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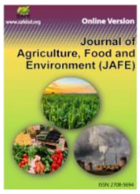

Research Article

Characterization of Potato Leaf Disease by Digital Image Processing Technique

Husna A[1,2*], Ahamed S[2], Jannat M[2], Muhit AA[2], Islam MH[2]

[1]Department of Farm Power and Machinery, Khulna Agricultural University, Khulna-9100, Bangladesh
[2]Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

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***Corresponding author**

Husna A, E-mail: asmaulhusnafpm@kau.ac.bd

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A B S T R A C T

Potato is a significant staple crop in Bangladesh. The productivity of potatoes decreases by factors such as disease, insect infestation, and rapid variations in climate conditions. The classification of potato leaf disease shows a vital role in preventing a damage of product. To identify the signs of disease immediately appearing in plant, it is essential to use automated detection techniques. If these epidemics are identified at the initial stage and proper activity is selected, the farmers would not suffer from significant financial losses. In this study, the classification of diseases of potato leaf was proposed using a digital image processing technique. The steps followed in this technique were acquisition, pre-processing of image, segmentation of image, feature extraction from image, and disease classification. For image acquisition, the early blight, healthy leaf, and late blight of potato leaf were clicked using DSLR camera. Enhancing the contrast and removing noise, RGB images were pre-processed. The diseased portion, normal portion, and background area was segmented through k-means clustering. Then the diseased portion was converted into a grayscale image. Feature extraction was done using an algorithm known as Gray Level Co-occurrence Matrix(GLCM). The classification of disease was done using Support Vector Machine (SVM). The proposed method achieved in identifying the early blight infected leaves, late blight infected leaves, and healthy leaves, was 95%, 76.5%, and 90%, respectively. Therefore, the proposed potato leaf disease finding by means of image processing may be a successful technique nowadays.

INTRODUCTION

Bangladesh is an agrarian nation and 70% of the citizens rely on agriculture (Athanikar and Girish, 2016). Different types of crops are being produced in our country and potato (*Solanum tuberosum*) is one of them. The production of potatoes for maximum produce and high-quality yield is really technical and it can be upgraded by scientific support. Plant disease identification is a skill along with a science (Arivazhagan *et al*., 2013). Production should take account of diseases resulting from pests, pathogens, and others. Diseases can be seen in the leaves of the plant in most cases. The proper detection of diseases and their causal agents is a prerequisite for control measures. An unhealthy plant has been compromised from its regular healthy condition. It can be stated that a disease interrupts the plant's produce and reduces its vitality. Pathogens causes these diseases and the type of crop cultivated during the season influence them. There are important diseases affecting potato leaves: late blight, rolling viral disease, and early blight (Chugh *et al*., 2020). In the case of late blight, the leaves turn dark brown to black, and in the case of early blight, there's a target spot on the leaves (Rozaqi and Sunyoto, 2020). In general, the leaves are green. The discoloration due to disease restricts the photosynthesis process and that’s why the production reduces. The damage caused by disease is not visible to the unaided eye. Renugambal and Senthilraja (2015) found that the farmer tries to identify the disease by means of their knowledge but this is not a suitable way. Consequently, diagnosis is a vital aspect of plant pathologist training. Researchers have developed different strategies to avoid crop losses caused by diseases. Using optical inspection to diagnose potato plant disease symptoms on plant leaves can occasionally be somewhat challenging. Experienced plant pathologists and agronomists are often unsuccessful to effectively diagnose exact diseases. Besides, experts should monitor continuously. This could become excessively costly for large farms (Oo and Htun, 2018). Farmers usually identify plant diseases through experience assumptions, resulting in incorrect diagnoses because the symptoms on the leaves often seem similar and are difficult to separate at a glance. So, the precautionary actions taken by farmers may be useless, possibly harming crops due to insufficient knowledge and misinterpretation of disease severity, resulting in either extreme or inadequate treatment dosages (Sholihati *et al.*, 2020). Accurately detection and grouping of diseases of plant are necessary for progressing agriculture. In agricultural research, image processing technology has made major advancement. Fastness and accuracy are the two keys requirements for machine-learning systems in the identification of plant disease. Usage of automatic methods for leaf disease detection is useful as it decreases the amount of work related to observing extensive agricultural farms and detects disease signs early on when they first develop on leaves of plant. Using machine vision and image processing methods are the most popular for detecting the leaf disease of plants. Image analysis can be employed for the following purposes: i) identifying diseased leaf, stem, fruit, ii) computing infested area by disease, iii) defining the borders of the infested area , iv) defining the colour of the infected area, v) assessing size & shape of leaf and vi) categorizing the Object properly (Rathod *et al.*, 2013). Researcher has built an automated system to recognize and categorize potato leaf disease using image processing techniques in different countries.

