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Image Processing System based Identification and Classification of Leaf Disease: A Case Study on Paddy Leaf

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Abstract—Paddy is the main nourishment in the south sections of India. It straightforwardly influences the country's infrastructure. Bacterial leaf blight, brown spot and leaf smut were its main illnesses found in paddy field crops, which also significantly affect its profitability. This work presents an image processing system based automatic identification and classification of various paddy leaf diseases by affecting the cultivation of paddy namely bacterial leaf blight, brown spot, and leaf smut. The key phases of proposed methodology are pre-processing of images, segmentation, feature extraction and classification. The technique used in the proposed work to identify paddy leaf disease involves Otsu threshold method for segmentation, grey level co-occurrence metrics for feature extraction and k-nearest neighbors algorithm for classification. The proposed system aims at achieving rapid and accurate identification of disease and classification of the disease type and also helps in classifying the various paddy leaf diseases by utilizing the texture and shape features that majorly contributes in leaf disease recognition.

Keywords—Image processing, Otsu, GLCM and KNN

I. INTRODUCTION

Agricultural work is aimed at rising production and nourishment standard on lower expense along with better benefit, and in the present time has acquired significance. Diagnosis is a very challenging activity to manually conduct because it's an activity of a variety of parameters like climate, nutriment, life forms etc. Through current developments in image processing and pattern recognition techniques, an autonomous framework for field detection of diseases can be expanded by miles. The application of various chemicals to regulate the diseases would completely destroy the crop field. Digital image processing has a rapid growth in the field of science and engineering. The uncertain or invisible object can be made visible and certain by the use of image processing. The image processing is fast, accurate, cheaper and consistent compared to the traditional manual method in the disease diagnosis. There are various image processing algorithms developed to examine the diseased crops. The image processing method is unique to detect different diseases in different crops. Until now, experts manually detect the existence of the disease in the crops, but it is costly for a farmer to communicate with a specialist because of their distant supply. The proposed research is therefore necessary if the indications of crop infections are to be identified effectively as soon as they occur in the field. Rapid identification and classification of paddy crop disease can enable farmers prevent major losses. Technology advancement will aid them in early disease identification, reducing percentage expenses, and make the field appealing for their activities. They are legally liable for much destruction, and they are classified by fungal and bacterial issues. This is the motive for the visual indications dependent on the detection and diagnosis of diseases affected to agricultural crops is suggested to technically support farmers. The main advantage of utilizing digital image processing in farming is that they are more effective, more detailed and more productive relative to real-world human beings. In the real world farmers and agriculture experts visually carry out inspection of agriculture crops such as cereals, commercial crops, fruits, vegetables as effected by various recognition and classification diseases. However, this process is time consuming and very subjective in addition. A human investigator's decision-making ability often relies on his physical environment, emotional state influenced by aspects of work such as inadequate light sources and atmosphere. Developing an image processing system to identify and diagnose infected disease on crops in cultivation could avoid human involvement and therefore lead to accurate, impartiality decisions about infectious disease and its possible evaluation. Implementing this automated system also lets farmers prevent expert consultation. Machine learning technologies and image processing techniques are actually benefiting farmers in all aspects of cultivation practices. The proposed work would thus be able to recognize the field issue in a reasonable amount of time and the guidance allows the farmer to take the necessary steps to improve the quality of the crop production, avoid major crop losses and the manufacturing costs preserving the environment.

The objectives of the work include identifying and classifying the three major disease of paddy leaf through image processing methodologies such as

- Pre-processing of image – In pre-processing, RGB image i.e., query image is pre-processed using Adapt histogram equalization for enhancing the image.

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- Segmentation of image - In segmentation, threshold method is used i.e., Otsu segmentation is applied in which it uses gray threshold function.
- Feature Extraction - Gray level co-occurrence metrics method is used for extracting color, structure and design of the input image using mathematical operations in the proposed work.
- Classification – k-nearest neighbor classifier applied to categorize the affected disease into the paddy leaf.

II. LITERATURE SURVEY

This section presents a brief literature about identification and classification of the various crop diseases.

