial Canker, Powdery Mildew Cutting Weevil (Die Back), Gall Midge and Sooty Mould. In addition to detecting diseases, it provides treatment suggestions and general tips for leaf care, such as organic solutions. High-risk periods for disease spread are continuously analyzed, and alerts are generated based on prevailing weather conditions. System supports multiple languages (Marathi, English and Hindi) which makes the user interface Farmer Friendly; increase usability in different regions, this will contribute for early diagnosis improved crop management.

Keywords: Mango Leaf Disease Detection, Deep Learning, Precision Agriculture, Decision Support System, Environmental Risk Analysis

Introduction

Cultivation of mango is a major agricultural industry in many parts of India, producing around 25-30 million tones each year. However, mango plants are frequently affected by leaf diseases such as Anthracnose, Bacterial Canker, Powdery Mildew, Cutting Weevil, Die Back, Gall Midge, and Sooty Mould. If these diseases are left untreated, then it will affect both quantity and quality of crop yield. The conventional way of diagnosing diseases is based on visual assessment by farmers or agronomy specialists, which can be slow and expensive as well as inaccurate in some cases. In rural areas, the limited access to expert guidance and lack of technical knowledge leads to difficulty of early leaf disease identification. So, there is a higher demand for such systems which helps farmers to detect mango leaf diseases in the early stage and save their crops[5]. With the growing use of artificial intelligence and deep learning techniques, crop diseases can now be identified using leaf images. Deep learning model such as CNN can be able to analyze leaf images by learning visual features such as colour, texture patterns and shape differences[2]. In this project MobileNetV2 model is used to classify the mango leaf images such as healthy or diseased.

According to this, transfer learning is a method that improves the accuracy of future models while reducing computational cost which would in turn be one of the prerequisites for deploying such system in real-world. Along with the disease identification the system gives treatment recommendations

and provides disease risk alerts by analyzing real time weather alerts. Temperature, humidity and rainfall variation are the key factors in spread of plant diseases at large, continuous weather monitoring can help to predict high risk conditions. To cater farmers from various regions to use the system comfortably, one of the applications helps has multilingual support (e.g., Marathi, Hindi and English)[4]. A simple user interface developed using streamlit allows users to upload mango leaf images, view disease results and access treatment recommendations, organic and chemical alternatives, general leaf care tips easily. This system assists in recognizing mango diseases and talks about how to treat these diseases as well by blending advanced technology with traditional farming methods, integrating deep learning, climate analysis and user interface.

Motivation and Problem Statement

Mango leaf diseases such as Anthracnose, Bacterial Canker, Cutting Weevil, Die Back, Gall Midge, Powdery Mildew, Sooty Mould impacts mango leaves heavily. It poses a great threat to mango cultivation which subsequently influence the yield quality as well as quantity. Classical methods for identification relying on a specialist visual inspection and are expensive, demanding too many hours in rural area. Recent advances in deep learning and image recognition have made it possible to assist the disease identification process through leaf images[2].

The system used MobileNetV2 model for effectively recognizing mango leaf maladies by checking the visual traits like colour, texture and patterns existing on the leaf to classify it into diseased and healthy leaves. It has one more useful Information as it recommends the treatment, organic and chemical sources to prevent these crops from different kinds of diseases. It is even combined with weather based notifications which help farmers to keep the distance from disease hazard their crops reflect on temperature and humidity patterns. Farmers can detect any disease and increase crop productivity.

Literature Review

This paper[1] introduces a lightweight VIT (Vision Transformer) based Model for the mango leaf disease detection in smart agriculture. It uses runtime data augmentation and transfer learning to improve the accuracy with low computational cost. This model achieves high performance and suitable for the real-time smart agriculture systems.

This paper discusses[2] a developed a deep learning based system to detect and classify mango leaf diseases using image based analysis. They used CNN models to identify different types of mango leaf diseases. Their results showed strong classification performance, proving that deep learning works well for automatic disease detection.

In this paper[3] a real-time application using a CNN system for classifying mango leaf diseases is developed. Their model can identify various mango leaf diseases and provide rapid results. This shows that deep learning can be effectively used to help farmers in real agricultural settings.

