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A Study of Fruit Disease Detection using Pattern Classifiers

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***Abstract*—** A country like India, where economy is strongly driven by agricultural products. If plants are suffering from any kind of disease, it may amount loss in both quantity and quality of the agricultural products. The disease diagnosis is one of the very challenging tasks for farmers. Usually, the disease or the symptoms of the disease such as spots or streaks are seen on the leaves or stem of a plant. Most of the diseases in plants are caused by bacteria, fungi, and viruses. In order to prevent such loss, it is vital to detect and diagnose the disease at the early stage. This paper presents a survey of various fruit disease detections using image processing techniques and neural networks. Various authors have proposed different techniques for fruit disease identification and classification. The techniques such as texture feature extraction using GLCM, color-based segmentation, artificial neural network and different classifiers are used. The focus of work is to carry out the analysis of different fruit disease detection techniques.

***Keywords*—**ArtificialNeuralNetworks,Supervisedlearning,TextureFeatureExtraction,FruitDiseases.

I. INTRODUCTION

Artificial Neural Networks (ANN) are very similar to the human brain. The neural networks consist of neurons which are very similar to biological neurons present in the human brain. They are connectionist systems or complex adaptive systems i.e; based on the information flowing through the network it will change the internal structure by adjusting the weights. The neural networks have different types of layers: input layer, hidden layer and output layer as shown in figure1.These layers are connected to each other through a link and each connection is assigned with a weight. The weights contain information about the input signal. The weights can be negative or positive. The negative weights are called inhibitory weights,and the positive weights are called excitory weights. A neuron typically works by applying an activation function on the weighted sum of inputs. The output of a neuron may further activate large number of other neurons. A variety of activation functions are available for both discrete and continuous types of input and output. If a neural network generates an output which is equal to the desired output, no error will be present, so network will not adjust its weights. On the other hand, if the output is not equal to the desired output, error will be present and that error will be fed back to the network, and network adjusts its weights accordingly. An ANN has been used in variety of applications which mainly focus on pattern classification, pattern recognition, and prediction. The major application areas of ANN include medical diagnosis, agricultural expert systems, management decision support system,etc.

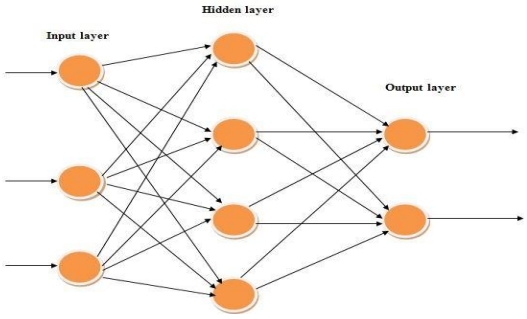

Figure1: Artificial neural network

A. Learning in ANN

The important property of ANN is its capability to learn. In boarder sense, learning can be categorized into two:

a) *Parameter learning:* In this type of learning, the network adjusts its weights.

b) *Structure learning:* In this type of learning, the network structure changes.

There are different types of learning in neural network:

1) ***Supervised learning:*** In supervised learning, the teacher is involved to calculate the error. In this type of learning, the output is already known by the teacher. The network will produce the results by making guesses. The results will either generate an error or will produce accurate output. If error is present, the network will make adjustments accordingly.
2) ***Unsupervised learning****:* This type of learning does not require a teacher. In this method, input vectors of similar type are combined to form clusters. When an input pattern is given to the network, it will produce an output response indicating to which class belongs to. A new class is generated if class cannot be found for an input pattern. There is no feedback mechanism. The network must discover features, patterns itself and assigning output to the given input. This learning is also called self-organizing neural nets.
3) ***Reinforced learning:*** This type of learning is similar to supervised learning. For each input pattern, correct value of target outputs is known. The exact information is not available, only critic information is available. The network also receives some feedback from the environment and this feedback is called reinforced signal and the learning is called reinforced learning.

B. *Steps of Image Processing*

Figure2 shows how image processing is done through different steps:

- *Image Acquisition*

This is the preliminary step of image processing where the image is captured using a digital camera and is stored in any kind of digital media.

- *Image Pre-processing*

This step is used to improve the quality of the image. It includes removing noise, smoothening of image by various filters, conversion of RGB images into grayscale images,etc.

- *Image Segmentation*

To partition the images into various sections.

- *Feature Extraction*

This is used for obtaining the important features of an image like texture, colour, shape, perimeter, etc.

