Multimedia Tools and Applications
https://doi.org/10.1007/s11042-018-7126-7

Agricultural leaf blight disease segmentation using indices based histogram intensity segmentation approach

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Received: 4 October 2018 / Revised: 5 December 2018 / Accepted: 26 December 2018
Published online: 14 January 2019

Abstract
Grouping of pixels based on certain kind of similarity or discontinuity among the pixel called Segmentation. Segmentation of ROI from the given input image determines the success of analysis. Validity metrics helps to measure the similarity of the segmented image result. Most important and required for human survival is food. In that scenario Agriculture industry plays a vital role and the industry faces lose because of certain reasons. One of the reason to yield lose is unaware of disease diagnosis and most of the time farmer can predict disease at last moment. By implementing technological improvement in agriculture industry try to improve the crops lose and that results increasing farmer income. Indices based intensity histogram segmentation technique used to segment the disease affected part from unhealthy leaf with better accuracy rate. Segmentation is important stage in image processing technique and it helps to diagnose the diseased region. After categorizing the disease affected area it is most important to validate the segmented image. Validation algorithms are used to validate the segmented part and most famous similarity measures are Dice index measure, over lab coefficient measure, Jaccard coefficient measure, Cosine measure, Asymmetric measure, Dissimilarity measures etc. The introduced method successfully segments the affected region with 98.025% accuracy also the segmented region have 0.964% of mutual information.

Keywords Cotton leaf disease · Indices based histogram intensity segmentation · Leaf disease identification · *Solanum nigrum* leaf disease · Validity measures

1 Introduction

Agriculture industry in very essential one and doing agriculture is not simply ambitious starts and physical work. One small bad occurrence of disease in the plant will

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result big lose to the farmers' profits. Introducing technology into the agriculture cultivation helps the farmer to predict the disease at the initial stage and possible to rectify the yield lose. Many disease affect the crop some of the disease are [4] begins as dark sores in the leaf petiole and advances into leaf axils, blight disease on the leaf etc. *Solanum nigrum* leaves play a vital role in curing human diseases. The plant helps to purify the blood, treatment of measles, cure the ulcer, get relief from ear pain, benefit to cure liver disease and cure the cardiac pain [8] .It is important to use healthy leaf for this medicine purpose. The plant consists of more vitamins such as calcium, iron and vitamin C. Sometimes *Solanum nigrum* affected by black leaf spot, blight disease then such case fertilizers are used to preserve the plant from the disease [15]. Early prediction of disease is very important otherwise it fails to lead excess use of fertilizer and harmful to the human health. In order to reduce the economic loses of farmer it needs to improve the cultivation process. Implementing new technologies in crop cultivation field is the one of the way to reduce technological gap in agriculture industry. *Solanum nigrum* also known as black nightshade is one of the most familiar crop and it can grow up to 120 cm,the leaf can grow up to 7.5 cm [9]. The leaf of the plant get affected by some of the disease like black leaf spot disease and blight disease.

In India, cotton production plays a major role and cotton take important part in Indian economy. The present farming system of cotton consumes more fertilizer than the average consumption in Indian. Indiscriminate [7] utilize of fertilizer pollute the environment such as water, soil and air etc. Through the sticky monitoring system for pest and cotton disease management helps to reduce the hazards of using surplus of fertilizer and pesticides. It is important to raise the productivity of cotton and upgrading the cotton quality by implementing the technological advancement. Population growth and less yield production challenges to the agriculture industry. It is important to improve the production rate and crops lose to overcome this problem. Agriculture Digital Image processing [11] technique involves the steps preprocessing, feature extraction, segmentation and classification. Among these steps Color image segmentation [5] gives more useful information than gray scale image. Similarity based image segmentation [6] can be done by thresholding an image, Region growing method, Region merging and Region splitting methods. Thresholding can be subdivided into local threshold, global threshold, Adaptive threshold and optimal threshold. Depends on the application the segmentation technique has to be selected. Segmentation technique [2] is very useful in finding ROI from agriculture image, satellite image, medical image etc. Due to the importance of the image segmentation process, in this work effective indices based intensity histogram segmentation technique is applied to analyze the plant leaf to segment the affected region with good accuracy rate of sub division. In addition to this segmented region, the validation algorithm is applied to examines the quality of the segmented part and efficiency is evaluated in terms of using Dice index measure, over lab coefficient measure, Jaccard coefficient measure, Cosine measure, Asymmetric measure, Dissimilarity measures etc.

