Classification of Rice Blast, Brown Spot, Leaf Blight and Hispa Paddy Leaf Diseases in Transformed YUV Color Space

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Abstract

Paddy is one of the major crops in India.The various leaf diseases affect the crop yield and it is difficult to detect these diseases efficiently by farmers with their limited knowledge. These diseases directly or indirectly affect paddy crop yield. To ensure better yield, it is more essential to detect and classify diseases with prior time. In this paper, we are proposing a system that detects and classify paddy leaf diseases by using YUV color space. Initially, the input RGB color space image is transformed to YUV color space, further converted to binary image by eliminating false positive using proposed Binary conversion and segmentation in YUV color space, extracted disease infected region boundary by applying Maximum Gradient Difference (MGD) and sobel operator. Further, we have extracted 13-features from segmented image and fed to Support Vector Machine (SVM) classifier, which classifies Healthy leaves, Rice Blast, Brown Spot, leaf Blight and Hispa paddy leaf diseases. The proposed system trained and tested on the Rice Diseases Image Dataset: collected from Kaggle along with our own dataset. The proposed system gives accuracy of 94.64%, 92.59%, 93.61%, 88.23% and 97.84% for Brown Spot, Leaf blast, Hispa, Leaf blight and Healthy leaves respectively for combined dataset (Kaggle dataset+ our own dataset), it is noticed that the larger the dataset for SVM classifier, better in accuracy.

Keywords: Binary conversion, Crop yield, Maximum Gradient Difference, Support Vector Machine (SVM), Kaggle Dataset.

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Introduction

Agriculture is one of the most important sectors of Indian Economy. India's agriculture sector accounts: 14% of the country's economy, 42% of total employment, 55% of India's arable land depends on precipitation. Major Crops in India: Rice, Sugarcane, Wheat, Tomato, Potato, Onion, Mango, Cotton, Beans, Coconut and etc., India is second largest production of milled rice in 2018-2019 crop year, i.e., 116.42 million metric tons [5]. Paddy is dominant crop & the pre-eminent crop in India, Rice is essential and principal food for the people of southern and eastern parts of India. Rice requires a temperature of around 25 degrees Celsius and more than 100cm of rainfall.

Indian agriculture is known for its divergence. Variation in resource, climate and historical, institutional and socio-economic factors. The weather conditions, diseases and pests are major impact on yield and also the planning of harvest. Malnutrition,

environmental damages and disease spread are the major factors for crop failure directly or indirectly. Disease spreads drastically among the neighboring plants due to the wind speed, direction and weather conditions. Increase in plant disease severity level leads to loss in crop yield and quality, this impacts on financial stage of farmers and also Indian economy.Paddy is the one of the major crops in India, 52% of growth in exporting non-basmati rice in the first two months of fiscal year 2020. Globally, invasion in pest due to climatic conditions threatens the rice/paddy cultivation, this challenges in irrigated agriculture all over the world. Farmers are losing crop yield on average 37% estimated globally due to diseases and pests every year.Major Leaf Diseases of Rice are: leaf Blight, Brown Spot,Rice Blast, hispa and Smut. The rice crop yield loseas high as 70-80% due to rice blast diseases when predisposition factors like higher humidity (85-89%), high mean temperature, excessive nitrogen fertilization [6]. Quality and quantity losses affected by brown spot diseases. On average, 5% loss of rice yield in South and Southeast Asia, if severely infected, then it causes rice crop yield up to 45% lose [15]. Bacterial leaf blight is major leaf disease it may leads to yield lose is up to70% in favourable environment to disease, higher in yield lose if earlier in the disease infection [16]. 20% lose estimated in Bangladesh due to rice hispa disease [17] and around 10-15% of yield lose due to smut.

