A Review on Plant Leaf Diseases Detection and Classification Based on Machine Learning Models

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ABSTRACT

For farmers, India is very famous in agriculture. The economic growths for all nations are dependent on agricultural products. Due to plant diseases, the quantity and quality of agriculture yield are reduced. The study of plant disease refers to the study of clearly visible patterns of plant leaves. So, recognition of the unhealthy regions of plants may be thought about the way of saving the decrease of productivity and crops. The early-stage diagnosis of plant diseases like viruses, bacteria, fungi, etc. is most essential to control and cure the disease. The manual identifications of diseases are a time-consuming process. Hence, some experts are required to recognize the disease. There are varied standard methods such as classification model, image processing, and machine learning models that are utilized to detect and recognize the disease on agricultural yields. This article provides varied existing models are made familiar with the detection of disease in agricultural product. Further, it presents a survey on varied classification models with the analysis, which could be utilized to classify and identify the plant leaf diseases. It also discusses the outline of segmentation, feature extraction, and varied classifier techniques.

Keywords: Machine Learning (ML) Classification, Leaf Disease, Image Processing, Pre-processing, segmentation, Feature Extraction, Disease Classification and Detection.

1. INTRODUCTION

The Indian economy depends heavily on the productivity of agriculture. In today's world, the agricultural land mass is more than just being a feeding sourcing [1]. Hence, in the agriculture field, identification of disease in plant leaves has played a major role. Because of diseases, the quality and quantity of the leaf gets affected. Leaf streak, brown spot, false smut, leaf blight, and leaf blast are some diseases which occurred by fungus, bacteria, and virus. In some cases, it might happen because of deficiency of necessary minerals [2], [12].

Historically, detection of disease has been supported by different institutions or agriculture organizations like local plant clinics [3], [13]. Disease on plant leaf will be the significantly reduced in both the quantity and quality agriculture crops. For successful crop production in the farm, need to monitor the disease and health on plant leaves. In earlier days, some experienced person were executed all these analysis and monitoring of leaf diseases manually, which is a time consuming process [4]. Therefore, early identification of these diseases will be helpful to farmers to keep away from any losses [5]. Agriculture is the main part and support of the Indian economy, along with an income for Indian people. If agriculture had gone wrong, then nothing else would have an opportunity to go directly into the nation.

The requirement of food is increasingly higher because the production of agriculture is minimal. To avoid that, analysts, researchers, scientists, government, specialists, and farmers attempt to put additional effort with different approaches to boost up the agriculture productions to meet the requirements. In agriculture field, there are enormous advancements with the help of technology. Farmers face difficulties due to the plant diseases and global environment change factors. The image processing methods will be utilised for detection of plant diseases. In many cases, symptoms of diseases have seen on the fruit, stem as well as leaves. Identification of plant leaf disease is taken here for the symptoms of disease. In this article, the preface of image processing method provides here for plant leaf disease identification. In addition to this, discussed the percentage of accuracy for detecting and classifying the leaf diseases at the early stage of disease by applying Machine Learning (ML) models [6], [14] and find a way to keep away from this leaf diseases.

The remaining part of this article can be arranged in the following way: Sect. 2 illustrates the related work of classification methods for leaf diseases; Sect. 3 introduced an in depth rationalization of image classification and detection procedure. Sect. 4 discussed about several ML models, and finally Sect. 5 has concluded the paper with the future work of this problem.

2. LITERATURE SURVEY

Plenty of work and researches are in progress in the area of automated leaf detection to identify the plants species. In this article, some related works are discussed here.

In paper [15], [16], discussed and implemented a methodology to analyze defects of peach and apple, having average accuracy rate of 70% with the help of Near-Infrared (NIR) images.

In paper [15], [17] applied a Neural Network (NN) model which is utilised for color grading of apples with an accuracy of 75%. In this paper, color information is applied to rate apple like poor red, normal red etc.

In paper [6] used varied ML models for leaf disease classification and detection of maize plant, which considers supervised machine learning models like Random Forest (RF), Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Decision Tree (DT) and Naive Bayes (NB). These models take images of the plant as input to identify the maize leaf disease. The above mentioned classification methods are analyzed for comparing the accuracies plant disease predictions that utilised to get the highest accuracy with the help of best suitable method. The RF model resulted with high accuracy of 79.23%. The precautionary measure for the farmers to detect and classify the new test images of disease in early stage is to use the all above mentioned trained models.

