Application of Deep Learning in the Identification of Diseases in Plants: A Review

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Abstract: This review is related to plant disease detection. The plant disease detection technique is the combination of image processing and classification. The image processing techniques can process the pixels which are stored in the form of pixels and classification techniques can predict the disease type. The plant disease detection has various phases like data input, pre-processing, segmentation and classification. The data which is taken as input can processing to increase contrast value of the data. The technique of segmentation can divide the input image into certain parts to reduce the execution time. This review focusses on the different techniques which can be utilised in detection of plant disease.

Keywords: Plant disease, Image processing, Segmentation technique, Classification technique.

I. INTRODUCTION

Recognition of plant disease by using various tools is of paramount importance in the field of agriculture. The old practices involving identification of diseases in plants by recognizing spots and lesions on various parts of plants is not only outdated but also not at all reliable. The new machine vision technology is replacing the old one. The most sought out technology of current times is the image recognition method based on deep learning.

The origin of deep learning concept begin in 2006. Basic concept behind this technique is utilization of neural network for analysis of data. Several layers which are hidden are extracted by this method. Each layers are used for feature extraction. The low level features are then combined for obtaining high level features. This results in alleviation of local problems.

Deep learning model has multiple layers which contributes to its good autonomous learning ability and feature expression ability. Deep learning methods have developed many well known deep neural network models including CNN (convolutional neural network). CNN model consists of input layer, convolution layer, pooling layer and output layer. The popularity of CNN in the field of deep learning is because of its ability to complex information on the basis of basic structural characteristics. The local receptive field of this model is the convolution layer. During data processing this convolution core slides onto feature map to extract part of feature information. Further in pooling layer, neurons are put for more extraction of feature. The two layers then enter into full connection layer where neurons are connected with upper layer neurons. The softmax method is then used for classification of full connection layer. These values are then transmitted to output layer.

The strong feature extraction capability of CNN has made it the most commonly used pattern in classification of diseases in plants. The feature extraction of CNN consists of cascaded convolution layer, pooling layer, connection layer along with softmax for classification of structure. When a test image is put into classification network, network analyses the image and returns a label which classifies the image.

II. USE OF COMPUTER VISION SYSTEM IN DETECTION OF PLANT DISEASE

All across the globe, India ranks on the first position in terms of contributing towards the farming occupation. The social as well as economic development of India is also growing with the growth of agriculture in the economic sector. Around 210 million acres of farming land is available in India itself for farming purposes. The major crops growing in our country are pulses, sunflower, Jowar, wheat, and groundnuts. A mechanism that is designed for agricultural applications is commonly known as Computer Vision Systems (CVS). This technology helps in categorizing fruits and identifying food products through fruit processing, classifying grains, detecting the weeds and performing many such similar tasks. Digital camera is used for acquiring digital images and image processing techniques are applied for processing them [1].

The important features required are extracted by applying these image processing based techniques on those images.
Various researchers have attempted to use image processing and pattern recognition techniques in the previous decade. The plant disease symptoms are recognized and classified automatically for designing a machine vision system. Through various pathogens generated by the crops, general symptoms are exhibited by different kinds of diseases. Among the large number of disease symptoms in plants, fungi are the most responsible for causing plant diseases. The time and efforts required when applying an automatic detection approach are less and this approach also provides highly accurate results. The viral, fungal and bacterial diseases, the early and late scorch and the brown and yellow spots are few of the general diseases found in plants. To detect the affected region, image processing follows certain steps which are explained below.

