Detection and Classification of Disease Affected Region of Plant Leaves using Image Processing Technique

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Abstract

Objective: There is the existence of a variety of plants on this earth surface that plays enormous role in human life. But various factors are there that can destroy plant growth like weather conditions, non-availability of accurate resources, plant diseases and lack of expert knowledge to care plants. Statistical Analysis: Plant diseases are one of the major factors responsible for the reduction of plant growth. In the ancient years, it was not easy to detect the plant diseases on time. But in this computing era, digital image processing rapidly developed that it can be used for various real life applications. Findings: In this research work, plant leaf diseases are detected and classified using the image processing techniques. The fundamental steps of image processing and leaf disease detection and final optimization are used in this work. Here, image acquisition is performed by considering RGB colour based disease affected leaf image. Image contrast is enhanced using Histogram Equalization. Image segmentation is performed with K means clustering. Image feature extraction is performed to extract the features of leaf disease symptoms by maintaining Grey Level Occurrence Matrices. Support Vector Machine is used for the leaf disease detection & classification and finally ant colony optimization is applied for the optimization of concept. Applications/Improvements: For the experimentation, dataset of plant leaf affected from bacterial disease ‘Bacterial Blight’ and fungal diseases ‘Alternaria alternata’, ‘Fungal Leaf Spot’ and ‘Fungus Anthracnose’ are considered. The proposed concept is also evaluated by comparative analysis with the existing concepts of SVM and Improved SVM.

Keywords: Ant Colony Optimization, Histogram Equalization, Image Processing, K-Means Clustering, Plant Leaf Disease Detection, Support Vector Machine

1. Introduction

India is a land of farmers and agriculture is their primary occupation. In India, cultivation area is more than one half of the country’s total area1. We can say that Indian Economy is highly dependent on productivity of agricultural crops/plants. So, there is the need to provide extreme attention to take care of plants/crops. One of the major factors responsible for the crop destruction is diseases. The major categories of plant leaf diseases are based on viral, fungal and bacteria2. Here are some common symptoms that should be kept in mind if plant growth seems low.

1.1 Fungal disease symptoms

Plant leaf diseases, those caused by fungus are discussed e.g. Late blight caused by the fungus. Initially it affects older leaves that look like, water-soaked and spot of grey-green color. Further disease affect increases, affects other leaves also and older spots become dark.
1.2 **Bacterial disease symptoms**
The disease is characterized by tiny pale green spots which soon come into view as water-soaked. The lesions enlarge and then appear as dry dead spots.

1.3 **Viral disease symptoms**
Among all plant leaf diseases, those caused by viruses are the most difficult to diagnose. Viruses produce no tell-tale signs that can be readily observed and often easily confused with nutrient deficiencies and herbicide injury. Aphids, leafhoppers, whiteflies and cucumber beetles insects are common carriers of this disease, e.g. Mosaic Virus, Leaves might be wrinkled, curled and growth may be stunted.

In this research work, we are concentrating only on the bacterial and fungal based plant leaf diseases. Manual detection of these plant diseases just increases the human efforts as it is not easy to check each individual plant. So, there is the need of some autonomous method to detect the plant diseases that can monitor the large crop fields and thus can automatically declare the disease type by analysing the symptoms that appear on leaves. In this research work, we are using image processing based autonomous method to detect and classify the disease affected leaf portions. Image processing covers the basic steps of acquisition, pre-processing, segmentation, feature extraction and leaf disease detection and final optimization.

Here, image acquisition is performed by considering RGB colour disease affected leaf image. Image pre-processing is performed by using histogram equalization to intensify image. K-means clustering is used to divide the image into parts. Image feature extraction is performed to obtain the features of leaf disease symptoms. Image classification is performed using support vector machine and finally optimization is performed by using ant colony optimization. The basic of these considered concepts is here.

Histogram Equalization is a traditional approach used to enhance the image contrast. In this method, image is enhanced by the adjusting the pixel intensities. In most of the cases, this image enhancement approach work well by enhancing the image contrast value. But it is not compulsory that there will be always enhancement in the image contrast, sometime image contrast may decrease. In this approach, contrast is enhanced by stretching the pixel intensity.

Clustering can be defined as the partitioning of group data points into possible number of clusters. K-means method is a type of unsupervised learning algorithms that have the capability to solve various problems related to clustering. K-Means clustering method performs the clustering of n objects into k clusters using the nearest mean approach of each object.