Srunitha et al., [1] proposed procedures for the picture will identify the sick leaf by pre-processing and ordering unpleasant places for the leaf. This paper conveys an inappropriate position and description of the Mango Leaf use. In the proposed function Multiclass SVM is used by k-means to identify and distinguish sicknesses. The test findings indicate the appropriateness of the suggested technique in perceiving mango leaf affected by the sicknesses. Color image segmentation utilizing k-means clustering for the segmentation process is used in this research article, GLCM for object extraction is used, and KNN classifier is used for classification.

Anand R et al., [2] proposed study sets out a methodology for the detection of crop leaf infections and the framework including effective identification of diseases. The main aim of the implemented research will use image processing and artificial neural techniques to examine brinjal leaf sickness. The maladies on the brinjal are a fundamental problem that marks a severe reduction in brinjal growth. Premium examination is the leaf instead of the whole brinjal plant on the grounds that around 85-95 per cent of maladies existed on the brinjal leaf such as, Bacterial Wilt, Cercospora Leaf Stain, Tobacco mosaic infection (TMV). Pre-processing is achieved by histogram equalization in the planned study work, resizing the image and the framework for color transformation. Then, k-means algorithm used for segmentation clustering. Using artificial neural network (ANN) they also used GLCM parameters and disease identification to measure features in this study.

D. Nidhis et al., [3] In the proposed study Rice blast, brown spot, and bacterial blight were the main disorders which could be found in the paddy crop's plant That also impact overall quality significantly, the suggested approach uses methods of image recognition to distinguish the illness had infected the plants as well as to determine the extent of the infection by measuring the degree of area covered, which could be used to monitor over-consumption of pesticides. The referred infections were the dominant ailments that occur among numerous diseases in paddy crops that enormously affect the yield and thus impact the farmers' monetary salary. Throughout this article, clustering of k-means is implemented for segmentation of the file. Thus the clustered image obtained can then be transformed into a binary image.

R. P. Narmadhaet al., [4] Plants are one of the big assets to hold free from a global warming transition on the earth. Be that as it can, the diseases such as Blast, Canker, Black spot, and Brown spot, bacterial leaf type Blight and Cotton damage the plants. The purpose of this paper is to perceive the infections with paddy. A portion of the paddy infection is Blast Disease (BD), Brown Spot Disease (BPD), Narrow Brown Spot Disease (NBSD) which prevents the paddy from developing and insuring. At different stages of growth, sickness will taint paddy and other parts of the plants, such as the leaf neck and core.The aim of the operation was to remove the programmed clamor, human error and restrict the time required to calculate the impact of paddy leaf disease. In fact, it also builds accuracy. Study right now, k-means procedures for locating the paddy leaf and identifying the proof. Extraction of form and color characteristic in this proposed research. Various forms of classification functionality have been introduced including SVM, ANN and Fuzzy classification.

Rashedul Islam et al., [5] Bangladesh is a peasant nation. Paddy is a check to instructions. For its cultivation and handling a large number of people rely on paddy by method for their living. Impacts in paddy leaves are the most widespread disease that occurs on the leaves as dark colored dots. It may trigger the exceptional misfortune if not handled on time It can be achieved by concentrating on the exposure regions, with most of the correct amount as well as absorption of the drug through determining the extent of the disease utilizing the image handling method. Unaffected leaf districts and areas infected by disease are used in such pictures to assess the degree of impacted pixels. By measuring the extent of the severity of the disease of affected pixels, it can be shown which prompts suitable steps to be taken for care. The purpose of the proposed research is to measure the percentage of pixels of a paddy leaf affected by the disease. Original image is segmented into 3 forms of images according to color variation in order to section the image.

Tushar H Jaware et al., [6] proposed k-Means clustering approach is a popular approach utilized to tackle undertakings in the low-level division of photos. The above segmentation approach is unified and aims to improve the parceling decision based on the starting arrangement of the bunches identified by a client, which is refreshed after each iteration. In the initial stage, the hued pixels are mainly identified as white. First, such pixels' mask based on clear maximum esteems that are recorded using Otsu's technique, after which stage those are protected mainly by green pixels. Another breakthrough was that the points containing nulls in the values red, green and blue as well as the points at the edges of the affected group (object) have been absolutely removed. The exploratory results show that a strong procedure for identifying plant leaves diseases is the proposed strategy.

