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A Survey on the Plant Leaf Disease Detection Techniques

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Abstract: Agricultural productivity is something on which the economy highly depends. This is one of the reasons that disease detection in plants plays an important role in the agricultural field. Having a disease in plants is quite natural. If proper care is not taken in this area then it causes serious effects on plants due to which respective product quality, quantity, or productivity is affected. For instance, little leaf disease is a hazardous disease found in (chili, banana, potato, and tomato) plants. Detection of plant disease through some automatic technique is beneficial as it reduces the large work of monitoring big farms of crops, Employing automated techniques for detecting plant diseases is beneficial, as it greatly reduces the extensive labour required to monitor large agricultural fields. The leaf diseases often manifest their symptoms on the leaf area during the early stages of infection. These infections can be analyzed and classified automatically using computer vision and machine vision systems, which employ image-processing techniques to interpret the information. The paper gives a brief review of major plant diseases that show symptoms in leaves and explains in details by involving image processing techniques.

Keywords: Leaf disease, Digital image processing, Color classification, Pattern classification.

I. INTRODUCTION

Agriculture is an important sector as it provides food and livelihood for millions of people. It also gives support to the country's economy. More than 80% of people's income depends on agriculture Leaf disease detection is an important task here because various types of diseases in the crop reduce the overall yield. We have surveyed various types of vegetable and fruit leaf disease and their detection techniques. We can notice vegetable and fruit leaves like potatoes, tomatoes, chili, and bananas with the diseased part. This disease can be easily detected using image processing techniques. Image processing follows steps like Image Acquisition, Image Pre-processing, Image Segmentation, and Feature extraction.

Classify into various categories of leaf disease, such as Bacterial spot, Early blight, Late blight, Mold, Septoria leaf spot, Spider mites, Two-spotted spider mite, Target Spot, Mosaic virus, Yellow Curl Virus, and Healthy. The main aim of this paper is to provide a survey on various leaf disease detection systems that can improve agricultural production.

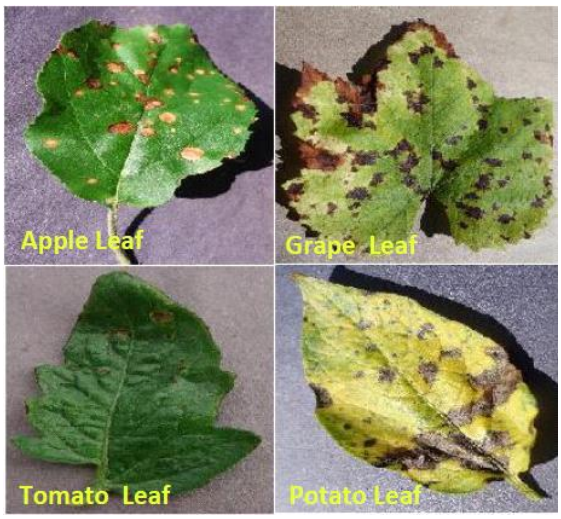

Figure 1.1 leaves with the diseased part

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II. LEAF DISEASES & SYMPTOMS

Leaves can be impacted by bacteria, fungi, and viruses. Symptoms of plant disease are observable effects of the disease on the plant. These symptoms can involve noticeable changes in color, shape, or how the plant functions in response to the pathogen. It's important to recognize these disease symptoms, especially if plant growth appears to be slow or diminished.

A. 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 are often confused with nutrient deficiencies and herbicide injury. Aphids, leafhoppers, whiteflies, and cucumber beetles insects are common carriers of this disease, e.g. Mosaic virus, and look for yellow or green stripes or spots on foliage, as shown in Fig. 1. Leaves might be wrinkled, curled, and growth may be stunted **[1].**

Figure 1.1 Viral Disease Symptoms

B. Bacterial Disease Symptoms

Pathogenic bacteria are responsible for numerous significant diseases in vegetables. They typically do not enter plant tissue directly but instead, require entry through wounds or natural openings in the plant. These wounds can occur due to insect damage, infections from other pathogens, or through activities like pruning and harvesting with tools.

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 Fig 2.2

Figure 2.2 Bacterial Disease Symptoms

C. Fungal Disease Symptoms

Plant leaf diseases, those caused by fungus are discussed below and shown in Fig. 2.3. E.g. Late blight caused by fungus. It first appears on lower, older leaves like grey-green spots, water-soaked. When fungal disease matures, these spots darken, and then white fungal growth forms on the undersides.