Support Vector Machine (SVM) is statistical learning method which is used to classify problems with strong theoretical foundations which are based on the standard of structural risk minimization. In SVM, proper selection of parameters is most important. The overall goal of SVM is to provide an analytical model that can predict the target data instance values from testing set attributes.

Ant Colony Optimization, introduced by Marco Dorigo, is a swarm based technique. In ACO, artificial ants generate the optimized solution of any complex problem by adapting pheromone substance based communication scheme and maintain solutions in local and global form. In ACO, ants use a substance name pheromone to share their experience with the path of other ants. Ant Colony Optimization is an iterative algorithm mostly used for the purpose to find the shortest optimized path with the help of several iterations.

Dataset of plant leaf affected from the diseases of Alternaria alternata, Bacterial Blight, Fungal Leaf Spot and Fungus Anthracnose are considered. The proposed concept detects the plant leaf diseases with the percentage of leaf affected region.

Remaining paper has following sections: Section 2 describes the existing work for the plant leaf disease detection. Section 3 describes the proposed concept for leaf disease detection. Section 4 describes the dataset used in the research work. Section 5 presents the evaluated results with comparison and analysis of proposed concept with existing approaches and conclusion of the paper is given in Section 6.
In this computing era, researchers have structured some efficient approaches and algorithms that can be used to detect the diseases in plants on time with less man labour.

In[5] author has presented the work for the identification and classification of horticulture/agriculture crops affected from fungal diseases. Authors have used Nearest Neighbour (NN) classifier for fruit crops, principal component analysis and local binary patterns for vegetation crops, discrete wavelength transform method for commercial crops and SVM for cereal crops. The overall results for each crop shows efficient results.

Various authors have used neural network based algorithms for the detection of plant leaf diseases. In[10] author has used technique of feed forward back propagation from neural network for the diagnosis and classification of diseases in grape leaf. Results are experimented on downy mildew and powdery mildew images with simulation in MATLAB. In[11] author developed an application of image processing and neural network methods for classifying and identifying the supremacy of Arcca nuts. In[12] author has used the neural network based system to classify the watermelon leaf diseases of Downey Mildew and Anthracnose. The overall performance is depicted with downy mildew and powdery mildew images with simulation in MATLAB. In[13] author developed a technique to recognize digital image and pattern detection of plant infection. In this method various neural network methods are used, i.e. generalized regression networks (GRNNs), probabilistic neural networks (PNNs), back-propagation (BP) networks and radial basis function (RBF) neural networks to differentiate between rust and wheat leaf to discriminate downy mildew infection from powdery mildew infection. In[14] author have proposed an enhanced neural network based support vector machine concept for the disease detection and disease affected portion in plant leaves.

Some other methods for different crops and vegetation are discussed by various authors. In[15] author have developed identification and classification system to distinguish the paddy infection and that is Blast Disease. In[16] author have performed the process of image processing for detection of unhealthy region of citrus leaf. Authors have considered the citrus in the form of oranges, limes, lemons and grapefruit. Citrus diseases are like citrus canker, anthracnose, overwatering and citrus greening disease. Final classification was done with support vector machine. In[17] author has proposed pattern recognition techniques for the detection and classification of cotton leaf diseases of Alternarnia, Myrothecium and Bacterial Blight. In[18] author measured the disease severity in the sugar cane with the help of digital image processing. In this method simple threshold method is used for calculating the leaf area, the triangle threshold method is used for segmentation the lesion area. Fuzzy logic is used for calculating the percentage infection information. In[19] author have used support vector machine concept for the detection and classification of soybean plants as diseased or healthy species. The proposed concept for soybean plant diseases shows an average accuracy of 93.79%. In[20] authors have studied & discussed about the pathogens in cultivated area. The result indicated the yield losses in field crop by pathogens and represents less income to the farmers Wavelet transform and SVM classifier is used for feature extraction and classification respectively. The disease is classified into five classes Healthy, Ramularia, Bacterial Blight, Ascochyta Blight and Unknown disease.

In[21] author have done comparison between rgb image and gray scale image in order to find the image which detects disease better. Author had used median filtering for finding the diseased part of the image. It was found that colored image gave better results than gray scale image.

Different authors presented their work for the different plant disease detection. In current work, image processing concept is used with final classification & optimization using SVM and ACO algorithm.

