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Severity and Disease Affected Area Measurement in Paddy and Maize Crop Leaves using Image Processing Techniques

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***Abstract*— Large population of India is dependent on agriculture directly or indirectly for their livelihood. To achieve better yield and quality in agricultural products, it is good to diagnose crop diseases at very initial stages. Pathogens like fungi, bacteria, viruses and adverse environment are the main reasons for agricultural crop diseases. For sustainable agriculture, continuous observation of crops from early stage may play prominent role. Early stage crop disease detection and severity measurement is very significant as far as profit in good forming is concerned. Paddy and Maize are two major crops grown in the country which not only provide feeding but also give major contribution to GDP. In the proposed work, K-means clustering with fuzzy logic is adopted to measure the disease affected area of the leaf and in turn to determine the severity of the diseases. For this experiment numbers of Paddy and Maize diseased leaves are taken. Later the results are validated with ImageJ tool to check accuracy from the proposed method..**

***Index Terms*— K-means clustering, Fuzzy logic, ImageJ, Severity.**

I. INTRODUCTION

Agriculture sector in India is the main job producer and contributing about 15 per cent of national Gross Domestic Product (GDP) and importantly, more than half of the country's population is directly or indirectly dependent on agriculture and its associated activities for their livelihood [23] and this number is huge and very significant. As health of plant is decided by color, shape and size of leaf, it is very important to monitor the leaf growth of any crop for good agriculture. Color of leaf will change automatically whenever the crop is suffering by diseases or by any deficiencies. Automatic detection of crop leaf diseases and severity measurement is an important research area as it may provide huge benefits in providing good yield to the farmers and food security [1]. If diseases are not treated on time, leads to severe loss. Even excessive use of pesticide may lead burden on farmers and pollution to the environment hence it must be minimized. Excessive use may lead to the danger of toxicity in agricultural product directly affecting the human health. If we estimate the severity of disease then we can decide on the amount of pesticide usage effectively and can be concentrated on the affected area. For precise results we cannot depend on naked eye observation. Paddy is majorly grown as rainy (kharif) crop in the region of malnad and southern part of the Karnataka, a state in India, and in some other areas where abundant water supply (Dams, water reservoirs, canals etc) is available. Similarly Maize (Zea mays) is another major crop grown

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during summer season as a second or alternative crop. Both the crops contribute a lot in food production, food security and bring handsome amount of revenue for farmers. Most common paddy plant diseases are leaf blast, brown spot, leaf blight, etc. [22] and most common pests include yellow stem borer, rice leaf folder, rice bug. Most common maize diseases are brown spot, common rust, polysora rust, maydis leaf blight, charcoal stalk rot etc. Both the crops suffer a lot of diseases caused by various sources and reasons.

Image processing can be used in agriculture particularly in crop leaf disease identification and classification. And also in the following cases [2].

1. To find disease in fruit, stem.
2. To calculate disease infected part.
3. To find size and shape of leaves, fruits.
4. To determine mineral deficiency in plants.
5. To grade agriculture products.

Leaf is an essential part in plant and its close observation provides condition of the plant. Montgomery [3] suggested a method to measure leaf area. Where length, width and coefficient of leaf are multiplied together. Though the method is easier but does fail to give uniform result among all plants because of variation of coefficient of leaf. A destructive method [4], where grid counting is adopted. Remove a leaf from the plant. Place it over a grid paper. Draw the outline of the leaf and measure the number of grids covered. Results were accurate but consume more manual time. Millimeter graph paper method [5], where a nondestructive leaf area measurement technique is introduced. They estimated the leaf area with equation, Leaf Area (LA)=x/y, where x is the weight in grams of the area covered by the leaf outline over a millimeter graph and y represents weight of one cm^2 of the same graph paper. The method was accurate, easier and inexpensive one. Severity of the disease will definitely force the farmer to find a solution to cure it or takepreventive and corrective actions. With help of technology a farmer can minimize his loss and can get better yield. A fast, automatic, robust, accurate and less expensive method is need of the day.