a. Image Acquisition: A camera device is used for click the images of plant leaves. The RGB from of image is generated through this device. For the RGB image, color transformation structure is created and for this structure, a device-independent color space transformation is designed. [2]
b. Image pre-processing: For improving the image or extracting important information from it, operations are performed on the image through image pre-processing technique. The associate feature of an image can be extracted in this step which is similar to that of signal processing. In engineering and computer science based fields, this step provides a core research domain.
c. Image Segmentation: The parts in an image with similar features are partitioned through segmentation process. A digital image is divided into various segments that include sets of pixels otherwise known as super-pixels in this step. The simplification of image and its representation into any meaningful form that is easier to analyze is the major objective of segmentation [3].
d. Feature Extraction: To identify various objects, feature extraction plays any important role. For plant disease detection, features like edges, morphology, color and texture can be extracted. Reducing the dimension is performed through feature extraction.
e. Detection and Classification of plant disease: The corresponding levels based on homogeneous characteristics are assigned by performing classification on remotely sensed data. Multiple objects present within an image are distinguished from each other through this method. Depending upon the spectral features, classification is executed.

III. TECHINIQUES OF IMAGE PROCESSING

For the worldwide agricultural trade, huge production and economic losses are faced due to the diseases in plants. For property agriculture it is important to observe the health and detect the diseases of plants and trees. Several techniques have been designed to detect plant diseases from images. Among them, few important and commonly used techniques are presented below:

a. Neural Networks: For segmenting the images into leaves and background neural networks are applied. From every RGB and HIS representation of image, different size and color options are extracted here. Further, the neural networks and applied mathematics classifiers which confirm the conditions of plants are fed with the parameters extracted in previous step [4].
b. Support Vector Machine: To execute SVM, various color representations are required in this method. The MLP neural network is used to distinguish among leaves and image backgrounds. An unsupervised

and undisciplined self-organizing map is used to cluster the colors present on the leaves. The morbid and healthy regions are separated using SVM.

c. k-Nearest Neighbor: To identify the categories of features depending upon the distinctive closest neighbors the k-NN machine learning based approach is applied. To determine the class of query, the neighbors are used here. Therefore, based on the minimum distance among the detected feature and various points, that feature is categorized using k-NN.

IV. HISTORY OF APPLICATION OF CVS ON PLANT DISEASE IDENTIFICATION

Sukhvir Kaur, et.al (2018) used the idea of *k*-means algorithm for developing a rule oriented semi-automated model [5]. The main aim of this model was to differentiate between normal leaves and infectious leaves. Moreover, the classification of infectious leaf had been carried out in one of the three disease types. In order to carry out tests, several attributes such as color, texture, and their mixture had been used individually. These features carried out the training of SVM (Support Vector Machine) based three disease detection models. In order to generate outcomes, several hundred images from a dataset called PlantVillage had been taken. The recommended model outperformed the other exiting models in terms of accuracy. This model also measured the seriousness of the infection in efficient manner.

Konstantinos P. Ferentinos, et.al (2018) designed CNN (convolutional neural network) for detecting infections in plants [6]. These models made used of clear pictures of plant leaves. These pictures were classified as normal and infectious using deep learning approaches to diagnose the infection. An openly available database containing 87,848 pictures had been used in this work to train these models. This database included images captured from twenty five different plants. The testing of various models had been carried out for achieving the success ratio of 99.53% in plant disease detection. The model achieving maximum success rate in plant disease detection could be used as an extremely valuable alternative. This model could be modified further to assist the detection of integrated plant infection in real-time crop growing circumstances.

Huu Quan Cap, et.al (2018) introduced a leaf localization technique for plant disease detection. The images of leaf captured on-location using a high resolution camera were used for this purpose [7]. The recommended approach was used with a deep learning approach. This work provided a simple and precise leaf area detection mechanism. This mechanism was quite similar to other available disease diagnosis mechanisms. The recommended technique achieved F1 score of 0.78. This work made use of almost all healthy leaf images. The future work would be focused on investigating and evaluating the recommended techniques in real-time scenario with multiple diseased leaves.