2. Proposed Concept

In this section, the proposed image processing technique is presented for plant leaf disease detection and classification. Here, image acquisition is performed by considering RGB colour based disease affected leaf image. Histogram Equalization is used to further enhance the image contrast. K-means clustering is used to divide the image into
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Image feature extraction is performed to extract the features of leaf disease symptoms. Support Vector Machine is used for the leaf disease detection & classification and finally ant colony optimization is applied for the optimization of concept. In this proposed approach, major disease detection, classification & optimization is performed by SVM and ACO. Support Vector Machine is statistical learning concept used as the classification and regression models. Ant Colony Optimization is swarm intelligence based concept well known for the local and global best optimized search solution. Here, we have considered ACO approach to optimize the solution upto the maximum possible iterations for plant leaf disease detection.

In this proposed concept, disease affected leaf image is considered as the input and possible disease type is determined as output with the percentage of disease affected portion. The detailed concept is explained as below:

**Input:** Disease affected leaf image.

**Output:** Leaf disease type with percentage of affected portion.

**Algorithm**

**Step 1: Image Acquisition**
In this section, disease affected leaf image is considered as an input image from the dataset of disease affected leaves. Image is considered in RGB color value which is further transformed in gray scale image using color scale transformation.

**Step 2: Image Pre-Processing**
After insertion of image, image is pre-processed. Pre-processing is performed to reduce the noise value and enhance the contrast of the image using histogram equalization method. In Histogram equalization, intensity of the image is distributed using cumulative distribution function. Finally, remapping function is used to obtain the equalized intensity of image.

**Step 3: Image Segmentation**
Enhanced image is segmented using k-means clustering method. K-means clustering method clusters the image based on the presence of number of feature classes. In k-means clustering, segmentation of pixels is based on the minimizing the Euclidean Distance values which can be calculated using the equation (1.1) below:

$$\text{dist}(x, y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}$$

Equation (1.1)

Here, as per the available feature classes, image is segmented in three sub-feature images with three different type of Region of Interest (ROI).

**Step 4: Feature Extraction**
Here, diseases affected Region of Interest is selected from the segmented images. Then, Convert the RGB color (ROI) image into grey scale image and maintain the Grey Level Occurrence Matrices (GLCMs). In this matrix, we are maintaining the disease symptoms by calculating the feature values of Skewness, Standard Deviation, Homogeneity, Contrast, Smoothness, Correlation, Kurtosis, Energy, Entropy, Mean, Variance, RMS, and IDM. These are calculated from disease affected portion. Based on these values, finally image features are extracted.

**Step 5: Disease Detection and Classification**
Apply Support Vector Machine for the feature extraction and disease detection using the equation below:

$$\text{SVM} = \text{SVMtrain} (\text{disease_feat, disease_type})$$

Equation (1.2)

Where,

- SVM is the SVM training function.
- disease_feat maintains the values of disease affected leaves of all the disease types.
- disease_type maintains the corresponding disease labels of Alternaria Alternata, Bacterial Blight, Fungal Leaf Spot and Fungus Anthracnose.

Based on the symptoms, expert dataset values and extracted features, disease type is evaluated.

**Step 6: Optimization**
Apply the Ant Colony optimization for the optimization of results of disease type. Ant Colony Optimization pro-
cess begins with a casual ant crowd to get the local and global best solution. This processes solution refines in certain iterations.

- Here, ants are considered as the image pixels. And food sources as the disease type. So, overall objective is to detect the optimized disease type with accuracy percentage.
- Each ant leaves their home over the outer search environment, where the shortest path of ants is attained according to the concentration of the pheromone deposited by the ants on the way to search space.
- The performance of each ant depends upon the level of optimization problem,
- Each ant starts searching through n-dimensional search space & keep the following information to find the shortest path:
  - $\tau_{ij}(q)$ – Revised pheromone concentration linked with $l_{ij}$ at iteration $q$
  - $\tau_{ij}(q-1)$– Pheromone Concentration at preceding iteration ($q-1$)
  - $\Delta\tau_{ij}(q)$ – Change in concentration of pheromone

Objective function is used to evaluate each ant. Thus, pheromone concentration for each possible path is calculated as follows by Equation (1.3):

$$\tau_{ij}(q) = \rho\tau_{ij}(q-1) + \Delta\tau_{ij}(q); \quad q = 1,2,3, \ldots, Q$$

Equation (1.3)

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**Figure 1.** DFD level 0 for Leaf Disease Detection.
where, $Q$ = total number of iterations, $\rho$ is the pheromone evaporation rate (0–1) and $\Delta \tau_i(t)$ is the change in pheromone concentration.