II. RELATED WORK

Mrunalini R et al (2011), in their proposed method [1], work flow is given in four phases. During first phase, K-means clustering is used to create four clusters as healthy and diseased part. As second phase, green pixels are masked which are healthy using global thresholding method. In third phase, for feature extraction Color Co-occurrence Method (CCM) is applied. Diseases are detected by neural networks in the fourth phase. Anand.H.Kulkarni et al. (2012), have considered pomegranate fruit and leaves for their work [6], SCILAB color space is used for segmentation to get diseased area and Gabor filters are used to extract the features. Classification is done by ANN. S. Arivazhagan et al. (2013) included banana, lemon, beans, rose and many other leaves for their experiment [7]. First, image in RGB is converted in to HIS color space. Later, masking the green pixels and removal of masked green pixels is carried out. Next, useful segments are obtained to compute texture features using color co-occurrence method. Finally, diseased leaves are classified by SVM.

Piyush Chaudhary et al. (2012), in their work [8], initially color transformation is done on RGB image to create color spaces in HIS, YCbCr, CIELAB. Median filters are used to remove unwanted spots. H, Cr, A components are used to detect disease spot from color spaces of HIS, YCbCr, CIELAB respectively. Ostu's method is used to get better segments and results are compared to choose best one. Finally they claimed, using H component in CIELAB yields better results. Rashedul Islam et al. (2015), have presented a work in two phases [9], where diseased paddy leaves are used. During first phase, k-means clustering is used to segment the image to differentiate the healthy part with diseased one. In second phase, convert the diseased and healthy segments into binary. Find the number of pixels in both cases using simple math and find the percentage of diseased area. Later severity is calculated as in the table II [11]. Jagan Bihari Padhy et. al. (2016) have compared K nearest neighbor with SVM to detect and classify the various diseased leaf images along with advantages and disadvantages [10].

S. B. Patil et al. (2011) have taken brown spot affected sugarcane leaves for their work. A simple method where, severity of the disease is determined by measuring unhealthy part and total leaf area ratio. As a first step, leaf region segmentation is done from the background removal and total pixels are taken into account. In second step, image is transferred from RGB color space to HIS color space. Triangle thresholding method is used to select the threshold value to differentiate lesion area from the healthy region. They proved their proposed method could achieve about 98% accuracy [11]. NurulHanisahNajwa A. Halim et. al. (2021) [12], have taken paddy brown spot leaf images. Using MATLAB tool, initially back ground of leaf images is removed out. Used masking process on segmented binary and segmented RGB images. Obtain pixel values of segmented RGB image and of masked image. Finally calculate the affected area and then find severity of the disease. The work mentioned by V. A. Gulhane et al. (2011) in [13], uses cotton leaves to find affected area. Color segmentation method is used to extract intensity pattern.

SantanuPhadikar& Jaya Sil [14] considered rice plants to develop a software prototype to identify infected parts. Image growing was adapted along with segmentation to find disease in their work. Renugambal et al. (2015) [18], have used sugar cane leaves for their work. Preprocessing is done using histogram equalization, filtering, color transformation and k-means clustering to segment the leaf area from the diseased part. SVM is applied for classification with GLCM feature of affected area. Another similar work is carried out by E. Ratnasari et al. (2014), [19] where sugarcane leaves are considered, first RGB image is converted in to L*a*b color space, the segmented spot is obtained from thresholding a component. Diseased spots are extracted with maximum standard deviation of segmented spots that is used for detection of type of disease. They claim 80% accuracy and 5.73 error severity estimation average. S. Jadhav et al. (2019), [20] in their work Soybean leaves are used for the experiment. Using thresholding method backgrounds are removed and ROI are obtained. Color based segmentation technique in incremental k-means clustering is applied to the region of interest for separating the diseased part from healthy one. Severity is measured by quantifying the pixels present in segmented areas. KNN and SVMs are used to classify the diseases. AakankshaRastogi et al. (2015) [21], in their two phase work Maple and Hydrangea leaves are considered. In first phase, preprocessing is done using resizing, binarization and filtering techniques. Features are extracted by GLCM matrix method and k-means clustering is used for segmentation. In second phase, Artificial Neural network and Fuzzy logic methods are used to classify and to find severity of the diseased leaves respectively.

III. PROPOSED WORK

Main objective of the proposed work is to find the disease affected area of the leaf and severity. The basic steps used to find the disease affected area and severity are given in the figure 1.