Then the rest of the section is organized as follows, section 2 deals with the different researchers opinions, thoughts, research idea about plant leaf analyze process. Section 3 discusses about the indices based intensity histogram segmentation approach along with the validating algorithm. The efficiency of the indices based intensity histogram segmentation approach is examined in section 4 and concludes in section 5.

2 Related works

Image segmentation is division of the digital image processing technique and it is used to separate the ROI from the whole image [3]. Proposed method based on color histogram and the method tested with different disease of the plant group. Myrothecium leaf spot and Areolate mildew diseases of cotton taken for the research and produces overall result of 76% accuracy on disease detection. Crops such as Wheat, sugarcane, citrus, corn considered for the study of work. This paper proposed a new algorithm and enhanced segmentation result for leaf lesion recognition [13]. Applied segmentation and classification algorithms for identifying the frog-eye spot on tobacco leaf. First extracted the lesion part then CIELAB color model used to segment the ROI. Author segmented the lesion part on the tobacco leaf as Anthracnose and frog eye disease part and healthy leaf. After segmentation Dice measures used as a performance measure for the disease part of the tobacco leaf image.

[20] combined discrete wavelet transform with K-Means clustering to get appropriate segmentation of leaf disease area. Diseased leaf image taken as input and 3-level decomposition applied. Noise removed using filtering option then K-Means algorithm applied for segmentation. Validity metrics such Jaccard, Dice used to measure the goodness of cluster image [8, 18]. Proposed classification algorithm to identify the fruit disease. Segmentation algorithm K-means and C-means used to separate the disease affected part. The disease affected partitioned area similarity measured by dice metrics. GLCM used to extract the feature of segmented image and the resultant image classified using KNN algorithm. K-means gives better segmented result compared to other.

[19] identified plant disease using convolution neural networks. This system helps to identify 13 types of plant diseases. Drawn square around the disease affected part to identify ROI. Introducing new framework called deep learning to classify the healthy leaf and disease affected leaf. Resultant images evaluated using cross validation technique. This method helps to automatically classify the disease affected leaf. Watershed algorithm treats intensity of the image as height of the watershed area. Depends on the application the catchment area and watershed line differs. In some application watershed gives over segmentation [10]. Implementing the method to identify the leaf spot on tomato, grapes by applying pattern matching algorithm. K-means algorithm is well known method of segmentation. In this method select the centroid value and number of clusters initially. Selection of centroid and number of Regions at initial stage will be the biggest challenge in K-means Algorithm. According to the above discussion, the region growing algorithms are mostly used to segment the affected region for analyzing the further disease related issues. In addition to this, the discussed Region growing [17] and seed based region growing algorithm helps to identify the ROI from given input. Select seed from the input image and based on seed value taken calculate the Euclidean distance from each pixel. Depends on the seed segmentation result varies. Selection of appropriate seed is a major task in region growing segmentation method. The method of seed Region growing (SRG) plays important role to find the plant pathology. Given input image can be split up to the ROI [1, 14] reached after splitting the resultant image can be merged. The method have a challenge of which split up contains ROI is a challenging task. For balancing the discussed research gap, in this work introduce the indices based intensity histogram segmentation approach along with the validating algorithm for examining the affected region from plant leaf with effective manner. Then the detail explanation of indices based intensity histogram segmentation approach along with the validating algorithm is discussed as follows.

3 Goodness of segmentation in agricultural leaf blight disease

In this section analyze the goodness of segmentation process in agriculture leaf blight disease. Xanthomonas axonopodis is one of the proteobacteria that is the main reason for blight disease in Cotton and it is the one of devastating disease. Similarly *Solanum nigrum* plant loses its 27–57.36% yield lose by blight disease. According to the discussions, the sample blight disease affected cotton leaf image is shown in Fig. 1.

