Priyanka Thakur et al. International Journal of Recent Research Aspects ISSN: 2349-7688, Vol. 4, Issue 3, Sept 2017, pp. 22-27

Plant Disease Detection and Classification using Image Processing: A Review

Priyanka Thakur*[1], Preeti Aggarwal[2], Mamta Juneja[3]

UIET, CSE Department, Panjab University, Chandigarh, India

tpriya1278@gmail.com[1], pree_agg@pu.ac.in[2], mamtajuneja@pu.ac.in[3]

Abstract- **Diseases in plants lead to crop losses of up to 30% each year, thus causing significant losses to farmers and threatening the global food security. Hence, it is very important that plant diseases are detected in their earlier stages only. Till now various methods have been developed to detect the diseases in plants but the algorithms using image processing techniques are providing good accuracy. Initially on the basis of input images provided by the farmers, the agricultural scientists approximate the damage in plant (leaf, stem) caused by any disease and further using various image processing techniques they detect and classify the disease. These results help and guide the farmers to protect their crops. This paper provides a review and comparison of the different image processing methods used for detecting and classifying plant diseases based on the features extracted i.e. color, texture, shape and hybrid features. These features are helpful in differentiating the type of plant disease based on the infected region. Plant diseases can be classified in many ways but in this paper the major consideration is on those diseases which are caused by pathogens i.e. fungal, bacterial or viral diseases.**

Keywords— Feature extraction, Image processing, Pathogens, Plant diseases, Color Co-occurrence Method (CCM)

I. INTRODUCTION

In the recent times, the balance between the growing food demand of the world population and the global agricultural output is alarming [1]. The Global food crisis 2008 is such an example. History also shows that how the economies of some nations were damaged by the severity of some plant diseases. Two such instances are Irish potato famine and Chestnut blight. Irish potato famine [2] occurred in 1845-1847 in Ireland. Because of huge dependency of Ireland's population on potato as the base food when the late blight disease hit the potato crop approximately 1.5 million people died from starvation and many people were forced to migrate to other parts of the world. Chestnut blight is a fungal infection which affected the American chestnut tree in the early 1900s and had a devastating effect on the economy and society of the Eastern United States. It later spread to other parts of the world also such as Italy and killed approximately 4 billion trees. Apart from these there are several other recurrent plant diseases like Rice blast, Citrus canker, Wheat blast, etc. that cause huge crop losses often in many parts of the world. The direct yield losses due to plant diseases range between 20-40% of the global agricultural productivity. Therefore, the protection of crops against plant diseases is becoming important day by day. The agricultural sector in India too accounts for the largest share of workforce which is around 60-70%. But still the procedure used by farmers for detecting plant disease in many parts of India and other developing countries is through naked eye observation. Therefore, we need a rapid, cost effective and reliable method for plant disease detection.

Diseases in plants are caused either by Biotic factors i.e. those caused by living components (such as pathogens and parasitic plants) or Abiotic factors (such as nutritional deficiencies, extreme weather conditions, etc.). It is illustrated in Fig. 1.