The detection and classificationof paddy leaf diseases plays animportant role in ensuring the high efficiency, high yield and high quality of rice directly or indirectly. The general process involved to detect leaf diseases automatically are: leaf image acquisition, pre-processing, binarization, segmentation, feature extraction and classification.Bakar et al., [1] proposed a integrated method to detect and categorize the rice leaf blast diseases, spreading and stage of disease. This proposed system consists pre-processing as HSV color space conversion, multi-level thresholding and segmentation, and classifying the diseases. Finally, severity level of leaf blast disease is estimated [1]. Nalini et al., [19] proposed paddy leaf disease detection in images using a novel deep neural network (DNN) model, in this model the region of disease infected area was extracted using thresholding and k-means clusteringtechnique has applied to remove the uninfected regions, Gray Level Co-occurrence Matrix (GLCM) features are extracted from preprocessed and segmented images and used DNN & crow search algorithm in training and fine-tuning process to classify paddy leaf disease images.

Ramesh and Vydeki [18] proposed Optimized Deep Neural Network with Jaya Optimization Algorithm (DNN_JOA) to recognize and classify paddy leaf disease like bacterial blight, sheath rot, blast and brown spot disease along with normal leaves. In preprocessing, the captured leaf images from the farm field will convert from RGB to HSV color space, the disease and non-diseased parts are extracted by converting hue and saturation part to binary image. The background clustering is used to segment the disease, normal portion and background. The color and texture features (GLCM) are extracted and used DNN_JOA to classify the paddy leaf diseases.Prajapati et.al., [2] proposed centroid feeding-based K-means clustering technique to classify three rice leaf diseases, they are, bacterial leaf blight, leaf smut and brown spot. The proposed k-means clustering removes the green pixels in the disease portion, further extracted features in color, shape and texture categories to classify leaf diseases by using Support Vector Machine as a classifier.The Convolutional Neural Network (CNN) model with transfer learning is presented to classify rice leaf diseases like leaf blast, leaf blight and brown spot. Data set is collected from farm field and internet [7].

Ahmed et. al., [8] presented a system to classify paddy leaf diseases (leaf smut, brown spot & leaf blight) using machine learning approaches. The dataset is trained with K-Nearest Neighbour (KNN), Naïve Bayes, J48-Decision tree and Logistic Regression techniques for classification. Ramesh&vydeki presented classification of rice blast infected leaf and healthy rice leaf using machine learning

algorithms. They have used 300 images for training and testing [9]. Pothen & Pai [10] proposed the classification of Bacterial leaf blight, Leaf smut and Brown spot diseased rice images. Segmented the disease images using Otsu's method, Histogram of Oriented Gradients (HOG) and Local Binary Patterns (LBP) features are used to classify rice leaf diseases using SVM.

Sudarshan S. Chawathe [11] provides automated system to classify rice plant diseases by analyzing photographs of rice leaves. The pipeline of image processing techniques to detect leaves and disease induced lesions in rice leaves. Dimensions, numbers, shape, color characteristics of lesions along with the intact portions of leaves are the features used to classify the disease using Deep convolutional neural networks (DCNNs).Phadikar and Sil [12] presented a software prototype to detect rice leaf diseases on infected image. Leaf images are captured using digital camera, uses Hue Intensity Saturation (HIS) model & Entropy based bilevel thresholding techniques are used to segment the infected region. Finally Self organizing map (SOM) neural network is the classifier used to classify the rice leaf disease. Suresha et. al., [13] proposed a method to detect the Blast and Brown spot diseases in rice leaves using global thresholding to conversion of color to binary or gray images and kNN classifier to classify the leaves diseases. Yao et. al., [14] presented an application to detect paddy diseases in early stage using image processing techniques. Texture and Shape features are extracted to classify paddy leaf blight, sheath blight and blast using SVM classifier.

Binarization and segmentation makes huge impact on classifying leaf diseases, extracting region of interest i.e., disease part in leaves makes direct impact on performance of classifying diseases. In this paper we are proposing a system to binarize and segment disease part in infected leaves in YUV color space, we have extracted GLCM features and SVM classifier to classify rice blast, brown spot, leaf blight, hispa and healthy leaves, detailed description is explained in proposed system section. In Experimental results section, we have discussed regarding datasets used for testing and training purpose, metrics used to evaluate the performance of proposed system and tabulated the accuracy of proposed system and compared with existing approaches.