Different types of methods are studied for identifying different types of leaf disease occurred in plants. Kulkarni and Patil (2012) provided a system that detects diseases of plants initially and precisely using artificial neural networks (ANN) and a number of image-processing methods. Mondal *et al.* (2015) presented classification and detection methods that were utilized for classifying leaf disease of plant. Image processing was used for this work. Researchers use different techniques but these are really expensive. Some researchers determine the leaf disease of potato using multiclass SVM along with segmentation. Image segmentation, feature extraction, and classification by SVM were the following steps (Islam *et al.*, 2017, Suttapakti and Bunpeng, 2019). A paper evaluated the capacity of a method to distinguish and categorize where tomato leaf infested with either early blight or Powdery mildew (Mokhtar *et al.*, 2015). A work was proposed to detect the infection in grape plant leaf using artificial intelligence methods on images. Researcher used K-means clustering to segment grape leaf disease (Sannakki *et al.*, 2013). Researchers suggested a solution through software for the automatic recognition and computation of leaf diseases of cotton and soybean plant. Mainly Five steps: initially, creating a color conversion structure for the input RGB image, secondly removing the noise i.e. excessive part using a certain threshold value, after that segmenting the image, lastly the ANN was used for classification (Kanjalkar and Lokhande, 2013). A modern method was introduced to detect diseases related to leaf along with fruit. In the work, an algorithm named k-means combined with a multi SVM algorithm was developed in MATLAB (Raut and Fulsunge, 2017). A study presented a technique to recognize and categorize the leaf diseases of citrus through an image analysis and classification method. By capturing an image of the leaf, they were analyzed by monitoring the health condition of all plants. K means clustering and SVM was utilized for segmentation and classification, respectively (Gavhale *et al.*, 2014). Generally, recognition of image-based leaf disease has two steps: mining color and shape features from lesions and then classifying infected leaf images via a machine learning method. A paper analyzed the effectiveness of the classification implemented based on the extracted features using KNearest Neighbor, Support Vector Machine, and Decision trees (Nandhini and Bhavani, 2020).

Though few researchers have previously worked on leaf disease identification by image processing, only a limited number of current advancements are documented in the field of leaf disease recognition by means of machine learning approach (Dey *et al.*, 2016) and that too for potato leaf is the rarest in Bangladesh. Hence, to eliminate the shortcomings of the traditional way, there is a prerequisite for a rational machine vision method to farmers. Therefore, the specific aim of this study was the development of an image processing algorithm for the identification and characterization of potato leaf diseases.

MATERIALS AND METHODS

The procedures in this study followed in the detection of potato leaf diseases are acquisition of image, pre-processing of image, segmentation of disease spot, feature extraction, and classification of disease. A block diagram of the suggested methodology of detection of automatic plant leaf disease is presented in the figure 1.