This paper[4] reviews weather-based machine learning models for predicting crop diseases and pests. The study explained the environmental factors such as temperature and humidity in the disease spread. It also highlighted the importance of combining deep learning based disease detection with treatment recommendations and weather based alerts to develop a complete disease management system for farmers.

In paper[5] a comparative study between the Convolutional neural network model and a vision transformer model for the mango leaf disease identification is presented. The results showed that Vision transformer model achieved high accuracy compared to Conventional neural network for the leaf disease detection and making it effective for the automated leaf disease monitoring and reliable agriculture applications.

A multilayer convolutional neural network for the classification of mango leaves infected with the anthracnose disease is discussed in[1]. The results showed that Convolutional neural network model effectively captures visual features for leaf disease classification and provides high accuracy for reliable leaf disease identification.

The early leaf disease classification using the feed-forward neural network combined with hybrid feature selection techniques is presented in[2]. The study showed improved detection accuracy by selecting relevant features for early disease identification and making it effective and reliable for leaf disease identification.

LeafNet[3], a convolutional neural network based method for detecting mango leaf diseases. The model achieved better performance by using feature extraction. In their research, it was shown that accurate dataset and training model helps achieve high classification accuracy.

An early prediction model for plant leaf disease using MobileNetV2 is proposed in[4]. Their study showed that lightweight deep learning models can give high accuracy with lower computational resources.

Proposed System

The proposed system helps to find mango leaf diseases automatically using AI. It also provides treatment ideas and weather based alerts to help farmers take care of their crops. This system is able to conduct inspection of diseases in less time and easier than previous methods where leaves had to be checked by observing them.

MobileNetV2 a deep learning model trained to recognize healthy or diseased mango leaf (The diseases are Anthracnose, Bacterial Canker, Cutting Weevil, Die Back, Gall Midge, Powdery Mildew and Sooty Mould) is the core of this complete system. When the user uploads image of mango leaf, it scans and identify about the disease.

After finding the disease it also provides with treatment and prevention. When the user uploads the picture of mango leaf the system analyses the image and detect the disease. The system takes real-time weather data and provides alerts of disease risk. The weather data helps farmers take precautionary measures before a disease proliferates, because the speed at which diseases spread depends on factors like humidity, rain and temperature.

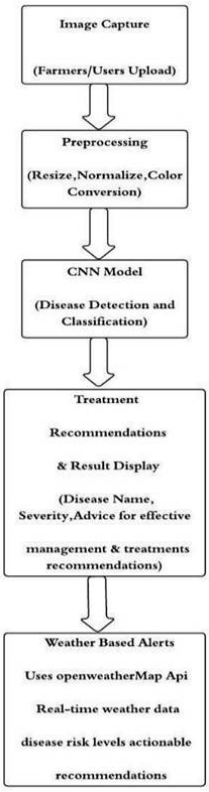

Fig. 1: Workflow Diagram

Before classification, the image is resized and normalized as:

$$I' = \frac{\text{Resize}(I)}{255}$$

This step ensures that all pixel values fall within the interval $(0, 1)$, which helps to improve the model performance. The CNN Model learns a transformation function $f(\cdot)$ that extracts the important features from the processed image and give the prediction.

$$\hat{y} = f(I')$$

here, $\hat{y}$ consider as the predicted disease label.

The model is trained using the categorical cross-entropy loss function: Here, The model is already trained using the categorical cross-entropy loss function:

$$L = -\sum_{i=1}^{c} y_i \log(\hat{y}_i)$$

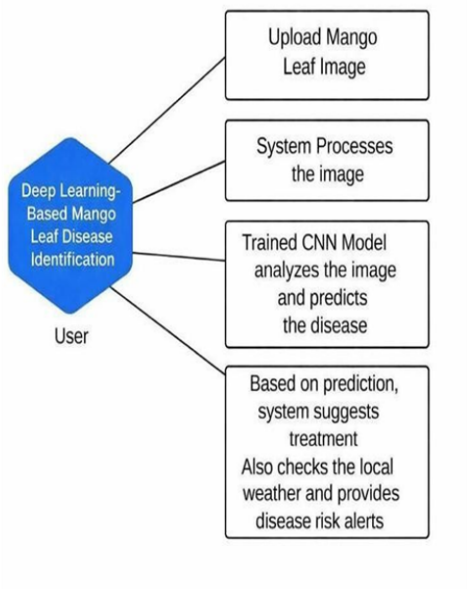

Fig. 2: Use Case Diagram

Mathematical Formulation

The proposed system uses a Convolutional Neural Network (CNN) based on the MobileNetV2 architecture for mango leaf disease classification. Let the input leaf image be represented as:

$$I \in \mathbb{R}^{H \times W \times 3}$$

where H and W denote the height and width of the image, and 3 represents the RGB color channels.

Model Architecture

The proposed system uses the mobilenetv2 architecture due to its lightweight structure and its efficiency. So, this model is designed to automatically identify the mango leaf image whether a mango leaf is healthy or affected by one of seven diseases. The whole pipeline begins with capturing a mango leaf image and ends with the disease prediction. In this system model receives a mango leaf image and resizes this image to 224 × 224 × 3 RGB colour channels so all images look same to the model. Then pixel values are normalized to small numbers

so model trained faster. Extra fake images also created using rotation, shift and zoom to help the model learn better. Mobilenetv2 architecture scan the image and extract the important features from this image like yellow spots, black patches or white powdery layer, etc. that represent specific diseases. After feature extraction stage, Global Average Pooling layer is applied to reduce the spatial dimensions of the feature maps and convert them into a compact feature vector.

This vector is then passed to a fully connected dense layer with ReLU activation, which helps to learn the complex relationships between the extracted features. To improve the generalization performance of model on unseen data, prevent overfitting by randomly deactivating 50% of neurons during training. Finally, the output layer uses the softmax activation function gives a probability score to all 8 classes and whichever scores highest becomes the final answer either Healthy or one of the 7 diseases.

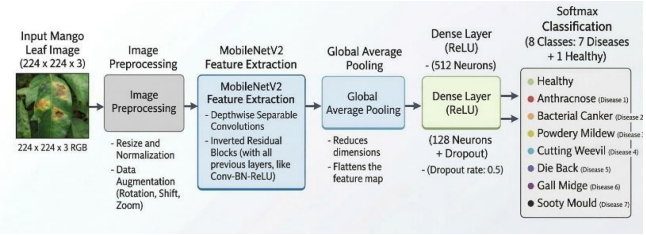

Fig. 3: Model Architecture Diagram

Methodology

The proposed methodology is used for disease detection in mango leaves using deep learning with weather data and user friendly interface. In the first proceed, images of mango leaves are collected for performing the detection process. These consist of healthy leaves as well a diseased ones such as anthracnose, bacterial spot and powdery mildew. Images are cleaned and resized such that the model can understand it easily. It helps the model to more accurately learn and generate results from data. The detection is done by using a deep learning model, MobileNetV2, with the image data collected previously to train and learn to differentiate healthy leaves from infected ones. After training, the model is able to determine whether a new leaf image is healthy or affected by a disease. The images are cleaned and resized prior to modeling so that the model will function correctly. Moreover, this helps to increase accuracy. MobileNetV2 being used for classifying. So, the collected pictures are used to train it in order to teach how healthy and ill leaves appear. The system is easy to use and has a simple screen made using Strealit. This system also uses live weather data (temperature, rain and humidity) to caution about the possibility of spread of disease. Farmers are notified by sensors the way high humidity and rainfall creates conditions suitable for an infection outbreak. This approach assists farmers in early-detection of leaf diseases and offering them guidance to safeguard their crops, thus enhancing the production yield of mangoes.