Proposed System

In proposed system, it is detected and recognize paddy leaf diseases by using YUV color space. The proposed algorithm is described in Algorithm-1. In proposed system, we are using YUV color space processing and proposed binary conversion and segmentation technique to detect disease part in paddy leaf. GLCM features are extracted to classify Healthy leaves, Rice Blast, Brown Spot, Hispa and leaf Blight paddy diseases using SVM classifier. Each processing steps of proposed system is explained further in this section.

YUV color space: The brightness of the color (luminance/luma) is determined by 'Y' component and its rages from 0 to 255 in digital forms (or 0 to 1). The color (chroma) is determined by 'U' & 'V' components and ranges from -128 to 127 in signed digital form, 0 to 255 in unsigned digital form (or -0.5 to 0.5).

The conversion between RGB & YUV using following equation:

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.2126 & 0.7152 & 0.0722 \\ -0.09991 & -0.33609 & 0.436 \\ 0.615 & -0.55861 & -0.0563 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

This matrix multiplication is demonstrated has shown below.

$$\mathrm{Y} = \mathrm{T}(1,1) \times \mathrm{R} + \mathrm{T}(1,2) \times \mathrm{G} + \mathrm{T}(1,3) \times \mathrm{B} + \mathrm{yuvoffset}(1);$$
$$\mathrm{U} = \mathrm{T}(2,1) \times \mathrm{R} + \mathrm{T}(2,2) \times \mathrm{G} + \mathrm{T}(2,3) \times \mathrm{B} + \mathrm{yuvoffset}(2);$$
$$\mathrm{V} = \mathrm{T}(3,1) \times \mathrm{R} + \mathrm{T}(3,2) \times \mathrm{G} + \mathrm{T}(3,3) \times \mathrm{B} + \mathrm{yuvoffset}(3);$$

Where, T is the 3x3 matrix values shown in eq(1). yuvoffset = [16; 128; 128].

Binary Conversion and Segmentation: R, G and B-band images are converted to YUV color space. Y, U & V images are in grey scale, in this section we convert these Y, U & V images to binary format by considering threshold value 0.5.

Let B_Y is the binary image for Y space image, B_U is the binary image for U space & B_V is the binary image for V space. The final binary image i.e. B_{YUV} is evaluated by using Algorithm 1, the mathematical formulation for binary conversion is shown in following equation:

$$B_{YUV}(i,j) = \begin{cases} 1 & if\ B_Y(i,j)\ and\ B_U(i,j)\ and\ B_V(i,j) = 1 \\ 0 & else \end{cases}$$

Where, i& j are co-ordinate values.

Maximum Gradient Difference (MGD) is applied on B_{YUV} to connect disconnected components in disease part. In MGD we have considered 3×3 filter, MGD for each pixels of $B_{YUV}$is evaluatedby using following:

$$MGD(i,j) = Max - Min$$

Where i& j are co-ordinate values, Max is the maximum value in 3×3 mask, Min is the minimum value in 3×3 mask.

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Algorithm 1: Binary image conversion and segmentation in YUV colour space

//Input: Let'I' is the input paddy leaf image with sizem × n × 3.

Where, m is number of rows, n is number of columns, 3 indicates image is in RGB colour space.

//Output: 'bin_img' is the binary image with region of interest. i.e. segmented part of disease part in leaf.

Step1: Convert input paddy leaf image I to R, G and B-band.

Step 2: Convert R, G and B-band images to YUV color space using eq(1), this will produce Y, U and V component images.

Step 3: Convert Y, U and V images to respective binary images by considering threshold value as 0.5.

Let B_Y, B_U and B_V are the binary images of Y, U and V images respectively.

Step 4: The resultant binary imageB_{YUV} is evaluated as follows:

```
fori←0 to m:
    forj←0 to n:
        ifB_Y(i,j)=1&&B_U(i,j)=1&&B_V(i,j)=1 then:
            B_YUV(i,j)=1
        else
            B_YUV(i,j)=0
```

Step 5: Detect edges of Region Of Interest (ROI) by applying following

MGD_img=MGD(B_{YUV})

$Sobel_{edges}$=Sobel(MGD_img)

$Canny_{edges}$=Canny(MGD_img)

bin_img is evaluated using following equation:

$$\text{bin\_img}(i,j) = \begin{cases} 1 & if\ \text{Sobel}_{\text{edges}}(i,j)\ or\ \text{Canny}_{\text{edges}}(i,j) = 1 \\ 0 & else \end{cases}$$

Step 6: Apply Bounding Box(BB) for the result of bin_img.

