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FOREWORD

Welcome to the 16th Volume of ESTEEM Academic Journal for December 2020 issue: an online peer-referred academic journal by Universiti Teknologi MARA, Cawangan Pulau Pinang, which focusing on innovation in science and technology that covers areas and disciplines of Engineering, Computer and Information Sciences, Health and Medical Sciences, Cognitive and Behavioral Sciences, Applied Sciences and Application in Mathematics and Statistics.

It is a pleasure to announce that ESTEEM Academic Journal has been successfully indexed in Asean Citation Index and MyCite, a significant move, which will increase the chance for this journal to be indexed in SCOPUS. ESTEEM Academic Journal has also been nominated as one of the top 3 of the best science and technology journals in Universiti Teknologi MARA. Starting year of 2021, the publication issue will be moved to March and August for every year.

In this 2020, the world has been impacted on the Covid-19 issue that has changed our daily life to a new normal. Although Covid-19 issue has still affected the world not only on academician and research area, ESTEEM Academic Journal have received tremendous supports and responses from authors internationally and locally from various backgrounds in science and technology areas. Nine articles from the field of innovation in science and technology are successfully published after undergoing screening and reviewing processes that involved international and local reviewers. It is our aim to ensure that all the published articles are of the highest quality.

It is an honour to have a form of partnership and assistance from panel of international advisors and editors for this issue. Thus, I would like to take this opportunity to thank many people who have worked together for the issue to be released. In particular, my greatest thanks are due to our Rector, Professor Ts. Dr Salmiah Kasalong and the Deputy Rector of Research, Industry, Community and Alumni Network, Associate Professor Chem. Dr. Nor Aziyah binti Bakhari for their unfailing support and advice towards the successful publication of this issue. My deepest gratitude also goes to the editorial team of ESTEEM Academic Journal December 2020; Dr Syarifah Adilah, Dr Ainorkhilah, Puan Suzana, Dr Mah Boon Yih, Pn Isma Noornisa, Dr Salina and Dr Vicinisvarri Inderan for their support, commitment and expertise in making this issue published on time.

My greatest appreciation also goes to the panel of reviewers for their persevering and attentive efforts in reviewing the articles voluntarily by giving constructive and invaluable comments to ensure the quality of the articles. Finally, my gratitude goes out to the authors who have submitted articles to ESTEEM Academic Journal, for their trust in us in publishing their research works. Last but not least, as this year is ending, may the New Year bring tremendous joy and success for all of us. Happy New Year 2021! Dr.

Ir Dr Nor Salwa Damanhuri
Chief Editor
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p-ISSN 1675-7939; e-ISSN 2289-4934

CONTENT OF JOURNAL

1 **Wait Time Analysis to Optimize Number of Opened Counters**
Noraini Noordin, Nurul Elfieqah Rostam and Nur Ariena Farhana Noor Hamizan 1-10

2 **Anthropometric Characteristics of Malay Nose-A Pilot Study**
Tengku Fazrina Tengku Mohd Ariff, Farah Farhana Muhamad Hanafi, Nur Wardah Hanis Abdul Razak, Narissaporn Chaiprakit and Hazmyr Abdul Wahab 11-20

3 **Absorption Study of Triangular and Rectangular Slotted on Hollow Pyramidal Absorber**
Mohamad Faisal Asmadi, Hasnain Abdullah, Mas Izzaty Binti Fazin, Ahmad Rashidy Razali, Mohd Nasir Taib , Azizah Ahmad and Norhayati Mohamad Noor 21-30

4 **Forecasting Electricity Demand from Daily Log Sheet with Correlated Variables**
Mohamad Syamim Hilmi, Sofianita Mutalib, Sarifah Radiah Sharif and Siti Nur Kamaliah Kamarudin 31-40

5 **Paddy Leaf Disease Recognition System using Image Processing Techniques and Support Vector Machine**
Hayatun Syamila Mamat, Nur Azwani Zaini and Suhaila Abd Halim 41-50

6 **PRESIMS: Requirements and Design for Preschool Management System Using Usability Theory**
Nor Hasnul Azirah Abdul Hamid, Normalina Ibrahim@Mat and Nurul Najihah Mustopa 51-64