A huge number of leaf disease works is completed by different researchers with different algorithms and found their accuracies by comparing the several forecasting methods in the prediction of leaf disease. A few of them are outlined in Table (1).

Table (1): Summary of Plant leaf disease prediction by using ML techniques.

Authors	Applications	Algorithms	High Accuracy
Kutty et al. [18]	Categorize the watermelon leaf diseases of Downey Mildew and Anthracnose	NN based system	75.9%
Malvika Ranjan et al. [19]	Distinguish the healthy and diseased samples of leaf diseases.	ANN	80%

Miller et al. [15], [20]	Spectral reflectance evaluation of apple blemishes to recognize varied patterns in different apple	Unimodal Gaussian, Multi-layer back propagation, K-nearest neighbor and nearest cluster algorithms	85%
Joshi et al. [2], [21]	Classify rice diseases	K-Nearest Neighbor classifier (KNN), Minimum distance classifier (MDC)	KNN= 87.02, MDC=89.23%
S. Prasad et al. [7]	Detection of plant leaf disease	Gabor Wavelet Transform (GWT)	89%
R. Pydipati et al. [15], [22]	Citrus disease detection	NN classification	90%
Ajay Gurjar et al. [23]	Cotton Leave disease detection	Eigen feature regularization and extraction technique	90%
Monika Jhuria, Ashwani Kumar & et al [24]	Disease categories using morphology, texture and colour feature vectors of apple and grapes	Neural Network with back-propagation	90% in morphology
Kulkarni et al. [1], [25]	Plant diseases detection	ANN	91%
Jing Liu et al. [15], [26]	Plant leaf recognition	Locally Linear Embedding and Moving Center Hypersphere Classifier	92%
Shiv Ram Dubey et al. [27]	Apple fruit diseases detection and classification	Multi-class Support Vector Machine	93%
Dheeb Al Bashish et al. [28], [29]	Automatic detection of five types of leaf diseases	NN classification	93%
S. Prasad et al. [7], [30]	Plant leaf recognition	Support Vector Machine (SVM)	95%
H. Muhammad Asraf et al. [28], [31]	Classifying nutrient diseases in oil palm leaves	SVM	95%
S. Prasad et al. [7], [15]	Plant species recognition	SVM classifier	95.36%
T. Rumpf et al. [28], [32]	Detection and differentiation of sugar beet diseases	SVM and spectral vegetation indices	97%
Gayathri Devi [2]	Classify the leaf disease and non-disease plants	multi class SVM	98.63%

S. P. Mohanty [3]	Plant disease detection	Deep Convolutional Neural Network	99.35%
Sannakki et al. [33]	Diagnosis and classification of diseases in grape leaf	back propagation Neural Network	100%
Orillo et al. [2], [34]	Identify rice plant diseases	back propagation Neural Network	100%

3. DISEASE DETECTION AND CLASSIFICATION PROCEDURE

The working procedures as well as the complete architecture of the classification models are described in this section [6]. The block diagram and basic steps for plant leaf disease detection and classification using image processing is shown in Fig (1). The proposed methodology contains several steps like image acquisition, image preprocessing, image segmentation, feature extraction, classification, and performance evaluation. Initially, it captures the leaf images, pre-processes the input image according to the dataset and then applies the image processing methods to extract useful features for detection of diseases [9]. All the above steps will be executed to detect the diseases present in the infected leaf image. After that, apply any classifier models to categorize the diseases in accordance with the relevant data set [9]. The detailed explanation of each process is as follows [6].

Input Image

This step is also called as Image Acquisition step. The first step of all ML classifiers methodology is input image. Image acquisition is the procedure wherein acquiring and converting to the desired output format. In this step, either we can download from any genuine website of plant image, containing different types of infected leaf images or could be taken through a digital camera. All healthy and diseased images are saved in RGB color form in image database and these are located manually with given unique names and numbers [5], [10], [37]. Create color transformation structure for the RGB leaf image, after that apply a device-independent color space transformation for the same [4], [35].