False positive pixels or BB are eliminated on following constraints:

BB_Width< 2 pixel

BB_Height< 3 pixel

Density < Threshold value 0.001

Aspect_Ratio< Threshold value 0.005

Where Density and Aspect_Ratio are calculated as follows:

$Aspect\_Ratio = \text{BB\_Width} / \text{BB\_Height}$
$Density = Sum\ of\ pixels\ in\ BB / (\text{BB\_Width} \times \text{BB\_Height})$
returns segmented binary image i.e., bin_img.

Sobel operator detects most of the straight edges, where as canny operator detects most of the curved edges. In our proposed algorithm, we have combined both edge detection technique to retain the infected region edges. The false positive elimination is applied to eliminate wrongly detected pixels (i.e., width of bounding box is less than 2 pixels, height of bounding box is less than 2 pixels) is described in Algorithm 1. Eliminating false positive regions will helps to improve performance of classification.

Table 1. The Mathematical formulation of Features.

Features	Formula
Mean	$\mu = \frac{1}{N}\sum_{I=1}^{N} A_i$
Standard Deviation	$S = \sqrt{\frac{1}{N}\sum_{i=1}^{N} \lvert A_i - \mu \rvert^2}$
Entropy	$e = \sum p.\log_2 p$
Variance	$V = \frac{1}{N-1}\sum_{i=1}^{N} \lvert A_i - \mu \rvert^2$
Correlation coefficients	$\rho(A,B) = \frac{1}{N-1}\sum_{i=1}^{N}\left(\frac{A_i - \mu_A}{\sigma_A}\right)\left(\frac{B_{i-}\mu_B}{\sigma_B}\right)$
Contrast	$C = \sum_{i,j} \lvert i-j \rvert^2\, x(i,j)$
Kurtosis	$K = \frac{E(\chi-\mu)^4}{\sigma^4}$
Skewness	$S = \frac{E(\chi-\mu)^3}{\sigma^3}$
Root mean square (RMS)	$X_{RMS} = \sqrt{\frac{i}{N}\sum_{n=1}^{N} \lvert X_n \rvert^2}$
Homogeneity	$H = \sum_{ij}\left(\frac{1}{\lvert 1-(1-j)2 \rvert}\right) * P(i,j)$
Smoothness	$R = 1 - \frac{1}{1+\sigma^2}$
IDM (Inverse Difference Moment)	$IDM = \sum\left(\frac{P(i,j)}{[1+(i-j)*2}\right)$
Energy	$E = \sum_{ij} p(i,j)^2$

The GLCM features are extracted for bin_img, i.e., returnedsegmented binary image from Algorithm 1, features are: mean, standard deviation, contrast, Correlation coefficients,entropy, energy, variance, kurtosis, Root-Mean-Square (RMS), skewness, homogeneity, smoothness, Inverse Difference Moment (IDM) and. The mathematical formulation of these features is listed in Table 1 [3].

Classification: Classification is the process of categorized classes or images into different categories by labelling the classes or image by the help various features of same. Training and Testing are the major role in classification process. In training phase, we train the classifier using the features extracted from images and labelled these with unique name for each class. In testing phase, we test and classify the extracted features from new data to respective class. We have used SVM classifier to classify Healthy leaves, Rice Blast, Brown Spot, leaf Blight & Hispa paddy leaf diseases by giving GLCM features to classifier.

EXPERIMENTAL RESULT

The results produced by proposed system classifies paddy leaves to five disjoint classes, they are: Healthy leaves, Rice Blast, Brown Spot, leaf Blight and Hispa paddy leaf disease classes. The proposed system is experimentally demonstrated to evaluated the performance. i.e., how accurate the proposed system features are classified by SVM classifier.

