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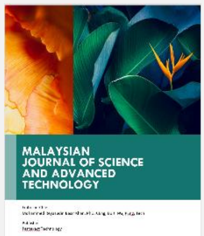

Plant Leaf Disease Detection Using Image Processing: A Comprehensive Review

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ABSTRACT

In this review paper, previous and current works for plant leaf disease detection have been studied. The traditional manual visual quality inspection cannot be defined systematically as this method is unpredictable and inconsistent. Moreover, it involves a remarkable amount of expertise in the field of plant disease diagnostics (phytopathology) in addition to the disproportionate processing times. Hence, image processing has been applied for the recognition of plant diseases. This paper has been divided into three main parts. In the first part, a comprehensive review based on algorithms is provided were the major algorithms and works conducted using image processing and artificial intelligence algorithms have been compared. The second part discusses the frameworks and compared the previous works. Then, a comprehensive discussion based on the accuracy of the results was provided. Based on the review conducted, a detailed explanation of the illnesses detection and classification performance is provided. Finally, the findings and challenges in plant leaf detection using image processing are summarized and discussed.

1. INTRODUCTION

Agriculture in Bangladesh has emerged as a significant contributor to the country's overall economic expansion. Agriculture contributes a significant amount of Bangladesh's GDP and is the country's primary industry. Consequently, crop damage would result in a significant drop in overall productivity, which would have a negative impact on the economy. Because they are the most delicate portion of the plant, the leaves are the first to exhibit signs of any disease. From the very beginning of the crop's lifecycle up to the point at which it is ready to be harvested, it is necessary to keep an eye out for and treat any diseases that may affect the plants. Traditional naked eye observation is a method that has been used for a long time to monitor plants for illnesses. This process is very much intense and takes a lot of time, and it requires professionals to manually monitor crop fields. Initially, this method was utilized. In recent years, a good number of different methodologies have been implemented in order to produce an autonomous and half-autonomous plant leaf disease detection process. The traditional approach for manual observation carried out by farmers has been shown to be slower, more expensive, and less accurate than the systems that have been developed so far. Because of this, it is imperative that researchers implement technological solutions for identifying plant leaf diseases that are more advanced and do not require the participation of humans. Leaf plant disease locations can benefit from the image handling method. Improved image quality can be achieved by using pre-processing. Image processing analysis will yield excellent results. Color space alteration, image enhancement, and image segmentation are all included. On the leaves, stem, and fruits, infection symptoms are most noticeable. The plant's leaves may show signs of illness. Processing an image to make it more suitable for a certain purpose is what is meant by the term "image processing." An image pre-processing comprises enhancing edges, enhancing sharpness or deblurring an out-of-focus image, boosting image distinction, or brightening and reducing noise. Then the image processing can identify a few types of leaf plant illnesses, such as the borders of the sick leaf and stem; and ii) the diseased leaves and stems. in order to determine the exact size and contours of the diseased region,

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The color of the affected region can be determined by iii. iv) image segmentation v) image layer separation [1]

The purpose of this work is to review a variety of approaches to the diagnosis of plant diseases and to explore these approaches in terms of several different factors. The sections that follow are the organizational structure of the paper. The first part of this article provides a concise overview of the significance of diagnosing plant diseases. In the second portion, we will talk about background research. After that, we will talk about the recent work that has already been done in this area, and we will also evaluate the algorithm, the methodology, and the outcomes. In conclusion, this section will discuss the implications of this paper along with potential next steps.

2. BACKGROUND STUDY

The investigation and detection of plant diseases is a crucial topic of research in the realm of machine vision. This technology involves the acquisition of images using machine vision equipment for the purpose of determining whether the obtained plant images include any illnesses [2]. At the present time, one of the first sectors to adopt computer vision-based crop diseases and identification technology is agriculture, which has partly replaced the traditional way of diagnosing plant diseases by visual examination.

