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Computer Vision-based Plant Leaf Disease Recognition using Deep Learning

Nasrin Sultana, Touhidur Rahman, Nargis Parven, Muhammad Rashiduzzaman, Ismail Jabiullah

Abstract*: Computer vision-based applications play a vital role in the era of computer science and engineering. Now-a-days peoples are facing different problems in agricultural fields to improve their cultivation. So, a better approach is proposed for plant leaf disease recognition using deep learning techniques for agricultural improvement. This research is very much helpful for the farmers to identify the leaf diseases of a plant. This proposed system has three subsections. One is feature extraction, second is trained networking generation and the third one is classification. This system first takes an image as the input and extracts the features from the image using K-means clustering. Secondly, it generates a trained network using Convolutional Neural Networks (CNNs). Then compare the original leaf image with the generated trained database in the classification section and recognition of the disease of the plant. Different techniques are used in this system for properly recognized the diseases. After analyzed the 3000 trained images, three types of leaf diseases are properly recognized by this system, which are Cercospora Leaf Spot, Mosaic virus, and Alternaria Leaf Spot. The overall accuracy of this system is very good and which is up to 95.26%.

Keywords: Leaf Disease, Deep Learning, Image Processing, Computer Vision, K-Means Clustering, Convolutional Neural Networks (CNNs).

I. INTRODUCTION

Bangladesh is an agricultural country and most of the people in Bangladesh depend on agriculture for living their earning. In our country, farmers are usually producing different types of crops like rice, jute, vegetables and fruits. As the improvement of agricultural fields an increasing the production day by day, similarly the diseases of plants are increasing. These diseases are most often seen on the leaf of a plant. It is very difficult to detect this leaf disease only with eye observation. Currently, various researchers are researching about recognition of diseases, so that it can detect disease very easily using digital techniques. Identifying plant leaf diseases using image processing play a vital role in successful cultivation.

Artificial Intelligence applications have achieved explicable growth, leading to the improvement of methodologies and models, which now form a new category of Deep Learning [2]. Convolutional Neural Networks (CNNs) is one of the basic tools of deep learning that plays an important role in disease recognition of plant [4]. Applied CNNs method for the automated recognition of plants, based on leaves images. An automated system has been developed in this research so that farmers can easily identify the plant's diseases by capture images. The system analyzes the image and extracts the feature where uses K-Means Clustering and classifies the image using Convolutional Neural Networks (CNNs).

II. EXISTING WORKS

Many researchers have adopted many different techniques to detect different kinds of diseases. Some of the related work discussed here.

The existing system has done by image processing technique and discussed oil leaf disease detection using a multiclass SVM classifier. Here uses K-Means Clustering for image segmentation and classifies the feature extracted image using a multiclass SVM classifier. It's only recognized two diseases [3]. Some authors have used Convolutional Neural Networks (CNNs) for input image classification, where 18,160 images are used for the data-set and classify 10 different diseases only for tomato leaves. The accuracy rate of this system is 94-95% [4]. Other researchers discussed deep learning and used three main families of detectors: Faster Region-based Convolutional Neural Network (Faster R-CNN), Region-based Fully Convolutional Network (R-FCN), and Single Shot Multibox Detector (SSD) for proposed work. This system can identify different types of diseases [5].

Some researchers describe the image processing technique, where collected carbon copy from data-set and process them with several algorithms. They are used SVM to compare with both training data-sets and precise data-sets. This technique gives good accuracy [6]. Another paper used 500 leaf images of 6 different types of vegetables for vegetable plant recognition and classification.

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* Correspondence Author
Nasrin Sultana*, pursuing M.Sc. in Computer Science & Engineering at Daffodil International University, Dhaka, Bangladesh. Email: tonnydiu@gmail.com
Md. Touhidur Rahman, Assistant Programmer, Department of Computer Science & Engineering, University of Dhaka, Dhaka, Bangladesh. Email: touhidjpi@gmail.com
Nargis Parven, pursuing M.Sc. in Computer Science & Engineering at Daffodil International University, Dhaka, Bangladesh. Email: nargis21nishan@gmail.com
Muhammad Rashiduzzaman, Research Associate, Department of Computer Science & Engineering, Daffodil International University, Dhaka, Bangladesh. Email: rashid.shimul@gmail.com
Md. Ismail Jabiullah, Professor, Department of Computer Science & Engineering, Daffodil International University, Dhaka, Bangladesh. Email: drismail.cse@diu.edu.bd