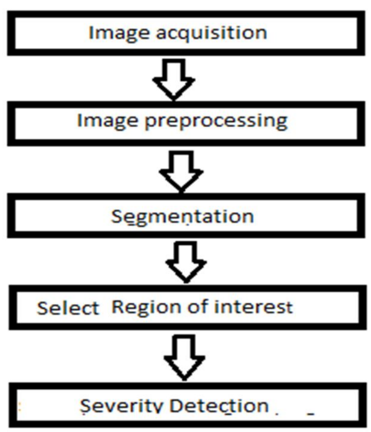


Figure 1: Basic Steps to find severity of disease.

A. Image acquisition:

Collection of appropriate digital images is very crucial task. In the proposed work, various paddy and maize crop disease affected leaves are collected directly from farm land and from kaggle data set [15]. Kaggle is a web based platform that offers a no-set up, customizable, code development environment for developers and research enthusiast. It allows us to access free GPUs and huge repository of community published data set. For our experiment, the collected data set was in unstructured format. Later it had to undergo different process to get in structured format. A total of more than 5000 Maize crop leaf images with different diseases and more than 3500 paddy leaves with different diseases are collected.

B. Image Preprocessing

Another important step is preprocessing where image is made adequate enough to be used for future purpose. Resizing, background removal, noise removal, image enhancement, etc are the various steps can be adopted. In the proposed work, Images are resized to 256x256 and background is removed using slazer online tool as shown in the figure 2a.

While removing the noises, one should take care about edge preservation. Median filter is one such technique where edges are preserved under certain conditions. Because of this feature median filter has been adapted in our proposed work to remove noise. Figure 2b. Shows image with noise and application of median filter. Median filter is applied to R,G,B color channels individually and then later combined to form original image.

Image enhancement is done by histogram equalization that redistributes the intensity of the given image. Histogram equalization on RGB image does not yield image enhancement. It is quiet tricky where we need to convert the RGB image into HIS color space first. Later enhance the intensity by preserving the hue and saturation component.

A standard histogram equalization process is given in equation (1), where p indicates normalized histogram for each possible intensity values of the input image [24].

$$p_n = \frac{Number\ of\ Pixels\ with\ intensity\ n}{Total\ Number\ of\ pixels} \qquad n=0,1,\ldots\ldots L-1 \tag{1}$$

Where L is the intensity normally varies from 0 to 255. The histogram equalized image g will be defined by

$$g_{i,j} = floor((L-1)\sum_{n=0}^{fi,j} p_n) \tag{2}$$

Histogram equalization steps

1. Obtain HIS image from RGB
2. Convert HIS image matrix into intensity matrix
3. Update the Intensity Matrix from the HSI Image matrix with the histogram equalized Intensity matrix
4. Obtain back RGB from HIS

Figure 2c shows Histogram equalization before and after. Image enhancement will certainly improve the visibility of the region of interest. That can be clearly seen in figure 2c, where disease affected part is clearly visible and highlighted. The graphs clearly indicate redistribution of intensity components uniformly after applying histogram equalization.

Figure 2a: Original Image and background removed

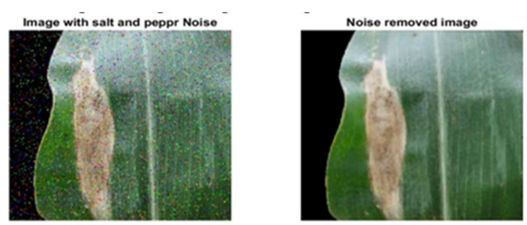


Figure 2b: Image after Noise removal

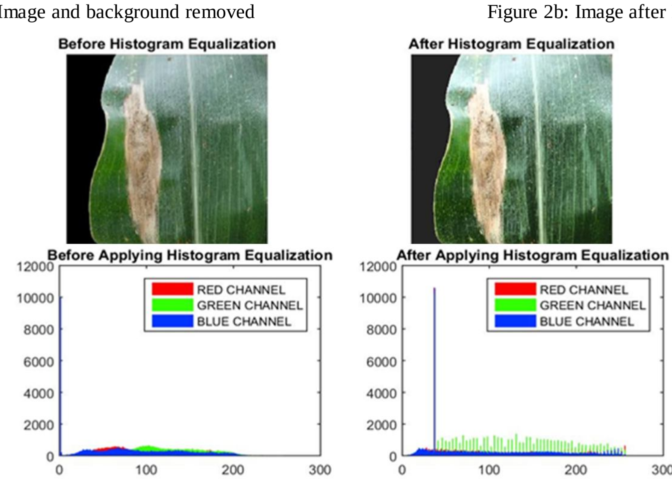


Figure 2c : Histogram equaliza

Using binarization, total pixels present on the leaf are determined as area in terms of pixels. The same value will be used to find severity.