The above described input cotton and *Solanum nigrum* leaf images are considered as the input image that is denoted as I and the affected region of interest (ROI) is written as follows,

$$I = \sum_{x=1}^{n} S_x \tag{1}$$

In Eq. (1), n is represented as number of regions in input image, the given input images are segmented into n number of regions that is represented in terms of $S_1 + S_2 + \dots \dots \dots . S_n$. Let us take two different regions then S_i not equal to S_j for all$i \neq j$. This property is called as disjoint property. To improve the segmentation and classification result of above algorithm new algorithm called indices based histogram intensity segmentation algorithm is proposed. Because of wrong diagnosis or late prediction of disease the farmer get a chance to applying excess fertilizer [16] and it may leads to cause the side effect in human body. To avoid this crucial situation the early prediction of disease is very important and also important to maintain the quality of the food product. To avoid economic loses of agriculturalist it is necessary to find the disease accurate and fast manner. Then the blight disease identification process includes the image preprocessing segmentation and validating measure, each step is explained as follows.

(a) Cotton Leaf Images

(b) Solanum nigrum Leaf Images

Fig. 1 Sample blight disease images

3.1 Preprocessing disease affected leaf

In this section discusses about the noise removal process, the given input may have probability to have unwanted signals which is called as noise. Denoising is a process to remove the unwanted signals from the image and also preserve the useful information. Denoising is an important step to preprocess the image and assist to improve the accuracy of output. The noises removed by median filter. The matrix of size 3 × 3 taken as input to the median filter process is represented as follows.

123	118	114
124	114	113
123	118	113

Input

$\longrightarrow$ 113,113,114,114,$\boxed{118}$,118,123,123,124

Let M be the input matrix then apply sorting method to sort all the values of M and find the median of M. In the above example by replacing neighborhood values with median value 118 the image gets smoothed. Then the contrast of the image adjusted. The above process is applied to the input image pixel representation process for eliminating the noise from the image for retrieving the exact affected region from leaf image. Based on the above process, the noise removed images are shown in Fig. 2.

The above Fig. 2, indicates that noise removed leaf images. The median filter is applied to the three different diseases such as Foiler, rot and rust affected leaf images. Then the preprocessed images are fed into region segmentation process that is defined as follows.

3.2 Segmentation of leaf image

Thresholding technique can also be used to segment the ROI from image. ROI is the region of interest and it may be the part of the image or the whole image it varies to the application. Choose a threshold value (T) based on peaks and valley of the histogram. Depends on the application it is possible to apply local threshold, global threshold or optimal threshold technique [21]. Combined OTSU threshold method with canny edge detection operator and segmented jujube leaf into number of regions. The method suitable for one particular applications and may not get accurate results for other domain like to find leaf blight disease. *Solanum nigrum* leaf image converted into digital format using MATLAB and it is represented by the function f(x, y). Threshold value denoted by T, the image has segmented by choosing the threshold value. If the value of pixel intensity greater than T then it assigns value as 1 otherwise it takes the value as 0. The formula for thresholding the leaf disease on *Solanum nigrum* is represented as follows,

$$Threshold = \begin{cases} 1 & if\ f(x,y) > T \\ 0 & if\ f(x,y) < T \end{cases} \tag{2}$$

Fixing the threshold value depends on the application. Some predefined functions are available to choose the T value but the result varies based on the selected domain. Same T value could not give accurate ROI for all kinds of input image. Implementation of the