The change in pheromone concentration can be calculated as by Equation (1.4):

$$
\Delta \tau_j(q) = \sum_{k=0}^{m} \left\{ \frac{R}{\text{fitness}_k} \right\}
$$

if option $l_{ij}$ is chosen by ant $k$

$\text{otherwise}$

Equation (1.4)

where, $R$ is the constant well known as pheromone reward factor; and $\text{fitness}_k$ is objective function value that is calculated for ant $k$.

Update the positions for each ant and store the global best solutions.

More the value of pheromone concentration, more optimized will be the global solution.

The complete data flow for the plant disease detection using image processing steps based integrated SVM and ACO approach is explained using DFD level 0, level 1 and level 2 shown in the Figures 1 to Figure 3 respectively.

**Figure 2.** DFD level 1 for Leaf Disease Detection.
Figure 3. DFD level 2 for Leaf Disease Detection.
As shown in Figure 1, DFD level 0 diagram has considered the end components as User/Farmer and Domain Expert. Here, user/farmer apply the image processing technique steps for identification of plant leaf disease. Initially, user made the visual analysis and finds the disease affected leaves. Based on this image processing techniques applied and with the help of domain expert having knowledge of disease symptoms and disease types, disease is evaluated.

Figure 2 shows the DFD level 1. In level 1 DFD, leaf image is considered from the image store. If leaf is find to be disease affected, then try to find the disease type so that further plant/crop can be cured. For this, image processing technique is applied and using expert data disease type is detected.

Figure 3 shows the DFD level 2. Complete process of disease detection is explained here in DFD level 2. Initially, image considered from data store, then image acquisition is performed and RGB color value pixel information stored. Further, image noise is removed by enhancing the image contrast using histogram equalization. Further image is segmented into clusters using k-means clusters so that the disease affected portion can be separated. Disease affected ROI is selected and their feature are extracted which are stored into Grey Level Occurrence Matrices (GLOMs). Further, consider the expert dataset values along with stored GLOMs values and apply support vector machine to find the disease type. There may be the possibility of disease or leaf can also find to be healthy. For final optimization, ant colony optimization is applied with expert data consideration. Finally, disease type and percentage of affected portion is calculated.

### 4. Dataset Considered

The proposed integrated concept is used to detect plant leaf diseases. For this, we have considered the expert dataset having leaf of four different types of diseases (Alternaria Alternata, Bacterial Blight, Fungal Leaf Spot and Fungus Anthracnose). In this concept, we have considered the dataset images of mainly fungal and bacterial affected leaf images. Bacterial Blight is bacteria affected leaf disease. *Alternaria alternata*, Fungal Leaf Spot and Fungus Anthracnose are fungus affected leaf diseases. In this dataset, some healthy leaf images are also considered for the evaluation of results.

### 5. Experimental Results and Discussion

In this section, performance of the suggested concept is calculated for pant leaf disease detection. The overall results of the suggested concept are calculated in terms of accuracy.

#### 5.1 Experimental Setup

Initially, disease affected dataset image is considered as the input with RGB color value. Then image is enhanced using histogram equalization by distributing the intensity of the image using cumulative distribution function. Then image intensity is restored to get enhanced image. This enhanced image is segmented using k-means clustering in the form of three segments as disease affected ROI, Unaffected ROI and rest background ROI. From these segments, disease affected image portion is considered to check the type of disease and to find out the percentage of disease affected portion. For this, image features are extracted by maintaining the Grey Level Occurrence Matrices (GLCMs). In this matrix, we are maintaining the disease symptoms by calculating the feature values of Skewness, Standard_Deviation, Homogeneity, Contrast, Smoothness, Correlation, Kurtosis, Energy, Entropy, Mean, Variance, RMS, and IDM. Based on these values feature are matches with expert dataset values. Support vector machine is used to find out the type of disease by matching with the feature classes. Also the percentage of disease affected portion is evaluated. Finally optimization is performed to find out the accuracy of results. For this optimization process, we have used ant colony optimization with the local and global solution. To find out the global solution, we have considered 500 iterations values.
Figure 4. Leaf suffering from Bacterial Blight.

Figure 5. Leaf suffering from Alternaria Alteranata.

Figure 6. Leaf suffering from Fungal Leaf Spot.

Figure 7. Leaf suffering from Fungus Anthracnose.

Figure 8. Healthy Leaf.
Individual results are considered as the local accuracy evaluated by the individual ants. Overall accuracy is evaluated in terms of global accuracy by 500 ants. Different images of disease affected leaves are shown in Figure 4, 5, 6, 7 and Figure 8.

