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Detection and Classification of Ring, Rust and Yellow Sugarcane Leaf Diseases

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Abstract*: Agriculture is an important sector in Economic and Social life. Crop disease detection is an emerging field in India. We can minimize the diseases infection on sugarcane leaf by detecting and grading the leaf disease in early stages. In this paper, we are detecting and recognize Sugar cane leaf diseases by using grey scale and color image processing and analyze the efficacy by comparing both. In grey scale processing, we presented Gradient Magnitude, Otsu method, Morphological Operations and Normalization to extract the Region of interest (ROI) i.e., disease part. In color processing initially converted RGB to L*a*b format, later K-means clustering and edge detection operations are applied on L*a*b image format. The features of Grey scale & color processed image are extracted and feed to Support Vector Machine (SVM) classifier which classifies ring, rust & yellow spot sugarcane leaf diseases. The Sugarcane leaf diseases are classified successfully with an average accuracy of 84% & 92% for grey scale & color features respectively.

Keywords*: Color Processing, Gradient Magnitude, Grey Scale Processing, K-means clustering, Normalization.

I. INTRODUCTION

About 58% of Indian populations the main source of income or livelihood is agriculture. Rs. 17.67 trillion (USD 274.23 billion) Gross Value Added (GVA) by agriculture, fishing & forestry in financial year 2018 [1].

The Indian food and grocery market is the world's sixth largest, with retail contributing 70% of the sales. The Indian food processing industry accounts for 32% of the country's total food market, one of the largest industries in India and is ranked fifth in terms of production, consumption, export and expected growth. It contributes around 8.80 and 8.39 per cent of GVA in Manufacturing and Agriculture respectively [1].

In India farmers are called the backbone of India. Agriculture is the major income for farmers, they are dependent on agricultural production and income. Global warming is the major problem in world, growing plants and trees are one of the solution to reduce the global warming.

Malnutrition causes the crop failure directly and the infectious disease spread and environmental damages causes the crop failure indirectly, crop failure maybe loss of yield or the quality of crop. Plant diseases are drastically spread among surrounding plants, this effects the production of crop yield and also the quality of crop, the loss of crop yield effects the financial stage of farmers intern the country economy. Around 15% sugarcane is defected by leaf diseases [3]. We can minimize the diseases infection on sugarcane leaf by detecting and grading the leaf disease in early stages.

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(a)


(b)


(c)

Fig. 1. Major three sugarcane leaf diseases. (a) Sugarcane ring spot disease. (b) Sugarcane rust disease. (c) Sugarcane Yellow Leaf Disease.

In India there are around 50 different types of sugarcanes are cultivating, there are more than 30 different types of sugarcane diseases. Farmers are forced to change the type of sugarcane in many parts of world, even in India changing type of sugarcane forcefully whenever pathogen number increases. There are more than 100 fungi, 50 species of roundworm or threadworm, 10 viruses and 10 bacteria [6]. Usually these pathogens are in upper hand whenever farmers try to cultivate sugarcane to achieve more production in small or limited area with maximum plants. The spots appears on sugarcane leaf mainly caused by fungi diseases and they are predominant diseases caused by fungi [4].

Ring spot is a minor fungal disease principally affecting the lower leaves of the sugarcane canopy shows in Fig. 1(a). Symptoms are well defined circular lesions on the older leaves. Lesions are straw colored in the center with a darker grey-brown margin bordering on the green leaf tissue. Lesions vary considerable in size and shape. The disease occurs commonly in all cane growing regions but has rarely, if ever, been of economic concern [5].

Sugarcane rust disease is another major disease, rust pathogen spread over the neighbouring sugarcane crop rapidly in warm temperature & in high humidity through wind and water. Initial symptoms are small, extended yellowish spot & it's visible on both side of the leaf. Later,

size of the spot increases in length, gradually color of the spot will turn brown from red-brown, around these spot it creates pale yellow-green circle of shadow. In severe case, it turns to brown or rusty appearance on individual leaves shown in Fig. 1 (b), due to this causes the severe loss of crop.