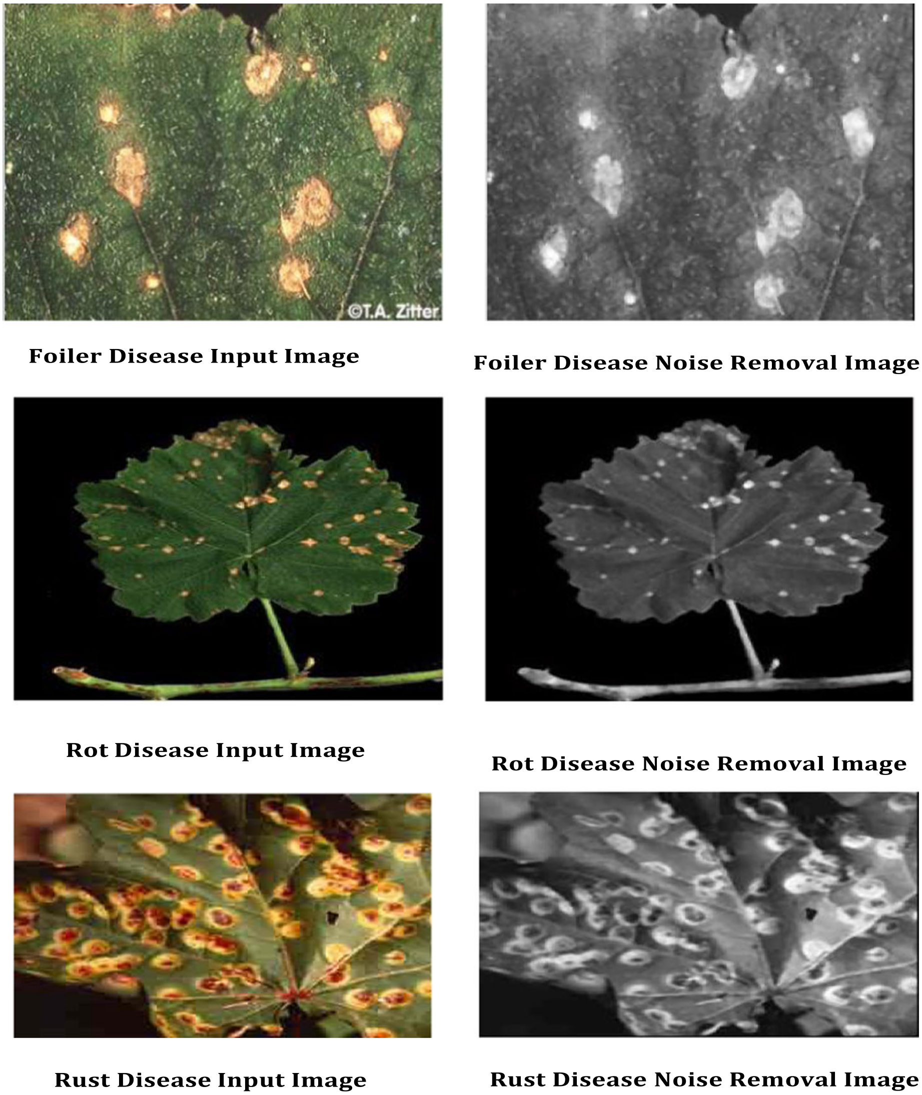

Fig. 2 Preprocessed leaf images

image segmentation technique used to separate the disease affected part from the background image. Region growing is one of the most valuable techniques used in image segmentation. In this scenario first choose the seed point from the image. By using the seed point separate the diseased part. Choosing seed point is one of the biggest challenges in region growing method and wrong selection of seed point may lead to over segmentation [12]. Implemented Region growing method in cucumber downy mildew disease and get more accurate segmentation result compared with otsu and K-means algorithm. Foliar disease of the leaf can be detected by using proposed region growing method and produced better result compared with existing algorithms. In this paper new algorithm is introduced based on the indices of histogram. During the analyze process, *Solanum nigrum* leaf images taken as input with the size of 256×256.

$$\boldsymbol{Img}(\boldsymbol{x},\boldsymbol{y}) = \begin{bmatrix} \boldsymbol{i}(\mathbf{1},\mathbf{1}) & \boldsymbol{i}(\mathbf{1},\mathbf{2})\ldots\ldots\ldots & \boldsymbol{i}(\mathbf{1},\boldsymbol{n}) \\ \boldsymbol{i}(\mathbf{2},\mathbf{1}) & \boldsymbol{i}(\mathbf{2},\mathbf{2})\ldots\ldots\ldots & \boldsymbol{i}(\mathbf{2},\boldsymbol{n}) \\ \boldsymbol{i}(\boldsymbol{m},\mathbf{1}) & \boldsymbol{i}(\boldsymbol{m},\mathbf{2})\ldots\ldots\ldots & \boldsymbol{i}(\boldsymbol{m},\boldsymbol{n}) \end{bmatrix} \tag{3}$$

In Eq. (3), Value of m = 1,2…..256 and n = 1,2……..256.