Image Pre-processing

Image pre-processing is the second step for detection and classification of leaf disease. It is utilized to extract the required content from the images. It requires for providing some functions like elimination of noise as well as background [5]. The noise might be thought of as the existence of insect excrements, dust, dewdrops on plant leaves [6]. To resolve these issues, the input RGB image is converted into a grayscale image to get the correct outcomes. All applications in this area are need to reduce the size of input image because the input image size is very large, which is utilized to minimize the memory size [6].

In more formally, we can say that the pre-processing of images consists of image enhancement, color conversion, removal of noise [10], [39]. In Image enhancement the quality of image is enhanced to increase the visuality. In color space conversion, the RGB image is converted into greyscale using various color models such as CIELAB, YCbCr and HSV. For the purpose of noise removal, various filters are used [10], [38]. The RGB image is converted into CIELAB, YCbCr and HSV because RGB is device dependent color space and image processing system needs images in device independent color space models [10], [41]. After performing the resizing, color space conversion and enhancement, Histogram equalization methods are used to designate intensities [10], [40].

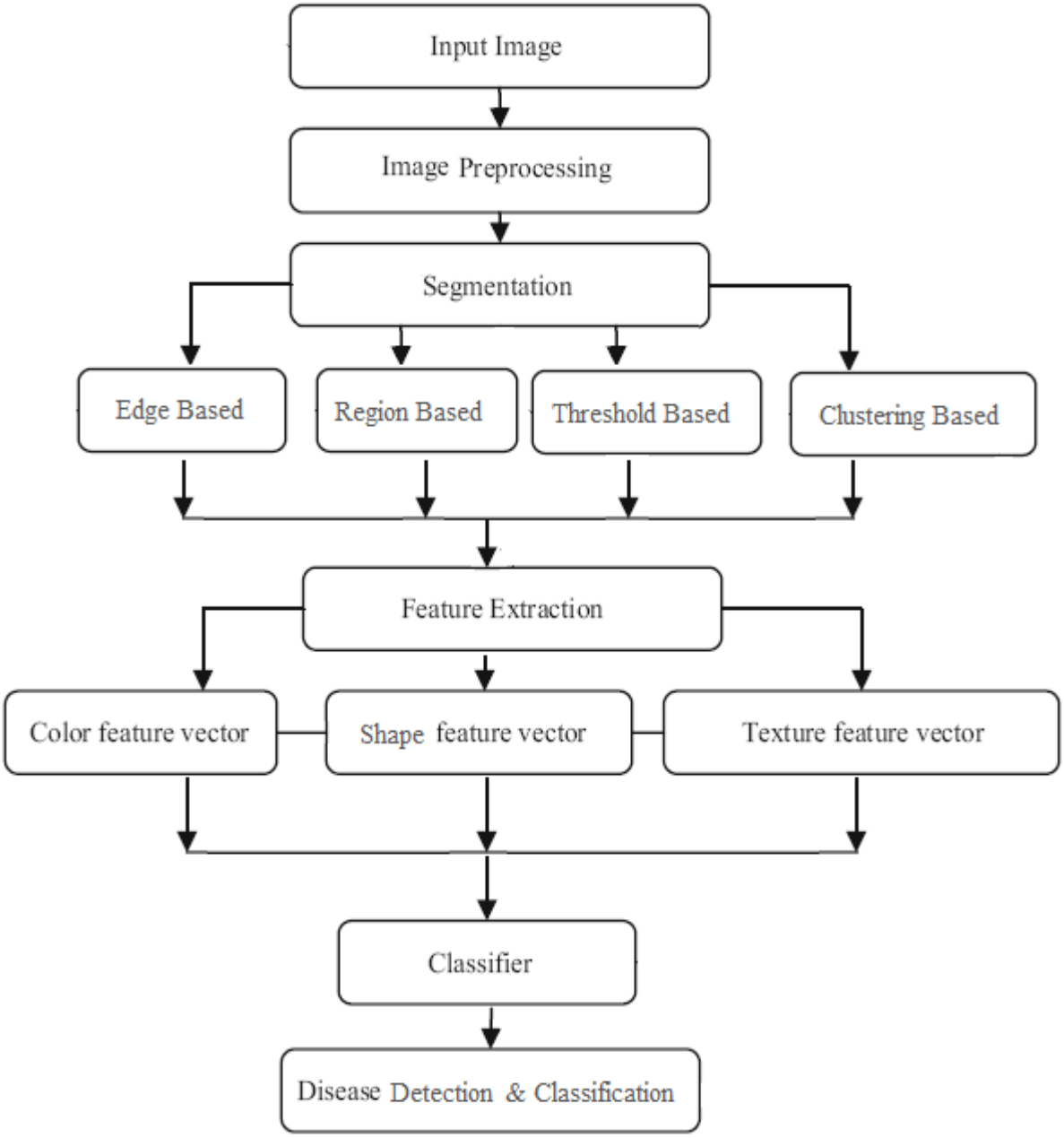

Figure 1. Steps of Plant Leaf Disease Detection and Classification

Image Segmentation Techniques

Image segmentation has played a key role in plant leaf disease detection and classification. This divides the image into various regions or objects [6]. In other words, the large dataset are grouped into small clusters [2]. This is a process, which can classify the image into varied groups or clusters for analyzing [2]. Further, it processed to extract relevant information by analyzing the image data. This image segmentation can be done in two different ways dependent on discontinuities and similarities. In discontinuities, the images are divided dependent on the unexpected changes in the intensity of values like edge detection. However in similarities, the images are divided dependent on some predefining criterion. Thus, in image segmentation, the label edge detection methodology is applied. In addition to this, it computes the gradient of image intensities at each pixel of the image [6].

Generally, the segmentation could be achieved with the help of varied methodologies like conversion of RGB image to HIS model, k-means clustering, otsu' methodology etc. [4]. In this step k-Means cluster is used because it is best to identify the leaf disease, which has been used by numerous researchers. In the disease affected leaf, K- Means cluster separates the image into three groups of the cluster. Using these clusters, the segmentation process is done [8]. Color, locality, thresholds or edge based segmentation methods works well with plant disease detection systems [36].