Jiang, et.al (2019) initially built ALDD (Apple Leaf Disease Dataset) for detecting infections in the leaves of apple plant [8]. In order to create this data set, the images from laboratories and complex backdrops had been gathered. On the basis of this dataset, a new apple leaf disease detection model had been presented in this work. This model made use of deep convolution neural network (CNN) models. In addition, the new deep CNN (convolution neural network model) had been designed by commencing the GoogLeNet Inception module and incorporating the Rainbow concatenation. This model was named as INAR-SSD. The main aim of this model was to make improvements in the performance of multi-level infection object identification and less infectious object identification. The tested outcomes depicted that the recommended model achieved detection accuracy of 78.80% mAP on the constructed data set. This model also detected diseases with a high speed of 23.13 FPS. The tested outcomes depicted that the recommended model diagnosed diseases in apple plant in early stage. This model could be used to detect infections practically with better precision and speedier than conventional approaches.

Uday Pratap Singh, et.al (2019) made an attempt for developing a suitable and efficient technique to diagnose different types of plant infections and their early signs [9]. There was the need of an inexpensive system that could detect infection within plants in early stage. Deep learning approaches had become quite popular in the past few years because of their efficiency in plant disease detection. These approaches efficiently classified different types of fungal infections. For this reason, a novel approach called MCNN (Multilayer Convolutional Neural Network) had been recommended in this work. The main aim of this approach was to classify the diseased leaves of mango tree. This work made use of practical dataset for the validation of recommended approach. This dataset contained total 1070 images of leaves. This dataset had both fine as well as diseased images of leaves. The recommended approach outperformed the other existing techniques of plant disease detection in terms of classification accuracy.

Parul Sharma, et.al (2019) analyzed that almost all deep learning models had a common issue of low efficiency for automated infection recognition [10]. These models generally faced this issue after their implementation in realistic images. This work made use of segmented and annotated images rather than original images to train a CNN (convolutional neural network) model. The training of a CNN model using segmented images generated better results in contrast to the training using original images. The use of segmented images increased the model's performance in disease detection from 42.3% to 98.6%. The future work would be focused on using superior datasets for plant disease detection.

Halil Durmuş, et.al (2017) made an attempt for detecting infectious leaves of tomato plants. In this work, a deep learning approach was implemented for detecting different types of infections on tomato plant leaves [11]. The main aim of this work was to run the deep learning algorithm on the robot in practical manner. This was done to make robot efficient in the detection of plant infections. This robot could wander both in manual or automatic manner for this purpose on the farm or in the conservatory. The training of deep learning model could be done on the farm in case of novel infection recognition with new images. This study implemented realistic infection recognition ability to robot. The future work would be focused on studying leaf image withdrawal from the complicated backdrop for the completion of model.

Omkar Kulkarni, et.al (2018) presented a deep learning model for plant disease detection. The training of this model was carried out using an openly available dataset. This dataset included images of healthy and infectious plant leaves [12]. The main aim of recommended model was to classify the images of leaves into different types of diseases on the basis of disease pattern. In this work, the formulation of deep CNN (Convolutional Neural Networks) was carried out for the classification of plant types and detecting infections on pictures. The testing of recommended approach was done on the five categories of plants and three sorts of infections for all classes. The tested results depicted that InceptionV3 model showed higher accuracy rate and lower justification loss than the MobileNet model. This work would be extended in the nearby future. The future work would focus on classifying those images which were not clicked in a good atmosphere and had numerous orientations.

Robert G. de Luna, et.al (2018) designed a pioneering approach for efficiently detecting disease in the leaves of tomato plants [13]. This work made use of a motor-controlled image acquiring envelope. The main aim of this envelope was to click images of four sides of each tomato plant for detecting and classifying leaf infcetions. A particular species of tomato called Diamante Max was used in this work as the testing topic. The designing of system was done for detecting the leaf infections. The training of a deep CNN (convolutional neural network) model was carried out for detecting three infections. For this purpose, a dataset containing 4,923 images of contaminated and healthy tomato plant leaves was used in this work. The tested outcomes depicted that the recommended model achieved classification accuracy of 91.67 % in plant disease detection.