7 **Computational Analysis of Fluid Flow Past a Bluff Body at Low Reynolds Number in Different Apex Angle**
Jusoh, M.Z.M., Nur Ain, A.R and Muhammad Wafi Md Nor 65-74

8 **Bending Effects Study on Flexible Wearable Antenna for 2.45 GHz Body Centric Wireless Communications**
Aslina A. Bakar, Amirul A. Mustafa, Ahmad R. Razali, Norhayati Mutalib and Amirudin Ibrahim 75-87

9 **Evaluation of Organic Solvents Efficiency for Ink Samples Extraction**
Nur Atiqah Zaharulli 88-95

p-ISSN 1675-7939; e-ISSN 2289-4934

ESTEEM Academic Journal
Vol. 16, December 2020, 41-50

Paddy Leaf Disease Recognition System using Image Processing Techniques and Support Vector Machine

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ABSTRACT

Paddy is a crucial agroculture sector since rice is the staple food for the majority of the world's population. However, the production of paddy is slower and less productive since many factors have affected the growth of the paddy. The existence of disease in paddy component affects the quality of rice produced. Hence, the recognition of the disease at the beginning stage is crucial as the initial approach for prevention purposes. In this study, a system is developed to detect the paddy leaf disease such as bacterial leaf blight, brown spot and leaf smut. All the processes involved are implemented and compiled using MATLAB R2020a. A set of 105 image data with disease is converted to binary image using thresholding. 6 features from all the data are extracted and divided to testing and training set before the classification process. A cubic support vector machine is used for the classification process. Lastly, accuracy, precision, and misclassification for each disease are calculated for performance evaluation. Results show that the average performance of the diseases on accuracy, precision, and misclassification are 88.57%, 82.97%, and 11.43% respectively. The use of the processes act as assistance to the paddy farmer to identify the existence of the paddy leaf disease. This could improve the quality of the paddy produced by reducing the process of manual disease checking.

Keywords: *MATLAB; Cubic Support Vector Machine; binary image; image processing; paddy leaf disease.*

1. INTRODUCTION

Paddy also known as rice is the starchy seeds of an annual Southeast Asian cereal grass (Oryza sativa) that is cooked and used for food. Rice is an important food crop worldwide and is the staple food for most of the world's population. However, due to pests and diseases, the paddy productions have become slower and less productive. This is because of the limited resources and technology to determine the paddy diseases at the early stage. The paddy disease diagnosis is also limited by human visual capabilities because the first symptoms are too small or microscopic. Even though the diseases are being determined, the error might still occur due to the false diagnosis.

For the past few years, the paddy disease had been detected manually by the farmers. A paddy farmer is usually trained at Malaysia Agricultural Research and Development Institute (MARDI) to be able to analyze the type of paddy diseases. Once the paddy disease has been diagnosed the suitable treatment is done to cure the diseases. However, paddy farmers have to

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spend a lot of time and energy to detect the disease and it is hardly possible to accurately estimate the infected areas seriously in large-scale farming. By using manual observation, incorrect disease identification might occur as the symptom of one disease is similar to the others. The implementation of technology is essential to accurately detect the diseases and the prevention can be taken directly to prevent further spread. As such, the digital image processing is one of the new diagnostic processes that can be embedded with the method to classify paddy diseases through its leaf, stem or soil.

The use of technology has successfully minimized the work of paddy farmers in detecting type of disease from paddy leaf. Hence, in this study, sets of image processing techniques are applied and compiled using MATLAB. There are plenty of algorithms that exist for classification, but the selection of classifier is still an open problem as they offer from low to complex algorithms that are able to increase the accuracy of the model.

The application of classification offers several classification techniques in the field of agriculture such as paddy leaf [1], chilli leaf [2], brinjal leaf [3], crop leaf [4]. Back-Propagation Neural Network (BPNN) is one the mostly used neural network techniques. besides support vector machine (SVM). Although Swathi and Barathi [5] proposed the use of ANN on real time image, they also suggested that more features are required and the application of SVM would be able to gain a better performance in future. Convolutional Neural Network (CNN) performed better than logistic regression, K-Nearest Neighbours (K-NN) and SVM on leaf of crops such as apple, potato, tomato, grape, strawberry and corn [4]. Deep learning is suitable in this case as the data used is about 20,000. [6] evaluated the performance of multiple classification techniques that are BPNN, Radial Basis Function Neural Network (RBFN), General Regression Neural Network (GRNN) and SVM with RBFN. The modification of SVM with RBFN offers the highest accuracy rate as compared to the other techniques.