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Different types of diseased and disordered leaf images classified by using two-level classification k-nearest neighbor (K-NN) and Probabilistic Neural Network (PNN). The overall accuracy rate of the vegetable identification and abnormality detection using k-nearest neighbor (K-NN) & Probabilistic Neural Network (PNN) is 80.72% [7]. The basic Deep Learning Techniques used for analysis Plant Leaf Disease Detection. Also, explain the benefit of using Convolutional Neural Networks (CNNs). They discussed various research work and reviewed the architecture used for the detection of plant leaf disease [8]. Detection of leaf diseases and classification completed by using Gray-Level Co-Occurrence Matrix (GLCM), Support vector machine (SVM) and K-means clustering technique, where used K-Means clustering for image segmentation, GLCM for feature extraction and SVM method used for disease classification. The method tested only citrus leaves and the accuracy rate of this system is 90% [9].

III. METHODOLOGY

In this section, the complete procedure of this thesis has described. It has two subsections which are a block diagram and a theoretical background.

A. Flow Diagram

Fig. 1 has shown the flow diagram of the disease recognition methodology. At first, this system takes an image from the user for image acquisition. In the pre-processing part, this system resizes the image and measure the dimension of that image. After that this system doing the segmentation to remove the leaf image background.

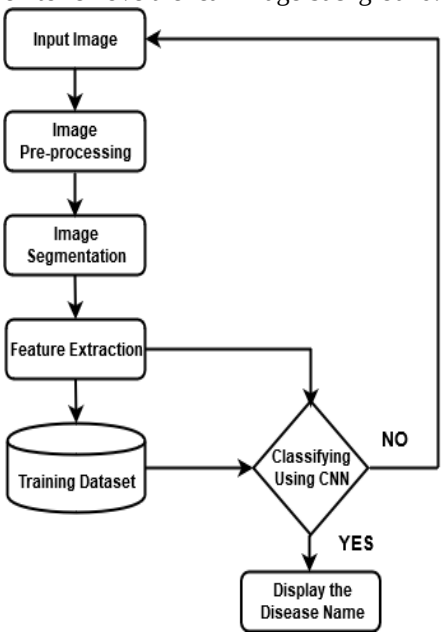


Fig. 1: Block Diagram of the Proposed System

For feature extraction, this system used k-means clustering and generate a trained network using Convolutional Neural Networks (CNNs). Finally, the system takes an input leaf image and classify with the trained network and recognized the disease of the respective leaf image. All the processes are described below.

B. Theoretical Background

1. Image Acquisition

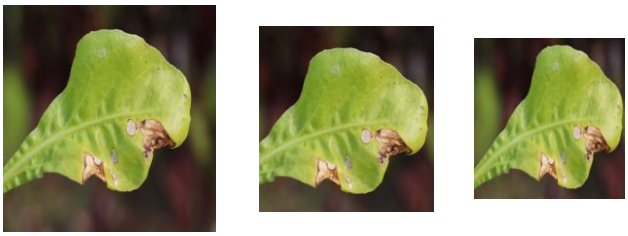
In this paper, at first various types of leaf diseased images have been collected from different rural areas using a digital camera with the required resolution. Here 3000 images have been collected for analysis and a data-set has been created of this image. After that, it's divided into 3 classes of diseases. The name of the diseases is Cercospora Leaf Spot [13], Mosaic Virus [14] and Alternaria Leaf Spot [15] [16].

(a) Alternaria Leaf Spot **(b) Cercospora Leaf Spot** **(c) Mosaic Virus**

Fig. 2: Sample Images of Three Types of Leaf Diseases

2. Image Pre-processing

Image pre-processing is an important part of this system which used enhanced the quality of image for better analysis. In this phase, Image crop, rotate and resize has done. Here resized this original image into 512 x 512 pixels. After cropping the image, it is loaded into the system.



(a)Original Image **(b) Crop Image** **(c) Resize Image**

Fig. 3: (a) Original Image (b) Crop Image (c) Resize Image

3. Image Segmentation

In image segmentation, a digital image divided into multiple segments. Here uses color code for identifying the foreground and background for image segmentation. A different function is used for removing the background which is shown in Fig. 4.

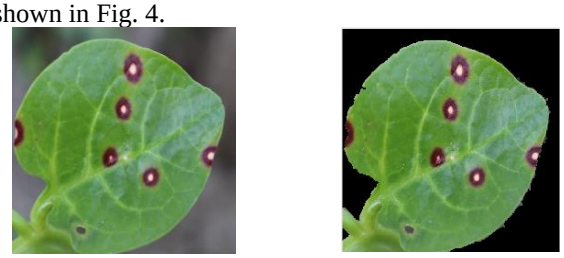


Fig. 4: Background Removed Image from original Image

Firstly, detects the foreground and background of an image and generated a new image and finally masking with the original image for removing the background region of the original image.