To extract the disease affected part of the leaf, first calculate the minimum value of Image value. After finding the minimum value calculate the difference between minimum value and each pixel of Image.

$$Min = \min(Img) \tag{4}$$

$$Img(x,y) = Img(x,y) - Min + 1 \tag{5}$$

$$h(Img(i)) = h(Img(i)) + 1 \tag{6}$$

According to the Eq. (6), the histogram of the image is created H represents the histogram of Eq. (6). Histogram represents the number occurrence of each pixel. Find the indices of the each histogram value. L be the length of indices value. Then calculate histogram length (HL) and represent it in m. K represents number of cluster and calculate the centroid μ value.

$$\mu = \frac{(1:K)*L}{(K+1)} \tag{7}$$

In Eq. (7), K = 1,2….n. Depends on the users requirement the value of K varies. Using Euclidean distance measures calculate the distance from μ to indices value and store the resultant values in Histogram Clustering (HC) variable.

$$C = abs(ind(i)) - \mu \tag{8}$$

$$CC = find(C = \min(C)) \tag{9}$$

Retain the non-zero pixel and store the CC information in HC. Repeat the process (3) to (9) until the μ gets unchanged. After that create mask and use this mask information to hide unwanted information. Then store the remaining information and store it in another matrix. Extract the required information and display the segmented part of the input image. ROI information can be stored and it will be used for further process of identification. Based on the above process, region affected images are shown in Fig. 3.

The above Fig. 3, indicates that region segmented leaf images. The Indices based intensity histogram approach is applied to the three different diseases such as Foiler, rot and rust affected leaf images to segment affected region. After the segmentation it is essential to discuss about importance of validity metric. Similarity measures are the key to calculate the identical part of the segmentation image. Sorensen-Dice Similarity calculated to get the similarity measures of the segmented image. The highest value of Dice measures obtained from segmented image represents the most appropriate result. The validation is done by as follows

$$Dice\ Similarity = 2*\frac{(A\cap B)}{(A\cup B)} \tag{10}$$

In Eq. (10), where A –segmented image and B – Ground truth image.

$$Dice\ similarity\ value = 1\ if\ A = B \tag{11}$$

$$Dice\ Similarity\ value = 0\ if\ A \neq B \tag{12}$$

Based on the above process, the segmentation part is validated using above Eq. (11 and 12). Quality of segmentation can be validated using similarity index metric. This process is repeated continuously until to segment the affected region from leaf image. Then the efficiency of the system is evaluated using experimental results which are discussed as follows.

