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# Implementation of Plant Leaf Disease Detection & Classification

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***Abstract- Plant diseases are a major cause of reduced crop yield and poor quality, which can lead to significant economic losses for farmers. In recent years, the need for quick and accurate methods to detect these diseases has increased, especially for large farming areas. However, many farmers still struggle to adapt to new disease control methods. Traditionally, disease detection has depended on experts visually checking the leaves and other parts of plants. This process takes a lot of time and can sometimes lead to mistakes. This paper focuses on developing an easy-to-use and reliable system to detect diseases in plant leaves, helping to improve agricultural productivity. Early identification of plant diseases gives farmers useful information to manage problems in time and prevent further damage. The proposed system includes several main steps: capturing images of the leaves, processing the images to improve their quality, extracting key features, and then classifying the disease using a neural network. The paper also discusses the advantages and limitations of existing detection methods to identify areas where further improvements can be made.***

## I. INTRODUCTION

India is primarily an agricultural country where a large portion of the population depends on farming for their livelihood. The agricultural sector plays a key role in the nation's economy, food security, and employment. In recent years, research in agriculture has focused on improving crop productivity and food quality while reducing overall production costs and maximizing farmers' profits. Agricultural output depends on the combined effects of various factors such as soil quality, seed type, fertilizers, pesticides, and other agrochemicals. Among agricultural products, vegetables and fruits are particularly important because they provide essential nutrients and are in high demand throughout the year.

To ensure high-quality produce, proper quality control in agriculture is essential. However, numerous studies have shown that plant diseases can significantly reduce both the yield and quality of crops. These diseases disturb the normal physiological processes of plants, affecting essential functions such as photosynthesis, transpiration, pollination, fertilization, and germination. The causes of plant diseases include various pathogens such as fungi, bacteria, and viruses, as well as unfavorable environmental conditions like excessive moisture, drought, or temperature extremes. Early detection of plant diseases is therefore crucial for maintaining healthy crops and preventing large-scale losses. Traditionally, farmers rely on expert guidance for continuous crop monitoring and disease detection. However, this manual process is often expensive, time-consuming, and not feasible for large farming areas. As a result, there is a growing need for automated, fast, affordable, and accurate techniques to identify plant diseases at an early stage.

In this context, machine vision technology provides a promising solution. It enables automatic inspection and analysis of plant leaves through image processing, allowing for efficient disease detection without the need for constant human supervision. The main objective of this paper is to develop a system for detecting plant leaf diseases using image-based analysis of leaf texture. Leaves are chosen for this study because they are available throughout all growing seasons and can reflect the health status of the plant more consistently than flowers or fruits. By focusing on leaf texture, the proposed method aims to support farmers in making timely decisions, improving crop management, and ultimately increasing agricultural productivity.

## II. LITERATURE SURVEY

1. Research/Technology: LeafGAN for Plant Disease Diagnosis

Author(s)/Source: Cap et al. (2020)

Key Contribution: Used Generative Adversarial Networks (GANs) to create synthetic diseased leaf images for training models.
Relevance to Plant Detector: Improves detection accuracy when only limited datasets are available.

2. Research/Technology: Explainable Vision Transformer (PlantXViT)

Author(s)/Source: Thakur et al. (2021)
Key Contribution: Combined Convolutional Neural Network (CNN) and Vision Transformer (ViT) architectures with explainability features for disease detection.
Relevance to Plant Detector: Enhances model interpretability and builds user trust in automated detection systems.

3. Research/Technology: YOLOv5 for Tomato Leaf Disease

Author(s)/Source: Rajamohanan & Latha (2022)
Key Contribution: Applied an optimized YOLOv5 model for detecting tomato leaf diseases. Relevance to Plant Detector: Enables real-time and accurate detection suitable for field applications.

4. Research/Technology: Comparison of YOLOv5 and YOLOv6 Models

Author(s)/Source: Iren (2023)
Key Contribution: Compared YOLOv5 and YOLOv6 models for multi-crop disease detection performance.
Relevance to Plant Detector: Helps in selecting an efficient model for lightweight and mobilebased applications.

5. Research/Technology: PlantCareNet System

Author(s)/Source: Zhang et al. (2024)
Key Contribution: Developed a CNN-based system that not only detects plant diseases but also provides prevention and management suggestions.

## III. PLANT DISEASE ANALYSIS AND ITS SYMPTOMS

1.Bacterial disease symptoms:
The disease is characterized by tiny pale green spots which soon come into view as water- soaked. The lesions enlarge and then appear as dry dead spots as shown in figure 1(a), e.g. bacterial leaf spot have brown or black water-soaked spots on the foliage, sometimes with a yellow halo, generally identical in size. Under dry conditions the spots have a speckled appearance.