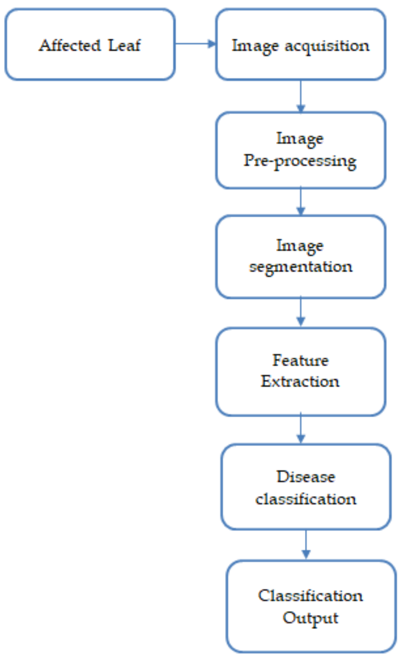


Figure 1: Block diagram of automatic potato leaf disease detection technique.

Image acquisition

Images of three categories of potato leaves such as healthy leaves (Figure 2), early blight infected leaves (Figure 3) and late blight infected leaves (Figure 4) were collected from a potato field of Dhonbari, Tangail, Bangladesh. The Canon EOS 800D model DSLR camera was used to take pictures of potato leaves. With the DSLR camera set up against a white background picture of a potato leaf was taken while staying around 35 cm away. From the collection of images, the clear 100 images for each category were sorted out and uploaded to a computer for analysis using MATLAB software.

(a) (b)

Figure 2: Healthy leaves.

(a) (b)

Figure 3: Early blight.

(a) (b)

Figure 4: Late blight.

Image pre-processing

Image pre-processing was employed to increase the image quality essential for subsequent pre-processing and analysis. It involves some method to convert the original image into some informative images. This technique was used to explain details that were hidden or only to emphasize specific features of interest in an image. With image enhancement, the image is more readable for machine or humans. The image of leaf was clipped to acquire the region of interest and smoothing of image is ready by means of the smoothing filter. Image enhancement is also applied to enhance the contrast (Singh and Misra, 2017).

Image segmentation

Image segmentation involves dividing an image into numbers of objects or organizing parts and mining the essential attributes from it. Among numerous segmentation methods, k-means clustering is notable. Clustering, a process that groups the image into clusters (Ramesh and Vydeki, 2019). This clustering extracts the infected portion from the leaf disease. In a leaf image the clusters are estimated for the non-infected part and the infected part. This method is employed to the hue component of the HSV model of the image with background removed. The hue component represents only the pure colour; it does not comprise any data like intensity and obscurity. Centroid value is served to create flawless segments to reduce the uncertainty problem of the cluster based on the analysis of the histogram of hue components. Additionally, the unnecessary green part was eradicated from the infected part.

Feature extraction

After separation of the infested region, several features were mined to define the infested region. The GLCM process describes the texture of an image by analyzing the spatial relationships within the image (Suttapakti and Bunpeng, 2019). Various features of colour oriented, shape oriented were extracted using MATLAB commands. Various features for example mean, variance, standard deviation, and other features were mined to recognize the health of the leaf.

Disease classification

Researcher uses the Support Vector Machine for image classification. There are numerous methods of image classification. Majority of the classifiers, for example minimum distance, neural network, decision tree and support vector are creating an ultimate decision regarding the land cover class and need a training trial. There are some neural networks like Probabilistic Neural Network (PNN), Artificial Neural Network (ANN), Convolutional Neural Network (CNN). An SVM classifier (Figure 5) was chosen for the trials built on formerly recognized studies reporting application and effectiveness in high dimensional problems. Training and testing were conducted for assessing the classifier's performance. SVM is founded on statistical learning concept with a severe mathematical foundation. It is a type of classifier named binary using a hyper plane between two classes known as the decision boundary (Padol and Yadav, 2016).