Plants have grown in global significance in recent decades. Many scientists and technologists have long been concerned with the possibility that in current attempts to minimize global warming as well as in health, energy production, and other fields, plants may be crucial. As a result of a decrease in global plant cover, there is an increased danger of global warming and related difficulties. Many research programs have been launched to offer scientists with the necessary knowledge to construct a cutting-edge convolution layer system that allows for image detection and plant disease classification. Image detection may be utilized when it is crucial to separate healthy leaves from unhealthy ones. Images of plants can be compared using convolutional neural networks (CNNs), which can identify potential anomalies in the plants' natural environment. Background research demonstrates that scientists in this sector use scanning photographs of healthy and ill plants as a basis for comparison.

Traditional machine learning vision-based plant leaf disease and identification approaches often use conventional algorithms for image processing or manually created features and classifiers [3]. When designing an imaging scheme, this kind of technology will generally utilize the many traits of plant diseases. Additionally, it will select an appropriate source of light as well as angle of shooting, that is crucial for obtaining photos with uniform illumination. Imaging schemes that have been carefully built can significantly simplify the development of traditional algorithms; however, this comes at the expense of an increase in the cost. However, it is sometimes impractical to expect the traditional algorithms to totally minimize the effects of transitions on recognition outcomes while working in natural environments [4]. This is because natural environments are constantly shifting, and the algorithms were not designed to account for this. In a complex ecosystem in nature, the identification and diagnosis of plant leaf diseases are met with several obstacles. These difficulties include small variations in the lesion area's size and type, low contrast, considerable variations in the lesion area's size and type, and a sizable quantity of disturbance in the lesion image. In addition to this, when taking pictures of crop diseases and insects in environments with natural light, there are a great deal of distractions. At this point in history, the old and classical procedures frequently appear to be powerless, and it is difficult to produce superior detection outcomes.

One sort of deep learning model, convolutional neural networks (CNNs), has lately demonstrated success in several computer vision (CV) applications, incorporating facial expression identification [5], scenario of text detection [6], traffic detection [7], medical photographs recognition [8], and many others. Companies from both the United States and abroad have developed practical uses for deep learning within the field of crop diseases and detection of diseases, including WeChat applets and photo recognition APPs. To put it another way, deep learning-based algorithms for detecting plant diseases have both scholarly and practical uses.

3. REVIEW BASED ON ALGORITHM

The detection of plant diseases by image processing has attracted considerable attention in the agricultural sector. Numerous studies are conducted to find these illnesses. Listed below are the many methods used by researchers in their study of plant diseases. A study of the most common plant diseases has been completed.

3.1 SVM

Gathering characteristics from leaf photos K-means clustering was introduced in this paper [9]. The algorithms are put through their paces using data from the training set. Results from identifying and classifying fungal infections on cereal crops using the SVM were shown to be superior. This paper [10] focuses on the segmentation of pictures of leaves and fruits. Once features have been retrieved, during training and classification, the SVM is utilized. A proposed computer program consisting of five essential steps which make effective use of SVM, and the minimum distance criteria can accurately diagnose and categorize the studied disorders [11]. Farmers may use the web-based application [12] which can diagnose fruit disease. The picture is downsized, then features are retrieved using criteria like color, morphology, and contrast, and finally, the picture is classified as infected or not using SVM for classification. The study in [13] employs a feature extraction and picture segmentation approach. SIFT is used to recover properties of shape and color. The SVM classifier evaluates the results after feature extraction. Another study in [14] suggested the creation of an image processing system that would be able to recognize and categorize four distinct forms of plant diseases. This experiment was carried out for a total of over 500 photos using the SVM classifier. The author in [15] describes a strategy for detecting and identifying the kind of illness that affects tomato plants that employs the Gabor wavelet transform system to extract pertinent characteristics from an image of a tomato leaf and SVM Machines with different kernel functions. Ycbcr and Lab color spaces provide K-mean clustering, which may be used for illness component extraction using clusters. SF-CES offers superior improvement in color images [16]. Following that, GLCM texture features and color texture characteristics are retrieved for the sake of further categorization. Last but not least, a classification based on SVM. K-means clustering is utilized for segmentation, while the Support Vector Machine (SVM) is used for classification. In this paper, they examine how to identify plant diseases using several different approaches [17]. The authors in [18] created a composite feature vector to be trained by a Support Vector Machine (SVM). The proposed decision support model employs a variety of machine learning approaches to categorize and identify leaf plants. To segment images, the gray level co-occurrence matrix concept was used to extract features, and a multi-class support vector machine was used for classification [19].