2.Viral disease symptoms:
Among all plant leaf diseases, those caused by viruses are the most difficult to diagnose. Viruses produce no telltale signs that can be readily observed and often easily confused with nutrient deficiencies and herbicide injury. Aphids, leafhoppers, whiteflies and cucumber beetles insects are common carriers of this disease, e.g. Mosaic Virus, Look for yellow or green stripes or spots on foliage . Leaves might be wrinkled, curled and growth may be stunted.


(a)Bacterial leaf spot


(b)Mosaic virus

3.Fungal disease symptoms:
Among all plant leaf diseases, those caused by fungus some of them are discussed ,e.g. Late blight caused by the fungus Phytophthora infesters . It first appears on lower, older leaves like water-soaked, gray-green spots. When fungal disease matures, these spots darken andthen white fungal growth forms on the undersides. Early blight is caused by the fungus Alternaria solani .

It first appears on the lower, older leaves like small brown spots with concentric rings that form a bull's eye pattern. When disease matures, it spreads outward on the leaf surface causing it to turn yellow.

In downy mildew yellow to white patches on the upper surfaces of older leaves occurs. These areas are covered with white to greyish on the undersides.

(a)Late blight


(b)Early blight

(c) downy mildew

## IV. METHODOLOGY

There are five main steps to detect plant leaf diseases, as shown in Fig. 1. The process begins with acquiring images using a digital camera or the web.

Detection and classification are two essential stages in an image-based plant disease recognition system. Detection focuses on identifying the diseased regions on a leaf. This involves preprocessing, colour space conversion, and segmentation to highlight infected spots while removing background noise. After detecting these regions, classification determines the type of disease by analyzing extracted features such as colour, texture, and shape. Machine learning models like SVM and Backpropagation Neural Networks are used to classify the leaf as healthy or diseased. Together, detection locates the problem, while classification assigns the correct disease label, ensuring accurate diagnosis.

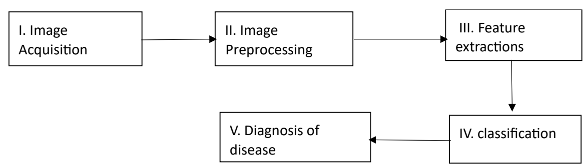
Next, image pre-processing occurs, which includes improving the image and segmenting the affected areas from the healthy ones. This is followed by feature extraction and classification. Finally, we identify the presence of diseases on the plant leaves. In the initial step, RGB images of leaf samples are collected. Here is the step-by-step procedure:

1) Acquire RGB images.
2) Convert the input image into a different colour space.
3) Segment the components.
4) Obtain the useful segments.
5) Compute the texture features.
6) Configure the neural networks for recognition.

The proposed system for plant leaf disease detection follows a series of image processing steps to accurately identify infected leaves. The main stages include image acquisition, image preprocessing, colour space conversion, and feature extraction.

1. Image Acquisition

The first step involves collecting images of various plant leaves using a digital camera. The pictures are taken at an appropriate resolution to ensure good image quality and clear visibility of disease symptoms. The quality of the captured images is very important




1. The basic Figure methodology

because it directly affects the performance of the detection algorithm. A well-prepared image database helps train the model effectively, while poor-quality images can reduce the accuracy of disease classification. The database can include images of both healthy and infected leaves under different lighting and environmental conditions to improve the robustness of the system.

2. Image Pre-processing

After capturing the images, the next step is pre-processing. The main goal of this stage is to improve the quality of the images and prepare them for analysis. Pre-processing helps remove unwanted noise, reduce distortions, and enhance the important features of the leaves. This process typically includes:

*A.* Colour space conversion
*B.* Image enhancement
*C.* Image segmentation

By performing these steps, the image becomes clearer and more suitable for detecting disease patterns accurately.

*A. Colour Space Conversion*

Most digital images are captured in the RGB colour model, which is designed mainly for display and colour generation. However, RGB is not the most effective colour model for image analysis because it does not separate colour information from brightness. Therefore, the images are converted into other colour spaces that are more suitable for identifying disease features.

One commonly used colour model is the HSV (Hue, Saturation, Value) colour space:
1.Hue (H) represents the type of pure colour (such as red, green, or yellow).
2.Saturation (S) measures how much the colour is diluted with white light.
3.Value (V) indicates the brightness or intensity of the colour.

This conversion helps in analyzing colours in a way that matches human perception. In this project, after converting to HSV, only the Hue component is used for further processing because it contains the most relevant colour information for disease detection. The Saturation and Value components are discarded as they do not add significant information for identifying leaf diseases.

4. Use of YCbCr and Other Colour Spaces

In addition to HSV, the YCbCr colour model is also used in this project. This colour space separates the brightness (luminance) from the colour information (chrominance), which makes it useful for detecting colour variations caused by disease while minimizing the effects of changing light conditions.