Feature Extraction

The process of extracting the features from the images is named as feature extraction process. All the extracted features are illustrated as an entity, which further classified into three groups like texture, color, and shape [6]. Heterogeneous datasets require a combination of features. However, texture is identified as a best feature for detection of plant diseases. Likewise, for shape, the identified features are concavity, eccentricity, area and roundness [42]. From the binary segmentation images, two shape features are extracted like area and perimeter [9], [43]. Generally, color is defined as histograms and moments [42]. The features of colors are extracted from color segmentation images. The color features include mean, variance and skewness of gray values of R/G/B and H/S/V component respectively. Also, include the color ratio in RGB color model [9], [43]. Properties like, entropy, variance, homogeneity, and contrast, can be put together to texture.

Classifier

The final step is classification of images. Classifiers are used to classify the images [2]. In this article, we have discussed the popular classification models, which are used by numerous researchers, like Artificial Neural Network (ANN), Random Forest (RF), Support Vector Machine (SVM), K-Nearest Neighbor (KNN), Decision Tree (DT), Naive Bayes (NB), and Minimum Distance Classifier (MDC). The details of all the above classifier models are described in the next section.

4. MACHINE LEARNING (ML) CLASSIFICATION MODELS

Machine Learning (ML) Classification models are of two types such as supervised classification and unsupervised classification. In the supervised classification the set of classified classes are known in advance but on the other side in unsupervised learning set of classes are not known. Classifiers are used for the purpose of classification [10], [44].

Naive Bayes (NB)

Naive Bayes classifier is a "probabilistic classifier". On the basis of Baye's theorem, Naive Bayes classifier is implemented with the independence presumption among the features [2], [45]. It presumes that the prior probabilities of the patterns are well-known and the posterior probabilities are assigned to the class labels. With these hypotheses, the posterior probability is computed with highest probability which belongs to a specific class label. Though these hypotheses usually do not hold in the real-life environment, it is quite doing well in many classification applications [6].