Adedamola Adedoja, et.al (2017) analyzed an algorithm based on deep learning for detecting infections in plant leaves [14]. This approach used transfer learning to identify infectious leaf images. This work made use of NASNet framework for CNN (convolution neural networks). An openly available dataset was used in this work for the training and testing of recommended model. This dataset contained various images of plant leaves with manifold differences in disease category and setting in the plants. This model after training showed accuracy rate of 93.82%. The tested outcomes depicted that the recommended model could efficiently detect different types of leaf images as either infectious or healthy in spite of the multifaceted variations.

V. SEGMENTATION AND CLASSIFICATION FOR PLANT DISEASE IDENTIFICATION

5.1 Segmentation Technique for Plant Disease Identification:

Shanwen Zhang, et.al (2018) recommended a new plant unhealthy leaf segmentation and detection technique based on IOT (Internet of things) [15]. The recommended technique was the combination of super-pixel algorithm, K-mean algorithm and PHOG (pyramid of histograms of orientation gradients) approaches. At first, super-pixel clustering carried out the division of infected leaf picture into some compressed super-pixels. After that, the segmentation of lesion image had been carried out using K means clustering. This process segmented this image from all super-pixels. At last, the PHOG attributes were fetched out from three color elements of every fractional (segmented) lesion image and its grayscale version. Here, the integration of four PHOG descriptors had been carried in the form of a vector. Several tests were conducted on the two datasets of plant infected leaf image. The tested results depicted that the recommended approach was quite efficient. This work presented a real-time approach for segmenting infected leaf image and detecting leaf infection.

Trimi Neha Tete, et.al (2017) made a discussion on several image segmentation techniques for detecting diseases in different types of plants [16]. In this work, various disease classification techniques were reviewed as well. k- Figures represented the real images for several inputs. Afterward, the output had been provided by thresholding and K means clustering algorithm as segmented image. K means clustering algorithm required a priori measurement regarding the quantity of cluster centers. This algorithm provided more efficient segmentation results in contrast to thresholding approach. This algorithm showed optimum results for different datasets.

Rajat Kanti Sarkar, et.al (2015) used an automated SRG algorithm for segmenting plant infection marks [17]. Initially, a new two-dimensional lookup table was presented to label the neighbors so that regions could be merged. In order to make table, the traversing of image had been done in vertical and horizontal manner. Any variation in the labels of pixels was noted down in the table. The integration of table provided support in more efficient ordering during the combining of region. This also assisted in the more segmentation of picture. It was analyzed that the functioning of colored image segmentation was highly based on the selection of color space. Initially, the implementation of this algorithm was carried out in YCbCr colour space. Afterward, this algorithm had been applied in some other color spaces as well for evaluating the performance of segmentation algorithm. The tested outcomes revealed that the recommended algorithm along with suggested improvement provided high quality outcomes for region merging in the YCbCr space for segmenting the disease of plant leaves.

Vijai Singh, et.al (2017) presented an image segmentation algorithm. This algorithm was used for detecting and classifying plant leaf infections in automatic manner [18]. In this work, different plant disease detection classification algorithms were reviewed as well. This work made used of GA (genetic algorithm) for segmenting the image. Image segmentation played an important role in disease detection. The testing of recommended algorithm was carried out on ten different types of plants. Further, the infections of these plants were used for detection purpose. The recommended approach provided optimal outcomes with very less computation. These outcomes proved the efficacy of recommended approach in the detection and classification of plant leaf infections. This algorithm could also detect plant infections in early stage and this was the one more benefit of this algorithm.

5.2 Classification Technique for Plant Disease Identification

Melike Sardogan, et.al (2018) stated that the quality of tomato harvest had been severely affected by different types of leaf infections [19]. This work made use of a technique based on CNN (Convolutional Neural Network) and LVQ (Learning Vector Quantization) approach for detecting and classifying the infections in the leaves. A dataset containing four signs of infections was used in this work for disease detection. This dataset had 500 pictures of tomato plant leaves. The use of color feature was quite common for plant infection detection. The feature extraction and classification steps were implemented by modeling a CNN model. The implementation of filtering techniques was carried out on three channels on the basis of RGB elements. The training of the network had been carried out by inserting LVQ approach with the generated feature vector of convolution branch. The tested outcomes confirmed that the recommended approach could successfully identify four types of leaf infections in plant.