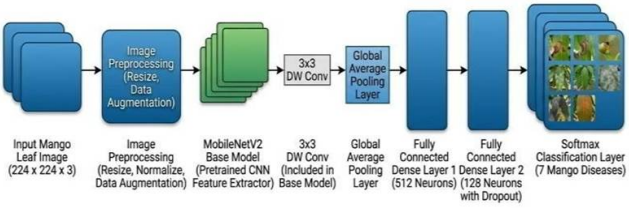

Fig. 4: System Pipeline Diagram

Table. 1: Training Parameters

Parameter	Value
Model Architecture	MobileNetV2
Input Image Size	224 × 224 × 3
Dataset Split	70% Training, 15% Validation, 15% Testing
Optimizer	Adam
Learning Rate	0.001
Batch Size	32
Number of Epochs	25
Loss Function	Categorical Cross-Entropy
Activation Function	ReLU (hidden layers), Softmax (output layer)
Dropout Rate	0.5
Framework Used	TensorFlow / Keras
Deployment Interface	Streamlit

Expected Outcomes

The proposed deep learning–based mango leaf disease identification and management system aims to improve the early detection and diagnosis of common mango leaf diseases such as like Anthracnose, Bacterial Canker, Powdery Mildew, Cutting Weevil, Die Back, Gall Midge and Sooty Mould.

The system classifies healthy and diseased mango leaves using a trained MobileNet V2 CNN model consequently it decreases the involvement of labour work and expert supervision for deep analysis. Already, computers can predict diseases based on the consistent appearance of leaves as their texture and color change in response to diseases[3].

Disease prediction not only identifies what is ailing the crop but also in what way best to react, from that which is the best course of treatment to what prevention measures may be put in place.

These in depth analyses will allow farmers to do timely interventions which in turn will see to it that there is large scale reduction in crop damage and yield loss within our agricultural systems.

The module will be augmented with real-time weather data, which will provide alerts for the probability of a disease

depending on its relationship with climate[4].

Through analyzing temperature, humidity, and rainfall parameters the system can tell in which year it is conducive to disease spread which helps in crop management[1].

Table 2: Environmental Factors Affecting Mango Diseases

Disease	Favorable Temperature (°C)	Favorable Humidity (%)	Spread Risk Level	Estimated Spread Probability
Anthracnose	24–30	80–90	High	75–85%
Bacterial Canker	25–35	70–85	High	70–80%
Powdery Mildew	20–27	60–80	Medium	55–65%
Cutting Weevil	25–32	60–75	Medium	50–60%
Die Back	25–32	65–80	Medium–High	60–70%
Gall Midge	24–30	70–85	Medium	55–65%
Sooty Mould	22–30	75–90	Medium–High	60–70%

The multilingual support feature helps to improve system accessibility and usability across various diverse regions which enables the farmers to interact with the application in their preferred language. This design helps practical usage among farmers and makes the system user friendly.

The goal is to create an understandable system for farmers that draws on weather analysis; deep learning, a form of artificial intelligence; and a library of available treatments[1].

This system we have developed is in many languages and we have designed it to support farmers in the implementation of very precise disease management strategies for mango crops. The system is used to improve crop health which in turn increases productivity, reduces economic losses and also promotes smart and sustainable agricultural practices.

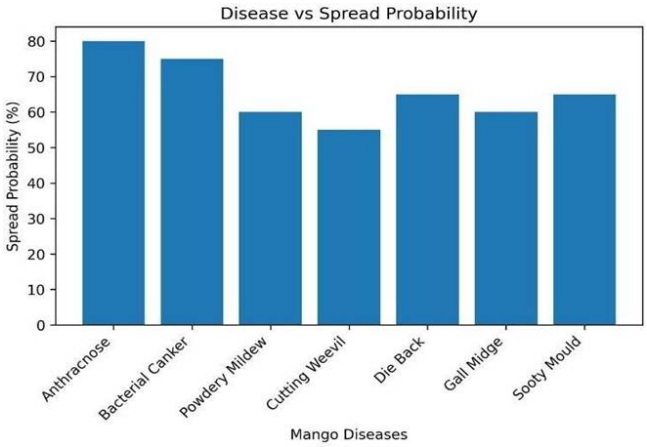

Fig. 5: Disease Spread Probability Graph

Conclusion

The system delivers an intelligent method for the identification of the mango leaf diseases using a deep learning model. In this work we look at the identification of healthy and sick leaves via use of MobileNetV2.The system not only identifies the leaf diseases but it also gives treatment recommendations, organic solutions and general leaf care tips. The integration of real time weather analysis along with the multilingual support in languages such as Marathi, Hindi and English makes the user interface farmer-friendly.

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