K-Nearest Neighbors (KNN)

KNN classifier makes the categorization of unidentified instances based on a similarity measures or distance function [2]. It is a supervised ML, lazy learning and nonparametric model. Normally, it uses in pattern recognition. It is based on the principle of nearest neighbor rule. For model generation, this classifier does not require any training pattern. All training patterns are utlised in testing phase to classify the test pattern dependent on similarity function. It behaves as a kind of instance-based learning where the functions are locally estimated and all the calculations have varied until the completion of classification method [6]. The result of the KNN classifier is a class membership value that it belongs to.

Decision Tree (DT)

It is a supervised classification and regression model. In supervised learning, which constructs the classifiers, divided the data into numerous smaller trees and sub-tree structures dependent on the division to construct the higher inconsistency. The attribute selection measures such as Gini index, entropy are usually employed as disparity measures. For implementers, evaluation of the results using this model will be easy. If the tree had learned with no restriction of tree depth then DT would have generate minimum training error. Several types of decision trees like CART, C4.5 and ID3 are most commonly used in ML and data mining applications [6].

Random Forest (RF)

It is an ensemble model of randomized DT classifiers. At the training time, multiple DTs are constructed. The testing dataset's class labels are determined by the voting of all classification trees, which becomes the result of this classifier. While building of each individual tree, this classifier model uses bagging and random features. This model endeavors to make an unrelated forest of trees. The prediction of forest of tree's performance will be more accurate than the individual tree [6].

Support Vector Machine (SVM)

SVM is a supervised machine learning classifier model [54]. It classified by the separating hyperplane. This model gets a best hyperplane, which maximizes the distance among the nearest data points. This distance is referred to as a margin [6]. SVM is of two types: linear and non-linear. In linear SVM classifier, the uniform distributions of data are allowed to draw a straight hyperplane among the classes. Whereas, in non-linear SVM classifier, data are spread in different directions and also have high dimensions [46]. Most of the real-world applications are solved by non-linear SVM classifier.

Kernel tricks are the property of SVM which will be helpful for nonlinear classification. It is done with the transformation of features with the help of varied general functions like radial basis, polynomial and linear function. The training time of the classification process increases due to the transformation of features. This transformation of features would increase the dimensions of feature space. It could also transform the features into the higher proportions by calculating the dot products with no transformation of the feature set [6].

Minimum Distance Classifier (MDC)

MDC is a classifier method to classify the images with Manhattan distance. The advantage of MDC is easy for implementation and also takes less time for classification [47], [53]. Manhattan distance is also termed as "cityblock" distance. A (x1, y1) and B (x2, y2) are the two pints and the distance between these two points are termed as Manhattan distance (d). It can be computed by using the equation 1.

$$d = |x_1 - x_2| - |y_1 - y_2| \quad (1)$$

Artificial Neural Network (ANN)

ANN is a ML model that is built based on the neural structure of the human brain. Problems beyond the capability of current computers can be solved by techniques like ANN that are inspired from the working of a human brain. Thus a neural network consisting of a number of hidden layers is designed based on the required inputs, target or the expected output to train the classifier [49], [35], [50]. The uniqueness or intelligence of the network depends on the weights of the neurons. Hence for a learning

neural network weights are to be adjusted to get the exact output. In that case back propagation neural network plays a significant role. Back propagation algorithm aims at minimizing the error function by following the gradient descent technique. Each layer in the network has specific weights and these are updated one by one at each iteration to reduce the error value [51], [52], [9], [22].

5. CONCLUSION AND FUTURE WORK

This article describes a detailed survey on the prediction of plant leaf disease detection and classification. The literature survey concludes better results for plant leaf disease detection and classification with several ML classifiers. Performance improvement for the detection and classification of plant leaf disease is said to be the complicated task. The review work of this article helps in doing that.

The following conclusion has come up from study of mentioned ML classification models. In more than five articles SVM and Neural Network were found above 90% accuracy, which compete with the best ML classification models available for classifying high-dimensional data sets. The optimal outcomes were got in low computing endeavors that prove the efficacy of all ML models in early recognition and classification of the leaf disease. Hybrid algorithms can even be used to improve the recognition rate in the process of classification. In future we are going to implement some of new and hybrid models for our research work.

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