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Leaf Disease Detection Using Image Processing

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Abstract: *A survey on leaf disease detection using CNN image processing is presented in this work. For the detection of illnesses in plant leaves, digital image processing is a reliable, time-saving, and accurate technology. Other algorithms can also be employed for the identification and categorization of leaf diseases in plants. The clustering approach, color-based image analysis method, classifier, and artificial neural network for illness classification are all examples of CNN techniques presented in this research. Our research focuses on analysing various leaf diseases using the CNN detection approach, as well as providing an overview of disease types and treatment and preventative methods.*

Keywords: Leaf diseases, CNN, SVM, image segmentation, pre-processing, features extraction, clustering, classification, symptoms and neural network technique

I. Introduction

India is primarily an agricultural country, with agriculture providing employment to the majority of the population. Fruits and vegetable crops are available to farmers in a wide variety of varieties. Modern digital and technological support can help them improve their crops. Agriculture research aims to boost productivity and food quality while lowering costs and increasing profits. Pathogens infect plants and cause disease in any setting. Diseases are usually visible on the leaves, fruits, and stems of affected plants; therefore, disease detection is critical for successful crop management and yield. Plant diseases are caused by pathogens, microorganisms, bacteria, fungus, viruses, and other microbes. Infected soil and water, which are also responsible for plant illnesses, can create an unhealthy environment. Observing the affected part of the plant with the naked eye is a traditional method of plant disease detection that is ineffective and inconvenient for vast areas of crop. Farmers require skilled monitoring on a constant basis, which can be excessively expensive and time-consuming. Plant disease identification is efficient, quick, and accurate when using the digital image processing technology. This strategy saves a lot of time, effort, and labour while also avoiding the use of needless fertilisers and pesticides. Alternative authors suggest different strategies for accurate plant disease identification using digital image processing. Different researchers are working on a variety of image processing algorithms. The advantages and limits of these prospective solutions are also compared in this research. Picture acquisition, image pre-processing, feature extraction, and neural network-based categorization are among the procedures.

The following sections make up this document: The necessity of leaf disease identification, plant leaf analysis, numerous forms of leaf diseases, and their symptoms are all covered in Section 1. Section 2 provides a brief review of the literature, including the strategies employed by various authors. Section 3 includes a table that summarises the strategies utilised by all authors for various works. This paper's conclusions are presented in Section 4.

1.1. Plant Diseases Analysis and its Symptoms

Agricultural research uses RGB picture feature pixel counting techniques widely. The following uses for image analysis are possible:

1. To identify illnesses in plant leaves, stems, and fruits.
2. To determine the disease-affected area.
3. Determine the impacted area's limits.
4. Find out what colour the damaged area is.
5. Determine the size and shape of the fruits.

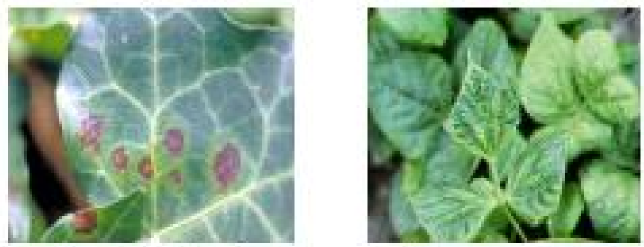
The symptoms of fungal, bacterial, and viral plant leaf diseases are listed here.

1.1.1. Symptoms of Bacterial Disease

The condition is characterised by little pale green spots that appear as water-soaked quickly. The lesions grow and subsequently appear as dry dead spots, as illustrated in figure 1(a); for example, bacterial leaf spot causes brown or black water-soaked spots on the foliage, often with a yellow halo, that are all roughly the same size. When the spots are dry, they have a speckled appearance.

1.1.2. Symptoms of Viral Infection

Virus-caused plant leaf diseases are the most difficult to diagnose of all plant leaf diseases. Viruses leave no visible signs and are frequently confused with nutrient deficiencies and herbicide injury. Mosaic Virus is spread by insects such as aphids, leafhoppers, whiteflies, and cucumber beetles. Look for yellow or green stripes or dots on foliage, as illustrated in figure 1. (b). Leaves may be wrinkled, curled, or stunted in growth.