Sugarcane Yellow Leaf Diseases (SCYLD) effects on the 5 to 6-month crop [8]. Usually spreads in dry weather condition, in India during the period from October to till March or end of the harvest. Initially yellowing of leaf appears on 3-6 leaves from the top in midrib & in bottom side as shown in Fig. 1(c). Further, it spreads from midrib to leaf blade based on the season changes. The yellowing is noticeable and most predominant in mature sugarcane [7].

Kartika Dewi & Ginardi [2], identified and extracted few features to classify sugarcane rust disease. Initially, datasets are collected, it contains normal and rust disease images, applied pre-processing techniques. Further, extracted shape, color & texture features. These features are feed to SVM classifier to classify the disease and normal leaf. We have selected appropriate & several combination of features to identify the rust disease.

A system to identify leaf spot diseases based upon spot segmentation techniques is presented in [3]. L*a*b format color space images are used to segment spots by calculating threshold a*. Maximum standard deviation features, color features & GLCM features are extracted to classify different type of leaf spot diseases using SVM classifier.

Sugarcane leaf spot diseases are caused by fungi, these are predominant and effect the crop yield if not treated in-time [4]. The harvesting cost will increase in use of pesticides for diseases treatment, and also cause the environment. A system to categorise the diseases in leaf, initially, simple & triangle Thresholding techniques are applied to segment the leaf & lesion area respectively in [5]. Finally, quotients are calculated for lesion & leaf area to categorise diseases.

The Speeded-Up Robust (SURF) are used to detect classify ring, rust and yellow sugarcane leaf diseases in [10]. Fuzzy set extended form neutrosophic logic based segmentation technique is used to evaluate the region of interest in [11].

In this paper we proposing an image recognition system that can detect, recognize Sugar cane leaf diseases by using grey scale and color image processing and analyze the efficacy by comparing both. SVM classifier is used to classify the diseases into three distinct classes like ring, rust and yellow leaf diseases.

II. THE PROPOSED SYSTEM

The proposed system is shown in Fig. 2. The proposed system mainly consists of two sections. In Section-1 we classifying Ring, Rust and yellow spot leaf diseases in sugar cane leaf using grey scale image & features. Initially, the gradient magnitude, Otsu Thresholding, Morphological operators, Normalization has been invoked for segmenting the images by partitioning it into 8 clusters & to get Region of interest. Further GLCM features are extracted from segmented image using boundary detection algorithm. These features defines the properties like color, shape & texture of the disease part or the segmented region. These features are passed to Support Vector Machine classifier, where the image is trained using SVM algorithm to recognize and to classify the disease.

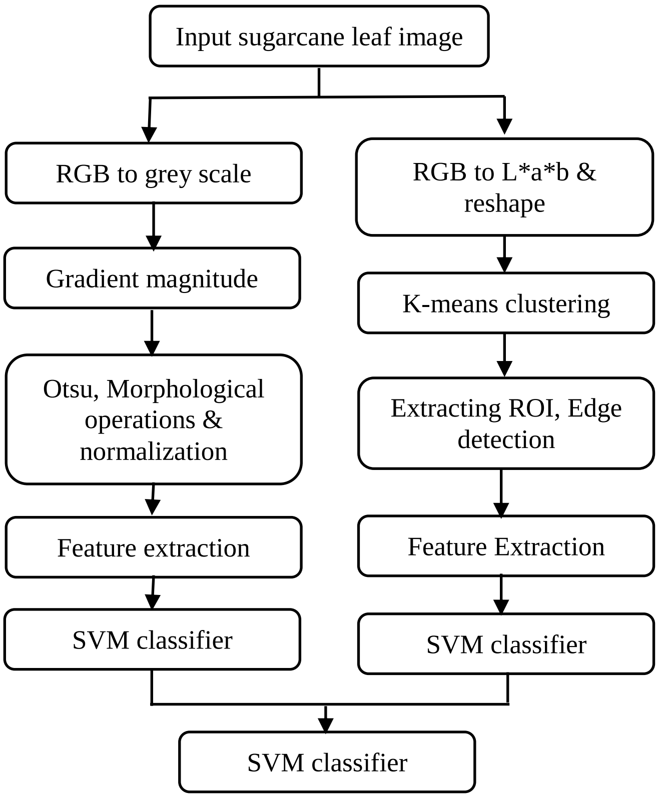

Fig. 2. The Proposed System.