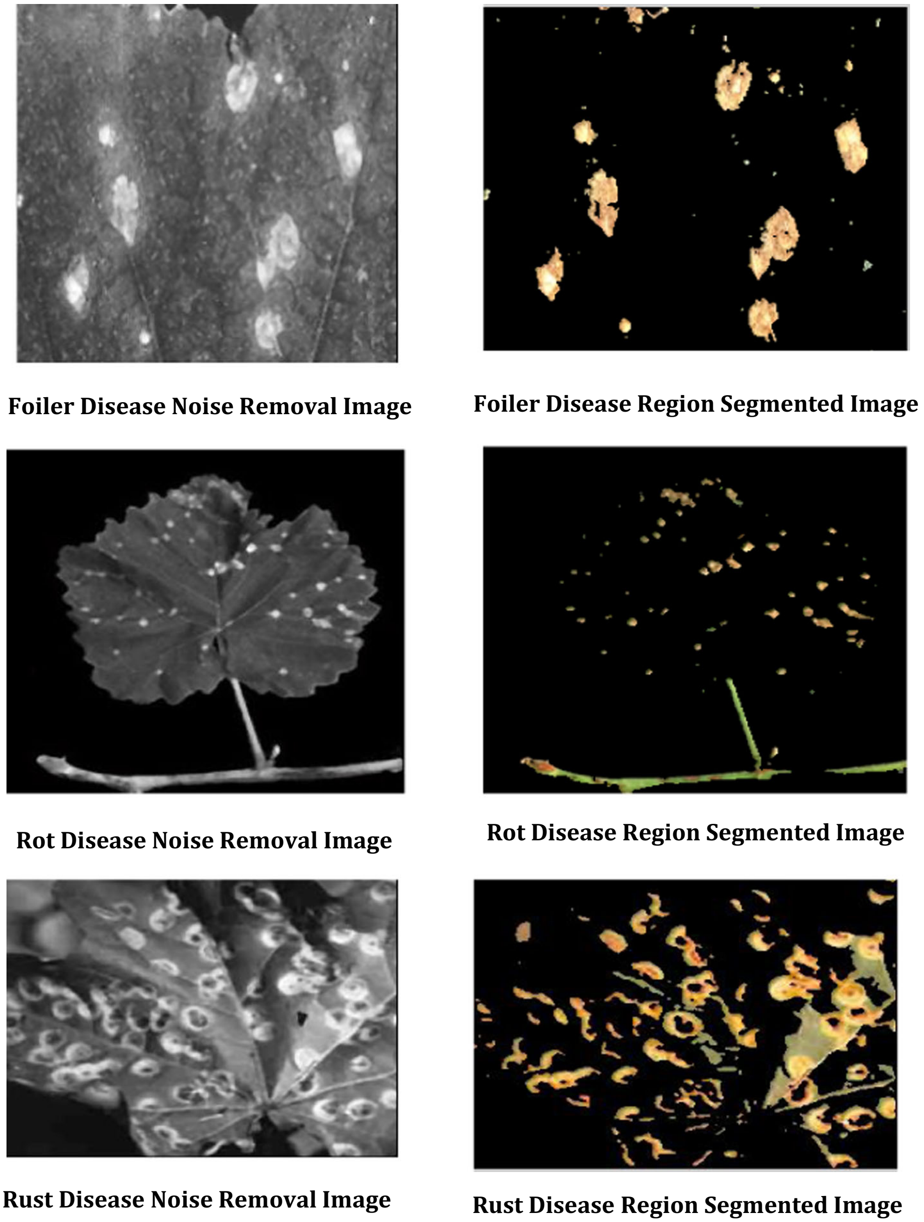

Fig. 3 Region segmented leaf image

4 Results and discussions

In this section discusses about the efficiency of indices based intensity histogram segmentation approach along with the validating algorithm is evaluated using MATLAB tool. During this process, Arkansas Plant Diseases Database (https://www.uaex.edu/yard-garden/resource-library/diseases/) and NARO (https://www.gene.affrc.go.jp/index_en.php) images are utilized to segment the region from affected leaf. Then the sample APS image dataset is shown in Fig. 4.

Fig. 4 Sample leaf images

The collected image is analyzed by many techniques used to validate ROI with ground truth images for analyzing the segmented region. The introduced segmented region efficiency is evaluated in terms of Dice similarity measure, Jaccard, cosine and asymmetric measure.

4.1 Dice similarity coefficient (DSC)

The first metric is dice similarity coefficient which used to analyze how effectively the affected region is segmented from the captured image. The DSC is computed as follows.

$$DSC = \frac{2TP}{2TP + FP + FN} \tag{13}$$

In Eq. (13), TP is represented as true positive (how correctly the affected image pixels are identified from the image), FP is denoted as false positive (how the pixels are select from the given condition while segmenting the region) and FN is false negative (how the pixels are absent from the given condition while segmenting the region. Based on the discussions, the obtained DSC result is shown in following Table 1.

The above Table 1, clearly indicates that the indices based intensity histogram segmentation method effectively segments the region from the affected plant disease with effective manner. The indices based intensity histogram segmentation method ensures the maximum similarity rate which means, Indices Based Intensity Histogram Segmentation approach segment the unhealthy leaf region successfully. Based on the Table 1, the value related graphical representation is shown in Fig. 5.

The Fig. 5 clearly shows that indices based intensity histogram segmentation approach ensures the comparatively better performance value of different plant leafs such as cotton blight disease leaf, cotton spot leaf, cotton powdery mildew and Solanum nigrum blight disease leaf. The segmented parts have useful information that used to analyze the disease

Table 1 Comparison of segmentation result

Input image of Plant leaf	K-means	Watershed	Barbedo's Histogram based segmentation	Indices Based Intensity Histogram Segmentation
Cotton blight disease	0.784	0.82	0.8943	0.9378
Cotton Leaf Spot	0.76	0.857	0.901	0.9465
Cotton Powdery Mildew	0.79	0.861	0.9154	0.9624
Solanum nigrum blight disease	0.803	0.875	0.9267	0.979