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Jagadeesh D. Pujari et al., [7] proposed paper provides an overview of the picture processing systems used for the identification and organization of infectious forms of disease affected by specific crops in agriculture. Farmers face enormous obstacles, as well as moving from one infection management technique to the next, e.g. based pesticide usage. Cost power, engineered correct identifiable proof and categorization of the infections according to its side effects were extremely helpful for agriculturalist and agribusiness researchers in addition. Early sickness detection is a critical check in the science of cultivation / agribusiness. Infections of plants are induced by bacteria, growths, fungus, nematodes, and so on, of which parasites are the basic disease that affects life. The ongoing study has centered upon quick identification and control of parasitic disease as well as its associated signs.

Shwetank et al., [8] proposed advanced image processing is a set of computer-based image management techniques and their implementations. This range of remote detection methods is often known as Satellite Digital Image Processing (SDIP). Since 1960, a space-borne Multispectral Image Processing System (MIPS) has been used as a standard system for managing satellite images to analyze details and to collect critical data from / in the earth's atmosphere. Due to the limited number of unearthly networks, the MIPS architecture provides restricted results. This is ordinarily alluded to as Hyper Spectral Image Processing System (HIPS). These exams subtle the parallels between MISP and HISP; and illustrates the usage and mapping of HIS for-Rice crop arrangement, plant growth, plant biophysics, biochemistry, physiology properties in various ghastly districts.

Lidi Wang et al., [9] proposed color highlight has played an important role in shading picture division, particularly in the fields of programmed position of harvest disease based on leaf image. Successful plan for photo division of cucumber leaf pictures is being introduced right now. The color space paradigm is broken down, to start with. A kind of shading spotlight is added at that stage to obtain the product diagram, which joins the RGB model and HSI model. Finally, the morphological technique is used to achieve the separation of images. This policy was effectively demonstrated by inquiries.

Jiang Lua et al., [10] In the proposed research infections of the crops are blamed for the severe downturn in productivity and financial misfortunes in rural industries worldwide. To monitor the spread of diseases and to actualize successful management, testing for yields' well-being status is crucial. This paper provides a structured in-field wheat disease conclusion structure based on a pitifully applied deep learning network, e.g. radically specific event realization, which accomplishes a mixture of wheat disease recognition and infection area limitation with image level clarification for image planning in wild conditions. Under two separate frameworks, such as VGG-FCN-VD16 and VGG-FCN-S, our architecture achieves the mean acceptance performance of 97.95 percent and 95.12 percent independently rather than 5-overlay cross-approval on WDD2017, beating the 93.27 percent and 73.00 percent effects of two typical CNN systems, such as VGG-CNN-VD16 and VGG-CNN-S for example. Exploratory findings reveal that, under a common test of criteria, the new system beats conventional CNN frameworks on recognition performance, then retaining correct containment for infection regions.

III. MAJOR DISEASES ON PADDY LEAVES

1. *Bacterial leaf blight*

Bacterial leaf blight is a pathogenic disease caused by Xanthomonasoryzae found on paddy leaf. It tends to cause seedlings to sag, and roll leaves to yellow and dehydrated. Leaves which are affected by the disease change green greyish and wrinkle. The leaves change yellow to crumb-colored and droop as the infection spreads, causing entire seedling to dry away and die. The sooner it is possible to identify the infection, the less the yield loss. Bacterial blight will not damage harvest when crops are affected at initial stages but leads in low quality grains and a huge proportion of damaged seeds.

Fig. 1. Bacterial Leaf Blight

2. *Brown spot*

Brown spot is a fungal disease that affects the protective sheath covering the leaf, leaves, leaf sheath, branches and outer husk surrounding the grain. Disease infected leaves have small circular, yellow brown spots or dark brown spots that may affect the coleoptiles and may kill the whole leaf. Brown spot is causing depletion of both quantities and consistency. Brown spot diseases can develop throughout all crop stages; however, the disease is most severe during complete crop maturation.