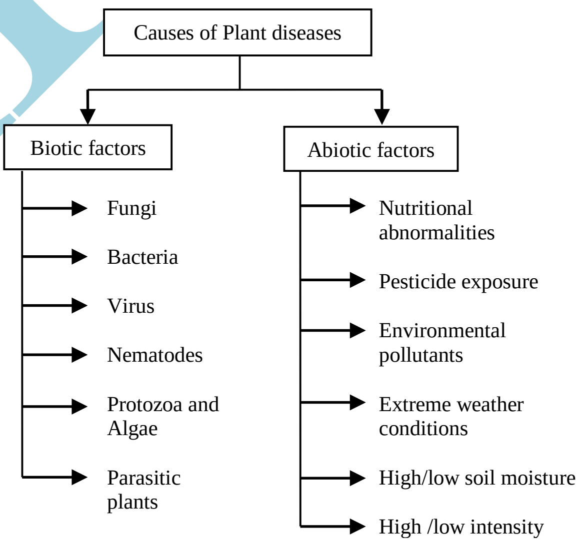

Fig. 1: Causes of Plant diseases

Biotic factors

Fungi are the largest group of pathogen which reproduce both sexually as well as asexually by the production of spores and other structures. Majority of the plant diseases, around 8,000, are caused by fungi. Fungal diseases can be controlled by using fungicides and other agricultural practices. Examples are Powdery mildew, Fusarium wilt, Anthracnose, Rust, etc. *Bacteria* mostly do not cause any harm to the plant itself. Only a small number of them, around 100 known species, can cause the disease, that too when they get some favorable environment which helps them to multiply quickly like high humidity, poor soil health, nutrients imbalance, etc. Bacterial diseases are mostly found in tropical and subtropical regions of the world. For e.g. Black rot, Bacterial leaf spot, Bacterial blight, Bacterial brown spot, etc. *Virus* often reproduces by taking over host reproductive machinery and spread slowly throughout the infected plant. They are generally transmitted from infected to healthy plant by a vector, but mechanical and seed transmissions also occur. The most important means of spread is by insect transmission. For e.g. Tobacco mosaic virus (TMV), Cucumber mosaic virus, Yellow dwarf virus, etc. *Nematodes* are small wormlike animals that mostly feed on the underground parts of the plant (roots, tubers, etc.) thus causing lesions or root knots. For e.g. Root knot nematodes, Stubby root nematode. *Protozoa* are single celled organisms that are transmitted as zoospores which are able to survive in the soil for many years e.g. Phytomonas. There are some colorless parasitic algae also which cause plant diseases e.g. Cephaleuros. *Parasitic plants* are those plants which fulfill their nutritional value from another living plant e.g. Dodder.

Abiotic factors

Nutritional abnormalities often show up as discoloration of leaves of the plant. It is classified as Nutrient deficiency and Mineral toxicity. Plants require some major elements (Nitrogen, Phosphorus, Magnesium, etc.) and minor elements (iron, copper, zinc) for their normal growth. Deficiency of any of these results in disease symptoms in the plant e.g. Nitrogen deficiency results in leaves becoming light green in color and small in size, lower leaves lighter in color than upper ones. Excessive quantity of mineral in the soil can lead to mineral toxicity in the plant which happens because of providing excessive fertilizers to the soil. *Pesticide exposure* caused by improper usage of pesticide can cause serious damage to the plant e.g. Glyphose (Roundup) damage to fruit trees. *Environmental pollutants* like sulphur dioxide, nitrogen dioxide when released from factories, power plants and automobiles, accumulate in the atmosphere and cause damage to the plants. It can be seen in form of spots and bleaching of young leaves. *Extreme weather conditions* can also cause plant injury such as frost or freeze can damage the sensitive parts of plant like buds, flowers, young fruits. Similarly high temperature can also cause damage to plant tissues. *High moisture* due to excessive watering and flooding can cause stunted growth in the plant and turn them yellowish. On the other hand, *low moisture* or drought like conditions can lead to the death of the plant. *High or low intensity* is not a big problem but indoor plants can be harmed by low light conditions which can result in yellowing of tissues.

In the field of plant pathology, a lot of research has been done but on the basis of literature surveyed it has been found that most of the diseases in plants originate from pathogens i.e. bacteria, fungi, virus etc. [3]. So this paper reviews the research work done in this field in terms of plant disease detection and classification (caused by pathogens only) using different image processing techniques that recognize the crop disease from its image based on the various color, texture, and other features extracted.

II. Literature Review

A plant on becoming diseased, displays a variety of symptoms on its leaf, stem and seeds such as stripe or some spots. These visual symptoms vary according to the disease in terms of color, shape, size, texture, etc. the following review is classified on the basis of various features extracted during the plant disease detection.