- *Classification*

  This step of image processing is used to organize the data into different categories. It uses the neural network for training and classification of fruit disease.

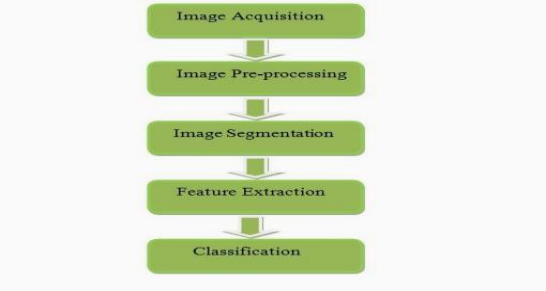

Figure2 Image processing steps

II. BACKGROUND

Various authors have proposed various methodologies for detection of various crop diseases. Different types of neural networks have been used for detection and diagnosis of diseases. Authors have used different algorithms for feature extraction, image segmentation, training and classification of crop diseases. According to Pooja Pawar et.al. (2016) Cucumber is the most cultivated plant and suffers from various diseases. The diseases like downy mildew and powdered mildew affect the foliage of these crops and results in losses in agricultural fields. Downy mildew is a very common disease and is very fast-moving disease. This disease causes leaves to appear as pale-to-bright yellow on the upper surface. Powdered mildew appears as the talc on the upper and the lower surface of the leave. After that the leave will become yellow. GLCM method is used to identify the crop disease. The GLCM is used to determine how pixel values differ from one another. It is a 2-D matrix where number of rows and columns defines the grey scale values. It measures the variation of intensity level at the region of interest. Firstly, the image is captured using a digital camera which will act as an input to the system the images are pre-processed using various filters (if required). Features are extracted by feature extraction step. Texture features are obtained by first order or second order statistical moments. First order statistical moments include: Mean, standard deviation, kurtosis, and skewness and second order statistical moments include contrast, correlation, entropy, inverse difference moment. Contrast defines local variations its value is zero for images of uniform intensity. Correlation defines how pixels are dependent on neighbouring pixels. The entropy measures complexity. Its value will be maximum when all the elements of the co-occurrence matrix are same. Inverse difference moment measures local uniformity of the image. When the images are having a high contrast, its value is low and vice versa. Energy is defined as the pixel pair repetitions. Texture features are input to the system and saved as .cvs file. Classification will be fire blight, downy-mildew, healthy plant. The network used is feed forward network with 28 neurons in the hidden layer. System provides 80.45% accuracy [1].

According to Sandesh Raut et.al. (2017) the old method of plant disease detection is based on visualization by eyes, and this method is very slow and less accurate. Consulting expert is often very intricate and prolonged. It is very important to detect the disease at the early stage automatically. This paper uses MATLAB based system and image processing techniques. Healthy & Unhealthy images are captured by digital camera and stored.SVM & K-means clustering method is used for training and classification. K-means clustering method is used to the images of leaf and fruit. Finally, diseases are recognized by the system. Features are extracted using GLCM method. To train the network, the SVM algorithm is used. In this paper, images of healthy and unhealthy plants are captured using a digital camera, and the images are pre-processed to enhance the quality such as changing size, shape, removing noise, to enhance the contrast or to convert the RGB image into the gray scale image. To classify the objects into different classes (k classes) according to set of features k-means clustering algorithm is used [2].

Bhavini J. Samajpati et.al (2016) detect the disease of apple namely apple scab, apple rot and apple blotch using random forest classifier where the feature level fusion techniques are used to combine texture and the colour features of the images. The Authors have used random forest classifier to classify the diseases. The infected part of the fruit is segmented by k-means clustering algorithm. To extract the colour features, they have used two techniques: Grey colour histogram and colour coherence vector. For texture feature extraction, they have used the local binary pattern, complete local binary pattern, local ternary pattern [3]