3.2 ANN

A K-means clustering technique has been devised in this paper [20]. This algorithm takes paddy leaf noisy photos that have been damaged by camera light and remove the noise. After that, it is able to detect the illness that is affecting the paddy plant by utilizing the classification technique ANN and FUZZY. The study in [13] employs a feature extraction and picture segmentation approach. SIFT is used to recover properties of shape and color. The ANN classifier evaluates the results after feature extraction. One way of assessing the general health of cotton plants is the acquisition and analysis of leaf images [21]. By combining several image processing techniques with an artificial neural network (ANN), the author provided a method for the quick and accurate diagnosis of cotton leaf diseases. The authors [18] created a composite feature vector to be trained by the machine learning (ML) method Artificial Neural Network (ANN). The proposed decision support model employs a variety of machine learning approaches in order to categorize and identify leaf plants.

3.3 KNN

Soft Computing. K-means clustering is utilized in this technique to identify diseased leaf tissue [22]. This study will utilize KNN to identify diseased leaves, classify them by disease kind, and display the results. The paper in [23] describes the development of an algorithm that is generic in the sense that it may be used for any ailment. It is a general supervised learning algorithm that, as a demonstration, determines the presence of grey fungus on cotton plant and then assesses the condition's severity to determine the disease stage. The study of the illness employs a feature extraction and picture segmentation approach [13]. SIFT is used to recover properties of shape and color. The KNN classifier evaluates the results after feature extraction. The author in [14] suggested the creation of an image processing system that would be able to recognize and categorize four distinct forms of plant diseases. This experiment was carried out for a total of over 500 photos using the KNN classifier. A new Deep Learning approach that is introduced in relation to an IoT strategy to get optimal prediction outcomes [24]. With the use of cutting-edge innovations like the Internet of Things, the LDEDLP method provided here can efficiently detect plant diseases and send out adequate warnings to the appropriate people.

3.4 CNN

The proposed method in [25] divides the disorders identified on plant leaves into 15 different categories using a convolutional neural network (CNN), with 12 groups representing the various plant diseases (bacteria, fungi, etc.) and the remaining three groups representing healthy leaves. One research in [26] shows the use of deep neural networks to classify leaf images to construct a plant disease identification model. The proposed model can identify plant leaves from their surroundings and detect 13 plant illnesses from healthy ones. Healthy leaves and backdrop images are consistent with the other classes, permitting the model to distinguish between ill versus healthier leaves from the surroundings by utilizing deep CNN. In another study as in [27], the authors employ a multi-stage classification process to thoroughly rule out potential outcomes and improve prediction accuracy. The same method has been deployed to analyze a plant's leaves for signs of disease using Convolutional Neural Networks, thereby solving the problem of plant disease identification (CNN). Pre-processed pictures were segmented by using IFFCMC and AO thresholding [28]. GLCM characteristics were derived from the segmented pictures. Using the PCA technique, the dimension of the retrieved features was lowered. Finally, a DCNN-based classification was executed.

3.5 Random Forest

In [29], GLCM was used to extract the feature, and finally, the classification technique was used for training and testing the leaves of the plants. This was an example of a systematic approach. As a classifier, a random forest was used. The authors in [30] employ seven classifier methods to recognize and classify diseased and healthy potato leaves based on their appearance in more than four hundred and fifty photos collected from publicly available plant village datasets. The accuracy of random forest classifiers was higher than that of the others. The summary of different algorithms for plant leaf disease detection is shown in Table 1

Table 1. Summary of different algorithms for plant leaf disease detection

Paper Title	CNN	ANN	SVM	KNN	RF	Accuracy
[18]		✓	✓			SVM-92.4%, ANN-99.5%
[28]	✓					97.43%
[24]				✓		99%
[30]					✓	97%
[11]			✓			94.74%
[31]						90.98%
[23]				✓		82.50%
[12]			✓			82%
[14]			✓	✓		SVM-98.2%, KNN – 80.02%
[15]			✓			100%
[16]			✓			96%