C. Segmentation

A decisive step where region of interest is determined. Since it has significant role to play, one should be careful enough to choose suitable method. Thresholding, binarization and k-means clustering etc are the available techniques. K-means clustering has been implemented in the proposed work where five (k=5) clusters are used to select the region of interest.

It is one of the most widely used segmentation algorithm as far as image processing is considered. This algorithm computes centroids repeatedly until an optimal is found. Initially we should know the number of clusters to be made and it is denoted by K. Elbow method is the best practice used to select K value. Euclidian distance between data points and centroids is calculated to assign the data points to the clusters. It is essential to note that reduced diversity within clusters leads to more identical data points within the same clusters. The same process is used in the proposed work.

Steps in K-means algorithm[16].

1. Start with K centroids by putting them at random place. Here K=5.
2. Compute distance of every point from centroid and cluster them accordingly.
3. Adjust the centroids so that they become center of gravity for given cluster.
4. Again re cluster every point based on their distance with centroids.
5. Again adjust centroids.
6. Re compute the centroids and repeat this till data points stops changing clusters.

D. Select Region of Interest

Segmentation results in images having region of interest. To find the severity, one should cleverly choose the images having the diseased part. In the proposed work, five clusters are being created for better visibility and accuracy. Since color and surface of leaf varies depending on the disease, in most of the cases no single cluster consists of unhealthy part. So we need to select more than one cluster to get total area of diseased leaf and their corresponding binary images are created to calculate the area in terms of pixels. Finally severity will be calculated by the same pixels obtained.

Percentage of affected area is calculated by dividingdisease affected area found in select region of interest stage by the total leaf area found in preprocessing stage in terms of pixels. It is given in equation 3.

$$\text{Percentage of affected area} = \frac{\text{Total Disease affected area}}{\text{Total leaf area}} \tag{3}$$

E. Severity detection

Depending on the amount of area affected, one can easily find the severity. Severity will guide the user to take appropriate action to prevent further loss in the crop. The proposed work uses fuzzy logic to estimate the total area affected and to find the severity as given in table I. In fuzzy logic output will be decided based on the assumptions and sets. To calculate the severity, Horsfall and Heuberger values are referred [11].

At later stage of our work ImageJ tool, which is an image processing tool to validate results obtained from the proposed method, is used. Accuracy can be compared by keeping ImageJ as bench mark or a standard measurement. For certain images K-means with fuzzy logic method provides better results compared to imageJ.

TABLE 1. SEVERITY MEASUREMENT

Severity Grade	Percentage of leaf affected area
0	0%
1	0-25%
2	26-50%
3	51-75%
4	75%

ImageJ tool

ImageJ is an open source tool to deal with image analysis process [17]. In this work we have used ImageJ to find the total area of the leaf and disease affected area manually. ImageJ is loaded with number of color thresholding methods to segment the image where we could select region of interest. In this process we have used Otsu's, Mean and triangle segmentation methods to measure the total leaf area. Here we could able to see better results using HSI color space. To select disease affected part ROI tool used. As a first step total leaf area is selected in pixels and in second step disease affected areas are calculated using HSI color space. If image is having multiple regions of disease affected part then ROI tool is used. Later using simple mathematical formula as given in equation 3, total affected area is calculated. Process is depicted as in figure 3.

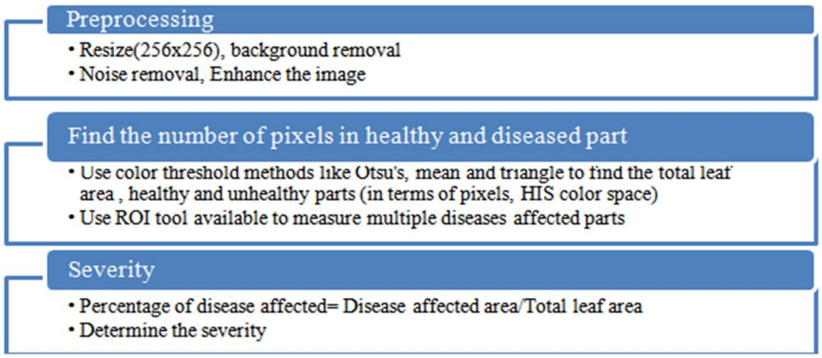


Figure 3: ImageJ to find disease affected area.