Fig. 2. Brown Spot

3. *Leaf Smut*

Paddy smut is a fungal disease found on paddy leaves which is caused by Entyloma oryzae. This infection is usually minor. The characteristic symptom of paddy with leaf smut disease is the presence of small black or yellowish brown spots on the leaves. They are slightly raised and angular and give the leaves the appearance of having been sprinkled with ground pepper and vary from region to region. The tips of some leaves with the most infection may die. As with many other function infections this one is spread by infected plant material in the soil. When healthy leaves contact the

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water or ground with old diseased leaves, they can become infected.

Fig.3. Leaf Smut

IV. METHODOLOGY

The implemented work is possible for images of any scale. Certain pre-processing of the input image is performed before segmentation and extraction of the feature. Pre-processing comprises the process of image retrieval preceded by image enhancement, then segmentation where the area of interest is differentiated. After segmentation, extraction of the feature is performed, and then classification. The global image threshold segmentation approach of Otsu is used for segmentation and GLCM [gray level co-occurrence metrics] is used for extraction of features, and KNN [k-nearest neighbor] is used as classifier.

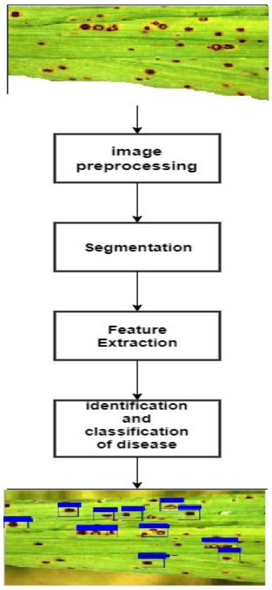

Fig. 4. Architecture of the proposed system

V. IMPLEMENTATION

Preprocessing

Pre-processing is a method by which noise is eliminated and the image is deblurred for the further operation or noticeable circumstances. The actual datasets are of RGB (red, green, blue). Then these images have been pre-processed using the Adaptive Histogram Equalization (AHE) method that is used to enhance image contrast and is ideal for improving local resolution and amplifying edge definitions in each image area. Adaptive histogram equalization (AHE) is a image processing technique used to enhance contrast in images. It differs from normal histogram equalization in the sense that the adaptive method computes multiple histograms, each corresponding to a discrete section of the image, and utilizes them to reallocate the smoothness values of the image. Thus, it is useful for increasing local contrast as well as enhancing edge boundaries in each area of an image.

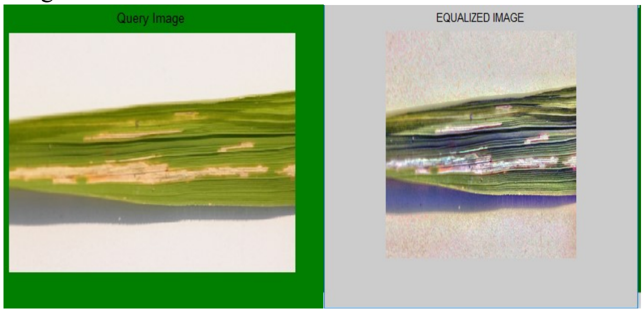

Fig.5. Preprocessing of an image

Segmentation

Segmentation is the method of distinguishing the image from foreground as well as background and identifying the relevant object from the foreground or background, here threshold-based segmentation is employed, which is the Otsu threshold approach in current research.

Otsu Segmentation

Otsu's methodology is used to execute the image threshold dependent on histogram structure or to reduce a gray scale image to a binary image as a result. Otsu's threshold method involves iterating over all potential threshold value and assessing a measurement of variance on either side of the threshold for the pixel range, i.e. the pixels which occur either in the foreground as well as in the background.

Otsu threshold class variance is given as follows:

$$\sigma_1^2(t) = \sum_{i=1}^{t} [i - \mu_1(t)]^2 \frac{P(i)}{q_1(t)}$$

$$\sigma_2^2(t) = \sum_{i=t+1}^{I} [i - \mu_2(t)]^2 \frac{P(i)}{q_2(t)}$$

.