Figure 2.3 Fungal Disease Symptoms

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Table 1

Plant disease symptoms, causes, and control policies [2][3][4][5]

Disease	Symptoms	Caused by	Control Policy
Blight -Late Blight -Early Blight	Sudden and severe yellowing, browning, spotting, withering or dying leaves	- Bacteria or fungus -Humid region temp ranges 4 and 29c - Warm moist spring weather	- overhead watering - better air circulation - use fungicides and antibiotic
Bacterial wilt	- Wilt from the tip of the leaves - leave become yellow at their bases	- bacteria - high temperature - soil moisture - low pH - infected seeds	keep beetle populations as low as possible
Spindle Tuber Viroid	- smaller leaves curl downward - the plant has growth upright habit	Viral disease spread through pollen and infected seeds	Use Pesticides
Septoria leaf spot	- Small, round to irregular spots with a grey center and dark margin on the leaf - Spots usually start on the lower portion of leaves and extend upward - At a later stage spots coalesce and leaves are blighted	- Fungus - nutrition deficiency - high humidity - moist weather with intermittent shower	- improve air circulation around the plant - remove diseased leaves - Mulch around the base of the plants - avoid overhead watering

III. BASIC METHODS OF LEAF DISEASE DETECTION

Plant leaf disease detection includes some basic steps of image processing to detect & classify plant leaf disease. These steps are image acquisition, image pre-processing, image segmentation, feature extraction, classification, and leaf disease detection. These steps are described below in Figure 3.1.**[6]**

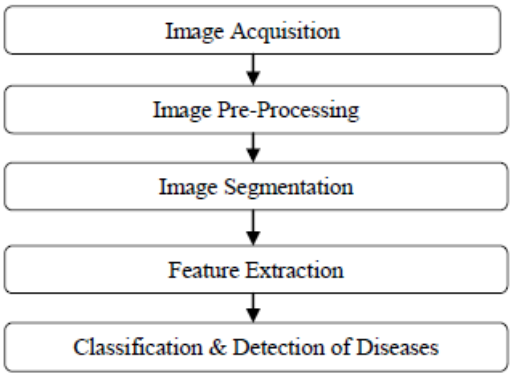

Figure 3.1 General Block Diagram

A. Image Acquisition

Image acquisition refers to the process of capturing digital images using cameras or other imaging devices. The efficiency of the concept depends upon the quality of database images. This image is in RGB (Red, Green, and Blue) form.

B. Image Pre-Processing

Image pre-processing involves enhancing or preparing digital images for further analysis or use. This can include tasks like noise reduction, sharpening, resizing, color correction, and normalization to improve the quality or suitability of images for specific applications.

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C. Image Segmentation

Image segmentation is the process of dividing an image into multiple segments or regions to simplify its representation and facilitate analysis. This technique is used to identify and separate objects areas of interest within an image based on their characteristics such as color, intensity, or texture.

D. Feature Extraction

Feature extraction involves identifying and extracting specific characteristics or features from images that are relevant to a particular task or analysis. These features could include edges, textures, shapes, or other patterns that help in distinguishing and describing different objects or regions within the image.

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E. Classification & Detection of Diseases

Finally, classifiers are used for the training and testing of the datasets. These classifiers may be support vector machine (SVM), k-nearest neighbour, neural network, fuzzy logic based, etc. These methods are used to classify and detect leaf diseases.

Table 2
Comparison between Different Techniques

Author Name	Year	Techniques	Description
Sachin D. Khirade, A.B. Patil **[7]**	**2015**	K-means clustering	Discussed various plant leaf diseases & classification method
Sannakki et al. **[8]**	**2013**	Feed Forward Back Propagation Neural network	Neural network-based classification is performed for grape leaf disease detection.
Kutty et al. **[9]**	**2013**	Neural Network	The neural network is used to classify watermelon leaf disease with an accuracy of 75.9%
P.R. Rothe, R.V. Kshiragar **[10]**	**2015**	Neuro-Fuzzy Inference System	Cotton leaf diseases of Alternarnia, Myrothecium, and Bacterial are detected.
Malti K. Singh, Subrat Chetia**[11]**	**2017**	Image Processing using MATLAB	Detection and Classification of Plant Leaf Diseases in Image Processing using MATLAB
Z. Husin, A.H.A. Aziz, R.S.M. Farook **[12]**	**2021**	Linear Regression algorithm	The algorithm to classify the chili plant diseases based on their color
Md. Abu Jubaer, ufrad Mustavi**[13]**	**2023**	k-means segmentation and Convolution neural networks	Using deep learning networks for classifying potato leaf disease
Bonkra, A.; Bhatt, P.K. **[14]**	**2023**	Machine learning; bibliometric, bibliographic coupling.	Using collaborative ML/DL methods for Apple leaf disease detection.
P. Tm, A. Pranathi, K. SaiAshritha **[15]**	**2018**	Convolution neural networks	With an accuracy of 94-95% the methodology proposed for accurate detection of tomato leaf diseases.