Color feature extraction

Color is an important feature as it does not change in terms of translation, scaling or rotation of an image. There are various color spaces available such as CIELab, HSV, RGB, etc. Out of these, RGB is good for color generation whereas HSV is good for color perception [4]. When used in segmentation, they have their own advantages and disadvantages [5].

Camargo and Smith [6] proposed an algorithm based on image processing which automatically identified the diseased region in the plant by analyzing its colored image. First the image was pre-processed to identify the color transformation which was best highlighted in the diseased region. The results indicated that H, I3a and I3b color transformations gave better results. Gaussian filter was further applied to highlight the target regions followed by Histogram of Intensities segmentation method to differentiate the target region from the background. At the end image post-processing removed the unwanted background region. The algorithm's strength is that it can correctly identify the diseased portion in the plant images having wide range of intensities distribution.

Barbedo et al. [7] proposed a method of identifying plant diseases, covering 12 different plant species, using color histograms, color transformations and a pair wise-based classification system. A confusion matrix was built for presenting the results for each plant which told about the accuracy of the algorithm in the main diagonal and revealed the disease having higher degree of similarity which increased the error rates. Advantage of this algorithm is its simplicity both in terms of implementation and computational complexity. The comparative analysis of algorithms described above is shown in Table 1.

Table 1: Plant disease detection algorithms based on color features

Author	Dataset size (plant images)	Color features extracted	Classifier used	Parameters used	Results
Camargo and Smith [6]	20 images (of 5 crops)	H, S, V and I1, I2, I3 components	-	Matching, Misclassification	70.6% (for H), 17.4% (for H)
Barbedo et al. [7]	1335 images (of 12 plant species)	Color Histograms	-	Accuracy	58%

Texture feature extraction

Arivazhagan et al. [8] proposed a method for detecting and classifying plant leaf diseases using texture features. The proposed algorithm was tested on ten species of plants. The acquired RGB leaf images were first converted into Hue-Saturation-Intensity (HSI) format. The green pixels were masked and removed using a particular threshold value followed by segmentation process. The texture analysis method called Color Co-occurrence Method (CCM) was used to obtain a set of texture features like contrast, energy, cluster shade, etc. from the infected leaf region. With these set of features, using Minimum distance criterion and SVM classifier, classification of the disease was done which resulted that SVM has a better accuracy.

Pujari et al. [9] used Local Binary Pattern (LBP) to classify fungal diseases from vegetable crop leaves. Vegetable crops like beans, sunflower, tomato, chickpea and soybean affected by fungal disease were considered in this paper. In order to segment the foreground from background in the image Chan-vase segmentation method was used. LBP, one of the best performing texture descriptors [10], was extracted from the diseased leaves and used as input to the classifiers Artificial Neural Network (ANN) and Neuro k-NN. Feature reduction was done with the combination of LBP and Principal Component Analysis (PCA) and the results show that out of ANN and Neuro k-NN, the latter gave better classification accuracy.

Mokhtar et al. [11] utilized Gabor wavelet transform technique to draw out texture features from the leaves of diseased tomato crop and then using various kernel functions of SVM classifier, the classification accuracy was evaluated. The stepwise proposed methodology is that firstly the dataset was constructed using the sample images of tomato leaves infected with two types of diseases namely Powdery mildew and Early blight. Second, pre-processing was done to enhance the smoothness and remove any noise from the images. It included leaf image isolation, image resizing and background removing. Third, 402 texture-based features were extracted and presented in a database as vector values. Gabor transform was used to describe the textural pattern of diseased tomato leaves. Lastly, classification was done using SVM classifier to identify the category of disease that infected the tomato leaves. The main feature of this paper is that SVM was trained and tested using the different kernel functions like Cauchy kernel, Invmult Kernel and Laplacian Kernel. Table 2 shows the comparative analysis of the algorithms described above.