Table 2. Paddy/Rice leaf Diseases image dataset along with healthy leaves

	Brown Spot	**Leaf blast**	**Hispa**	**Leaf blight**	**Healthy**
Kaggle	523	779	565	-	1488
Our own dataset	146	84	-	137	-
Total	669	863	565	137	1488

To evaluate the proposed system accuracy, we have used dataset that consists of our own dataset (Brown spot, leaf blast and leaf blight images are collected from various location in Karnataka and collected from agricultural students) and Rice Diseases Image Dataset collected from Kaggle [4]. The number of images belongs to disease classes are shown in Table 2. To train the SVM classifier we have used 75% of dataset andremaining 25% of dataset used for testing purpose.There are totally 3722 paddy leaf images by combining our dataset and dataset downloaded from Kaggle, out of these 2791 images are used to train SVM and 931 images are used to test proposed system efficiency. Testing and training image distribution is showed in Table 3.The experimental result and each intermediate image for brown spot, leaf blast, hispa and leaf blight are showed in Figure 1, 2, 3 and 4 respectively.

Table 3. Training, Testing dataset in number & Proposed System Accuracy in percentage (%)

	Brown Spot	**Leaf blast**	**Hispa**	**Leaf blight**	**Healthy**	**Total**
Training Dataset	501	647	424	103	1116	2791
Testing Dataset	168	216	141	34	372	931
No. of truly detected Disease Images	159	200	132	30	364	885
Accuracy (%)	94.64	92.59	93.61	88.23	97.84	95.05

The proposed system accuracy is evaluated using following:

$$Accuracy = \frac{No.of\ truly\ detected\ Disease\ Images}{No.of\ Images\ used\ for\ testing} \times 100$$

The number of truly detected disease images by the classifier and the performance of classifier to classify Healthy leaves, Rice Blast, Brown Spot, leaf Blight and Hispa paddy leaf diseases is shown in Table 3. The performance analysis of existing system and proposed system is showed in Table 4.