4. REVIEW BASED ON FRAMEWORK

The ability to monitor vast fields of crops with the aid of automatic disease detection is a crucial research area. For that, the use of image processing is quite popular and effective. Numerous studies are conducted to find these diseases. And for the techniques, various methods were used. Listed below are the frameworks that were used by the researchers in their study of plant disease:

This study in [22] is a multistage approach where there are two phases. A training set is one, and a testing set is another. The initial stage of the suggested framework is image acquisition. The second stage involves image pre-processing. The third stage is feature extraction after that. The three previously mentioned stages are repeated for both the training set and the testing set. In the fourth stage, training is done then the result goes to the testing set where classification is done. In the final stage, recognition is done. The two phases of the system are the training phase and the testing phase. The framework consists of the following steps: image acquisition, image pre-processing, image segmentation, and feature extraction. After features are extracted, the image data is compared with the permanent database [32]. After comparison the disease is detected then the result is displayed.

The author in [29] of this work proposed utilizing image processing to identify plant disease. In this paper, the proposed framework is like this, the first step is image acquisition, the second step is image pre-processing then image segmentation, after that feature extraction, and finally classification. In another study as in [9], the authors followed the common steps of image processing. Image capture, picture pre-processing, image segmentation, feature extraction, and classification are the stages that the framework suggests.

Following similar approach [33], the method that the authors followed is like this, the first step is Image Acquisition, after that, the input image is selected for segmentation. Two distinct segmentation techniques are used in this study. 1. Leaf region Segmentation, 2. Disease region segmentation. Finally, the severity of the disease is assessed. This study [10] is a multistage approach where there are two phases. A training set is one, and a testing set is another. Image acquisition is the first stage in the suggested framework. Image pre-processing is carried out in the second stage. The third stage is feature extraction after that. Both the training set and the testing set go through the same three steps that were previously discussed. In the fourth stage, training is done then the result goes to the testing set where classification is done. In the final stage, recognition is done.

The approach in [20] uses a number of techniques to diagnose paddy illnesses. Image acquisition, image pre-processing, image segmentation, feature extraction, and image classification are the steps in the suggested framework. The authors of this paper [25] presented a computer vision method for identifying plant leaf diseases. The suggested system includes a number of phases. The suggested system's fundamental framework is Image acquisition, Image Pre-processing, CNN Structure Design, Training, Testing, and finally Plant leaf disease detection.

The identification and classification of leaf diseases have been suggested in this paper [11]. RGB picture capture, Color Transformation, Pixel Masking and Removal, RGB Mapping, Segmentation, Obtaining Useful Segments, Computation of Texture, and Classification make up the study's suggested framework. The authors used the suggested framework, which included image acquisition, image pre-processing, image enhancement, colorspace conversion, image segmentation, and feature extraction, as well as classification and disease diagnosis [34]. In the proposed system in [31], the application does the following steps: input image, image pre-processing, image segmentation, feature extraction, matching content, and then display the disease and solution.

In this paper [23], the following steps of the framework are input image, image pre-processing, image segmentation, feature extraction, and lastly classification. Deep CNN training was carried out for this study in [26] using Caffe, an open-source deep learning framework created by the BVLC that includes a reference pre-trained CaffeNet model. The model was modified and adjusted to support the purpose of the research. In the proposed system, the following steps are Data Acquisitions, Image Pre-processing and Analysis, Image segmentation, and Pattern Classification [35].

The framework of the proposed system contains two phases. One for training and another for testing [12]. In the training phase, the steps are Input Image, Image Pre-Processing, Feature Extraction, Clustering, and finally Classification. In the testing phase: Input Image from the user, Pre-Processing, Feature Extraction, and finally Classification. In this study [13] the authors followed the common steps of image processing. Image acquisition, image pre-processing, image segmentation, feature extraction, and classification are the steps that the framework suggests.

To identifying plant leaf diseases, the authors have used image processing techniques in this proposed work [14]. The following stages demonstrate the suggested methodology that was used in this work: image acquisition, pre-processing, segmentation, feature extraction, and classification Using ANN, the authors in [21] proposed a technique that helps in identifying cotton leaf diseases. The framework of the proposed system contains the following steps: Input Image, Image Pre-processing, Feature Extraction, and Classification.