In this study, SVM is used to detect the paddy disease. The SVM is used since the techniques are simple, stable, easy to program, and it is a standard method that generally works well. This study aims to develop a system using MATLAB which can be used to classify the paddy leaf disease type and suggest the prevention action for the disease for the farmer reference.

2. LITERATURE REVIEW

Image processing plays important task in manipulating and processing the image data before further process. For classification purposes, SVM is one of the processes that can be applied.

2.1 Image Processing

Research and applications of image processing in detecting the diseases have arisen drastically due to the evolvement of computing technology. The colour-to-grayscale conversion process to convert the RGB image to Gray-scale image colour for further processing the image that aims for different purpose [7]-[9]. Median filter is commonly used to remove image noise as it has a good edge preserving properties and robust as it is able to remove outliers without blurring effects [10]. Histogram Equalization (HE) is used to enhance the contrast of the acquired image after resizing and noise restoration [11]. In addition to that, contrast enhancement and RGB to L*a*b transformation is one of the main processes in the pre-processing stage [12]. Besides, colour-to-grayscale conversion method and the Rayleigh distribution function also aims to improve the image contrast [6]. After pre-processing, image segmentation is required to

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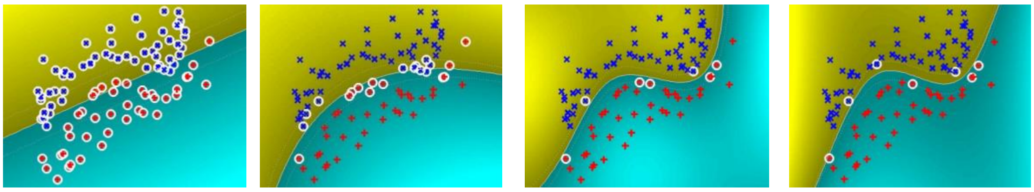
ESTEEM Academic Journal
Vol. 16, December 2020, 41-50

highlight the object. Thresholding is an image segmentation that converts grayscale to binary image. The technique is simple to implement and it works well as compared to global thresholding.

2.2 Support Vector Machine

The SVM is a supervised machine learning algorithm which can be used for both classification and regression. The SVM constructs an optimal hyperplane to find a separating line between data of two classes and maximize the margin of the data. There are several kernel functions in SVM as shown in Figure 1. Each kernel gives different effects as it depends on user requirement.



Linear Quadratic Gaussian Cubic

Figure 1. Different kernel functions in SVM, [13]

In the SVM, the kernel trick is a technique used to maximize the margin hyperplane and to transform the data. After the transformations, an optimal boundary between possible outputs is found. The kernel trick allows operating in the original function space without calculating the data coordinates in a higher dimensional space [14] . The SVM constructs its solution in terms of a subset of the training input (Awad and Khanna [15]). The system is used to determine the type of disease with the process of training and testing to reduce the number of errors in the network. Cubic kernel is represented as in Equation (1).

$$k\left(x_i, x_j\right) = \left(x_i^T x_j + 1\right)^3 \tag{1}$$

In this study, the cubic SVM is used to detect the paddy leaf disease. It is effective in high dimensional spaces. According to Khan et al. [16], a cubic SVM is a type of classifier where the classifier's kernel function is cubic given as $k\left(x_i, x_j\right)$ as in Equation (1).

One advantage of cubic SVM is that it gives the highest or gives a high accuracy. The study from Jain et al. [17] and Umar et al. [18] indicated that the cubic SVM classifier gives a high accuracy compared to other classifier. Mohan and Balasubramaniam [7] apply SVM to recognize the category of the diseases. The decision boundary hyperplane between two classes is required to classify the diseases [19].

3. METHODOLOGY

This project aims to develop a tool for paddy leaf disease detection by using image processing that is implemented using MATLAB R2020a. The image undergoes several processes and

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techniques until the image has been classified into different disease types. The flow chart of the process of the system is illustrated in Figure 2.