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Table 3
Comparison between Different Techniques with accuracies

Reference	Species	Dataset	Techniques used	Performance metrics
S. Ramesh et al. **[16]**, 2020	Paddy Leaf (Rice)	Real Field images	RGB to HSV+DNN with Jaya optimization algorithm is used as classifier	Accuracies of 98.9%, 95.78%, 92%, 94% and 90.57% for blast affected, bacterial blight, sheath rot, brown spot and normal leaf images respectively
PB Padol et al. **[17],** 2016	Grapes	Real Field images	Gaussian filtering + RBG to HSV and L*a*b conversion + Kmeans clustering for segmentation + Texture and colour features + SVM classifier	Average accuracy=88.89%
A Fuentes et al. **[18]**, 2017	Potato	Lab images	RGB to L*a*b conversion + Background removal by thresholding + Texture and colour features + Multiclass SVM as classifier	Average accuracy = 93.7%
M. Kerkech et al. **[19]**, 2018	Grapes	Real field images	SqueezeNet	Average Accuracy=95.8%
B Liu et al. **[20]**, 2018	Apple	Real field images	Custom CNN	Average Accuracy= 97.62%

IV. RESEARCH GAP

The current body of research demonstrates significant advancements in the detection of plant diseases using image processing and machine learning techniques. Various studies have applied different methodologies to a range of crops, achieving high accuracy rates in controlled and real-field environments. However, several research gaps persist that hinder the full potential of these technologies:

1. Crop-Specific Focus: Most research has concentrated on specific crops such as paddy (rice), grapes, potatoes, and apples. While these studies provide valuable insights, there is a comparative lack of focused research on banana crops, which are critical to many economies. Diseases like Panama disease and Black Sigatoka in bananas require more targeted detection and management strategies.
2. Technique Integration: The integration of various image processing and machine learning techniques remains underexplored. For example, while CNNs and SVMs have been individually applied with success, combining these with other techniques such as k-means clustering or Jaya optimization algorithms could enhance accuracy and robustness. Studies like those by S. Ramesh et al. (2020) and PB Padol et al. (2016) show the potential of such integrations but more work is needed to standardize and optimize these hybrid approaches.

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3. Real-World Application: Many studies, including those by A. Fuentes et al. (2017) and M. Kerkech et al. (2018), achieve high accuracy under controlled conditions. However, real-world agricultural environments present variable conditions that can affect detection performance. Developing systems that are resilient to these variables, such as fluctuating lighting and complex backgrounds, is essential for practical application.
4. Dataset Limitations: The datasets used in many studies are often limited in size and diversity, potentially affecting the generalizability of the findings. Expanding datasets to include more diverse images from different regions and under various conditions would enhance the robustness and applicability of disease detection systems.

V. CONCLUSION

In conclusion, the application of image processing and machine learning techniques to plant disease detection has shown substantial promise in improving agricultural productivity and sustainability. Studies have demonstrated high accuracy rates in detecting diseases in crops such as paddy, grapes, potatoes, and apples. Techniques such as RGB to HSV conversion, SVM classifiers, and custom CNNs have proven effective in various contexts.
However, there remains a need for further research to address several gaps. This includes a focused effort on banana crops, which are susceptible to severe diseases like Panama disease and Black Sigatoka, and require tailored detection methods. Integrating different image processing and machine learning techniques can enhance the robustness and accuracy of detection systems. Additionally, expanding the diversity and size of datasets, and developing systems that can function effectively in real-world conditions, will be crucial for practical application.
By addressing these research gaps, the agricultural sector can better utilize advanced technologies to safeguard crops, optimize yields, and contribute to economic stability. Continued innovation and targeted research will play a pivotal role in enhancing the effectiveness and applicability of plant disease detection systems, ultimately supporting global agricultural practices and food security.

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