According to Sima Kumari et.al (2015) the classification and detection of diseases on any fruit is observed by human eye. If the detection of disease is observed in initial phase of development it will be done through automatic detection. The three common diseases of apple are apple scab, apple blotch and apple rot. There are some others diseases also which can affect the surrounding areas of apple trees including roots, stems,etc. Images of apple fruit were extracted and then pre-processing of image is carried out and the segmentation is done by k-means clustering method to identify the infected part of the fruit and neural network is used for classification. The images were divided into 4 clusters one of the cluster contains the major portion of the diseased part. Data objects were divided into "K" number of classes and the Euclidean distance is used to compute the square of the distance between the data objects and the cluster. The clustering includes various steps: images acquisition, transforming RGB image into l*a*b colour space, using k-means clustering the colours are classified, then the pixels are labelled one by one, and then based on that select the segment that contains diseases. Area, perimeter, colour and roundness are extracted as features. Area is calculated in binary image, colour feature is calculated by reading the images that will be in the form of matrix, using binary and grayscale image roundness is calculated and the shape of the fruit is calculated using equation 1:

$$Shape = 4\pi(area/perimeter) \quad (1)$$

The neural network pattern recognition tool is used,and MATLAB is used for implementation of classification of apple diseases. Accuracy achieved is 85% [4].

According to A. Camargo et.al. (2008) when the plants become diseased many symptoms will start appearing on leaves such as coloured spots, or streaks. As the disease spreads the colour, shape and size changes continuously. Image processing is used. The acquired image is transformed from RGB to H, I3a and I3b.This transformed image is segmented based on the intensity values. The pixels which were not part of the target regions are not taken that is the extracted region,is post processed. The gradient of change between the two neighbouring pixels is analysed. The testing set is composed of 20 images corresponding to five crops, i.e. cotton, maize, banana and plantain, alfalfa and soya. In manual segmentation set, the grid is placed on the image and according to colour schema each box is evaluated. White means 0 value pixels represents the diseased region and black means 1 value of pixel represents the non-diseased region. The image is automatically segmented also the output produced is binary images where 0 represents the diseased region and 1 represents the non-diseased region. Two transformation techniques were used: HSV and I1I2I3.Gaussian filter is used to enhance the quality of image. This filter blurs the image and hence suppresses the high frequency values [5].

Zhang Jian et.al (2010) uses SVM classifier for recognition of cucumber disease. SVM is used for binary classification; they have combined multiple SVM binary classifiers as cucumber disease detection is a multi-class classification problem. Authors have applied various image processing steps to separate the leaf with spots from the background area with the image clipping property, image pre-processing to eliminate noise and finally separated the spot from the leaf using threshold property. The authors have extracted three features namely colour, texture and shape from spot image and saved it in text file. Three diseases of cucumber: downy mildew, brown spot, angular leaf spot are taken into consideration. Authors have carried out two separate tests: First, test is to train the network using each piece of leaf and then use it to identify diseases. The feature vector will detect the disease by using each piece of leaf as a sample. In the second test, they used each spot of leaf as a sample and feature vectors of each spot is different hence a leaf can have multiple feature vectors. If the number of spots of any of the disease A is more than other diseases then the leaf would be recognized as disease A. Three types of kernel functions were used kernel function, polynomial kernel function, Sigmoid kernel function to compare the accuracy [6].

Arti N. Rathod et.al (2014) has used image processing and neural networks for detection of diseases of leaf. In this paper the image is filtered using the median filter to remove the noise and then converted from RGB to CIELAB colour component. In the next step k-medoid method is used for the image segmentation and has obtained texture features using colour co-occurrence matrices developed by spatial grey-level dependence matrices(SGDM). The authors have used the feed forward network with 20 hidden layers and 6 output layers as the authors have taken 5 diseases of leaf and one neuron is for healthy leaf [7].

P. Mohanaiah et.al. (2013) proposed a methodology of how to obtain the statistical texture features by using Grey Level Co-occurrence Matrix(GLCM). It is a matrix where the number of grey levels 'G' is equal to the number of rows and number of columns. The matrix element p (i, j, x, y) is the relative frequency where x and y are the pixel distance having i and j as intensities. The matrix element p (I, j|d,θ) contains second order statistical probability value have 'd' as displacement distance, θ is the orientation and j are the grey levels. Using large number of intensity values means to store large number of data. GLCM'S are very useful to large number of data, and the number of grey levels is often reduced. In table I four different pixel values are used one pixel is used as reference pixel and immediate as neighbouring pixel. The top of the left cell is filled with the number of times (0,0) occurs within the area of an image a pixel with the grey level 0 of the reference pixel and so on [8].

Jobin Francis et.al. (2016) proposed a method to detect the leaf disease in pepper plant by image processing and neural networks. The authors have converted RGB image into HSV colour space. After conversion from RGB to HSV, hue and saturation contains most of the information. Computations from RGB to HSV were carried out per pixel basis.