The authors in [36] suggested using neural networks to diagnose and classify grape leaf diseases. In this proposed system the framework has several steps that were followed. The following steps are Image acquisition, Background removal, Pre-processing, Segmentation, lesion Extraction, Feature extraction, and Classification. In this proposed [15] SVM-based tomato disease detection approach, the authors used a framework that comprises four fundamental building phases. The phases are Image acquisition phase, Pre-processing phase, Feature extraction phase, and Classification phase. Meanwhile, the authors in [16] proposed a system that uses image processing methods to identify areas of citrus leaves that are unhealthy. Implementing image analysis and classification techniques for the extraction and classification of leaf diseases is the goal of this study or publication. For this work, the proposed framework is modeled into four parts: image pre-processing, segmentation, feature extraction, and classification.

The authors in [17] proposed an image processing technique that indicates plant leaf disease. The authors proposed a framework that indicates a multi-layered approach.

The layers consist of image acquisition, image pre-processing, segmentation, feature extraction, and classification.

The authors in [37] proposed a system that detects plant infection using image processing. In order to extract and classify plant leaf diseases, this paper aims to use image analysis and classification algorithms. For this work, the proposed framework involves several steps. The steps involved in plant disease detection are image acquisition, image pre-processing, segmentation, feature extraction, and classification. In another work deep neural network-based plant disease detection and classification were suggested by the authors [27]. In this paper, the classification is performed in multi-stages. The framework or the block diagram of the identification system consists of Input Image, Feature extraction using a Bounding box, Classification of leaf, Classification of disease, and Output labeling.

The authors in [18] presented a machine learning model or a framework that includes Edge feature extraction using canny edge detection technique, color feature extraction using grid color movement, and Texture analysis using Local Binary Pattern (LBP). A combined feature vector is trained under the algorithm. Finally, the result is Classified. Additionally, the model can identify rice plants and their diseases. Work in [28] proposed a system that automatically extracts features and detects plant leaf diseases using GLCM features and convolutional neural networks. In the proposed framework, there are several steps: Image pre-processing (Image filtering & Image enhancement), Segmentation, Feature extraction, and Classification.

The authors suggested utilizing machine learning methodologies to identify and classify diseases in potato plant leaves [19]. Python was used to put the proposed framework into practice. The major phases are image segmentation (K-means methodology), feature extraction (Gray level co-occurrence matrix), and Classification (Multiclass Support Vector Machine methodology). Work in [24] suggested combining deep learning networks with the Internet of Things (IoT) techniques for efficient plant leaf disease detection. A new deep learning method is introduced in this paper which is the Internet of Things (IoT). The proposed methodology of this paper is based on both principles of deep learning and the Internet of Things (IoT). The proposed approach consists of several operations like Image pre-processing, Feature extraction, Image segmentation, Classification and IOT assistance.

Image segmentation and machine learning were used to examine the detection of potato illness in [30]. The proposed paper approached a common framework that includes Image processing (Image Normalization and Color Space Conversion), image segmentation, feature extraction (GFD), Training, and Classification. Figure 1 shows the proposed approach.

5. REVIEW BASED ON RESULT

From the proposed work in [22], the results show that the system recognized Alfalfa diseases effectively by up to 90% which was achieved using K-Means Clustering, KNN algorithm, and Local Binary Pattern (LBP).

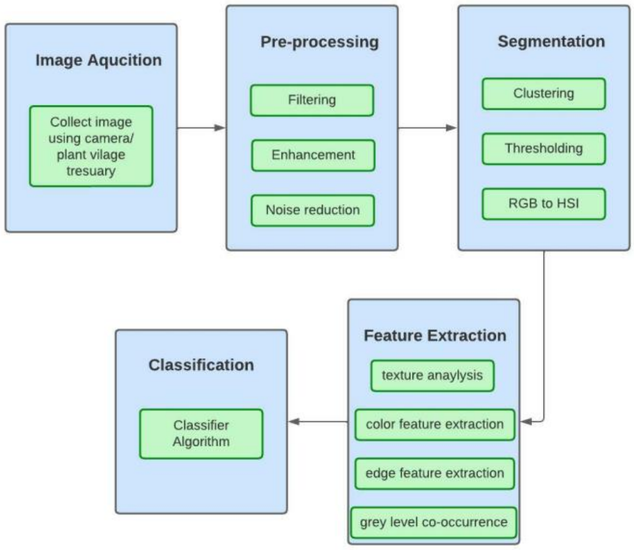

Fig. 1. Proposed methodology in [30]