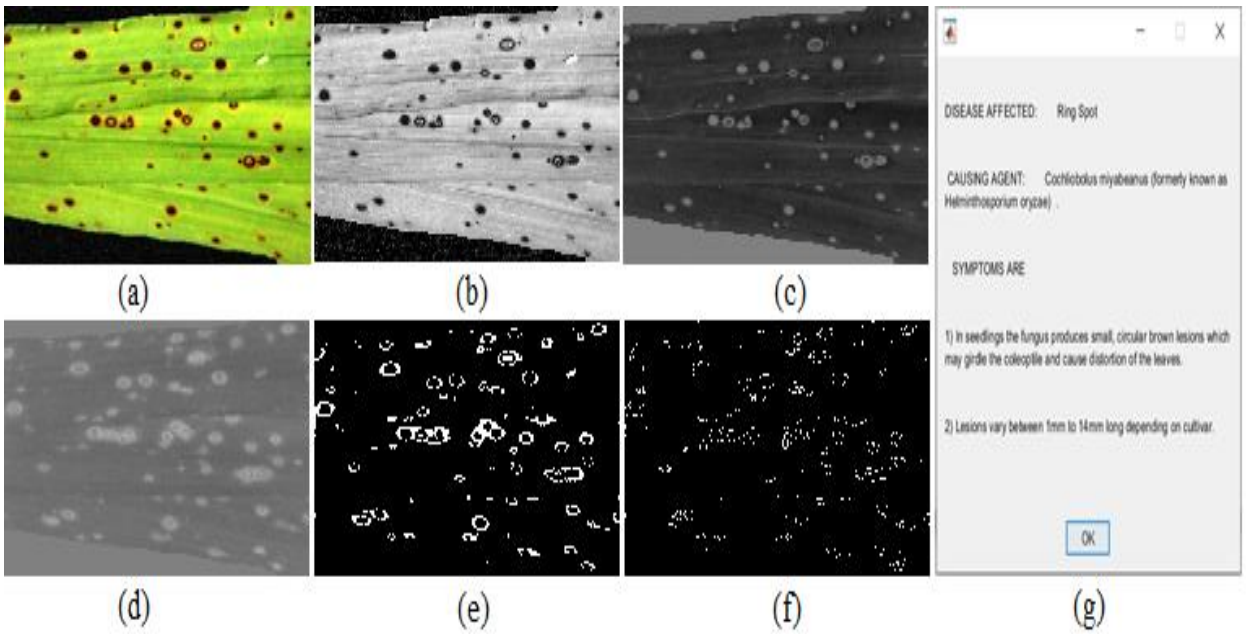

Figure 1. Experimental results for brown spot disease image. (a) Input image. (b) Y-component. (c) U-component. (d) V-component. (e) Proposed Binary image. (f) After MGD, Sobel operator and False positive elimination. (g) Classification result.

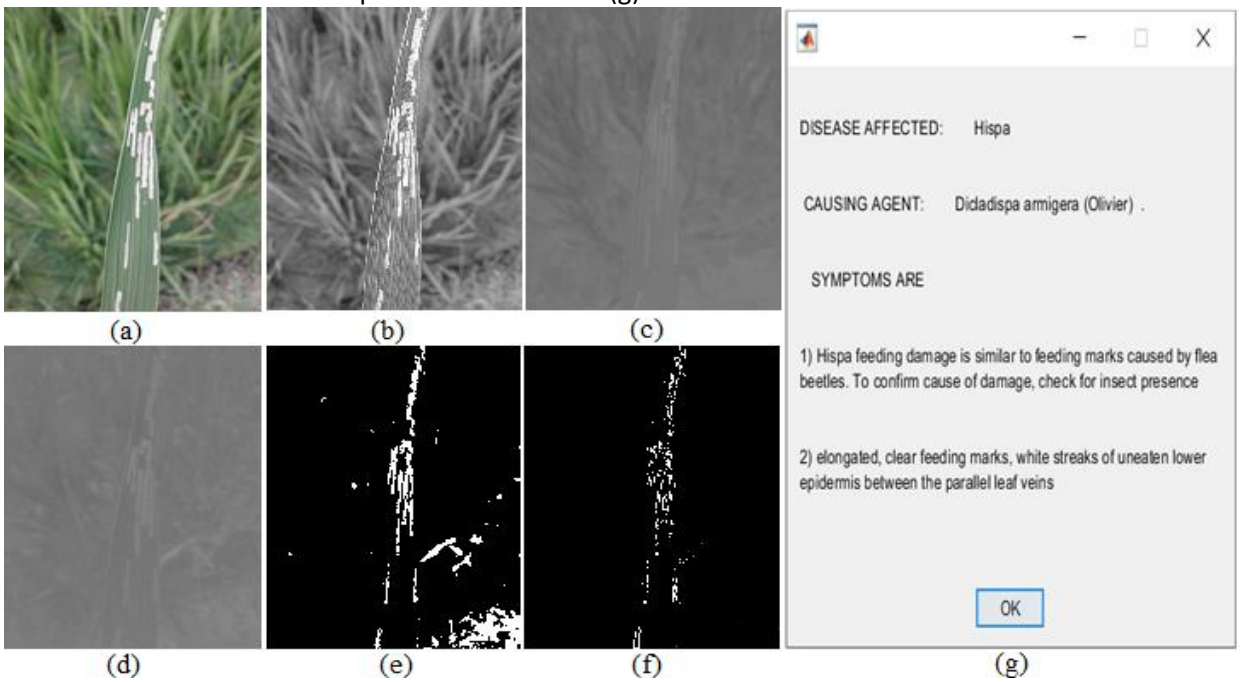

Figure 2. Experimental results for hispa disease image. (a) Input image. (b) Y-component. (c) U-component. (d) V-component. (e) Proposed Binary image. (f) After MGD, Sobel operator and False positive elimination. (g) Classification result.