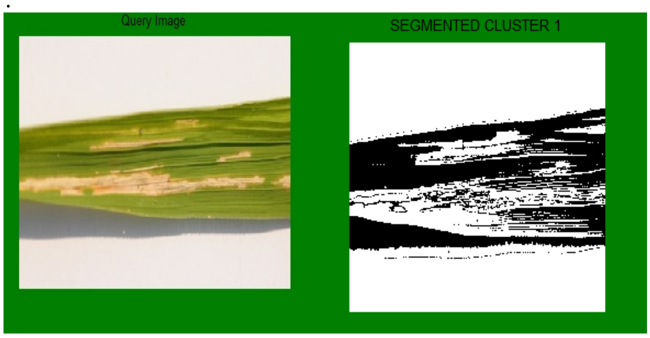

Fig.6. Segmentation of preprocessed image

Feature Extraction and Classification

The extraction of features is a process to prominent the selection of the actual datasets. Features are regarded mainly as areas of interest. This is performed by evaluating other attributes such as texture, color, and design. The GLCM (Gray level co-occurrence metrics) properties such as contrast, correlation, energy, homogeneity, mean, standard-

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deviation, entropy, RMS, variance, smoothness, kurtosis, andskewness are used in this implemented procedure. GLCM is a mathematical extract function technique. The method of measuring GLCM functions is shown below. Here (i, j, 1, 0) represents the intensity co-occurrence matrix, Ng represents number of gray level and pd is normalized metrics dimension of GLCM.

Contrast is a function of the contrast in intensity between a pixel as well as its neighbor over the entire image.

$$Contrast = \sum_i \sum_j (-j)^2 p_d(i,j) \quad (1)$$

Homogeneity is a value that calculates the proximity of the GLCM to the GLCM diagonal array of the components.

$$Homogeneity = \sum_i \sum_j \frac{1}{1+(i-j)^2} p_{d(i,j)} \quad (2)$$

Entropy measures an image's disorder and reaches its highest value when all elements in the matrix are equivalent.

$$Entropy = -\sum_i \sum_j p_{d(i,j)} \ln p_{d(i,j)} \quad (3)$$

Energy Returns the total of squared GLCM elements Angular Second Moment (ASM).

$$Energy = \sqrt{ASM}$$

$$ASM = \sum_i \sum_j p_d^2(i,j) \quad (4)$$

Correlation returns a calculation of how a pixel is correlated over the entire image to its neighbor.

$$Correlation = \sum_i \sum_j p_{d(i,j)\frac{(i-\mu_x)(j-\mu_y)}{\sigma_x \sigma_y}} \quad (5)$$

Mean returns the average pixel value existing in the image.

$$Mean = \sum_i \sum_j (i-j) p_d(i,j) \quad (6)$$

Standard deviation is noted as

$$Standard\ deviation = \sum_i \sum_j (i-j)^2 p_d(i,j) \quad (7)$$

The moment is calculated by the asymmetry of the estimated image feature

$$Moment = \sum_i \sum_j (i-j)^3 p_d(i,j) \quad (8)$$

The Kurtosis is evaluated as the comparative flatness height in an image

$$Kurtosis = \sum_i \sum_j (i-j)^4 p_d(i,j) \quad (9)$$

Skewness assigns properties of the textured intensity.

$$Skewness = \sum_{i=0}^{G-1} (i-\mu)^3 p(i) \quad (10)$$

The homogeneity of the reduced area is estimated by metrics of inverse difference (IDM).

$$IDM = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \frac{1}{1+(i-j)^2} p(i,j) \quad (11)$$

$$Smoothness(R) = 1 - \frac{1}{1+\sigma^2} \quad (12)$$

$$Angular\ second\ moment = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \left\{p(i,j)^2\right\} \quad (13)$$

The 13 features were extracted from the infected paddy leaf image and provided to classification algorithm. Fig. 7 shows the example of feature extraction using GLCM.

Classification

Classification is the method of determining classes based on certain attributes. It defines the position of the unidentified image of the leaf in a specific class, described objectively.