Table 2: Plant disease detection algorithms based on texture features

Author	Dataset size (plant images)	Texture features extracted	Classifier used	Parameters used	Results
Arivazhagan et al. [8]	500 images (of 30 plant species)	Energy, Cluster shade, Contrast, etc.	Minimum distance criterion, SVM classifier	Detection Accuracy	86.77% (using Minimum distance criterion), 94% (using SVM classifier)
Pujari et al. [9]	990 images	LBP features	ANN, Neuro-kNN classifier	Average classification accuracy, Average computation time	84.11% (using ANN), 91.54% (using Neuro-kNN classifier), Neuro-kNN is 13% faster than ANN classifier
Mokhtar et al. [11]	200 images	402 texture-based features were extracted using Gabor wavelet transform	SVM classifier	Accuracy	100% (using Cauchy kernel function), 98% (using Laplacian Kernel function), 78% (using Invmult kernel function), 99.5% (overall)

Shape feature extraction

Fadzil et al. [12] suggested a method for classification of two different classes of orchid leaf diseases i.e. sun scorch and black leaf spot. The pre-processing step involved intensity adjustment, histogram equalization and filtering methods such as Gaussian, disc and median filter. Further the border segmentation was applied which involved three morphological operations i.e. opening, closing and filled holes. Finally the classification of orchid leaf disease was done by calculating the number of white pixels in the segmented region. The disadvantage of this method is that it can only distinguish between these two types of orchid leaf diseases only. For classification of other diseases some new segmentation technique has to be developed.

Dandawate and Kokare [13] used a new technique called Scale Invariant Feature Transform (SIFT) in their proposed algorithm which extracts the shape features from the diseased soybean plants and help in its disease detection. Further they used the SVM classifier to distinguish between the healthy and diseased soybean leaves. The stepwise process used is that first the acquired images were resized to a fixed size to reduce time consumption. In the pre-processing step, RGB images were converted into HSV and a multi thresholding method known as Otsu threshold was applied on the HSV images. Then two techniques were used for segmentation i.e. color based background subtraction and cluster based background subtraction. In color based background subtraction, the intensity values of R, G and B components were used for removing the unwanted background. As green colored pixels represent the healthy part of the leaf, these pixels were preserved and the other pixels were made black. To get more accurate background subtraction, cluster based segmentation was used where the largest connected component (i.e. the leaf) was preserved and the other unwanted components were removed. For shape analysis of the leaves, SIFT technique was used which finds out feature points from the input image known as keypoints for feature matching purpose. It matches the keypoints of the reference image with that of the test image and calculates the matching value to find out the similarity between the two images. The features extracted in this algorithm for classification are correlation and keypoints which were obtained using SIFT technique. Finally classification was done using SVM classifier which classified the soybean leaves as healthy or unhealthy. The comparative analysis between the algorithms described above is shown in Table 3.

Table 3: Plant disease detection algorithms based on shape features

Author	Dataset size (plant images)	Shape features extracted	Classifier used	Parameters used	Results
Fadzil et al. [12]	44 images	Shape features were extracted using border segmentation techniques	-	Accuracy	81.8182% (for black leaf spot disease), 90.9091% (for sun scorch disease)
Dandawate & Kokare [13]	120 images	Correlation and Key points obtained using SIFT	SVM classifier	Average accuracy	93.79%

Hybrid feature extraction

Many researchers used a combination of features also to detect and classify the plant diseases. Camargo and Smith [14] considered 117 images of cotton crop having diseased regions in different parts of the crop i.e. leaf, fruit and stem, of a particular disease. They drew a cluster of features such as shape, fractal dimension, texture etc. from the diseased cotton crop. Co-occurrence matrix was used to draw texture features from the image like inertia, homogeneity, correlation, etc. To calculate fractal dimension and lacunarity, box counting algorithm and gliding box algorithm were used respectively. To overcome the problems of nonlinearity and multiple classes' classification, SVM classifier used the Radial Basis Function (RBF) kernel and the one-against-one method respectively. SVM classifier has become popular due to its effectiveness in real classification problems [15], [16]. With this approach it was found that features composing the group texture achieved the highest classification rate and features composing the group shape achieved the lowest rate. Results showed that texture features can be good differentiators when the input images lack proper color or shape domain pattern and machine learning systems can be used to identify the visual symptoms of plant diseases.