Table I.: Grey level co-occurrence matrix (GLCM)

value of neighbor pixel→value of ref pixel	0	1	2	3
0	0,0	0,1	0,2	0,3
1	1,0	1,1	1,2	1,3
2	2,0	2,1	2,2	2,3
3	3,0	3,1	3,2	3,3

The image segmentation is done on the basis of the Masking process and threshold. In masking process 1's and 0's were assigned to the unhealthy and healthy regions of the leaf respectively. Green portion of the leaf represents the healthy region. When the intensity of the green pixel is greater than the predefined value its assigned 0 value and after masking these pixels were discarded. In masking process, the diseased portion of leaf is identified using H&S plane value. Another method based on thresholding where a threshold value is chosen and image pixel is divided into several classes and objects are separated from the background. A binary image which is the result of masking is multiplied with the RGB image to obtain the diseased portion. The authors have taken leaf mask and the damaged mask for analysis. The damaged mask is multiplied with the resize RGB image obtained after pre-processing. The leaf mask containing 0's and 1's and the damaged mask containing 1's is multiplied so that diseased portion will come out. The diseased portion is detected using damaged ratio (DR) as mentioned in equation 2:

$$DR = \frac{leaf\ area\ damaged}{total\ area\ of\ leaf} * 100\ \% \qquad (2)$$

Features were extracted using GLCM approach. Feed Forward Back propagation algorithm is used for classification [9].

Sanjeev S Sannakki et.al. (2013) has used neural networks to diagnose and classify grape leaf disease. In the first step, authors have used image acquisition step to acquire images of grape leaf and has removed background by thresholding method. The authors have used Anitropic Diffusion for image pre-processing to preserve the information of affected portion, K-means clustering method of image segmentation. GLCM method to extracted the texture features of the leaf and feed forward backpropagation network for classification [10].

Sachin D. Khirade et.al. (2015) detects disease of leaf using image processing and neural networks. The authors have acquired images of leaf and converted RGB image into grey images and have used image clipping technique to get the region of interest. The authors have used image smoothing filter for increasing contrast. To boost the plant disease images, the histogram equalization which distributes the intensities of the images is applied on the image. The cumulative distribution function is used to distribute intensity values. The segmentation can be made using various methods like k-means clustering, Otsu method, converting RGB image into HSI model transformation. The boundary detection and spot detection are used to find infected part. They suggested that many features can be extracted for identification of an object like colour, texture and morphology. Colour co-occurrence Method can be used extract colour and texture features. SOFM with back propagation neural network can be implemented to distinguish colours of disease leaf. The back-propagation algorithm modified SOM, and Multiclass Support vector machines can be used for classification. Back propagation neural network can also be used for classification [11].

Mr.Patil.S.P et.al. (2015) has proposed a methodology to detect disease of grape leaf using image processing techniques. For the analysis of leaf images are acquired by digital camera and the image database has been created for

better efficiency. The acquired image is converted into RGB format. The RGB images of the leaf are converted into HSV image format. The pre-processing steps include: filtering, normalization, segmentation & object identification. In this paper only colour, texture, shape features are used and Back propagation neural networks architecture is chosen [12].

Abdul Kadir et.al. (2011) have extracted many features like colour, vein, shape, & texture features for leaf classification. Two kinds of shape features that were used in identification system are geometric features and polar Fourier-transform (PFT). Geometric features that were used are slimness and roundness and are calculated by equations 3&4 shown below:

$$Slimness = width of leaf / length of leaf \quad (3)$$

$$Roundness = \frac{4\pi(area\ of\ leaf)}{perimeter\ of\ leaf} \quad (4)$$

Dispersion or aspect ratio is used when object (leaf) has irregular shape. Polar Fourier transform (PFT) is used to capture shape of the leaf. Vein features were extracted using morphological opening. It's performed on grayscale image. The authors have used mean, standard deviation, skewness, kurtosis for colour feature extraction. Probabilistic neural networks (radial basis function) is used as a classifier and 93.75% accuracy is achieved [13].

A.Meunkaewjinda et.al. (2008), detect the disease of grape plant. For analysis, back propagation neural network and self-organizing feature map together were used to recognize colours of grape leaf. The authors have used Modified self-organizing feature map and genetic algorithm for segmentation. For classification, support vector machine is used. For pre-processing, Gabor wavelet filter is used after segmentation. SVM is again applied after segmentation [14].