4. Feature Extraction

Feature Extraction is a key role in the whole system. In this paper, Feature has been extracted using k-means clustering. In this section used background removal image as an input and applying the color-form, here classifying the colors in L*a*b* color space using k-means clustering. This feature is extracted from one cluster image into the three clustered. So, the image has 3 colors create 3 clusters and get the best clustering ROI (Region of Interest) by giving the input number (1-3) and detect the best features and finally masking with an input image. After that, it saves the images into the folder for making a category. So, the selection of cluster plays a vital role that is shown in Fig. 5.

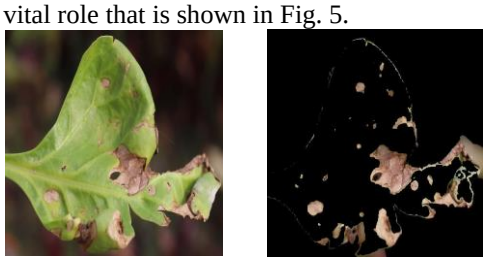
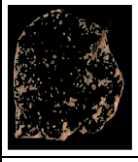
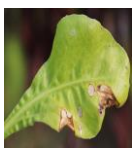
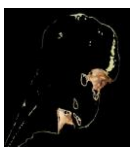


Fig. 5: Feature Extracted Image of this System

5. Generate Trained Database

This section is most important for any research. The proposed system has used Convolutional Neural Networks for generating the trained network. After the features extraction, the same category image saves in a folder and it making three folders for three diseases, which is shown in Table-I. It has needed for CNNs labeling.

Table-I: Image Sequence for Generating Trained Data-set

Original Image	Background Removed Image	Features Extracted Image	Name of Disease	Quantity of Images
			Cercospora Leaf Spot	1000
			Mosaic Virus	1000
			Alternaria Leaf Spot	1000

It resizes the image 128x128 which is suitable for the CNNs and it has used 1000 images for each category. The labeling images are used in the Convolutional Layers. This research has used four layers which are Convolutional, pooling, Rectified Linear Unit (ReLU), and Fully Connected layers. This system separated all categories of images into the train and test set. It used a 70% image for a train set and a 30% image for the test set. This system used Alexnet to generate a trained network by using stochastic gradient descent with momentum (SGDM), initial learning rate 0.0001, epochs 50 and batch size 64. It gives good result because the train and test set was successfully generated.

6. Classification

In this research classification is the main part. Basically, it is a user part. It first loads the pre-trained image database that is generated earlier by using CNNs. It is also taking an image from the user and doing pre-processing until to extract the features and classifying with the data-set.

(a) Input Image **(b) Output Image**

Fig. 6: Leaf Disease Classification Image

Here, the user gives an input number of affected regions that are shown on the user screen. Finally, it recognized the disease for the given input image which is shown in Fig. 6. The classification rate of this system for train and test sets is found very better.

IV. IMPLEMENTATION

This system has used a Computer with specification Core i5 3.2 GHz, 8 GB RAM and necessary software MATLAB R2019a, MATLAB Kit as a system requirement. The reasons for using MATLAB are very user-friendly, more efficient and easier to implement for computer vision programming. It is the best image processing tool. The whole work is completed by three steps. It has two interfaces: one is a classification interface and the other is a developer interface where trained related computation happens.

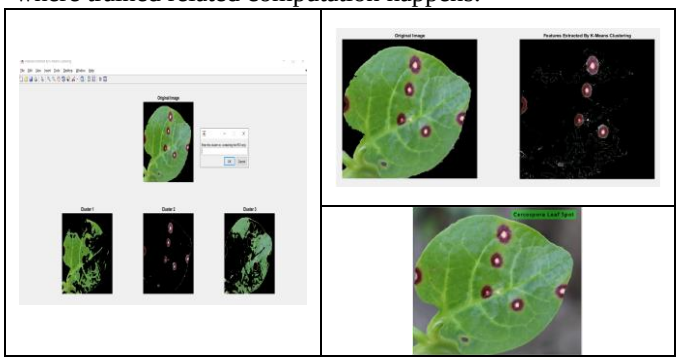


Fig.7: User Interface of the Proposed System

The classification interface is very much user-friendly, it takes a picture from the directory and shows the affected region into three clusters areas, where the user easily selects the best one by at a glance. After that, it classifying with a data-set and shows the result (Disease name).