Dubey and Jalal [17] used color features such as Global Color Histogram (GCH), Color Coherence Vector (CCV) and texture features such as LBP, Complete Local Binary Pattern (CLBP) to detect and classify apple fruit diseases. For segmentation, k-means clustering method was used where the input image was partitioned into four clusters. Then some color and texture features were extracted for apple disease classification as mentioned before. Finally classification was done using Multi-class Support Vector Machine (MSVM) classifier. All the features extracted were tested in both RGB and HSV color spaces. Results showed that GCH did not perform well and had lowest accuracy in both the color spaces because GCH feature has only color information and does not consider neighboring information. Also LBP and CLBP features gave better results than GCH and CCV features. It was also observed that each feature performed better in HSV color space as compared to RGB color space. Apart from this paper maximum work done for defect segmentation in apples is through simple threshold method [18], [19].

Pujari et al. [20] classified the symptoms of fungal disease on cereal crops like maize, wheat and jowar using SVM and ANN classifiers. Here color and texture features were extracted from the diseased portions using CCM. The fungal affected symptoms considered here are leaf blight, powdery mildew, leaf spot, smut and leaf rust. The stepwise methodology is that after image acquisition, pre-processing of image was done using shade correction, removing artifacts and formatting. To segment the visual symptoms of a fungal disease, k-means segmentation method was used. For feature extraction, CCM method was used where some of the texture features extracted were energy, homogeneity, entropy, correlation and contrast. In the end, classification was done using SVM and ANN classifiers where results showed that SVM achieved better classification accuracy as well as speedup than ANN. Some of the features extracted in this paper using GLCM are given in Eq. 1-4.

$$\text{Contrast} = \sum_{i,j=0}^{k-1} M_{ij}(i-j)^2 \quad \text{(Eq. 1)}$$

$$\text{Energy} = \sum_{i,j=0}^{k-1} (M_{ij})^2 \quad \text{(Eq. 2)}$$

$$\text{Homogeneity} = \sum_{i,j=0}^{k-1} \frac{M_{ij}}{1+(i-j)^2} \quad \text{(Eq. 3)}$$

$$\text{Correlation} = \sum_{i,j=0}^{k-1} M_{ij} \frac{(i-\mu)(j-\mu)}{\sigma^2} \quad \text{(Eq. 4)}$$

Where,

M_{ij}= Element i, j in the image

k = No. of gray levels

μ = mean value of all the pixels that were used in GLCM, its formula is:

$$\mu = \sum_{i,j=0}^{k-1} iM_{ij}$$

σ^2 = variance of intensities of all pixels referred is calculated as:

$$\sigma^2 = \sum_{i,j=0}^{k-1} M_{ij}(i-\mu)^2$$

Pujari et al. [21] suggested a method for detecting and classifying five plant diseases like bacteria, fungi, virus, deficiency diseases and nematodes which affect the agricultural crops, using a combination of color and texture features. Pre-processing of image included shade correction, removing artifacts, and formatting. For removing the artifacts like dust particles, dew drops etc., median filter and imfilter were used. For color feature extraction, RGB and HSI color components were used for features like range, mean, variance and standard deviation. Further color feature reduction was done based on threshold and delta value i.e. any feature value below threshold was discarded. CCM method was used for texture feature extraction. RGB components were used for extracting GLCM texture features like entropy, homogeneity, correlation, etc. Texture feature reduction was also done based on threshold and delta value. Finally classification was done using the SVM and ANN classifiers. Further a comparison was also done between the two classifiers from which it was evident that SVM classifier gave better classification accuracy than ANN. Main advantage of this approach is that less number of features were utilized to achieve better classification accuracy and to lessen the computation time. The comparative analysis of the algorithms described above is shown in Table 4.