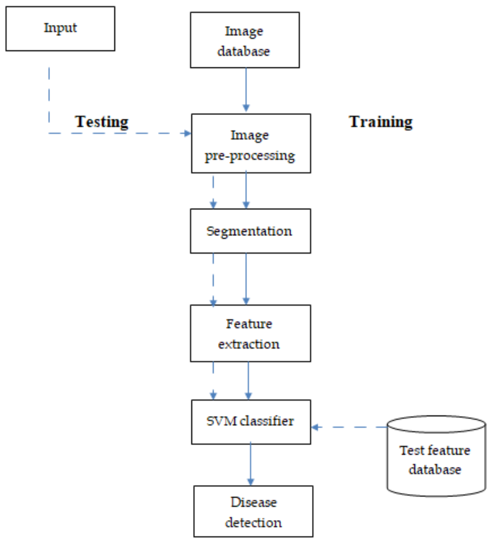


Figure 5: Flow diagram of SVM.

RESULTS

Initially, almost 300 different images were taken which belong to 2 types of diseases and healthy leaf. About 100 healthy leaves are in the dataset and about 200 are disease-infected leaves. Two phases named training and testing were the two divisions of the experiment. Of the dataset, training purpose uses 80% of the images while other 20% for testing purposes.

Training phase for creating a database of information

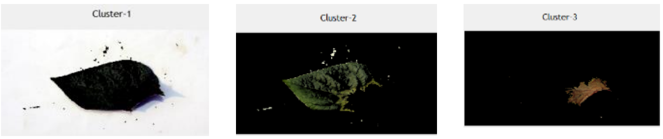
At first, the images were loaded into the system (Figure 6). Then the images were preprocessed for enhancing picture quality and image contrast (Figure 7).

From figure 7, it was noticed that the background of the image was very clear. The image enhancement was done here.

Figure 6: Loaded leaf image.

Figure 7: Pre-processed image.

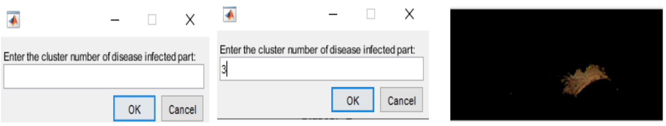
After that, clustering named K-means was employed for segmentation. By this clustering, the infected portion was separated from the leaf. Actually, images were classified into three different clusters. Cluster-1 (Figure 8a) was the total leaf area and cluster-2 (Figure 8b) was the healthy portion of the leaf. Cluster-3 (Figure 8c) was the disease-infected portion.



(a) (b) (c)

Figure 8: Clustering of image.

Disease-infected cluster was the Region of Interest (ROI) in this experiment. So, by entering the cluster number in a popup menu, allowed cluster-3 as the region of interest (Figure 9c)

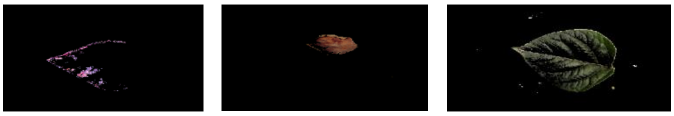


(a) (b) (c)

Figure 9: Selection of Region of Interest.

The GLCM Algorithm was then employed for extracting the textural features of images through a region-based technique. Various features related to colour oriented and shape oriented were extracted using MATLAB commands. To determine the health of the leaf, a number of parameters were extracted, including the mean, standard deviation, variance and other features.

SVM classifier was also used to classify the images into early blight disease-infected image (Figure 10a), late blight disease-infected image (Figure 10b) and healthy leaf image (Figure 10c). After training, a database of the leaf images was created which will be responsible for the better result of the classifier.



(a) (b) (c)

Figure 10: Classification of images.

Testing phase for accuracy

Twenty (20) early blight disease-infected leaves, 20 late blight disease-infected leaves and 20 healthy leaves were tested. An image was loaded in the database. The testing process was same as training from image pre-processing to classifier. Comparing with the database, it displayed which leaf was healthy and which was disease-infected leaf with either an early or late blight disease-infected. Table 1 shows the results.

Table 1. Accuracy of disease-infected leaf and healthy leaf detection.