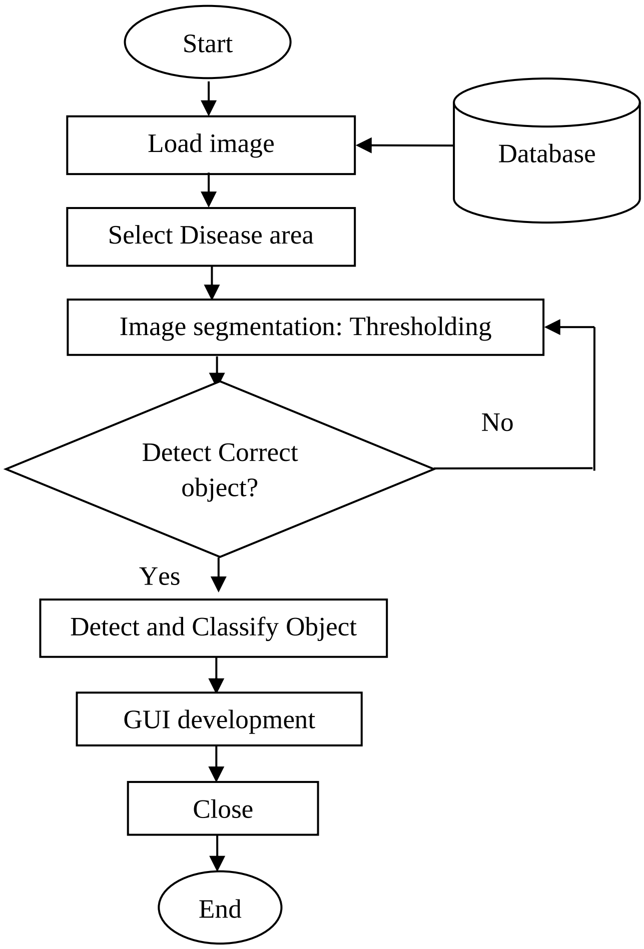

Figure 2: Flow Chart of Methodology

Figure 2 shows the flow chart of the processes involved in the methodology. A system is developed using MATLAB R2020a for paddy leaf diseases analysis. A total of 105 data from UCI database of Rice Leaf Diseases [20] for each disease is tabulated in Table 1.

Table 1: Total data of Paddy Leaf Disease

Disease	**Total Data**
Bacterial Leaf Blight	39
Brown Spot	33
Leaf Smut	33

Figure 3 shows the three types of paddy leaf disease samples that are bacterial leaf blight, brown spot and leaf smut are taken from the database.

p-ISSN 1675-7939; e-ISSN 2289-4934

(a) Bacterial leaf blight (b) Brown Spot (c) Leaf smut

Figure 3. Sample of Paddy Leaf Diseases

In order to reduce processing time, region of interset (ROI) for each image is required to be determined by manually selecting the region of disease area. Thresholding is applied for image segmentation, the image is converted gray-scale to a binary image using the global image threshold using the Otsu method. This method is widely used since it is easy to apply and time saving. This particular method segments the image into light region, $T0$ and dark region, $T1$. Region $T0$ is a set of intensity levels from 0 to t or in set notation $T0 = \{0,1,...,t\}$ and region $T1 = \{t, t+1, ..., 1, l-1, l\}$ where t is the threshold value, l is the maximum gray level. In the implementation, otsu thresholding in MATLAB is used. After thresholding, the required object highlighting the disease is highlighted.

If the disease is not correctly detected, then the thresholding process will be repeated using different threshold value. In disease detection, a set of features such as area, perimeter contrast, correlation, energy, and homogeneity are calculated.

The area and perimeter was obtained by using blob measurement from the blob function. After the outlines are created, the area and perimeter were calculated based on the region. The other four features that contrast, correlation, energy, and homogeneity are extracted from the Gray-Level Co-occurrence Matrix (GLCM).

$$\text{Contrast} = \sum_{i=0,j=0}^{N} p_{i,j}(i-j)^2 \tag{2}$$

$$\text{Correlation} = \sum_{i=0,j=0}^{N} p_{i,j} \frac{(j-\mu_j)(i-\mu_i)}{\sigma_i \sigma_j} \tag{3}$$

$$\text{Energy} = \sum_{i=0,j=0}^{N} \left(p_{i,j}\right)^2 \tag{4}$$

$$\text{Homogeneity} = \sum_{i=0,j=0}^{N} \frac{p_{i,j}}{1+(i-j)} \tag{5}$$

where N represents the total number of pixels, $p_{i,j}$ represents the probability of pixel values, μ represents the mean, and σ represents the standard deviation.