In Section-II, we classify Ring, Rust & Yellow Spot diseases in sugar cane leaf by using color image processing & features. Initially we convert the RGB format image to L*a*b format, further, we applied K-means clustering to cluster the disease and non-disease part, then Extract the Region of Interest (ROI) and edge detection using Sobel edge detection, Finally, Extract the features and feed these feature to SVM classifier to classify the diseases as like in Section-I.

A. Gradient Magnitude

The gradient magnitude is the process to identify directional change in intensity & color of an image, and it is best suited to extract the information from images. Gradient imaging is the process of measure the intensity changes in given direction for every pixel at the same point in original image. Gradient image is used in our proposed system to get the texture and feature of the disease part.

B. Otsu Thresholding

The Otsu Thresholding algorithm used calculate the threshold value to convert grey scale or to binary format. We can consider two classes or more than two. In our proposed system we considered 8-level Thresholding and select level that gives best ROI.

C. L*a*b color format

The *L*a*b* color space describes mathematically, all perceivable colors in the three dimensions *L* for lightness and '*a*' & '*b*' for the color opponents green–red and blue–yellow. *L* component closely matches human perception of lightness, Thus, it can be used to make accurate color balance corrections by modifying output curves in 'a' and '*b*' components, or to adjust the lightness contrast using the *L* component. In our system we convert RGB color input image to L*a*b format to match and to supress the background in input image.

D. K-means Clustering

In K-means, k- clusters will be created based on the nearest mean, serving as a prototype of the cluster from the 'n' observations. In our proposed system we have considered k vale as 3, we clustering all observations into cluster, due to this it gives infected area, normal leaf area & the surrounding region of the infected area as shown in Fig. 4(f), (g) & (h) for sugarcane ring spot disease.

E. Feature Extraction

Feature extraction is important process in image processing, it is the process of converting image into image attribute based on the size, structure, texture & color of objects in an image. These features are used for classification purpose.

The feature we extracting in the proposed systems are listed below.

- *Mean:* The mean of an input processed image 'A' is calculated by using following equation:

$$\mu = \frac{1}{N}\sum_{i=1}^{N} A_i \quad (1)$$

- *Standard deviation:* Standard deviation of random variable vector A is calculated using following equation:

$$S = \sqrt{\frac{1}{N}\sum_{i=1}^{N} |A_i - \mu|^2} \quad (2)$$

Where N is the scalar observation & μ is the mean of image A as in (1).

- *Entropy:* Entropy is determined by:

$$e = \sum p.\log_2 p$$

Where p is the normalized histogram counts.

- *Variance:* Variance of random variable vector A is calculated using following equation [9]:

$$V = \frac{1}{N-1}\sum_{i=1}^{N} |A_i - \mu|^2$$

Where N is the scalar observation & μ-mean, as in (1).

- *Correlation coefficients:* Let A and B are the two random variables, the scalar observation N in each variable, then correlation coefficient is:

$$\rho(A,B) = \frac{1}{N-1}\sum_{i=1}^{N}\left(\overline{\frac{A_i - \mu_A}{\sigma_A}}\right)\left(\frac{B_i - \mu_B}{\sigma_B}\right)$$

Where, μ_A- mean of A, as in (1), μ_B- mean of B, as in (1). σ_A is standard deviation of A, as in (2), σ_B is standard deviation of B, as in (2).

The correlation coefficient matrix of two random variables is:

$$R = \begin{pmatrix} \rho(A,A) & \rho(A,B) \\ \rho(B,A) & \rho(B,B) \end{pmatrix}$$

Since *A* and *B* are directly correlated to themselves, the diagonal elements are 1, i.e.,

$$R = \begin{pmatrix} 1 & \rho(A,B) \\ \rho(B,A) & 1 \end{pmatrix}$$

- *Contrast:* It differentiate or distinguish objects by differing the color or luminance of object in an image.
- *Kurtosis:* The normal distribution for kurtosis three. If the kurtosis is greater than three, then the distributions will be having more outlier prone than normal kurtosis, if kurtosis is less than three then distribution will be having less outlier prone. The kurtosis (k) of a distribution is:

$$K = \frac{E(\chi - \mu)^4}{\sigma^4}$$

Where, μ is mean of *x*, σ is standard deviation of *x*, and *E*(*t*) is the quality t with the expected values.
If flag is 1, then:

$$K_1 = \frac{\frac{1}{n}\sum_{i=1}^{n}(\chi_i - \bar{\chi})^4}{\left(\frac{1}{n}\sum_{i=1}^{n}(\chi_i - \bar{\chi})^2\right)^2}$$