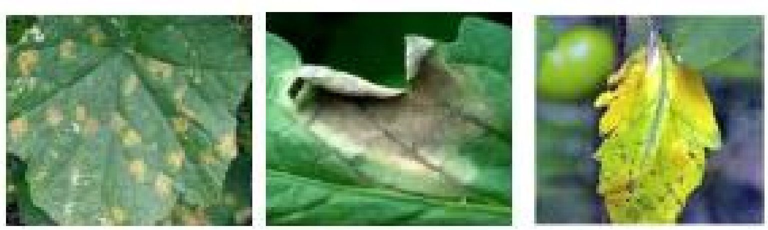


(a) Bacterial leaf spot (b) mosaic virus

Figure 1. Bacterial and Viral disease on leaves

1.1.3. Symptoms of Fungal Infection

Some of the fungus-caused plant leaf diseases are addressed below and illustrated in Figure 2, for example, Figure 2 shows late blight produced by the fungus Phytophthora infesters (a). It first shows as water-soaked grey-green patches on lower, older leaves. These patches darken as the fungal condition progresses, and white fungal growth appears on the undersides. The fungus Alternaria solani (seen in figure 2) causes early blight (b). It first appears as little brown spots with concentric rings that form a bull's eye pattern on the lower, older leaves. When the illness is fully developed, it spreads outward on the leaf surface, turning it yellow. Yellow to white patches appear on the upper surfaces of older leaves when downy mildew is present. On the undersides, these portions are coated with white to greyish, as illustrated in figure 2. (c).



(a) late blight (b) early blight (c) downy mildew

Figure 2. Fungal disease on leaves

II. PROPOSED APPROACH

The proposed effort focuses on utilising MATLAB to recognise illness on maize and peach leaves. The photos will be used to extract additional features, which will be done using one of the advanced algorithms. There are many features of photographs that have yet to be discovered; this initiated method will look into a few of them. The main goal of this programme is to help farmers who are losing money due to a lack of knowledge about a variety of diseases. The concept will be easier to understand. The system architecture and genuine progress of the concept are depicted in Figure 3.

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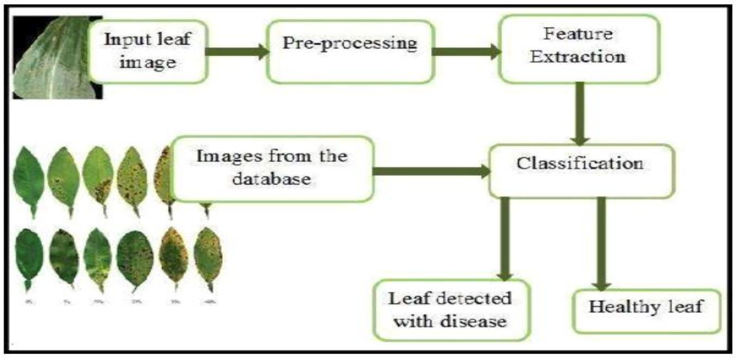

Figure 3: System Architecture

III. LITERATURE REVIEW

Ghaiwat et al. give a review of the many classification strategies that can be used to classify plant leaf diseases. For the current test case, the k-nearest-neighbour method appears to be the most appropriate and straightforward of the class prediction methods. It is difficult to establish ideal parameters in SVM if the training data is not linearly separable, which appears to be one of its shortcomings [1].

The authors of paper [2] describe the developed processing scheme as having four steps, the first of which is the creation of a colour transformation structure for the input RGB image, because this RGB is used for colour generation and the transformed or converted image of RGB, that is, HSI, is used for colour descriptor. Green pixels are masked and deleted in the second phase using a threshold value. In the third phase, when the image is segmented, green pixels are removed and masking is performed for the usable segments that were retrieved first in this stage. The segmentation is completed in the final or fourth main stage.

Mrunalini et al. [3] describe a method for classifying and identifying the various diseases that impact plants. In the Indian economy, a machine learning-based recognition system will be extremely beneficial because it saves time, money, and effort. The colour co-occurrence method is used to extract feature sets in this article. Neural networks are used to detect illnesses in leaves automatically. The proposed approach can considerably support accurate leaf detection and appears to be a key approach in the case of steam and root infections, while requiring less computational effort.

The illness identification process, according to paper [4, includes several processes, four of which are listed below: A colour transformation structure is initially created for the input RGB image, after which the green pixels are masked and deleted using a certain threshold value, segmentation is performed, and texture statistics are computed to obtain useable segments. Finally, the features retrieved to classify the disease are sent into a classifier. The suggested algorithm's resilience is demonstrated using experimental findings from roughly 500 plant leaves in a single experiment repository.