After all the features for the dataset is collected, they are used for training and testing using cubic SVM. According to [21], it is appropriate way to split the dataset into training and testing. In this study, all the data are separated into two tables which are 70% for the training while the

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other 30% for the testing [22]. The idea is to provide more training data which in turn makes the classification model better.

Then, the performance of the cubic SVM is evaluated using accuracy, precision and misclassification based on confusion matrix. Accuracy gives the percentage of correct predictions made by the system. Then, precision shows the percentage of positive predictions made by the system. Next, misclassification indicates the percentage of wrong predictions made by the system. The formulas for accuracy, precision and misclassification are as in (6), (7) and (8) respectively.

$$accuracy = \frac{TP + TN}{TP + TN + FN + FP} \tag{6}$$

$$precision = \frac{TP}{TP + FP} \tag{7}$$

$$misclassification = 1 - accuracy \tag{8}$$

where,

True Positives (TP): predicted yes for the paddy disease, and the paddy do have the disease.

True Negatives (TN): predicted no for the paddy disease and the paddy do not have the disease.

False Positives (FP): predicted yes for the paddy disease, but the paddy actually does not have the disease.

False Negatives (FN): predicted no for the paddy disease, but the paddy actually having the disease.

The last step is to develop a system that compiled all the processess. Figure 4 shows the design layout of the system of paddy leaf disease detector.

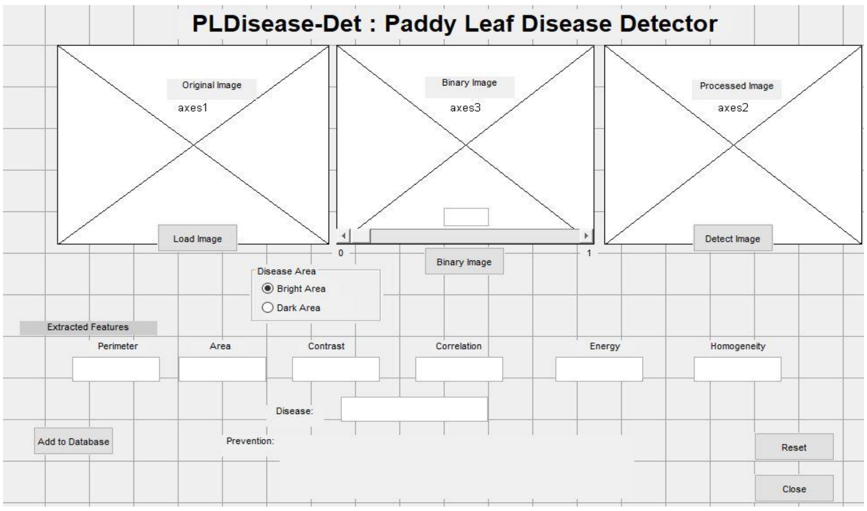

Figure 4: The design layout GUI for paddy leaf disease detector

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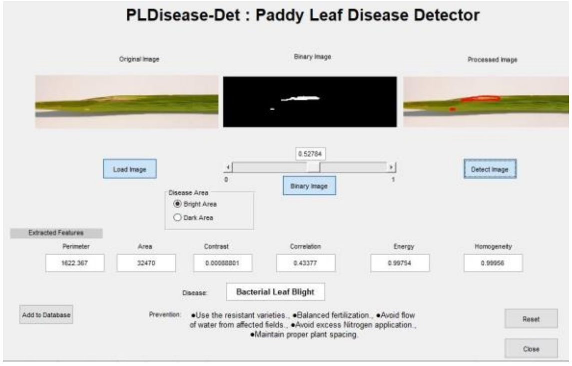
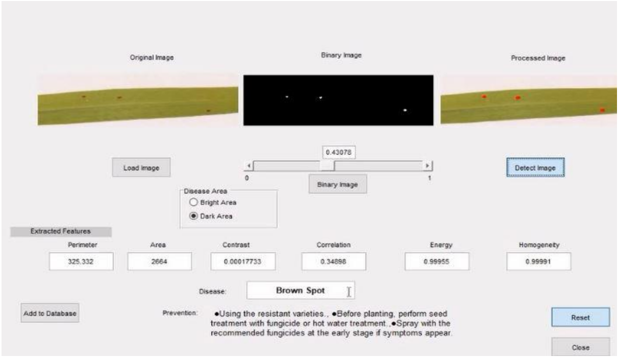
The user needs to load the image of the paddy leaf. Then, the user is required to select the ROI of the disease before the image is converted to binary image. The value of threshold is automatically calculated but it can be also manually adjusted accordingly. The cubic SVM is applied to train the dataset from all the calculated features.