Table 1. Various features extracted for different images shown in figure 4

| Features       | Image 1    | Image 2    | Image 3    | Image 4    | Image 5    |
|----------------|------------|------------|------------|------------|------------|
| Mean           | 40.9783    | 14.4389    | 28.757     | 39.1074    | 51.1105    |
| Standard Deviation | 71.8917    | 47.8117    | 52.4431    | 59.8351    | 70.0123    |
| Entropy        | 3.03959    | 1.70988    | 3.85904    | 3.76466    | 5.05855    |
| RMS            | 8.40448    | 5.57477    | 9.26738    | 9.49211    | 10.4259    |
| Variance       | 4972.75    | 2150.7     | 2442.26    | 3324.69    | 2942.88    |
| Smoothness     | 1          | 1          | 1          | 1          | 1          |
| Kurtosis       | 3.61601    | 15.5978    | 8.79477    | 3.4464     | 3.11891    |
| Skewness       | 1.45514    | 3.63201    | 2.38853    | 1.29686    | 1.17535    |
| IDM            | 255        | 255        | 255        | 255        | 255        |
| Contrast       | 2.19733    | 0.0788756  | 0.498085   | 1.59314    | 0.387286   |
| Correlation    | 0.742064   | 0.978321   | 0.877636   | 0.746278   | 0.950228   |
| Energy         | 0.455063   | 0.762589   | 0.453099   | 0.339103   | 0.2296     |
| Homogeneity    | 0.872022   | 0.974878   | 0.926901   | 0.84276    | 0.929742   |
5.2 Results and Comparative Analysis

From the evaluated results, we have determined that the leaves are affected from the diseases of Alternaria alternata, Bacterial Blight, Fungal Leaf Spot and Fungus Anthracnose. The proposed concept also evaluates the results if leaf is not affected from any disease. Then it will shows as healthy leaf.

To check the efficiency of proposed concept (SVM + ACO), a comparative analysis is made with SVM and Improved SVM concept\(^4\). The considered concept is evaluated based on the minimum and maximum calculated accuracy values.

The implemented concept is tested on number of disease affected plant leaves and concluded the results. Different leaves are affected with different percentage. Accuracy of results varies from 96.77 % to 98.42% for the proposed concept (SVM + ACO). From the existing work, we have considered the accuracy values of SVM and Improved SVM. Minimum range of SVM is 65% and maximum accuracy value is 75%. Minimum value of Improved SVM is 69% and maximum value of improved SVM is 79%. From the above results, we can say that proposed concept is efficient enough for the detection of plant leaf diseases.

| Parameters | Figure 4 | Figure 5 | Figure 6 | Figure 7 | Figure 8 |
|------------|----------|----------|----------|----------|----------|
| Disease    | Fungal Leaf Spot | Alternaria Alternata | Fungal Leaf Spot | Fungus Anthracnose | Healthy Leaf |
| Affected region | 19.6053 | 15.0113 | 15.6179 | 15.0077 | None |
| Accuracy % | 98.3871% | 96.7742% | 98.3871% | 96.7742% | 96.7742% |

6. Conclusion

In this research work, approach based on image processing to first detect and then classify leaves according to diseases is used. Here, image acquisition is performed by considering RGB colour disease affected leaf image. Pre-processing of an image is done to enhance the image using histogram equalization. Image segmentation is performed by making use of k-means clustering. Image feature extraction is performed to obtain the features of leaf disease symptoms. Image classification is performed using support vector machine and finally ant colony optimization is performed for the optimization of concept. Dataset of plant leaf affected from the diseases of Alternaria alternata, Bacterial Blight, Fungal Leaf Spot and Fungus Anthracnose are considered. These diseases are mainly of fungal and bacterial diseases. In proposed concept, SVM is implemented with ACO to improve the disease detection results. The GUI system for the evaluated results and accuracy are shown in Accuracy of the proposed integrated concept varies from 96.77 % to 98.42%. The comparison of the proposed image processing approach is better as compare to SVM and improved SVM. So, we say that proposed image processing concept is efficient enough to determine the plant diseases.
From the present work, it has been observed that the results obtained using proposed algorithm is highly satisfactory comparable with other techniques. Thus, it can be said that proposed algorithm is fit for the leaf disease detection.