IV. EXPERIMETAL RESULTS AND ANALYSIS

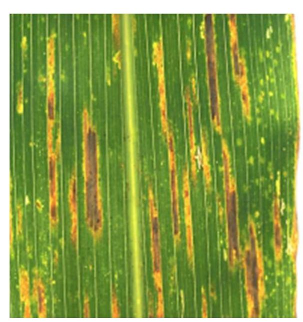
In the proposed work, paddy and maize leaves with various diseases are tested and validated. We have collected required data set from kaggle and from different farm lands in our neighborhood. In our experiment we have taken Maize crop leaf with diseases like corn blight, corn gray spot, common rust and paddy leaves with diseases like brown spot and leaf blast are considered. The experiment is conducted on more than 300 images of maize and paddy leaves together. Some samples are considered here for discussion as shown in the following tables. Diseased leaf images are from different stage of growth. Table II gives the number of leaf images considered for our work.

TABLE II: DATA SET COLLECTION

Disease Name	**Number of images**
Corn Blight	1250
Corn Grey Spot	700
Corn Common Rust	1300
Paddy Brown Spot	450
Paddy Leaf Blight	650
Healthy Corn	1200
Healthy paddy	1200

Sample paddy and maize leaf with most common diseases are given in figure4. From images we can say that some disease is restricted to certain part of the leaf (Corn blight) but some are distributed all over the leaf area (Corn grey Spot). Even some leaves are affected by multiple diseases which are very difficult to process.

Corn Blight



Corn Grey Spot

Corn leaf with multiple disease

Corn Common Rust

Paddy Leaf Blast

Paddy Brown Spot

Figure 4: Maize and Paddy crop leaf diseases.

Results can be analyzed in two cases, first case is where disease affected part is completely visible in only one cluster. In second case, unhealthy part is visible in more than one cluster. This variation occurs because of texture and intensity of the diseases affected part in leaf.

Case 1

As shown in the figure 5, a preprocessed paddy leaf with blast disease is taken and applied to the proposed method. The disease affected area appears in cluster 3. Using fuzzy logic method, percentage of disease affected area is calculated and in turn severity is determined as indicated in the same figure.

When we take the same leaf image and using ImageJ tool, diseased area and total leaf area are measured as shown in the figure 6. HSI color space is used and Otsu's color threshold technique is applied to measure the total leaf area in terms of pixels. Upon using ROI tool available with ImageJ, we could easily determine the disease affected area.

When we compare the results obtained, one can notice a significant similarity. A detailed comparison of results is given in the subsequent part of the paper.

Case 2

Corn blight disease affected leaf is taken and to find the diseased parts, multiple clusters are considered. Figures 7a and 7b show disease affected areas and corresponding binary images in two different clusters. Finally using fuzzy logic severity is calculated. Figures 7c and 7d show the results using imageJ tool.

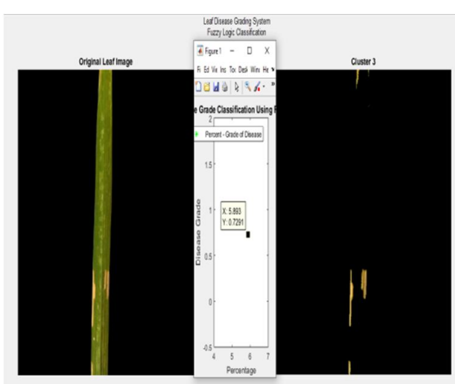


Figure 5: Paddy leaf blast disease using k-means+Fuzzy logic.

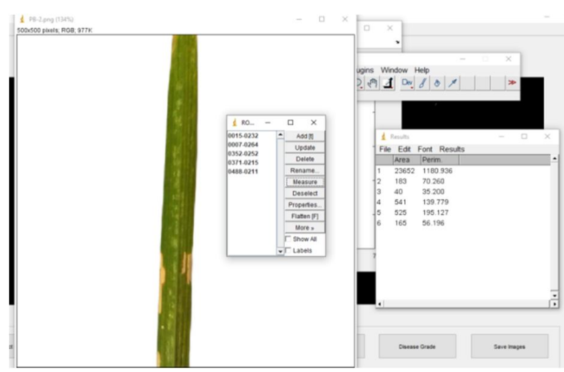


Figure6: Paddy leaf blast disease using ImageJ.