V. RESULT AND DISCUSSION

The result analysis is the evolution part of the research. This system work on three diseases. So, it tries to analyze the three diseases individually by using the CNNs algorithm and comparing it by two different algorithms Support Vector Machine (SVM) [9] and K-Nearest Neighbors (K-NN) [7].

The SVM and K-NN are used for another leaf recognition in the existing system, but the proposed system is not used the same diseases as the existing system. So, the recognition results are found different for those algorithms, shown in Table-II.

The accuracy rate has been calculated by using the following formula.

$$Accuracy = \frac{\text{Total Number of Recognized Image Samples Correctly}}{\text{Total Number of Images used for Testing}} * 100$$

Table- II: Result Analysis and Comparison of Accuracy Rate of Existing System and Proposed system

No.	Name of Leaf Disease	SVM	K-NN	CNN	Accuracy for SVM	Accuracy for K-NN	Accuracy for CNN
1	Cercospora Leaf Spot	92%	92.3%	95.5%	90%	89.43%	95.26%
2	Mosaic Virus	88%	89%	93.3%			
3	Alternaria Leaf Spot	90%	87%	97%			

The overall accuracy of SVM and K-NN are respectively 90% and 89%, where the accuracy of CNN is up to 95.26% which is found better compared to SVM and K-NN. The overall accuracy rate of the three classifier techniques is shown in Fig. 8.

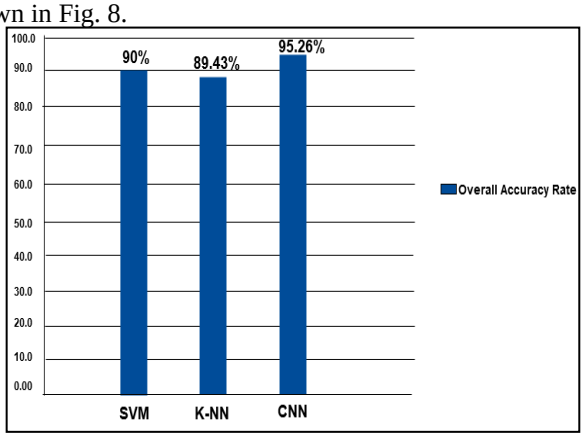


Fig. 8: Historical Chart of the Accuracy Rate

By doing several experiments, it is tried to improve the result by using the proposed system to achieve better accuracy.

VI. CONCLUSION

This system has the ability to recognize the diseases of Cercospora Leaf Spot, Mosaic virus and Alternaria leaf spot using CNNs by computer vision-based approach. It has used segmentation to remove the background and k-means clustering is used to extract the features for generating a trained network. This type of application is very needful to the farmers for increasing productivity in agricultural fields. But it is very difficult to remove the background of the leaf image, because most of the leaf images background is a leaf. So, separating the affected area is very challenging. Every stage of the system is not capable to remove the background leaf image, but overall it working well. Finally, the recognition rate of this system is found good and it's up to 95.26%. In the future, it will be trying to increase the recognition rate and work on more diseases.