Table 4: Plant disease detection algorithms based on hybrid features

Author	Dataset size(plant images)	Features extracted	Classifier used	Parameters used	Results
Camargo & Smith [14]	117 images	53 features extracted grouped as: Fractal dimension, Grey levels, Fourier descriptor, Texture, Shape, etc.	SVM classifier	Classification accuracy	83% (group texture), 55% (group shape), 90% (for all 53 features), 93.1% (for 45 features selected from 53)
Dubey & Jalal [17]	431 images	Color features: Global Color Histogram, CCV Texture features:- LBP, Complete LBP	Multi-class SVM classifier	Classification accuracy	93%
Pujari et al. [20]	750 images	Color(H, S, I) and 13 texture features were extracted using CCM	SVM classifier, ANN classifier	Classification accuracy, Average Computation time	between 68.5% and 87%(using ANN classifier),between 77.5% and 91.16% (using SVM classifier); SVM is 9% faster than ANN classifier
Pujari et al. [21]	900 images	24 Color features (mean, variance, range and standard deviation each for R, G, B and H, S, I components); 30 GLCM texture features	SVM classifier, ANN classifier	Precision, F-measure, Recall, False positive rate(FPR), True positive rate (TPR), Average classification accuracy (ACA) (%)	0.976 (using SVM), 0.823 (using ANN); 0.945 (using SVM), 0.834 (using ANN); 0.921 (using SVM), 0.847 (using ANN); 0.917 (using SVM), 0.953 (using ANN); 0.931 (using SVM), 0.847 (using ANN); 92.17 (using SVM), 87.48 (using ANN);

III. CONCLUSION AND FUTURE SCOPE

This paper provided a review of various plant disease detection and classification algorithms and was categorized on the basis of the types of features extracted to detect those diseases which can be color, texture, shape, or a combination of any of these features. Out of all the algorithms reviewed in this paper, highest accuracy obtained is 99.5% using texture features which indicate that texture features probably give better accuracy in plant disease detection and classification. The algorithm yielding best results in the hybrid or combinational feature extraction category has an accuracy of 93%. Also the results signify that SVM classifier is a better classifier for plant disease detection and classification. Future work can be done to improve the accuracy rate by increasing the dataset size and training samples to improve the disease identification rate. Also various neural network architectures like Fuzzy logic, etc. can be used in the classification step, which have not been explored so far. More categories of plant diseases can also be included and further tested. Integrating the image based algorithms with some expert system can make it more efficient and help the farmers to take necessary steps to protect their crops at an early stage.

REFERENCES

[1] S. Savary, A. Ficke, J. N. Aubertot and C. Hollier, "Crop losses due to diseases and their implications for global food production losses and food security", Food Secur., vol. 4, no. 4, pp. 519-537, 2012.

[2] J. B. Ristaino, "Tracking the evolutionary history of the potato late blight pathogen with historical collections", Outlooks on pest management, vol. 17, pp. 228-231, 2006.

[3] J. D. Pujari, R. Yakkundimath and A. S. Byadgi, "Automatic Fungal Disease Detection based on Wavelet Feature Extraction and PCA Analysis in Commercial Crops", International Journal of Image, Graphics and Signal Processing, vol. 6, no. 1, pp. 24-31, 2014.

[4] S. B. Dhaygude and N. P. Kumbhar, "Agricultural plant leaf disease detection using image processing", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 2, no. 1, pp. 599-602, 2013.

[5] L. Lucchese and S. K. Mitra, "Color Image Segmentation : A State-of-the-Art Survey", Proceedings of the Indian National Science Academy, INSA-A, vol. 67, no. 2, pp. 207-221, 2001.