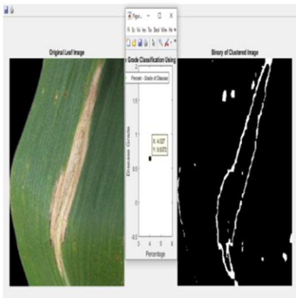
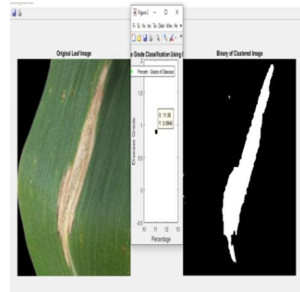
 

Figure 7a and 7b: Corn leaf blight disease using k-means+Fuzzy logic.

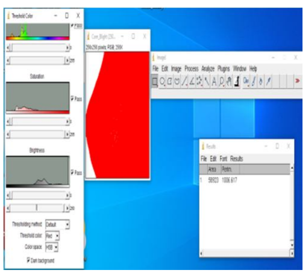
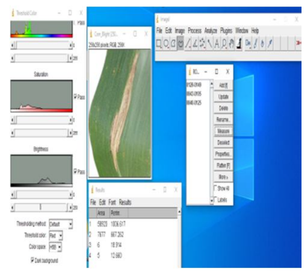
 

Figure 7c and 7d: Corn leaf blight disease using ImageJ.

Figure 8a to 8e shows a series of actions done to calculate the severity of the disease in the given maize leaf using the proposed method.

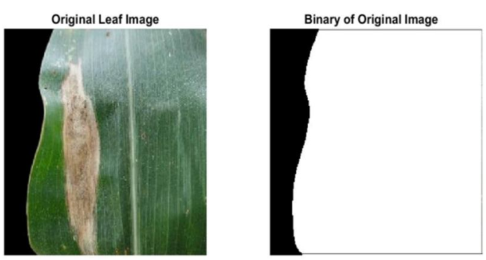


Figure 8a and 8b: original image and its binary

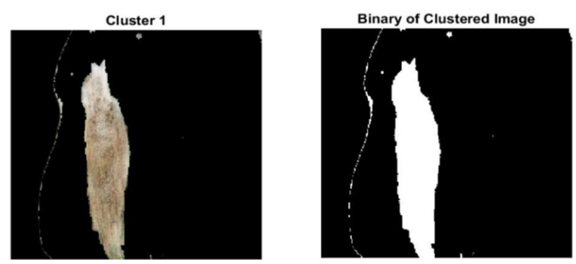


Figure 8c and 8d: Segmented part in cluster 1and its corresponding binary

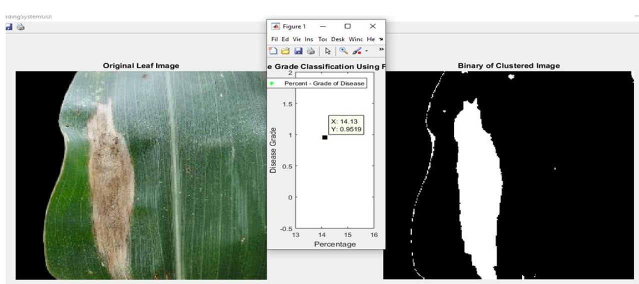


Figure 8e: severity of the diseases

To save the space, only part of the result analysis is taken for explanation. From table III, we can observe the proposed method gives disease affected parts in different clusters. Some diseases are present in only one cluster and some are in more than one cluster. It is evident in 5th and 7th row respectively.