Kulkarni et al. describe a method for detecting plant illnesses early and accurately using an artificial neural network (ANN) and other image processing techniques. Because the suggested method uses an ANN classifier for classification and a Gabor filter for feature extraction, it produces better results, with a recognition rate of up to 91%. An ANN-based classifier classifies distinct plant diseases and recognises them using a mix of textures, colors, and characteristics [5].

The authors offer a method for detecting disease in Malus domestic using K-mean clustering, texture, and color analysis [6]. It employs texture and color traits that are similar in normal and afflicted areas to identify and differentiate distinct farming. In the approaching days, Bayes classifier and main component classifier can also be utilised for classification K-means clustering.

Histogram matching is employed to identify plant disease, according to [7]. Because illness develops on the leaf in plants, histogram matching is performed using an edge detection technique and a colour characteristic. The training procedure employs a layers separation technique, which comprises the training of these samples to separate the layers of an RGB image into red, green, and blue layers, as well as an edge detection technique to detect the stacked images' edges. Color co-occurrence texture analysis is developed using spatial gray-level dependence matrices. Table 1.1 compares and contrasts several algorithms.

The triangular threshold and basic threshold approaches are presented in paper [8]. These strategies are used to segment the leaf area and to lesion region area. The quotient of leaf area and lesion area is used to categorise the disease in the final phase. According to the research, the offered approach for assessing leaf disease severity is quick and accurate, and leaf area is calculated using threshold segmentation.

Using image processing techniques, the authors present an algorithm for disease spot segmentation in plant leaves [9]. The influence of HSI, CIELAB, and YCbCr colour spaces on illness spot identification is compared in this research. The Median filter is used to make the image peaceful. Finally, by using the Otsu approach on the colour component, a threshold may be calculated to locate the illness location. Background noise, camera flash, and vein all contribute to noise in the experimental outcome. The noise is removed using the CIELAB colour model.

The publication [10] presents a state-of-the-art overview of various strategies for detecting leaf disease using image processing techniques. The existing methodologies investigations are aimed at enhancing throughput and reducing subjectiveness associated with plant disease identification and detection using naked eye observation.

Soft computing methods such as artificial neural networks (ANN), genetic programming, and fuzzy logic can be utilised to predict complex behaviour of materials like graphene, according to [15]. In order to solve issues, these algorithms require input training data. Based on the input, these computer algorithms generate meaningful answers for complex optimization problems. A three-layer feed-forward network can be utilised in numerous models. The number of neurons in the hidden layer can be determined using the root-mean-square error approach.

Tabu search is a meta heuristic search strategy that employs mathematical optimization approaches such as local search. Local searches take a potential solution to a problem and compare it to its close neighbours, that is, solutions that are similar except for small features, in the hopes of finding a better answer. Local search strategies are prone to become stranded in suboptimal areas or plateaus when several solutions are equally suitable. If a prospective solution has been visited before in a short period of time or if it does not satisfy a rule, it is tagged as "tabu." This prevents the algorithm from considering that possibility again [24].

Genetic programming is the most well-known method for addressing symbolic regression issues, and it is also commonly employed to solve optimization problems. The basic principles of GP and GA are similar, but there is one significant difference: GP provides answers in terms of weighted sums of coefficients, whereas GA provides solutions in binary or real form. As a result, we can call GP a structure optimization method and GA a parameter optimization method. MGGP is a type of genetic programming in which the evolutionary stage is made up of a collection of trees that are regressed using the least squares method. For effective implementation of MGGP, we can apply the trial-and-error method [16], [17], [19].

In their paper [18], Vijayaraghavan et al. said that a support vector machine is a very promising AI technology that may be used to handle classification difficulties. Support vector regression is a type of SVM that is used to tackle regression problems (SVR). SVR is particularly popular among researchers since it allows the solution model to be generalised.