7. Future Scope

Based on the performance of the suggested disease detection approach of SVM with ACO, we recommend the following future directions:

- The proposed concept can be used for viral affected plant leaf diseases.
- The proposed concept can be integrated with other swarm intelligence based concept to improve further results.

8. References

1. Kumbhar V, Singh TP. A comprehensive study of application of decision support system in agriculture in Indian context. International Journal of Computer Applications. 2013; 63(14): 1–6.
2. Oostendorp M, Kunz W, Dietrich B, Staub T. Induced disease resistance in plants by chemicals. European Journal of Plant Pathology. 2001 Jan 1; 107(1): 19–28.
3. Al Bashish D, Braik M, Bani-Ahmad S. Detection and classification of leaf diseases using K-means-based segmentation and Neural-networks based classification. Information Technology Journal. 2011; 10(2): 267–75.
4. Pizer SM, Amburn EP, Austin JD, Cromartie R, Geselowitz A, Greer T, Romeny B H, Zimmerman JB, Zuiderveld K. Adaptive histogram equalization and its variations. Computer vision, graphics, and image processing. 1987 Sep 30; 39(3): 355–68.
5. Kanungo T, Mount DM, Netanyahu NS, Piatko CD, Silverman R, Wu AY. An efficient k-means clustering algorithm: Analysis and implementation. IEEE transactions on pattern analysis and machine intelligence. Jul 2002; 24(7):881–92.
6. Tong S, Chang E. Support vector machine active learning for image retrieval, the ninth ACM international conference on Multimedia. 2001 Oct.p.107–8.
7. Dorigo M, Maniezzo V, Colorini A. Ant system: Optimization by a colony of cooperating agents. IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics. 1996; 26(1): 29–41.
8. Baxes GA. Digital image processing: principles and applications. New York: Wiley; 1994 Sep 15.
9. Pujari JD, Yakkundimath R, Byadgi AS. Identification and classification of fungal disease affected on agriculture/horticulture crops using image processing techniques, the Computational Intelligence and Computing Research. IEEE International Conference. 2014.p. 1–4.
10. Sannakki SS, Rajpurohit VS, Nargund VB, Kulkarni P. Diagnosis and classification of grape leaf diseases using neural networks, the Computing, Communications and Networking Technologies. Fourth International Conference. 2013.p. 1–5.
11. Huang KY. Application of artificial neural network for detecting Phalaenopsis seedling diseases using color and texture features. Computers and Electronics in agriculture. 2007; 57(1): 3–11.
12. Kutty SB, Abdullah NE, Hashim H, Kusim AS, Yaakub TN, Yunus PN, Rahman MF. Classification of watermelon leaf diseases using neural network analysis. Business Engineering and Industrial Applications Colloquium (BEIAC). 2013.p. 459–64.
13. Wang H, Li G, Ma Z, Li X. Application of neural networks to image recognition of plant diseases of the International Conference on Systems and Informatics (ICSAI). 2012.p. 2159–64.
14. Kaur R, Kang SS. An enhancement in classifier support vector machine to improve plant disease detection, the MOOCs. Innovation and Technology in Education (MITE). IEEE 3rd International Conference. 2015.p. 135–40.
15. Kurniawati NN, Abdullah SN, Abdullah S, Abdullah S. Investigation on image processing techniques for diagnosing paddy diseases. Soft Computing and Pattern Recognition (SOCPR). International Conference. 2009.p. 272–77.
16. Gavhale KR, Gawande U, Hajari KO. Unhealthy region of citrus leaf detection using image processing techniques. Convergence of Technology I2CT. International Conference. 2014.p. 1–6.
17. Rothe PR, Kshirsagar RV. Cotton leaf disease identification using pattern recognition techniques. Pervasive Computing (ICPC). 2015. p. 1–6.
18. Patil SB, Bodhe SK. Leaf disease severity measurement using image processing. International Journal of Engineering and Technology. 2011;3(5): 297–301.
19. Dandawate Y, Kokare R. An automated approach for classification of plant diseases towards development of futuristic Decision Support System in Indian perspective, the Advances in Computing, Communications and Informatics ICACCI. International Conference. 2015. p. 794–99.
20. Barbedo JG. Digital image processing techniques for detecting, quantifying and classifying plant diseases. Springer Plus. 2013;2(1): 1.
21. Padmavathi K, Thangadurai K. Implementation of RGB and Grayscale Images in Plant Leaves Disease Detection – Comparative Study. Indian Journal of Science and Technology. Feb 2016; 9(6):1–6.