In another approach as in [32], the authors divided the intensity of the infection into different percentages: 20%, 40%, and 75%. Based on these the solution is provided, and it was achieved using the Canny edge detection technique and Gaussian mixture model (GMM). The study in [29], the authors identified plant disease using an image processing technique that includes K-means clustering, Random Forest algorithm, and GLCM. Although the authors didn't mention the accuracy, the solution is said to be quite fast.

In one of research in [9], the authors developed a system that identifies plant disease using image processing. To demonstrate overall precision, accuracy, recall, and F-measure, the authors used a number of techniques. Comparing the accuracy of the algorithms we can see three of them exceeds 90%. The following are SVM (Linear Kernel) 95.63%, SVM (RBF Kernel) 94.23% and SVM (Polynomial Kernel) 95.87%. And the SVM polynomial kernel gives the best result. From the proposed work in [33], the accuracy of the experiment is 98.60 %. The accuracy of the algorithm was tested by using the simple threshold and triangle thresholding method.

The author suggested using MATLAB to detect plant diseases during image processing [10]. The authors said that the system will provide high accuracy but did not mention the accuracy percentage which was achieved using K-means clustering and support vector machine (SVM). The study in [20], the authors use image processing, including K-means clustering, ANN, and fuzzy classification, to identify and quantify paddy leaf disease signs. Although the authors didn't mention the accuracy, the solution is said to be more accurate.

For this paper, the author used a convolutional neural network (CNN) which obtained an excellent accuracy of 98% [25]. In this paper in [11], the authors proposed a system that detects unhealthy regions of plant leaves using texture features. The proposed algorithm's effectiveness has a 94% accuracy in detecting and classifying the studied diseases. It is achieved using support vector machine and Minimum distance criterion.

In another work as in [34], The authors presented a system to study and evaluate the use of image processing in cotton leaf disease identification. For this study, segmentation was carried out using the K-means clustering approach, while classification was done using neural networks. And the accuracy was 89.56%. The authors suggested identifying and classifying plant leaf disease which was done using color transformation, CBIR method, and K-means clustering [31]. The result is said to be fast and accurate. The accuracy of this study is 90.98%.

In another approach as in [23], two cascaded classifiers are used that the authors proposed. Local statistical features and hue and luminance from the HSV color space are two examples of the other. For this work, the KNN classifier was used, and the accuracy was 82.50%. Not only following this approach as in [26], but convolutional neural network also (CNN) was used in a new way by the authors to create a model for plant disease recognition based on the classification of leaf diseases. A deep learning framework called Caffe was utilized to execute the CNN. The accuracy was 96.3%.

The authors in [35] suggested a method for segmenting images that can differentiate between two categories of orchid leaf diseases. MATLAB was used to examine orchid leaves using boundary segmentation techniques. Morphological processing techniques were applied to classify the images. The accuracy of the system was 86.36% which is a moderate accuracy. By uploading photographs of fruit to the system, the authors suggested a web-based application that aids farmers in identifying fruit diseases [12]. The trained dataset of the system will be compared to the input dataset. K-means clustering approach was utilized for clustering, and Support Vector Machine (SVM) was employed for classification. The approach was effective, and the accuracy was 82%.

SVM classifier to automatically detect rich leaf disease by image processing in paddy leaf disease detection [13],. In this paper, features were extracted using SIFT. SVM and KNN classifiers were used to analyze the results. The following results were 95.5% and 92.2% for SVM and KNN. In similar research as in [14], the proposed methodology uses digital image processing methods to examine and find plant leaf diseases. In this study, segmentation was carried out using K-means clustering, while GLCM and LBP were used to extract features. The classification was done using three types of classifiers: KNN, SVM, and Ensemble. Comparing these three the best accuracy was found from SVM, and it was obtained under the cubic kernel. The accuracy is 98.2%.