R. Meena Prakash, et.al (2017) employed image processing approaches for detecting plant infections. Implementing classification techniques and performing image study was the main aim of this paper [20]. Image processing techniques efficiently detected and classified leaf infections. This whole work was divided into four segments. In the first stage, preprocessing techniques were implemented on the image for removing noise. The next stage was called image segmentation. For this purpose, this work made use of K-means clustering algorithm. This algorithm determined the infectious part. The third stage was identified as feature extraction. In this stage, relevant features were extracted from the segmented image. At last, the leaves were classified as healthy or infectious using a classification model called SVM (support vector machine).

Yogita K. Dubey, et.al (2018) recommended a novel approach for detecting and classifying infections in cotton leaves [21]. The recommended approach was based on the idea of roughness computation and effortless linear iterative clustering. The roughness measure or computation was used for the formation of an optimal number of superpixel set. This part extracted the required area of cotton leaves. This work also extracted GLCM (Gray level co occurrence matrix) attributes from the disease area. The cotton leaves were classified into four groups using SVM (support vector machine) classifier. The tested results demonstrated that the recommended approach accurately classified 94% of the cotton leaves using the existing dataset.

Neha G. Kurale, et.al (2018) implemented different classification techniques for detecting and classifying diseases in plant leaves [22]. These techniques included SVM (support vector machine), KNN (k nearest neighborhood) and Neural Network. This work was focused on the detection of mainly four types of leaf infections. Therefore, in this work, a database containing images of infectious leaves was used. The key aim here was to distinguish the infected and healthy parts of the leaves. The computation of infected region of plant leaf was carried out by classifying it. The performance of recommended approaches was evaluated in terms of their classification accuracy.

M.P. Vaishnnave, et.al (2019) developed software for determining and classifying the infections in groundnut leaves in robotic manner [23]. This approach could increase the production of yield. This approach had several steps similar to image processing. In this work, K Nearest Neighbor (KNN) was used for the classification of leaf infections. This classifier showed better classification accuracy than SVM. This work was focused on four types of leaf infections. The future work would be focused on extending the testing period for reducing the fake disease classification. For this purpose, additional classification models could be used.

H. Sabrol, et.al (2016) classified the infections of tomato leaves in five categories. On the basis of these infections, the classification of healthy plant leaf and stem images was carried out [24]. Different types of features such as color, shape and texture were extracted from normal and diseased images of plant leaves. The segmentation step was followed by the feature extraction process. The features retrieved from segmented picture were inserted into the classification model. At last, the leaf infections were classified into six categories. The classification results based on six different sorts of leaf pictures achieved accuracy of 0.973.

H. Hashim, et.al (2010) used spectrometer for classifying five different types of rubber leaf infections [25]. These diseases were employed in the form of patterns in this work. A spectrometer called MCS600 Carl Zeiss was used in this work to measure the impact of the diseased leaves pattern. Along this, the diseased parts of the leaves pattern were measured using a general spectroscopy program from Zeiss. Some analyzing tools from SPSS were used for the analysis and explanation. Several tests validated that a spectrometer could distinguish different types of plant infections.

Siddharth Singh Chouhan, et.al (2018) presented a novel approach called BRBFNN (Bacterial foraging optimization based Radial Basis Function Neural Network [26]. The main aim of this approach was to detect and classify the plant infections in automatic manner. This work made use of BFO (Bacterial foraging optimization) approach to assign most favorable weight to RBFNN (Radial Basis Function Neural Network). BFO also increased the speed and accuracy of the network in the identification and classification of plant parts infected by different infections. The region growing approach explored and grouped seed points that had similar features. In this way, this approach improved the efficacy of the network. This work was mainly focused on the detection of fungal infections. The recommended approach classified and detected different types of leaf infections with better accuracy than other existing approaches.