Danyang Cao et.al. (2010) have developed improved k-medoids clustering algorithm. In this paper CF-tree to preserve all the data and have used k-medoids method to cluster the clustering feature (CF) in the leaf nodes of CF-Tree. From the root of the CF-tree k clusters have been obtained. They have improved k-medoids algorithm to enhance the quality and scalability of clustering [15].

N.Valliammal et.al (2011) have acquired images of leaf samples in the forest and have converted the RGB images into grey level images for uniform distribution of colours. They have used image smoothing to enhance the quality of the image. The threshold technique is used to obtain binary image from the grayscale image. The binary image is traced to produce contour of the image by border tracing algorithm as shown in figure 3:

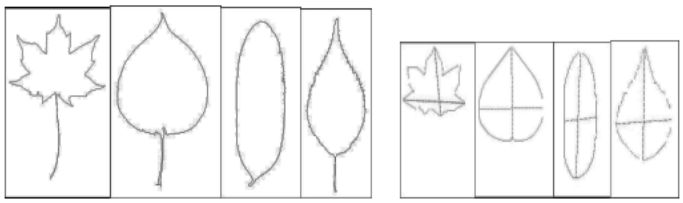

figure 3: border tracing

Preferential Image Segmentation (PIS) is used as a segmentation method but the drawback of PIS is it often neglects to provide boundaries. Features of the images were compared. Euclidean distance is used to compare the feature vectors [16].

A.H. Kulkarni et.al (2013) have proposed a Leaf Recognition Technique for Plant Classification. The authors have used Radial basis probabilistic neural network (RBPNN) as a classifier. Many features have been extracted like shape features, mean of colours, skewness of colours, texture features, standard deviation of colours, vein features. For improving performance an (GLCM) and colour transformation technique is used. GLCM is used to extract texture features and is given to the neural network. Four diseases of the pomegranate are taken into account. These diseases are detected and diagnosed. Feed forward backpropagation network is used as a classifier. Accuracy achieved is 90% [17].

Mrunmayee Dhakate et.al (2015) have proposed a methodology to diagnose pomegranate disease using neural network. Image processing techniques such as grey level co-occurrence matrix approach achieves similar classification accuracy of the human experts [18].

S. R. Deokara et.al. (2013) have proposed leaf recognition system for identifying the leaf image. The feature point extraction and the artificial neural network were used to develop leaf recognition system. Feed forward neural networks were used for classification of the leaf. Two feature point extraction methods were implemented that is 28 feature extractions and 60 feature extractions. Comparison is done and it is concluded that 28 feature extraction provides better result than 60. The performance analysis is carried out on the basis of three comparisons: For 28 feature point extraction the identification rate on obtained different data set is better than 60 feature point extraction, the time require for 28 feature point extraction and training is comparatively less than that of 60 feature point. From this the 28-feature point extraction method is very efficient technique for proposed leaf recognition system [19].

Nivedita.R.Kakade et.al. (2015) have proposed a system for detecting the grape leaf disease. The proposed system consists of five steps, in the first step RGB image is acquired and is converted into color transformation structure then structure is converted into (Hue, Intensity and saturation)

HIS image using threshold value, then the image is segmented using segmentation process and the useful segments are extracted. The Five texture features have been extracted are Energy, homogeneity, contrast, cluster prominence and cluster shade from the leaves by Spatial Gray-level Dependence Matrices (SGDM). Finally, the texture statistics is calculated disease on the plant [20].

Neethu K.S, P .Vijay ganesh et.al.(2017) have proposed a methodology of automatically detecting leaf disease and provides necessary fertilizer for that disease. The authors have used two diseases of lemon and mango leaves-means clustering algorithm is used. The artificial neural network is used for classification [21].

A.H. Kulkarni et.al (2013) have proposed a Leaf Recognition Technique for Plant Classification. The authors have used the Radial basis probabilistic neural network (RBPNN) as a classifier. Many features have been extracted like shape features, mean, skewness, texture features, standard deviation, vein features. For improving performance an additional feature called Zernike moments has been added [22].