If flag is zero (0), then:

$$K_0 = \frac{n-1}{(n-2)(n-3)}\left((n+1)k_1 - 3(n-1)\right) + 3$$

X- Minimum of 4-elements.

- *Skewness:* is the process of identify the skewness of asymmetry of data moving over the sample mean. For negative skewness, data is distributed along the left side of mean, for positive skew value, the data is distributed along the right side of mean. If it is zero, then it's a normal distribution.
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- *Skewness:* is the process of identify the skewness of asymmetry of data moving over the sample mean. For negative skewness, data is distributed along the left side of mean, for positive skew value, the data is distributed along the right side of mean. If it is zero, then it's a normal distribution.
The skewness distribution is:

$$S = \frac{E(\chi - \mu)^3}{\sigma^3}$$

If flag is set to 1, skewness is:

$$S_1 = \frac{\frac{1}{n}\sum_{i=1}^{n}(\chi_i \bar{\chi})^3}{\left(\sqrt{\frac{1}{n}\sum_{i=1}^{n}(\chi_i - \bar{\chi})^2}\right)^3}$$

If flag is set to 0, skewness is:

$$S_0 = \frac{\sqrt{n(n-1)}}{n-2} S_1$$

X contain minimum of 3 elements.

- *Root mean square(RMS):* The root-mean-square level of a vector, *X*, is :

$$X_{RMS} = \sqrt{\frac{i}{N}\sum_{n=1}^{N}|X_n|^2}$$

With the summation performed along the specified dimension.

- *Homogeneity:* Homogeneity is the inverse of contrast. Homogeneity is the checking and measuring non-zero entries of GLCM.

$$H = \sum_{ij} \left(\frac{1}{|1-(1-j)2|} \right) * P(i,j)$$

- *Smoothness & IDM (Inverse Difference Moment)*
The IDM is:

$$IDM = \sum \left(\frac{P(i,j)}{[1+(i-j)*2]} \right)$$

If the contrast of is less, then the IDM value is negative. If the image uniformity is more then it shows positive value. Where P(i, j) is the GLCM matrix, 'i' & 'j' are the grey level intensities.

- *Energy:* Energy E is described as below equation:

$$E = \sum_{ij} p(i,j)^2$$

F. Classification

Classification in image processing is the process of categorise the images into different categories using the various image features and data. Classification has two stages, training and testing. In training stage, the images features are trained with unique properties, based on these properties each categories are labelled with unique description, in other-words, it creates training classes. In testing phase, the extracted features from new incoming data will be classify with the same unique properties.

Classifying data has been one of the major parts in machine learning. We have used SVM classifier to classify the three major sugarcane leaf diseases like ring, rust & yellow spot.

III. EXPERIMENTAL RESULT

We obtained the output image using the proposed image processing techniques and the results produced by the application system are: It finds the disease that the leaf is affected with by classifying them to three disjoint classes and also it finds the accuracy of the SVM classifier i.e. how accurate it was in classifying the features of image.

Table- I: Extracted features from infected Region using grey Scale Image Processing

Feature	Img1_Ring	Img2_Rust	Img3_YellowSpot
Contrast	2.86134	0.834444444	1.750442774
Correlation	0.229696	0.897219309	0.829144339
Energy	0.869208	0.69356692	0.590986581
Homogeneity	0.948905	0.942143394	0.890108834
Mean	0.0393066	0.10971506	0.144948845
Standard Deviation	0.194325	0.295394564	0.332269523
Entropy	0.239104	1.847616014	2.404658414
RMS	0.153332	0.310944272	0.339838952
Variance	0.0348386	0.086337867	0.099300689
Smoothness	0.999612	0.999924051	0.999942512
Kurtosis	23.4819	7.648848119	5.439798126
Skewness	4.74151	2.475031634	2.002548922
IDM	25.1549	121.155665	178.1363042

The results are to illustrate that, the algorithm can automatically detect, classify three major sugar cane leaf diseases, we have taken 55 (19+20+16) images, where 19, 20 and 16 were Rust disease, Ring disease and Yellow disease images respectively. 30 Training data sets were used to train the SVM classifier, where 12-images belongs to Rust disease 10-images belongs to Ring disease and 8-images belongs to Yellow disease. The remaining 25 images are used for testing and analyze result.