3. RESULT AND DISCUSSION

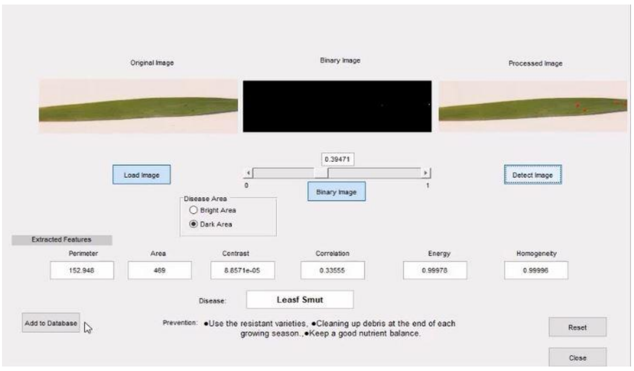
Figure 5 shows the result of three samples of (a) bacterial leaf blight, (b) brown spot and (c) leaf smut.



(a) bacterial leaf blight data



(b) brown spot data



(c) leaf smut data

Figure 5: The System of paddy disease detection

The confusion matrix is used to calculate the accuracy, precision, and misclassification for each of the disease. Figure 6 below shows the confusion matrix for the paddy leaf disease detection.

p-ISSN 1675-7939; e-ISSN 2289-4934

Figure 6. The confusion matrix for paddy leaf disease detection

From the confusion matrix, the values of *TP*, *TN*, *FN* and *FP* can be identified. The values are shown in Table 2.

Table 2. The calculation for accuracy for each of the paddy leaf disease

Bacterial Leaf Blight	**Brown Spot**	**Leaf Smut**
$TP = 32$	$TP = 28$	$TP = 27$
$TN = 64$	$TN = 62$	$TN = 66$
$FN = 6$	$FN = 6$	$FN = 6$
$FP = 3$	$FP = 9$	$FP = 6$

Table 3 shows that the percentage of accuracy, precision, and misclassification for each of the paddy leaf disease using the values in in Table 2.

Table 3: The Percentage of Accuracy, Precision, and Misclassification for Each of Paddy Leaf Disease

Disease / Measurement	Bacterial Leaf Blight	Brown Spot	Leaf Smut	Average
Accuracy	91.43%	85.71%	88.57%	88.57%
Precision	91.43%	75.67%	81.81%	82.97%
Misclassification	8.57%	14.29%	11.43%	11.43%

As for the result, it can be observed that the accuracy and the precision of bacterial leaf blight are the same at 91.43%. Furthermore, the brown spot and the leaf smut have the accuracy of 85.71% and 88.57% respectively. The precision for brown spot and leaf smut are calculated and the percentages for each disease are 75.67% and 81.81% respectively. Meanwhile, the misclassification for bacterial leaf blight, brown spot, and leaf smut are 8.57%, 14.29%, and 11.43% each. The average of the accuracy is 88.57% and the average of precision is 82.97% while, the average for misclassification is 11.43%. From this result, it is observed that the

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proposed method can identify and classify the paddy leaf disease at more than 80% in terms of accuracy and precsion while misclassification at less than 15%.

3. CONCLUSION

The set of processes developed in this study successfully detects the diseases using all the features value based on the sample image. The system can be used to assist the farmers and also the paddy researchers to detect the paddy disease through the leaf easily and they can take an action to control the diseases from getting widespread. This system is capable to detect the diseases earlier as soon as it occurs on leaf which can help avoid the loss and reduce the dependency on the export of some degree. For the improvement, less technical part of the system should be applied for the paddy farmer to use the system. A fixed value of threshold value is applied so that the user can get the output after inserting the image without the need to adjust the threshold value. Besides that, other part of paddy can be used for recognition purposes.

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