Table II: A Summary of Pattern Classifiers for Crop Disease Detection

AUTHOR	YEAR	NETWORK	PERFORMANCE	DISEASE-TYPE
PoojaPawar,VarshaTurkar,PravinPatil [1]	2016	Feed Forward Back-Propagation Network	Accuracy= 80.4%	Cucumber Disease
Sandesh Raut,Amit Fulsunge [2]	2017	k-means clustering; multisvm algorithm	-	
BhaviniJ Samajpati, SheshangD Degadwala [3]	2016	K-Means clustering, Random forest classifier	-	Apple Disease
Mienda,Bashir Sajo Yahya,AdibahGaladima,IbrahimAShamsir,Mohd Shahir [4]	2015	K-Means algorithm, SURF algorithm	Accuracy=85%	Apple Disease
A.Camargo,J. S.Smith [5]	2009	Distribution of intensities in a histogram	-	Banana Disease
Zhang Jian, Zhang Wei [6]	2010	RBFfunction and sigmoid kernel function;SVM	SVM Based on RBF kernel made the best performance	Cucumber Disease
ArtiN Rathod, Bhavesh A Tanawala, Vatsal Shah [7]	2014	CIELABcolormodel;ColorCooccurrence Method;SGDMMatrix;kmedoids;Feedforward network	accuracy= 96%	Early scorch, cottony mold, late scorch, brownspot,bacterial-fungal.
PMohanaiah,PSathyanaray,LGurukumar [8]	2013	GLCM method is used for feature extraction.	-	
Jobin Francis, Anto Sahaya Dhas D Professor, Anoop B K [9]	2016	Feed Forward Back Propagation network.	-	Pepper plants
Sanjeev S Sannakki, VijayS Rajpurohit, VBNargund, Pallavi Kulkarni [10].	2013	Feed Forward Back Propagation network.	---	Grape leaf Disease
Sachin D.khirade AB.patil [11].	2015	Back propagation network, modified SOM, multiclass support vector machine.	---	---

Mr.Patil.S.PMr.Kumbhar.V.P Mr.Yadav.D.R Ms.Ukirade.N.S[12].	2015	Back propagation network	---	Grape leaf Disease
Abdul Kadir, Lukito Edi Nugroho,AdhiSusanto,Paulus Insap Santosa [13].	2011	Probabilistic neural network.	93.75%	---
A.Meukaewjinda v.[14]	2008	Support Vector Machine	---	Cotton Disease
Danyang Cao, Bingru Yang [15].	2010	Algorithm is based on the clustering features of BIRCH algorithm; cf-tree; kmedoids	---	---
N.Valliammal,Dr.S.N.Geethalakshmi [16].	2011	Preferential Image Segmentation(PIS)	---	---
MrunmayeeDhakate ; Ingole A. B [17].	2015	Back propagation network	90%	pomegranate disease
Min Zhang Qinggang Meng [18].	2010	Local LBPH to extract local features. Adaboost classifier	---	Citrus canker
S. R. Deokar ; P. H. Zope; S.R.Suralkar [19].	2013	Multi-layer feed forward artificial neural network; nonlinear differentiable sigmoid function.	90%	---
Nivedita.R.Kakade; Dnyaneswar.D.Ahire [20].	2015	Support vector machine (SVM) classifier.	89.5%	Grapes leaf disease
K. S. Neethu, P. Vijay[21].	2017	K-means clustering, ANN training classifier,	- --	Mango & Lemon leaves
A.H.Kulkarni1, Dr.H.M.Rai2,Dr.K.A.Jahagirdar,P.S.Uppa ramani[22].	2013	Radial basis probabilistic neural network	93.82%	Flavia data set

III. COMPARATIVE ANALYSIS

The Table -II summarizes the use of different pattern classifiers for various applications in the leaf diagnosis. The application of pattern classifier broadly shows the pattern classifiers used for various disease detections. The TABLE-II highlights that most of the fruit disease has been diagnosed by using random forest classifier, SURF algorithm for pattern classification. Furthermore, most of the techniques are based on the parameters like color, texture, size and shape of the leaf of a tree or a plant. The major focus of the research has been restricted to cucumber disease, cotton, sugarcane, etc. Bhavini et.al. have developed k-means clustering and random forest classifier where authors have not computed the diagnostic accuracy of the system furthermore, another structure proposed by Meinanda et.al (2015) for apple disease diagnosis where performance is 85% which is comparatively low.

IV. CONCLUSION

Productivity of a crop cultivated by farmers is mainly dependent on the type of diseases that may be accurately predicted. The paper highlighted that computing techniques may help in early detection of some of the plant diseases by using leaves texture, shape, and size. This may be efficiently achieved by using image feature extraction and pattern classifier. Furthermore, a crop disease detection system may be developed for apple diseases like apple scab and Alternaria leaf blight. The quality of these prediction systems may be further improved by using hybrid pattern classification techniques.

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