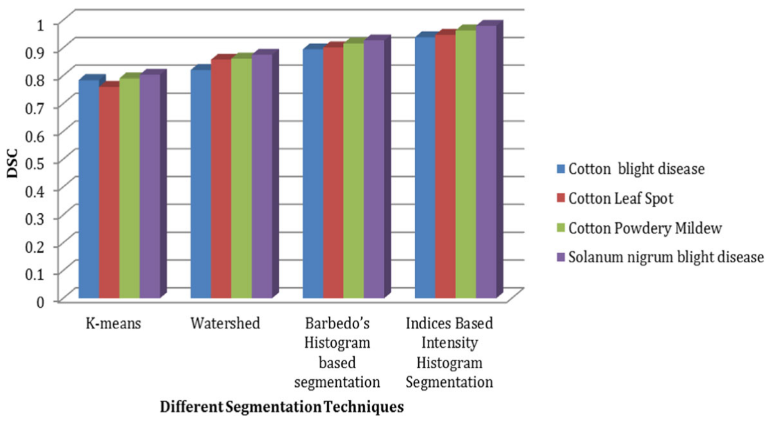

Fig. 5 Performance of segmentation techniques

Table 2 Mutual information for segmentation result

Input image of Plant leaf	K-means	Watershed	Barbedo's Histogram based segmentation	Indices Based Intensity Histogram Segmentation
Cotton blight disease	0.67	0.75	0.83	0.95
Cotton Leaf Spot	0.69	0.78	0.86	0.96
Cotton Powdery Mildew	0.73	0.80	0.89	0.968
Solanum nigrum blight disease	0.76	0.83	0.92	0.978

related features and information. Then the mutual information of the segmented region is shown in Table 2.

The above Table 2, clearly indicates that the indices based intensity histogram segmented region have several information about affected disease with effective manner. The indices based intensity histogram segmentation method ensures the maximum mutual information value which means, Indices Based Intensity Histogram Segmentation approach segment region have valuable information. Based on the Table 2 the mutual information value related graphical representation is shown in Fig. 6.

The Fig. 6 indicates that indices based intensity histogram segmentation approach ensures the high mutual information value of different plant leafs such as cotton blight

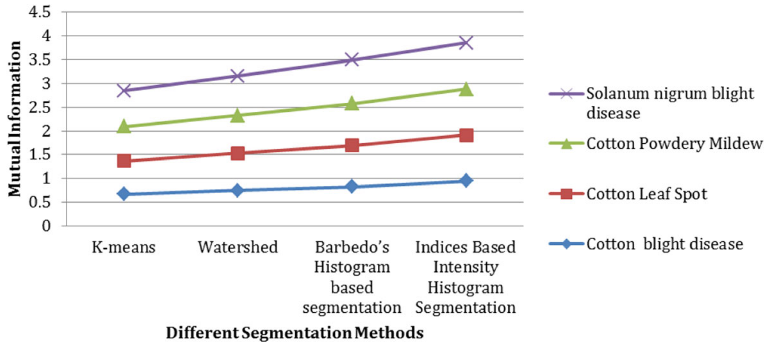

Fig. 6 Mutual information

Table 3 Sensitivity and specificity for segmentation result

Input image of Plant leaf	Sensitivity				Specificity			
	K-means	Watershed	Barbedo's Histogram based segmentation	Indices Based Intensity Histogram Segmentation	K-means	Watershed	Barbedo's Histogram based segmentation	Indices Based Intensity Histogram Segmentation
Cotton blight disease	0.85	0.862	0.91	0.956	0.952	0.96	0.958	0.979
Cotton Leaf Spot	0.9	0.91	0.92	0.973	0.961	0.964	0.965	0.982
Cotton Powdery Mildew	0.92	0.93	0.928	0.976	0.964	0.971	0.97	0.978
Solanum nigrum blight disease	0.91	0.92	0.93	0.982	0.972	0.976	0.98	0.99