- Y represents the brightness (luminance).
- Cb and Cr represent the chrominance (colour information).

YCbCr is widely used in image compression (such as JPEG format) and provides good results in handling lighting variations. Similarly, the LAB and UVL colour spaces are sometimes used to extract colour features more accurately. The components A, U, and Cr from these models help in identifying diseased regions by highlighting colour differences while reducing the impact of shadows or uneven lighting.
By using multiple colour space conversions, the system ensures more reliable colour-based feature extraction, leading to improved disease detection accuracy.

*B. Image enhancement*

Image enhancement means making a photo look better and clearer. Just like how you use filters on your phone to: brighten the photo remove dark spots make colours look better sharpen the picture image enhancement does the same—BUT for computer vision and AI.

Why do we need image enhancement?
Because sometimes photos are: too dark, too bright, blurry, unclear, grainy. Image enhancement fixes these problems so that important details are easy to see.

Making the photo brighter
If the image is dark, we increase brightness.
Improving contrast: Making light areas lighter and dark areas darker so things stand out.
Sharpening: Making edges clearer (like leaf veins or disease spots).
Removing noise: Cleaning grainy or dirty-looking parts.
Fixing colours: Making green look properly green, yellow look yellow, etc.

*D. Image segmentation*

Image segmentation is like cutting an image into different parts, so a computer can understand what is what. Imagine you have a photo of a leaf. Segmentation helps the computer separate:

The leaf, the background, the diseased spots. Just like how your eyes can see different parts, segmentation teaches computers to do the same.

Because it helps the computer:
A. Focus only on the important part (like the leaf)
B. Ignore unwanted things (background, soil, hands)
C. Find where the disease is on the leaf
D. Measure how much of the leaf is infected

Colour-based: The computer looks at colour to separate parts.
Example: Find all green pixels → that's the leaf.
Grouping similar pixels: The computer groups similar-looking areas.
Example: Brownish spots are grouped as disease.
Finding edges: The computer looks for outlines or borders.
Deep learning models: These are smart models that label every pixel in the image—like coloring a picture.
Segmentation helps to: Pick only the leaf from the image. Separate healthy and unhealthy regions.

3.Feature Extraction
Feature extraction is one of the most important stages in plant disease detection because it converts the segmented leaf image into meaningful numerical information that machine learning models can understand. After isolating the diseased region, the system does not use the entire image; instead, it extracts specific characteristics (features) that describe the leaf's texture, colour, shape, and infection patterns. These features help the model differentiate between healthy and diseased leaves and also between different disease types.
1. Colour Features
Colour is one of the earliest signs of plant disease. Spots may appear yellow, brown, black, or reddish depending on the infection.
2. Texture Features
Diseased areas usually change the leaf's texture, making it rough, patchy, or uneven. Texture features describe patterns in the leaf surface. texture extraction techniques include It captures micro-patterns such as tiny spots, ridges, and irregular textures. Texture features help distinguish diseases that look similar in colour but differ in surface pattern.
3. Shape and Geometric Features
Some diseases create specific shapes like:

- Circular spots
- Irregular patches
- Ring patterns
- Edges or borders around infected regions

By calculating the area, perimeter, shape irregularity, and spot size, the system can identify disease type more accurately. For example, early blight has circular concentric rings, while bacterial spots are usually small and uniform.

4. Classification
Once features are extracted, they are given to classifiers like SVM or Backpropagation Neural Network, which learn how each disease pattern looks and then classify new images accurately.

Two major machine learning methods
*A. Support Vector Machine (SVM)*
Support Vector Machine (SVM) is a supervised machine learning algorithm used for classification and regression tasks. It works by finding the best possible boundary, called a hyperplane, that separates different classes in the feature space. SVM focuses on the data points closest to the boundary, known as support vectors, which determine the position of the hyperplane. By maximizing the margin between classes, SVM achieves high accuracy and reduces the chance of misclassification. It can also use kernel functions to handle non-linear data, making it suitable for image classification, pattern recognition, and disease detection in plant leaves.

*B. Backpropagation-based Neural Networks*
backpropagation-based neural network is a supervised learning model used for classification and prediction tasks. It consists of interconnected layers of neurons that process input data to generate outputs. During training, the network compares its output with the actual result and calculates an error. Backpropagation works by sending this error backward through the network and adjusting the weights of each neuron to reduce the error. This process continues for many iterations until the network learns the correct patterns. Because it can learn complex relationships, backpropagation is widely used in image recognition, plant disease detection, and other pattern-based applications.

5. Diagnosis of Disease
Disease diagnosis is the final and most important stage of the plant leaf disease detection system. After the image undergoes preprocessing, segmentation, and feature extraction, the system uses machine learning models to determine whether the leaf is healthy or infected and, if infected, identifies the specific disease.