The work in [21], proposed a technique that can detect and classify leaf disease using artificial neural networks. For this work, the features are extracted using HSV then ANN classifier was used to classify the input images. The accuracy was 80% which is moderate. Meanwhile, the study in [36] aims to identify leaf disease using artificial neural networks and image processing. For this paper, K-means clustering was used for segmentation, GLCM was used to extract features, and Back Propagation Neural Network (BPNN) was used for classification. Surprisingly the accuracy was found to be 100%.

The study in [15] examines a support vector machine-based method for detecting diseases in tomato leaves. The author applied an SVM classifier with a variety of kernel functions, including the Cauchy, Invmult, and Laplacian kernels. For the Cauchy kernel, the accuracy that was obtained was 100%. On the other hand, the study in [16]discussed the image processing methods that were applied to plant disease early detection. And for this work, the authors choose unhealthy regions of a citrus leaf. K-means clustering was used for image segmentation, GLCM was used for feature extraction, and support vector machine was used for classification (SVM). Using the SVMRBF classifier the accuracy came to 96% and using SVNPOLY classifier the accuracy came to 95%.

This work in [17] suggests utilizing image processing to identify plant leaf disease. For this work, the segmentation was done using K-means clustering, and Region of interest (ROI) was selected for feature extraction. Finally, classification was done using Support Vector Machines (SVM). The overall recognition was 92.4%. In [37], the authors proposed an automatic detection of infected plants. For segmentation K-means clustering was used, the GLCM technique was used for feature extraction, and based on the extracted features the plants were classified. The system was able to identify and classify accordingly with 98.27%.

This study in [27], describes a deep learning method for identifying and categorizing plant diseases. For extraction, a YOLOv3 object detector was used. Then the extracted leaves were analyzed through ResNet18 models. Then CNN classifier was used to classify the results. The accuracy was 96%. The authors in [18], suggested a decision support system for locating illnesses in rice plants. Java technology is used to implement the suggested machine learning and image processing techniques-based framer decision support system. A machine learning model was implemented here which contained three types of feature extraction techniques. The combined feature vector was trained through SVM and ANN. And the accuracy was 92.4% for SVM and 99.5% for ANN.

In [28], the authors proposed a framework that has several parts. MATLAB software was used to simulate the proposed system. For this work, image filtering and enhancement were done using (2D AADF) and (AMA) techniques. Segmentation was performed by using IFFCMC clustering Algorithm and thresholding was performed using the AO thresholding algorithm. Features were extracted using GLCM. Finally, a novel DCNN architecture was used for classification. High accuracy of roughly 97.43% was attained using the proposed methodology. For the purpose of identifying and classifying diseases that affect potato plants, a methodology was proposed [19]. The framework was implemented using Python. Image segmentation was done using the K-means methodology. For feature extraction, the GLCM concept was utilized, and for classification, the multi-class support vector machine method was used. The suggested method can achieve a 95.99% accuracy rate.

To get the best prediction results with the necessary precision, a new deep learning technique is introduced in this [24] regarding the Internet of Things (IoT) approach. This methodology is referred to as Leaf Disease Estimation using Deep Learning Principle (LDEDLP). The proposed LDEDLP technique demonstrates that the final accuracy level was approximately 99%.

A machine learning-based image processing and autonomous system that can classify and identify potato leaf diseases are presented in [30]. A method based on creating masks utilizing color information was utilized for segmentation, and GFD was used for feature extraction. The Random Forest classifier has the highest accuracy (97%), making it ideal for classification. The summary of different plant leaf disease detection and their results are shown in Table 2.