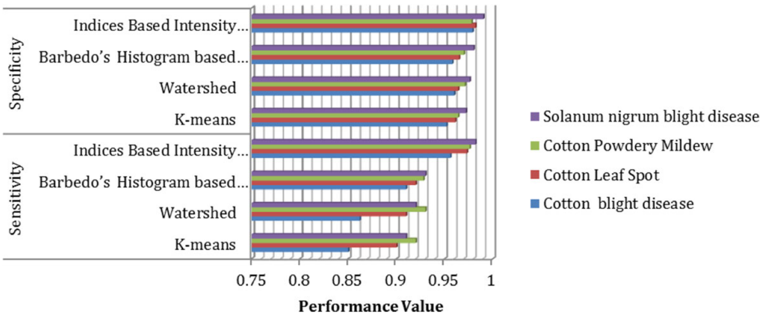

Fig. 7 Sensitivity and specificity

disease leaf, cotton spot leaf, cotton powdery mildew and Solanum nigrum blight disease leaf. The segmented parts have useful information that used to analyze the disease related features and information. From the segmented region, the disease related information is retrieved effectively and the accuracy of the segmented region is examined using sensitivity and specificity metric that is shown in Table 3.

The above Table 3, clearly indicates that the indices based intensity histogram segmented region segmented region have high accuracy (0.972% of sensitivity and 0.99% of specificity) about affected disease with effective manner. The indices based intensity histogram segmentation method ensures the maximum mutual information value which means, Indices Based Intensity Histogram Segmentation approach segment the input image into several regions with valuable information. Based on the Table 2 the mutual information value related graphical representation is shown in Fig. 6.

The Fig. 7 indicates that indices based intensity histogram segmentation approach ensures the high sensitivity and specificity value of different plant leafs such as cotton blight disease leaf, cotton spot leaf, cotton powdery mildew and Solanum nigrum blight disease leaf. The segmented parts have useful information that used to analyze the disease related features and information that used to retrieve disease related information with highest accuracy that is shown in Table 4.

The above Table 4, clearly indicates that the indices based intensity histogram segmented region segmented region have high accuracy (98.79%) about affected disease part with effective manner. Based on the result the graphical representation of the accuracy is shown in Fig. 8.

Thus the indices based intensity histogram approach successfully recognized the plant leaf blight disease from cotton and Solanum nigrum images when compared to the other methods.

Table 4 Accuracy for segmentation result

Input image of Plant leaf	K-means	Watershed	Barbedo's Histogram based segmentation	Indices Based Intensity Histogram Segmentation
Cotton blight disease	92.1	93.5	96.34	97.31
Cotton Leaf Spot	92.9	93.89	95.134	97.543
Cotton Powdery Mildew	93.1	94.21	96.43	98.46
Solanum nigrum blight disease	93.78	94.72	96.83	98.79

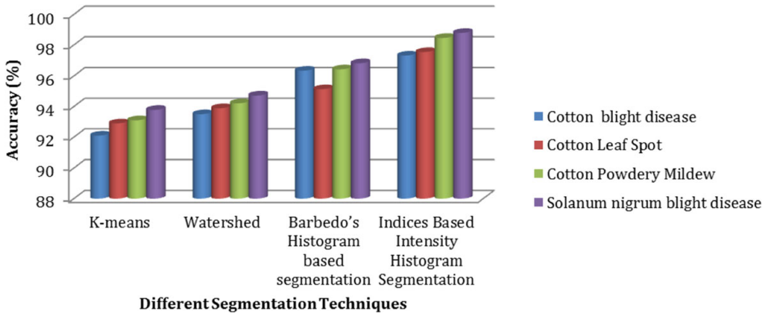

Fig. 8 Accuracy

5 Conclusion

These papers analyzed the importance of crop disease diagnosis at earlier stage and importance of the technological implementation in the agriculture industry. Image processing techniques play a vital role for prediction of disease at initial stage. The image preprocessing technique examines each pixel present in the image and affected regions are successfully eliminated from three different disease affected leaf disease. From the preprocessed image, affected region is segmented by computing each pixel according to the maximum histogram values and similarity of the affected region is examined using dice similarity metrics. Outcome of the Indices Based Histogram Intensity Segmentation bring 98.79% accuracy than the existing technique. In addition affected region also have 0.964% of mutual information that indicates the diseases are classified with higher accuracy.

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