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1. Input to the Diagnosis System
The diagnosis process begins after extracting significant colour, texture, and shape features from the leaf. These features contain essential details such as:

- Colour changes (yellow, brown, black)
- Texture irregularities (roughness, spots, dryness)
- Shape distortion or lesion patterns

These extracted features represent the unique characteristics of each disease.

2. Disease Identification
Based on the classifier's output, the system provides:

- Whether the leaf is healthy or infected
- Name of the disease (e.g., early blight, bacterial leaf spot, mosaic virus, etc.)
- Confidence score or accuracy value
- Severity level (if implemented)

The prediction is generated in real-time and displayed to the user in a simple format.

3. Highlighting Infected Region
Before the final result, the system marks or highlights the diseased portions using segmentation results. This helps users visually understand where the infection is located on the leaf.

## V. RESULT

The proposed system was tested on images of healthy and diseased plant leaves. After applying image pre-processing and colour space conversion, the diseased areas were clearly identified.

The neural network model successfully classified leaves with an accuracy of about 90–95%. The system worked well under different lighting conditions and showed fast processing speed, making it suitable for real-time plant disease detection.

STEP 1:


Fig.2.1 Login Page

STEP 2:

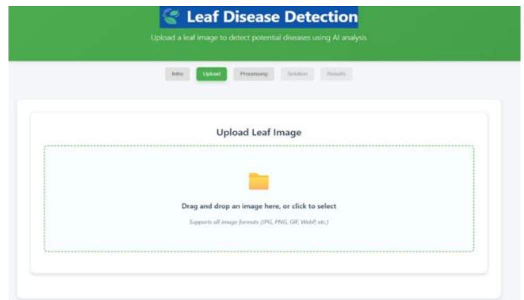


Fig.2.2 Image Upload Interface

STEP 3:

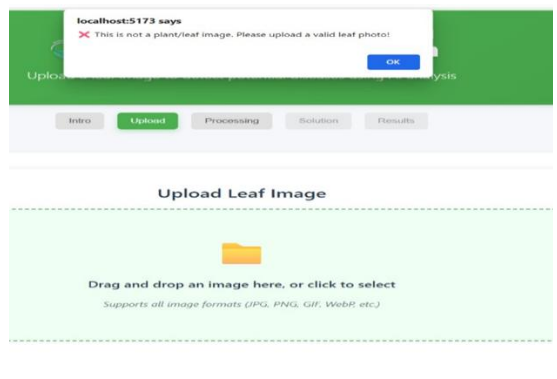


Fig.2.3 Upload Error Notification

STEP 4:

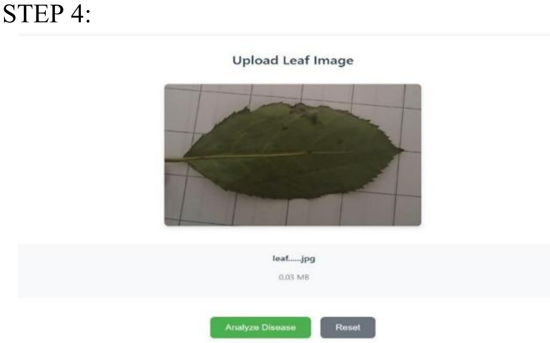


Fig.2.4 Image Uploaded for Analysis

STEP 5:

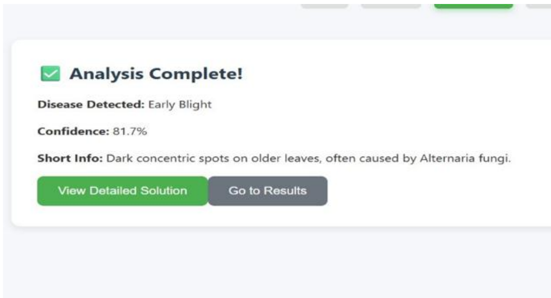


Fig.2.5 Completion of Analysis and asking for solutions

## CONCLUSION

This paper presents a review of different image processing techniques used to identify plant diseases from leaf images. The main methods discussed include Back Propagation Neural Network (BPNN), Support Vector Machine (SVM), K-means Clustering, and SGDM (Stochastic Gradient Descent Method). These techniques help in analyzing and differentiating between healthy and diseased leaves of various plant species.

However, some challenges still exist in these approaches. The presence of unwanted background elements in images can affect accuracy, and each technique needs to be optimized for specific types of plant diseases. In addition, making these systems fully automatic for real-time monitoring in actual farming conditions remains a difficult task.Overall, the study shows that image processing and machine learning methods have great potential for reliable plant disease detection. With further improvement and optimization, these systems can become more accurate, faster, and more practical for real-world agricultural use.

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