[6] A. Camargo and J. S. Smith, "An image-processing based algorithm to automatically identify plant disease visual symptoms", Biosyst. Eng., vol. 102, no. 1, pp. 9-21, 2009.

[7] J. G. A. Barbedo, L. V. Koenigkan and T. T. Santos, "Identifying multiple plant diseases using digital image processing", Biosyst. Eng., vol. 147, pp. 104-116, 2016.

[8] S. Arivazhagan, R. N. Shebiah, S. Ananthi and S. Vishnu Varthini, "Detection of unhealthy region of plant leaves and classification of plant leaf diseases using texture features", Agric. Eng. Int. CIGR J., vol. 15, no. 1, pp. 211-217, 2013.

[9] J. D. Pujari, R. Yakkundimath and A. S. Byadgi, "Neuro-kNN classification system for detecting fungal disease on vegetable crops using local binary patterns", Agric. Eng. Int. CIGR J., vol. 16, no. 4, pp. 299-308, 2014.

[10] T. Ojala, M. Pietikainen and T. Maenpaa, "Multiresolution gray-scale and rotation invariant texture classification with local binary patterns", IEEE Transactions on pattern analysis and machine intelligence, vol. 24, no. 7, pp. 971-987, 2002.

[11] U. Mokhtar, M. A. S. Alit, A. E. Hassenian and H. Hefny, "Tomato leaves diseases detection approach based on support vector machines", 11th Int. Comput. Eng. Conf., pp. 246-250, 2015.

[12] W. N. W. M. Fadzil, M. S. B. S. Rizam, R. Jailani and M. T. Nooritawati, "Orchid leaf disease detection using border

segmentation techniques", Proc. - IEEE Conf. Syst. Process Control. ICSPC, pp. 168-173, 2014.

[13] Y. Dandawate and R. Kokare, "An automated approach for classification of plant diseases towards development of futuristic Decision Support System in Indian perspective", Int. Conf. Adv. Comput. Commun. Informatics, ICACCI, pp. 794-799, 2015.

[14] A. Camargo and J. S. Smith, "Image pattern classification for the identification of disease causing agents in plants", Comput. Electron. Agric., vol. 66, no. 2, pp. 121-125, 2009.

[15] G. Cherian et al., "Application of support vector machines for automatic compliance monitoring of the conservation reserve program (CRP) tracts", Proceedings - IEEE International Geoscience and Remote Sensing Symposium, IGARSS, vol. 1, 2004.

[16] M. A. Hearst et al., "Support vector machines", IEEE Intelligent Systems and their Applications, vol. 13, no. 4, pp. 18-28, 1998.

[17] S. R. Dubey and A. S. Jalal, "Detection and Classification of Apple Fruit Diseases Using Complete Local Binary Patterns", Third Int. Conf. Comput. Commun. Technol., pp. 346-351, 2012.

[18] Q. Li et al., "Computer vision based system for apple surface defect detection", Computers and electronics in agriculture, vol. 36, no. 2, pp. 215-223, 2002.

[19] P. M. Mehl et al., "Detection of defects on selected apple cultivars using hyperspectral and multispectral image analysis", Applied engineering in agriculture, vol. 18, no. 2, pp. 219, 2002.

[20] J. D. Pujari, R. Yakkundimath and A. S. Byadgi, "Classification of Fungal Disease Symptoms affected on Cereals using Color Texture Features", International Journal of Signal Processing, Image Processing and Pattern Recognition, vol. 6, no. 6, pp. 321-30, 2013.

[21] J. D. Pujari, R. Yakkundimath and A. S. Byadgi, "SVM and ANN Based Classification of Plant Diseases Using Feature Reduction Technique", Int. J. Interact. Multimed. Artif. Intell., vol. 3, no. 7, pp. 6, 2016.