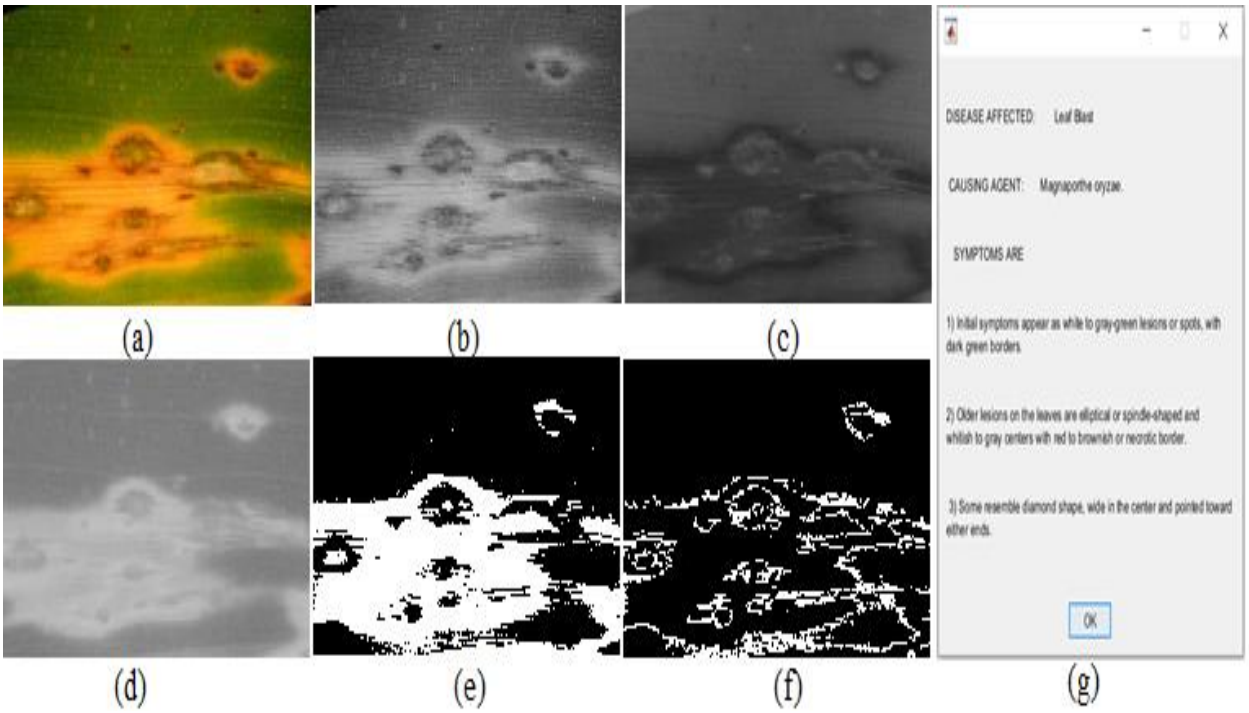

Figure 3. Experimental results for leaf blast disease image. (a) Input image. (b) Y-component. (c) U-component. (d) V-component. (e) Proposed Binary image. (f) After MGD, Sobel operator and False positive elimination. (g) Classification result.