KNN classifier

KNN classifier is a classification system which is not parametric. The performance in KNN classification is a membership of a class. An element is allocated by a majority vote of its neighbors, from the most basic class with its KNN nearest neighbors. If k=1, the element is assigned precisely to the class of the adjacent single neighbor. Training samples are vectors with a class name, each in a multidimensional feature space. The algorithm's training process consists only of the storage of the training samples' feature vectors and class labels. Each image is subjected to extract features using GLCM method and the resulted feature matrix values of the trained image is used to train the supervised KNN classifier algorithm. GLCM (gray level co-occurrence matrix) method for extracting each trained image with its class label defines a particular class of disease for each of the testing images. During testing each image in the testing samples are checked for equality of feature matrix values. Euclidean distance measure is used to find the nearest neighbor that is a match. Formula for Euclidean distance is given by,

$$d_{Euclidean}(x,y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)}$$

For each of the match and mismatch the count is maintained and hence the accuracy is found for each of the disease class and normal leaf images. Obtained match count of the test samples with the number of trained samples. Accuracy = (obtained match count / test samples) *100

Classification results on a few test samples are shown in Fig. 7 and Fig. 8.

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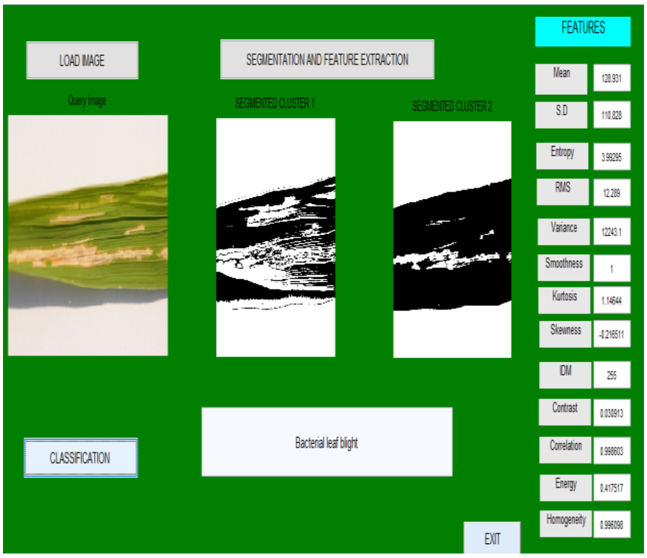

Fig.7. Feature extraction and Classification result of a disease affected leaf.

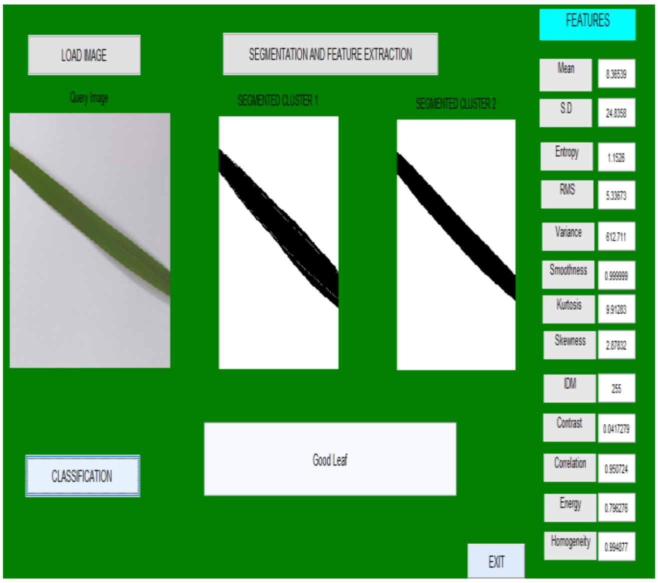

Fig. 8. Classification result of a healthy leaf image

VI. EXPERIMENTAL RESULTS

a. Dataset

The initial process is always to gather dataset for data basis. The dataset images are gathered from UCI machine learning repository. Sample images of dataset are composed of 3 classes. There are 40 images in Bacterial leaf blight, 40 in Brown spot, 40 in leaf smut and 70 healthy paddy leaf images per class. The images collected are provided for preprocessing to isolate the infected area from the disease.