TABLE III: SEVERITY MEASUREMENT USING K-MEANS PLUS FUZZY LOGIC

Sl. No.	Image Name	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	% of Affected Area
K-means+Fuzzy Logic							
1	Corn-blight-250	-	4.047	11.08	-	-	15.127
2	Corn-blight-265	-	6.089	2.936	-	-	9.025
3	Corn-blight-311	-	14.13	-	-	-	14.13
4	Corn-blight-351	-	-	12.88	-	-	12.88
5	Corn-blight-465	-	-	-	-	4.744	4.744
6	Brown-Spot	-	4.638	4.323	-	-	8.961
7	corn-gay-spot	-	11.53	10.9	-	7.652	30.082
8	corn-gay-spot(22)	-	13.55	-	10.03	-	23.58
8	Corn-gray-spot(570)	-	-	-	13.56	7.3	20.86
9	Corn-gray-spot(28)	-	14.91	20.6	-	-	35.51
10	Corn-common-rust(244)	-	-	-	14.28	-	14.28
11	Paddy-brown-spot-1	-	-	6.8	-	-	6.8
12	Paddy-brown-spot-2	-	-	-	-	2.876	2.876
13	Paddy-brown-spot-6	-	-	-	-	-	-
14	Paddy-brown-spot-7	-	-	-	-	-	-
15	Paddy-leaf-blast-2	-	-	5.893	-	-	5.893
16	Paddy-leaf-blast-3	-	20.62	-	-	14.69	35.31

Table IV gives a glimpse on results of severity measurement using ImageJ tool. Column 3 gives total leaf area in terms of pixels as explained in figure 7c. Column 4 and 5 give disease affected area and percentage of affected area in terms of pixels respectively as explained in the figure 7d.

TABLE IV: SEVERITY MEASUREMENT USING IMAGEJ

Sl. No.	Image Name	Leaf Area	Affected Area	% of Affected Area
ImageJ				
1	Corn-blight-250	58923	7688	13.04753662
2	Corn-blight-265	60264	5380	8.927386168
3	Corn-blight-311	65536	8880	13.54980469
4	Corn-blight-351	39257	4985	12.69837226
5	Corn-blight-465	65536	2940	4.486083984
6	Brown-Spot	200236	17164	8.571885175
7	corn-gay-spot	68100	20665	30.34508076
8	corn-gay-spot(22)	535207	124130	23.19289546
8	Corn-gray-spot(570)	87120	17154	19.69008264
9	Corn-gray-spot(28)	93450	32908	35.21455324
10	Corn-common-rust(244)	32014	4539	14.17817205
11	Paddy-brown-spot-1	51282	3485	6.795756796
12	Paddy-brown-spot-2	19972	539	2.69877829
13	Paddy-brown-spot-6	39063	1473	3.770831733
14	Paddy-brown-spot-7	31089	341	1.096850976
15	Paddy-leaf-blast-2	23652	1454	6.147471673
16	Paddy-leaf-blast-3	22715	7932	34.91965661

Table V gives comparison between the proposed method and ImageJ tool. From the table one can say about similarity between percentages of disease affected part. If we consider ImageJ as benchmark or a standard method then we could say a remarkable result obtained by using K-means clustering plus fuzzy logic method as shown in the table V. Our proposed method gives a total of 97% accuracy.

TABLE V: COMPARISON BETWEEN TWO METHODS

Sl. No.	Image Name	% of Affected Area (ImageJ)	% of Affected Area(K-means+ Fuzzy logic)	Severity
1	Corn-blight-250	13.04753662	15.127	1
2	Corn-blight-265	8.927386168	9.025	1
3	Corn-blight-311	13.54980469	14.13	1
4	Corn-blight-351	12.69837226	12.88	1
5	Corn-blight-465	4.486083984	4.744	1
6	Brown-Spot	8.571885175	8.961	1
7	corn-gay-spot	30.34508076	30.082	1
8	corn-gay-spot(22)	23.19289546	23.58	1
8	Corn-gray-spot(570)	19.69008264	20.86	1
9	Corn-gray-spot(28)	35.21455324	35.51	2
10	Corn-common-rust(244)	14.17817205	14.28	1
11	Paddy-brown-spot-1	6.795756796	6.8	1
12	Paddy-brown-spot-2	2.69877829	2.876	1
13	Paddy-brown-spot-6	3.770831733	---	1
14	Paddy-brown-spot-7	1.096850976	---	1
15	Paddy-leaf-blast-2	6.147471673	5.893	1
16	Paddy-leaf-blast-3	34.91965661	35.31	2

VII. CONCLUSIONS

In the proposed work leaf disease affected area and severity detection is introduced. 3 diseases of maize and 2 diseases of paddy leaves are considered. Image resizing, background removal, noise removal using median filter, contrast enhancement using histogram equalization are used as preprocessing methods. K-means clustering is used for segmentation and fuzzy logic technique is used to find the total area affected and severity. Ultimately the proposed method is validated against standard image processing tool ImageJ. Finally the proposed work is providing an accuracy of 97%. There could be always room for improvement; a hybrid technique where several features can be combined may help to get even better accuracy

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