Table- II: Extracted features from infected Region using Color Image Processing

Feature	Img1_Ring	Img2_Rust	Img3_Yellow Spot
Contrast	0.106484484	0.072595337	0.0774587
Correlation	-0.030610124	0.37312431	0.212906374
Energy	0.801532671	0.816869834	0.830130114
Homogeneity	0.946757758	0.963702331	0.96127065
Mean	0.054502115	0.061622453	0.051887735
Standard Deviation	0.227007547	0.240470405	0.221802063
Entropy	0.30522218	0.333852064	0.294362437
Variance	0.04752527	0.057513676	0.046998035
Smoothness	0.999717913	0.999750499	0.999703704
Kurtosis	16.40555579	14.29352041	17.32710442
Skewness	3.924991183	3.646028032	4.040681182
IDM	30.94951055	54.31413233	47.27797356

Table- III: Performance Analysis

Types of Diseases	Accuracy	
	Grey Scale Processing	Color Image *Processing*
Ring	85.71	85.71%
Rust	80.0%	90%
Yellow	87.5%	100%
Average	84%	92%

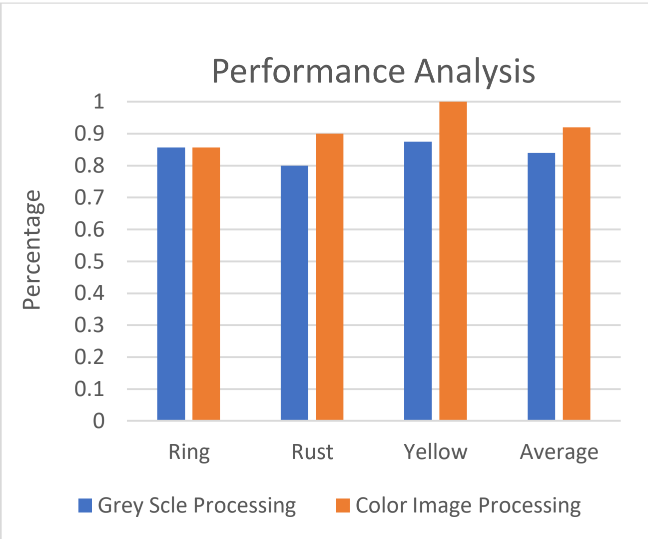

Fig. 3. Performance Analysis between grey scale & color image processing technique.