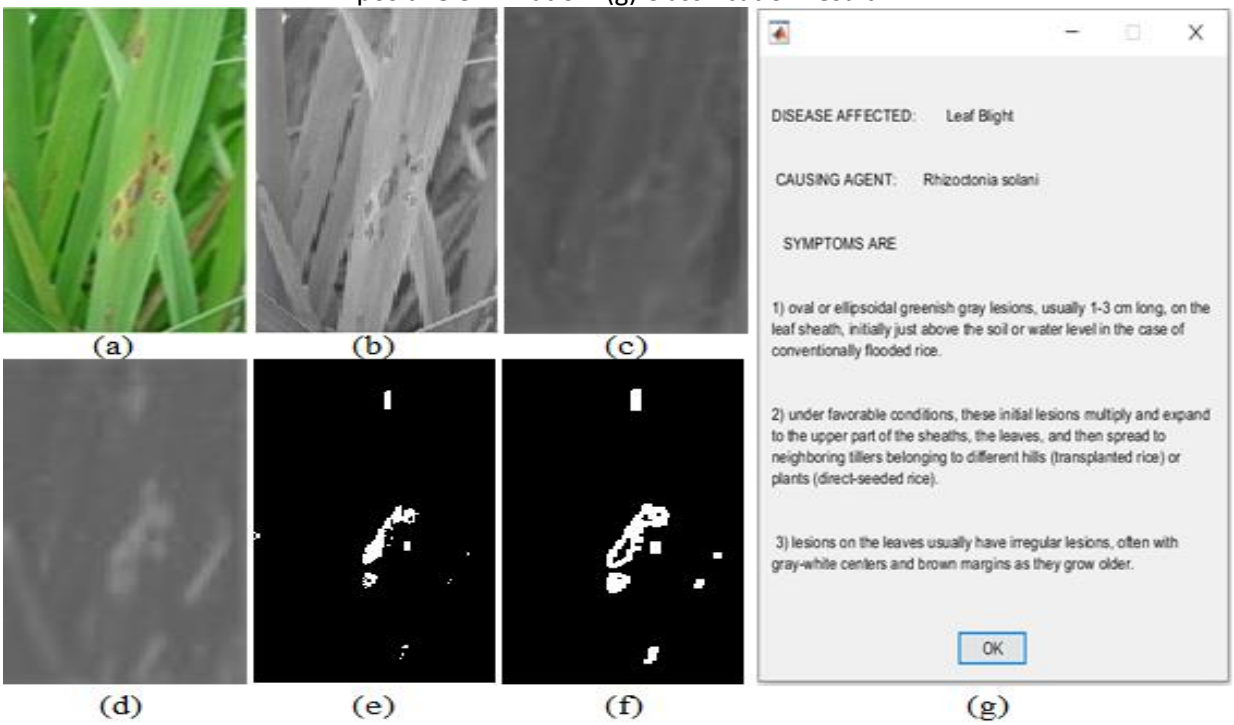

Figure 4. Experimental results for leaf blight disease image. (a) Input image. (b) Y-component. (c) U-component. (d) V-component. (e) Proposed Binary image. (f) After MGD, Sobel operator and False positive elimination. (g) Classification result.

Table 4. Performance Analysis in percentage (%)

Authors	**Type of Diseases classified**	**Features**	**Classifier**	**Accuracy (%)**
Suresha et. Al., [13]	Blast & BrownSpot	Area, minor and major axis length and Perimeter	KNN	76.59
Ramesh and vydeki [9]	Healthy & blast	GLCM	ANN	90 & 86
Phadikar and Sil [12]	Leaf blast & brown spot	Zooming algorithm	Self-OrganizingMap (SOM) neural network	92
Ghosal and Sarkar [7]	Rice blast, leaf blight, brown spot & healthy	-	CNN With Transfer Learning	92.46
Ramesh and vydeki[18]	Bacterial blight, Blast, Brown spot, Sheath rot and normal leaves	Color and GLCM	OptimizedDeepNeural Network withJaya OptimizationAlgorithm(DNN_JOA)	94.53
Pothen and Pai [10]	Leaf blight, smut & brown spot	HOG	SVM	94.6
Proposed	Rice Blast, Brown Spot, leaf Blight, Hispa & Healthy leaves	GLCM	SVM	95.05

Conclusion

Detecting plant diseases by a crop expert requires more time, hence it may lead to increase in severity of leaf disease and detection of plant leaf diseases using semi or fully automated, efficient tools will reduce the time and human errors. Hence, we have proposed a system to detect, extract and classify the paddy leaf diseases like Rice Blast, Brown Spot, leaf Blight and Hispa by using YUV color space processing. Initially, the input RGB color space image has been transformed to YUV color space, further convert these Y, U & V image to binary images, these three binary images are fed to proposed binary conversion and segmentation technique and resulted in detection of leaf disease part. GLCM features from segmented image has been extracted and fed to SVM classifier which classifies Healthy leaves, Rice Blast, Brown Spot, leaf Blight and Hispa paddy leaf diseases. The paddy leaf diseases are classified successfully with an average accuracy as 95.05%. The experimental results show that the proposed binarization, segmentation and features extraction from the proposed system gives better classification. The proposed technique can be implemented by combining global and local features for increasing recognition accuracy of the system.

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