b. Results

Training as well as testing of the current approach were performed on 190 data set samples of the leaves of infected and healthy paddy leaves retrieved from the conserved samples of the rice leaf disease repository. Training samples were obtained from 70 per cent of certain data set images whereas the remaining 30 per cent have been utilized for testing purposes. Accuracy is calculated for each of the disease class and for the normal leaf images, among those the bacterial leaf blight disease achieves 90 percent, brown spot disease achieves 87.5 percent, leaf smut disease achieves 80 percent and the normal leaf achieves 92.85 percent. K-NN classifier measures the GLCM feature matrix similarities between the training and testing samples of the dataset. By matching each of the obtained feature matrix values of the trained images with the testing images, it classifies the dataset to which disease type it belongs. Fig.9 displays the features got from each kind of paddy leaf disease being considered. The arrangements of 13 features of an image are used as feature vectors for training and classification.

Contrast	Correlati-on	Energy	Homogeneity	Mean	S.D	Entropy	RMS	Variance	Smoothness	Kurtosis	Skewness	IDM
0.2000	0.9340	0.3055	0.9048	179.5092	63.0860	6.2386	15.9600	3.5290	1.0000	3.4443	-1.3475	255
0.2050	0.9463	0.1782	0.8976	180.3577	66.6662	6.0938	15.8048	4.0625	1.0000	3.4487	-1.2630	255
0.2296	0.9476	0.1390	0.8857	159.2127	79.6549	6.7555	15.3241	5.7862	1.0000	2.0018	-0.6804	255
0.1269	0.9789	0.2471	0.9394	173.4947	71.3215	6.7176	15.7963	4.6148	1.0000	2.4485	-0.8017	255
0.1911	0.9564	0.2647	0.9064	189.4341	64.2682	6.3127	15.8855	3.5786	1.0000	3.6644	-1.3505	255
0.2271	0.9579	0.1465	0.8932	159.1173	71.8382	7.0934	15.8897	4.3266	1.0000	1.9993	-0.4992	255

Fig. 9. Shows the Feature extraction of few trained samples using GLCM.

The performance of the proposed system is as represented by the graph shown in Fig. 10

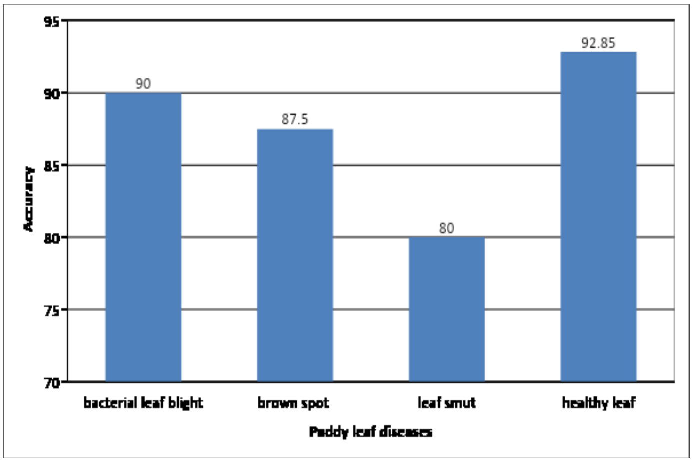

Fig. 10. Performance of the Proposed System.

VII. CONCLUSION

The proposed work mainly includes three implementation areas, the segmentation accompanied by feature extraction and classification using KNN (k-nearest neighbor) algorithm. The test results suggest that the model implemented works accurately in recognizing and classifying leaf diseases. Variations in texture, shape and

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color characteristics of the disease affected leaf made difficult in segmentation phase. These outcomes in longer training for the framework. By performing classification of testing leaf samples, overall accuracy of the classification is found to be 89.47%. When the procedure is applied, a conclusion is obtained in a way that speed and accuracy are the key criteria for any disease detection and classification. The project's future work can be carried out to identify diseases on other crops such as wheat, sugar cane, corn and maize and also to suggest suitable soil based on the crop requirement for better yield.

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