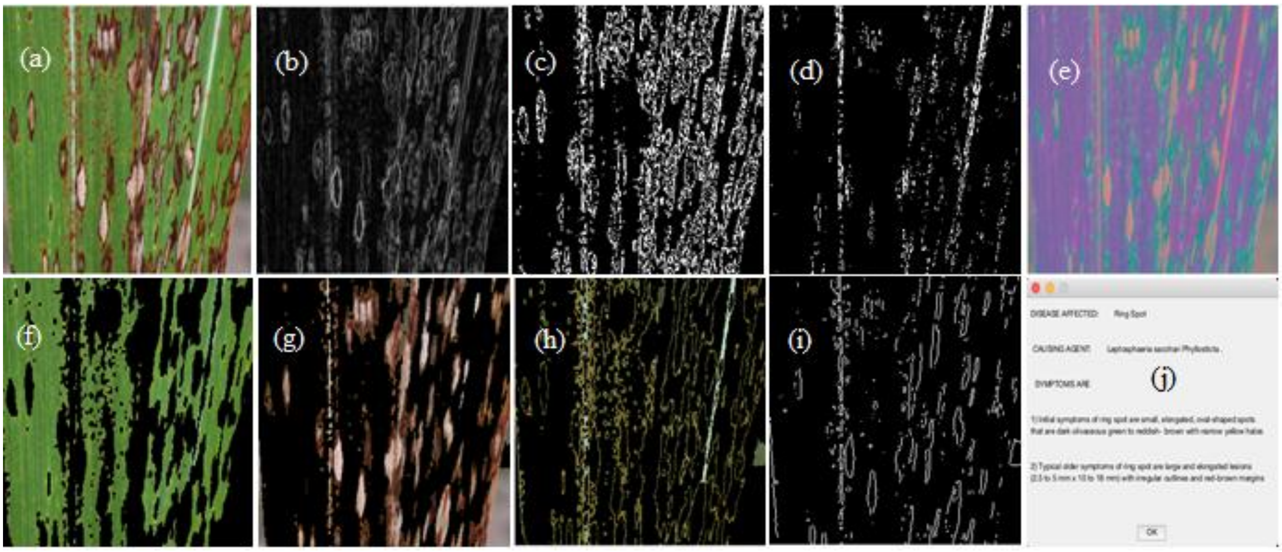

Fig. 4. Experimental Result for Sugarcane Ring Spot Disease. (a) Input Image. (b) Gradient magnitude. (c) Disease detection (ROI) using Otsu thresholding. (d) After morphological & normalization. (e) L*a*b format. (f) (g) & (h) K-means clustered images (3-clusters) (i) Edge detection of ROI (j) Classification using SVM classifier.

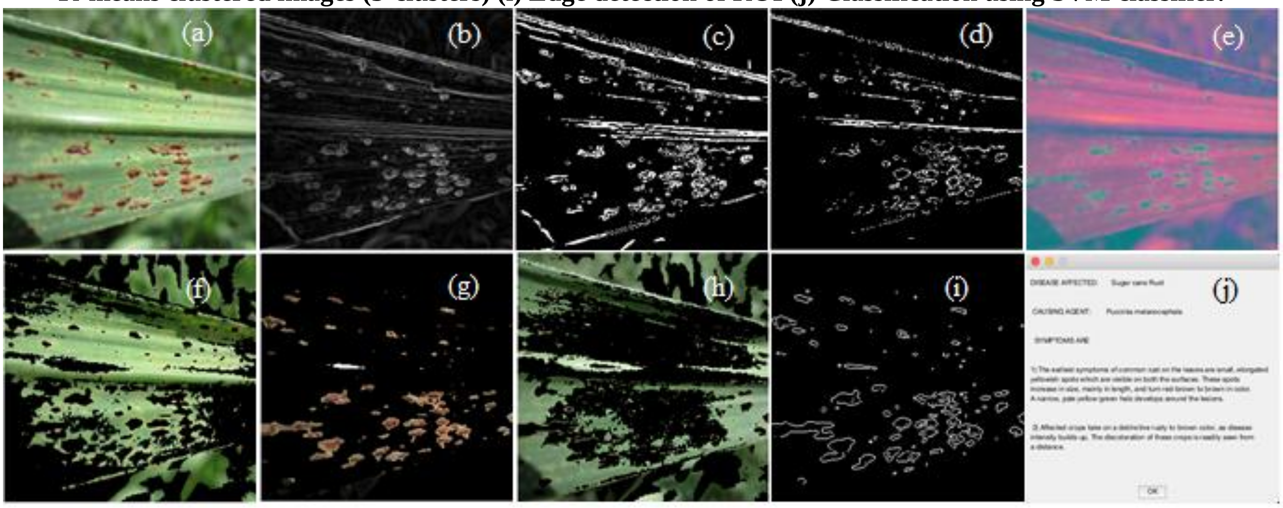

Fig. 5. Experimental Result for Sugarcane Rust Disease. (a) Input Image. (b) Gradient magnitude. (c) Disease detection (ROI) using Otsu Thresholding. (d) After morphological & normalization. (e) L*a*b format. (f) (g) & (h) K-means clustered images (3-clusters) (i) Edge detection of ROI (j) Classification using SVM classifier.