REFERENCES

1. Abhay Agarwal, Adrija Sarkar and Ashwani Kumar Dubey, "Computer Vision-Based Fruit Disease Detection and Classification", Smart Innovations in Communication and Computational Sciences, Advances in Intelligent Systems and Computing 851, 2019.
2. Konstantinos P. Ferentinos, "Deep learning models for plant disease detection and diagnosis", Computers and Electronics in Agriculture, February 2018.
3. Ahmad Nor Ikhwan Masazhar and Mahanijah Md Kamal, "Digital Image Processing Technique for Palm Oil Leaf Disease Detection using Multiclass SVM Classifier", IEEE International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA), 2017.
4. Prajwala TM, Alla Pranathi, Kandiraju Sai Ashritha, Nagaratna B. Chittaragi, Shashidhar G. Koolagudi, "Tomato Leaf Disease Detection using Convolutional Neural Networks", International Conference on Contemporary Computing (IC3), 2018.
5. M. Akila and P. Deepan1, "Detection and Classification of Plant Leaf Diseases by using Deep Learning Algorithm", International Journal of Engineering Research & Technology (IJERT),2018.
6. S.S. Saranya, Nalluri Chandra Kiran and Komma Jyotheeswar Reddy, "Identification of diseases in plant parts using image processing", International Journal of Engineering & Technology, 2018.
7. Sandhya Tippannavar and Dr.Shridevi Soma, "A Machine Learning System For Recognition Of Vegetable Plant And Classification Of Abnormality Using Leaf Texture Analysis", International Journal of Scientific & Engineering Research Volume, June, 2017.
8. Sunayana Arya and Rajeev Singh, "An Analysis of Deep Learning Techniques for Plant Leaf Disease Detection", International Journal of Computer Science and Information Security (IJCSIS), 2019.
9. R.Meena Prakash, G.P.Saraswathy and G.Ramalakshmi, Nagaratna B. Chittaragi and Shashidhar G. Koolagudi, "Detection of Leaf Diseases and Classification using Digital Image Processing", International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), 2017.
10. Kittipong Powbunthorn1, Wanrat Abudullakasim1 and Jintana Unartngam, "Assessment of the Severity of Brown Leaf Spot Disease in Cassava using Image Analysis", The International conference of the Thai Society of Agricultural Engineering, 2012.
11. Shivani and Sharanjit Singh, "Fruit Disease Detection Using Convolution Neural Network Approach", Asian Journal of Computer Science and Technology, Vol.7 No.2, 2018, pp. 62-65.
12. Dong Pixia and Wang Xiangdong, "Recognition of Greenhouse Cucumber Disease Based on Image Processing Technology", Open Journal of Applied Sciences, 2013, pp. 27-31.
13. Learn about pestnet, available at "http://www.pestnet.org/fact_sheets/bean_cercospora_leaf_spot_301.htm", Last accessed on 1-24-2020 at 9 PM.
14. Learn about planet natural research center, available at "https://www.planetnatural.com/pest-problem-solver/plant-disease/mosaic-virus/",Last accessed on 1-24-2020 at 10 PM.
15. Learn about harvest to table, available at "https://harvesttotable.com/alternaria-leaf-spot/", Last accessed on 1-23-2020 at 10 PM.
16. Learn about gardening, available at "https://www.gardeningknowhow.com/plant-problems/disease/alternaria-leaf-spot.htm", Last accessed on 1-23-2020 at 11 PM.

AUTHORS PROFILE

Nasrin Sultana, received her Bachelor of Science degree in Computer Science and Engineering from Daffodil International University, Dhaka, Bangladesh in 2018 and currently she is pursuing her Master of Science in Computer Science and Engineering at the same University. Her programming skill is very good and she is a dedicated person in her works. Her research interests include Computer Vision, Image Processing, Artificial Intelligence, Machine Learning, Deep Learning, Network Security and Information Security.

Md. Touhidur Rahman, received his BSc and MSc degrees from the Department of Computer Science & Engineering at Daffodil International University, Dhaka, Bangladesh in 2018 and 2019, respectively. He is currently working as an Assistant Programmer at the University of Dhaka, Dhaka, Bangladesh. He has already published one conference paper and one journal paper. His research interests includes Computer vision, Image processing and Human-computer Interaction, Artificial Intelligence, Machine Learning, Deep Learning.

Nargis Parven, received her Bachelor of Science degree in Computer Science and Engineering from Daffodil International University, Dhaka, Bangladesh, in 2018. She studying her Master of Science in Computer Science and Engineering at Daffodil International University. Her research interests are includes Network Security, Wireless Network, Information Security, Artificial Intelligence, Machine Learning, Deep Learning, Data mining and Image processing.

Muhammad Rashiduzzaman, received the Master of Science degree in Computer Science and Engineering from Daffodil International University, Dhaka, Banglsadesh, in 2020. He completed his Bachelor of Science in Computer Science and Engineering from Faculty of Science and Information Technology (FSIT) at Daffodil International University, in 2018. His research interests are includes Cryptography, Cyber Security, Network Security, Information Security, Satellite Network, Cryptocurrency, Steganography, Wireless Network, Mobile Network, Internet of Things (IoT), Artificial Intelligence, Machine Learning, Deep Learning, Image Processing, Software Security, Neural Networks and Big Data.

Md. Ismail Jabiullah, received Ph.D. degree in Computer Science and Engineering from the University of Dhaka, Bangladesh. His Ph.D. topic was in Cryptography and Network Security. He is currently a Professor in the Computer Science and Engineering Department at the Daffodil International University, Dhaka, Bangladesh. He has published 39 research articles in reputed journals and more than 78 research papers in the International Conferences. He authored more than 26 books. His research interests include Network Security, Information Security, Cryptography, Cyber Security, Cryptocurrency, Steganography, Wireless Network, Mobile Network, Artificial Intelligence, Machine Language, Deep Learning, Software Security, Satellite Network, Image Processing, Software Testing and Neural Networks. He serves as a reviewer for various reputed journals and conferences annually.