Pathogens manifesting in plantations is one of the most common causes of crop losses in various crops. Bernardes et al. describe a method for automatically classifying cotton illnesses based on foliar symptom feature extraction from digital photos. This method leverages the energy of the wavelet transform for feature extraction and an SVM for classification [20]. Ma et al. [21], provide an overview of the current medical image segmentation algorithms. Algorithms are divided into three groups based on their primary concepts: the first is based on threshold, the second is based on pattern recognition techniques, and the third is based on deformable models. As a result of extensive research, the third category of algorithms has recently concentrated on deformable models. Segmenting organs and tissues in the pelvic cavity is one of the most common uses for these algorithms. Several preliminary experiments are used to discuss these.

In their study [22], the authors categorised an algorithm based on the main approaches. Each category's algorithms are described, as well as the key concepts, application sectors, advantages, and downsides of each. Experiments using these algorithms to segment the tissues and organs of the female pelvic cavity are being conducted to demonstrate their distinct properties. Finally, the important guidelines for constructing pelvic cavity segmentation algorithms are presented.

According to Tavares, tasks including segmentation, extraction of representative features, matching, alignment, tracking, motion analysis, deformation estimates, and 3D reconstruction make image computational analysis difficult. Methods for processing and interpreting objects in photographs are proposed in paper [23], with applications in medicine, biomechanics, engineering, and materials sciences.

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IV. Analysis of Various Algorithms

Authors & year	Goals	Future perspective
[1] Savita N. Ghaiwat et al., Detection and classification of plant leaf diseases using image processing techniques: a review (2014)	Review of ANN, SVM, PNN, SELF ORG MAPS and fuzzy logic	When training data is not linearly separable, it is difficult to grasp the structure of the algorithm and identify ideal settings
[2] Prof. Sanjay B. et al., Agricultural plant leaf disease detection using image processing (2013)	Vision-based detection algorithm with masking the green-pixels and color co-occurrence method	NNs can be used to improve the categorization process' recognition rate
[3] Mrunalini R. et al., An application of K-means clustering and artificial intelligence in pattern recognition for crop diseases (2011)	K-means clustering algorithm with neural networks for automatic detection of leaves diseases	Crop diseases can be classified using artificial neural networks, fuzzy logic, and other soft computing techniques
[4] S. Arivazhagan et al., Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features (2013)	Color co-occurrence method with SVM classifier	The number of training samples can be increased, and shape and colour features, as well as the best features, can be used as illness identification input conditions
[5] Anand H. Kulkarni et al., Applying image processing technique to detect plant diseases (2012)	Gabor filter for feature extraction and ANN classifier for classification	The rate of recognition can be boosted
[6] Sabah Bashir et al., Remote area plant disease detection using image processing (2012)	Texture segmentation by co-occurrence matrix method and K-means clustering technique	Plant diseases can be classified using Bayes classifiers, K-means clustering, and principal component classifiers
[7] Smita Naikwadi et al., Advances in image processing for detection of plant diseases (2013)	The color co-occurrence texture analysis method was developed through the use of spatial gray-level dependence matrices	With a huge database and advanced colour extraction feature, a better detection result may be attained
[8] Sanjay B. Patil et al., Leaf disease severity measurement using image processing (2011)	Simple threshold and triangle thresholding segmentation methods	Helpful to farmers to decide the specific quasssntity for pesticide application which reduces the environment pollution.
[9] Piyush Chaudhary et al., Color transform-based approach for disease spot detection on plant leaf (2012)	Median filter is used for image smoothing and threshold can be calculated by applying Otsu method	The area of a disease spot can be calculated to estimate crop loss in agriculture. The dimensions of the illness spot can be used to classify the disease
[10] Arti N. Rathod et al., Image processing techniques for detection of leaf disease (2013)	Survey of different techniques for leaf disease detection	To improve the recognition rate of the final classification phase, hybrid algorithms and neural networks were developed

V. Conclusion

The current research examines and discusses numerous image processing algorithms for recognising plant diseases in a variety of plant species. CNN, SVM, K-means clustering, and SGDM are the most common algorithms for detecting plant diseases. These methods are used to determine if plant leaves are healthy or unhealthy. The effect of background data in the generated image, optimization of the technique for a specific plant leaf disease, and automation of the technique for continuous monitoring of plant leaf diseases under real-world field circumstances are some of the problems in utilising these techniques. Most researchers use artificial neural networks and classifiers to improve recognition rates, such as the CNN algorithm technique, which we used in our project. With some minor drawbacks, this disease detection technique appears to have good potential in terms of detecting plant leaf diseases more precisely. As a result, there is room for advancement in this field of research.

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