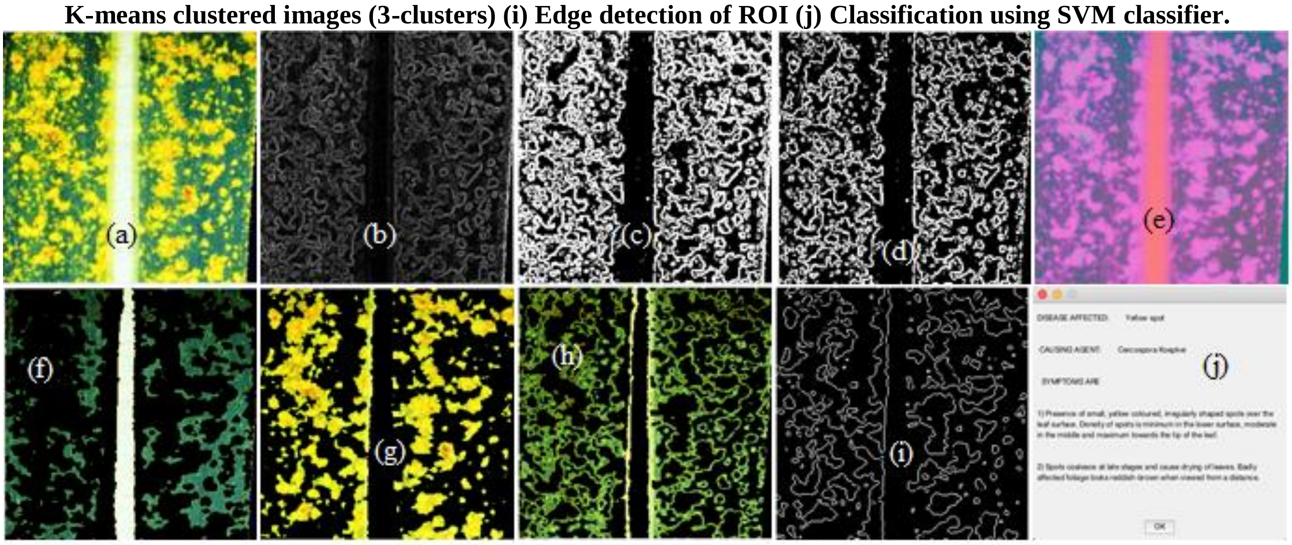

Fig. 6. Experimental Result for Sugarcane Yellow Spot Disease. (a) Input Image. (b) Gradient magnitude. (c) Disease detection (ROI) using Otsu Thresholding. (d) After morphological & normalization. (e) L*a*b format. (f) (g) & (h) K-means clustered images (3-clusters) (i) Edge detection of ROI (j) Classification using SVM classifier.

The number of truly detected sugarcane leaf disease images using grey scale and color image processing techniques are 21 and 23 respectively. The features extracted for grey scale processing & color image processing are shown in TABLE I & TABLE II respectively.

The experimental results for ring, rust & yellow leaf diseases by using grey scale image processing are shown in Fig. 4, Fig. 5 and Fig. 6 respectively. The accuracy of the proposed system is evaluated by using following equation:

$$Accuracy = \frac{No.of\ truly\ detected\ Disease\ Images}{No.of\ Images\ used\ for\ training}$$

The efficiency of the proposed grey scale and color processing to classify sugarcane leaf diseases is shown TABLE III & the graph for respective analysis is shown in Fig. 3. The experimental results show that the features extracted from the color processing gives better classification than the grey scale processing to detect sugarcane leaf diseases.

IV. CONCLUSION

Detection of plant diseases using automation tools will reduce the human errors. The proposed system detects, extract and recognize sugarcane leaf diseases by using grey scale and color image processing analyze the efficacy by comparing both. The experimental results show that the features extracted from the color processing gives better classification than the grey scale processing to detect sugarcane leaf diseases. Yellow leaf disease detection in color processing achieves 100% accuracy because of ample difference with features, ring and rust leaf disease classification accuracy is varying from 80% to 90% in grey scale and color processing because of similarity between both diseases. An undiscovered combination of pre-processing techniques to detect & to extract the region of interest i.e., disease part and feature extraction and selection can be explored to improve the classification accuracy

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