Disease type	Number of tested images	Successfully characterized	Accuracy (%)
Early blight	20	19	95
Late blight	17	13	76.5
Healthy	20	18	90

DISCUSSION

Here, image processing has been used to find out the potato leaf diseases. The result showed that there was a satisfactory result in the case of early blight with about 95% accuracy. The segmentation methods have performed well in these disease patterns. In the case of healthy leaf, the accuracy was about 90% which was favourable. In this case, the segmentation error happened. On the other hand, in the case of late blight, the result was poor. Here the segmentation method has not performed accurately. The image quality was not preferable to detecting the disease. Hence the accuracy of the disease detection was reduced. However, the suggested method for detecting the potato leaf diseases using SVM had an average 87.17% accuracy in detecting the leaves and could help to achieve research goals by offering a precise, practical, and economical means of disease detection. Different studies show different results. A study showed a significant result in classifying potato leaf disease 97.8% using multiple classifier (Tiwari *et al.*, 2020). (Iqbal and Talukder, 2020) proposed a method of image processing for detecting the potato leaf disease and the Random Forest classifier gave a precision of 97%. A research presented the detection of the disease from the images of potato leaf using CNN model and established 97% of great precision (Asif *et al.*, 2020). A work has shown that watermelon leaf diseases succeeded with 75.9% precision with its RGB mean color component along with neural network in MATLAB (Kutty *et al.*, 2013). A paper demonstrated that oil palm leaf disease detection technique using multiclass SVM classifiers and 97% accuracy was achieved (Masazhar and Kamal, 2017). Image processing technique was used to recognize and categorize of tomato leaf disease, and obtained 98.29% and 98.029% accuracy for training and testing, respectively (Jasim and Al-Tuwaijari, 2020).

In comparison with the results of other studies, this study was compatible. However, there were some limitations, further improvement or training of more datasets could enhance the accuracy. For potato farmers, this study could be useful for higher crop yields, productivity, and profitability. It is important to remember that these findings are based on particular datasets and circumstances and that the plant species, disease type, and other environmental factors may have an impact on how well the algorithms perform. It is also critical to consider the limitations of image processing, which include the requirement for high-quality photos and the incapacity to identify diseases whose symptoms are not readily apparent on leaves.

CONCLUSION

Disease management and detection are important for the sustainable development of agriculture. Through proper disease detection, appropriate safety measures can be taken in time and potato production can be increased thereby. A method for diagnosis (identification and classification) of potato leaf disease has been advanced in the MATLAB environment deploying image processing techniques and SVM classifier in this study. The result showed an accuracy of 95% for early blight disease-infected leaves, 90% for healthy leaves, and 76.5 % for late blight disease-infected leaves. The average accuracy of the proposed method for detecting the potato leaves was 87.17%. The motive of the study was to concentrate on reducing human effort and error in identifying potato leave diseases. Disease identification will be able to reduce confusion among the particular disease whether it is late blight, early blight, or yet to disease free. This study states a base for upcoming investigation and expansion of these models in precision agriculture. Eventually, this research aims to assist the advancement of capable tools for disease diagnosis in time and increasing the productivity of potato crops globally. As the above conclusion suggests, there is always a possibility for enhancement in this field.

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Bangladesh Agricultural University, Mymensingh, Bangladesh.

Authors contribution

Conceptualization, Asmaul Husna, Muntasir Jannat and Md. Hamidul Islam; Methodology, Asmaul Husna, Muntasir Jannat and Md. Hamidul Islam; Software, Asmaul Husna and Muntasir Jannat; Data analysis, Asmaul Husna and Muntasir Jannat; Writing original draft preparation, Asmaul Husna, Sahabuddin Ahamed, Muntasir Jannat, Abdullah-Al Muhit and Md. Hamidul Islam; interpretation, Asmaul Husna, Muntasir Jannat and Md. Hamidul Islam Writing—review and editing, Asmaul Husna and Sahabuddin Ahamed; Supervision, Md. Hamidul Islam. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare no conflict of interest.

Ethical approval

Not applicable.

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