Zhongqi Lin, et.al (2019) introduced a unified CNN (Convolutional Neural Network) model. This model was termed as M-bCNN (matrix-based convolutional neural network) [27]. The main feature of this model was the convolutional kernel matrix. The convolutional layers of this model were structured as a matrix in a parallel manner. In contrast to the generally employed plain networks, these layers could efficiently amplify the data streams, neurons, and link channels of the model by adding sufficient metrics. The images of wheat leaf infections were used for carrying out tests. In this work, a dataset containing 16,652 images was used. This dataset was gathered from a Chinese district called Shandong. The recommended model achieved training and testing accuracy of 96.5% and 90.1% respectively.

Shanwen Zhang, et.al (2013) proposed a novel approach called OLDP (orthogonal locally discriminant projection) for plant infection detection [28]. The recommended approach was a supervised orthogonal nonlinear size lessening algorithm. This approach detected the plant disease using the signs on leaves. The main aim of recommended approach was to locate a projecting matrix. For this purpose, this algorithm pulled the data objects in the similar class till the most possible level. At the same time, this algorithm pushed the data objects in separate classes to the farthest possible level. The recommended approach considered both local information as well as the class knowledge of the data. The effect of the noisy points and outliers were also considered by this algorithm. In this work, several tests were conducted on original diseases leaf images of maize plant. The achieved results depicted that recommended approach efficiently and feasibly detected leaf infections.

Ramakrishnan M., et.al (2015) stated that there were various techniques that could detect and classify different types of leaf infections robotically in accurate and efficient manner [29]. In this work, color images of plants were used for extracting and classifying the infections in groundnut plant leaves. Initially, the conversion of color images was carried out. Afterward, features were extracted using color co-occurrence matrix. The classification of leaf infections was carried out using a back propagation algorithm. The tested results revealed that this approach achieved classification accuracy of 97 %. The future work would be focused on detecting large numbers of leaf infections.

S. Ramesh, et.al (2018) recommended a machine learning approach for searching the signs of infections in the rice plant [30]. This approach detected plant infections in automatic manner. The recommended approach made use of normal and diseased leaf images. The extraction of features was carried out from the normal and infectious regions of rice leaf images. The database containing 300 leaf pictures was used in this work. The division of this dataset was carried out to perform training and testing. The recommended approach performed the preprocessing of images. The leaves were classified as normal or diseased in using recommended approach. The achieved simulation outcomes depicted that the recommended approach achieved classification accuracy of 99% and 100% for infectious images and healthy images respectively during training. The testing stage showed accuracy rate of 90% for diseased images and 86% for healthy images.

K. R. Aravind, et.al (2018) made use of two thousand observable images of maize leaves for disease detection [31]. These images were collected form openly existing Plant Village image database. The preprocessing of images was carried out for getting several features. A multiclass SVM classifier was used in this work for classifying infections using extracted features. This work found out textural features based on GLCM (gray level co-occurrence matrix) for classifying infection under the different patterns of SVM. This classifier achieved disease classification accuracy of 83.7% and 81.3% for the bag of features and the merged statistical features respectively.

VI. CONCLUSION AND FUTURE PROSPECT

The image processing is the approach which can process the digital data in the form of pixels. The plant disease detection is the major issue of the image processing due to data complexity. To solve the problem of plant disease detection various steps are followed which include the image input, pre-processing, segmentation, region of interest selection, feature extraction and classification. The technique of textural feature analysis can be applied which can analysis various type of textural features of the input image. In the last step, the classification technique can be applied which can detect the disease type from the input image. The type of disease which get detected from the input image depends upon the input image, textural features and classification algorithm. The main aim of this process is to accurately detect the disease type from the input image. In this existing approach, linear SVM is used for the disease prediction. The linear SVM is able to detect two diseases at a single time which affect efficiency of the system. The efficient system is required which can predict more than two diseases at a time and also affected area which is the main motivation of this research work. The accurate detection of the input image leads to increase accuracy for the plant disease detection. The more number of disease can be applied which can improve efficiency of the plant disease detection system

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