Table 2. Summary of different plant leaf disease detection and their results

Paper	Culture	Algorithm	Dataset	Accuracy
[18]	Rice	SVM, ANN	120	SVM- 92.4%, ANN- 99.5%
[28]	14 different crops	IFFCMC, Otsu Threshold, CNN	54206	97.43%
[24]	Different vegetable crops	KNN	54300	99%
[30]	Potato	Random Forest	450	97%
[11]	30 different crops	SVM	500	94.74%
[23]	Cotton	KNN	140	82.50%
[12]	Pomegranate	K Means Clustering, SVM	610	82%
[14]	Chilli, grape, rice, soya bean, wheat, rose, cotton, apple, mango	KNN, SVM	560	SVM- 98.2%, KNN – 80.02%
[15]	Tomato	SVM, K Means Clustering	200	100%
[16]	Citrus	SVM, GLCM, K Means Clustering	200	96%

6. DISCUSSIONS

The growth can be supported by the timely and accurate detection and classification of diseases. Diseases can be detected with simple naked-eye observation and experience-level ongoing monitoring, but it has a high price and takes a lot of time. It has been shown that image processing, in which a learning and optimization algorithm replaces the human brain, and a digital camera performs better as a substitute for human sight, is an effective technique for identifying and classifying plant diseases. To identify and distinguish diseases of agricultural and horticultural crops, numerous computer vision-based algorithms have been developed recently to overcome the challenges of manual processes. The above literature review discusses multiple techniques for identifying and categorizing various plant leaf diseases. Even though the subject of identifying leaf diseases using digital image processing has been studied for around 25 years, the improvements made seem a little hesitant. Some of the major points are needed to discuss:

a) Lack of technical expertise in image processing techniques: Effective performance of any computer vision system depends on the selection of classification strategies and image-processing techniques. Issues with huge sample sets, overfitting, and other issues arise when segmentation and classification approaches are evaluated. Sometimes authors fail to include the necessary technical details.

b) Processing Speed: Given the enormous amount of data we must analyse; processing speed of the detection and classification approach is a crucial concern. In order to minimize the dimensions of the received data and then evaluate it for further processing, several feature extraction and selection strategies are provided.

c) Setup requirements are too restrictive: Noise in the collected photos makes it very hard to analyze the quality. Conditions in the surroundings for taking pictures under regulated illumination are another restriction. Several challenges make it difficult to use image processing algorithms in real-world settings. While being studied under carefully controlled laboratory illumination settings, existing approaches show remarkable accuracy. However, their usage outside is a challenge because of the sharp decline in accuracy that occurs there. To minimize the impact of lighting, camera angle, capturing equipment, and object distance, robust calibration is needed. Due to colour's intrinsic unpredictability in natural illumination, the other major problem also exists.

d) Data (images) reliability: The absence of comprehensive and trustworthy data information is a further cause for worry. The kinds of devices, such as lighting configuration, camera angle, and distance, etc., that were utilized to achieve the findings are not entirely known. The biggest issue during the examination and confirmation of results is that many authors do not provide their testing and training data. Different trustworthy measures must be offered.

e) Relevance of universal strategy: It is challenging to create a system that can identify and detect every kind of plant leaf disease. Most of the methods or systems that writers suggest are exclusively effective against one type of plant disease. Consequently, a universal approach for the identification of plant leaf diseases must be created.

We might conclude by saying that the writers should spend more time studying and comprehending the technologies they want to employ. It appears that some writers produce excellent articles in which they explicitly outline their work with specific device classes, quantifiable criteria, and employed methods and instruments.

7. CONCLUSION

A benefit for the farmer is that by using an image processing strategy for plant infection categorization, the agriculturist can prevent an infection from spreading to a critical portion of the leaf before it affects adjacent leaves. Plant diseases were incorrectly identified and classified by the researchers using a variety of methods and frameworks. Significant economic and post-harvest losses in agriculture are caused in part by plant diseases, especially in recent years due to climate change. Many effective methods for detecting, monitoring, and assessing plant diseases have been developed over time. Biochemical and pathological analyses as well as expert visual interpretation are now well-established specialties. In recent years, non-invasive technologies have received more attention. A summary of disease classification techniques for the detection of plant diseases is provided in this study, along with a photo segmentation method that may one day be utilized to automatically detect and categorize plant leaf illnesses. As a result, associated plant diseases were collected to provide an accurate diagnosis. The suggested algorithm's efficacy in recognizing and classifying leaf illnesses was demonstrated by the optimal results that were obtained with minimal computational effort. Other algorithms can also be used to increase the accuracy of classification.

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