AN EXTENSIVE STUDY ON CLASSIFICATION BASED PLANT DISEASE DETECTION SYSTEM

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Abstract

Agriculture plays an important role in the Indian economy, therefore early prediction of plant diseases will help in increasing the productivity of crops thereby contributing to the economy’s growth. However, Manual identification of diseases in plants at every stage is very difficult since it involves huge manpower and requires extensive knowledge about plants. Multi disease patterns and pest identification can be automated using computer vision and deep learning techniques and by observing the controlled environmental parameters. Using, Internet of things the model can continuously monitor the temperature, humidity and water levels.

Keywords: Computer Vision, Deep Learning, Segmentation, Classification

I. Introduction

Plant diseases are caused by Parasitic and Non-parasitic elements [XXXVIII]. The Parasitic elements are diseases, caused by biological factors that affect the growth of plants. These are classified into three categories namely; Pathogen, Pests, and Weed.

i. A Pathogen is a microorganism that can cause disease in the plant. This is further divided into Viral, Bacterial, Fungal, and Chromista.

ii. Pests are the destructive insects that can attack the crops in the field. These are further divided into Mites, Slugs, Mammals, and Rodents.

iii. Weeds are unwanted plants in the field. These are classified into Monocots and Dicots.

The major task in increasing the productivity of the plants is to identify the correct disease at an early stage and take precautions accordingly. The productivity of the system increases by developing an intelligent decision supporting system. Using image processing techniques with deep learning, we can capture the images of plants and can detect the diseases. Plants suffer from three types of diseases, namely
Bacterial, Fungal and Viral diseases. Different diseases have different symptoms. The following table details a few bacterial diseases and their symptoms [XIV](The images are taken from planetnatural.com)

**Bacterial Disease Classification**

| Disease Name   | Leaf Image | Symptoms                                                                                                                                                                                                 | Plant Affected                                         |
|----------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| Leaf Spot      | ![Leaf Spot Image](image-url) | 1. The major symptom for leaf spot is spots on foliage.  
2. These appear as brownish in color                                                                                                                   | Shade trees and Ornamentals                            |
| Fire Blight    | ![Fire Blight Image](image-url) | 1. The infected plant tip will rapidly turn into brown or black.  
2. The leaves die but do not drop off                                                                                                               | Apple, Pears and other members of the rose family      |
| Bacterial Blight | ![Bacterial Blight Image](image-url) | 1. The disease symptoms are observed as brown spots on the margins.  
2. Generally, plants are infected with these types of diseases in the early stage with yellow color spots.                              | Jasmine, grape, beans, tomato, kiwi                   |
| Canker         | ![Canker Image](image-url) | This enlarges a twig or branch by killing the foliage beyond it                                                                                                                                             | All the plants that belong to a citrus family like lemon, grape |
| Wilt           | ![Wilt Image](image-url) | The leaf turns into yellow in color                                                                                                                                                                           | Tomato, cotton, and watermelon                         |
| Scabs          | ![Scabs Image](image-url) | 1. The scab spots appear as sunken and tan  
2. The centers of the scab will develop into velvety spores                                                                                         | Potato, cereals, tomato, cucumber                     |
The Non-parasitic elements are water, temperature, radiation, and nutrients. These are also known as disorders, which are occurred due to environmental conditions. Generally, these types of conditions will not have any symptoms. The deficiency in these elements can be detected using sensors like soil moisture sensor, temperature and humidity sensor (DTH11), MQ4 gas sensor, MQ7 Sensor. The readings obtained by these sensors are sent as a notification to the mobile app if they don’t meet the requirements of the threshold values using NODEMCU (ESP8266) WIFI component [XXI].

a. Soil Moisture Sensor  b. DHT11  c. MQ4 Gas Sensor  d. NODEMCU

Fig. 1: Few Sensors used for disease detection and communication.

II. Related Concepts

Image Preprocessing

Preprocessing is a technique to enhance the quality of the image and suppress the unwanted data from the image. The preprocessing technique plays an important role in improving the accuracy and efficiency of the system.

i. A Color is a powerful tool in image processing which can easily identify or extract the object from an image [VI]. The traditional color model i.e. RGB has few disadvantages. So to overcome this problem, it is better to convert the images into linear transformations viz. XYZ, CIELAB, HSV and HIS.

ii. The main purpose of image cropping is to extract the RoI (Region of Interest) from an image. The three issues to be considered while cropping the image are: finding the minimal rectangular window, maintaining a fixed aspect ratio of the rectangle, allowing to find multiple rectangular windows [XII].

iii. Image contrast is defined as the process of calculating the difference between the maximum and minimum pixel intensity. Image contrast can be done in two ways: Histogram Stretching can increase the contrast of an image and Histogram equalization can enhance the contrast of an image. In the latest trend, contrast and resolution problems are addressed by using the combination of super resolution and contrast enhancement techniques [XIX].

iv. During the image capture from digital cameras, an image can be suffered from noise, which is defined as exhibiting different intensity values than the true value. The most three common noises that can occur in an image are impulsive noise, additive noise and multiplicative noise [IX]. The best way to remove the noise is usage of filters
Blurring is a process to smooth the images. In plants, while capturing the images, it mostly suffers from motion blur. This can be eliminated using the interpolation mechanism. The algorithm pre-processing techniques for the detection of blurred images are used to analyze the variance in the images.

**Segmentation**

The process of dividing the image into different regions based on interest is known as “Segmentation”. It splits the image into linear structures and curves. Major applications of segmentation are object recognition and compression. The four popular mechanisms are Region based segmentation, Edge Detection segmentation, Clustering based segmentation and Segmentation based on weakly supervised learning.

**Feature Extraction**

The features of the image are extracted for image classification and recognition. The major aim of feature extraction is to obtain more relevant information from the image. Nowadays, the features can be automatically extracted by using deep learning models like Histogram of oriented gradients (HOG), Speeded-up robust features (SURF), Local binary patterns (LBP), HAAR Wavelets and color histograms. We can also improve the feature selection by using Ensemble learning models rather than the traditional image processing methods because the traditional algorithms suffer from uncertainty and inconsistency. Three types of attributes can be extracted from an image: Texture, Shape, and Color.

**i. Texture Features**

The texture features extraction can be done in various approaches.

![Classification of Texture Feature](image)

**Fig. 2: Classification of Texture feature**

**ii. Shape Features**

The shape of an image can be extracted either by using region based methods or contour based methods. In contour based method, it uses 4 shape descriptors namely:

**i. Fourier descriptors**, which is mainly used for character recognition.
ii. Curvature scale space descriptor, it analyzes one dimensional boundary in a single space.

iii. Angular radial transform is a two dimensional shape descriptor, which represents a moment description of an image.

iv. Image Moments, an invariant feature that is widely used in object recognition tasks.

iii. **Color Features:**

Colors are an important feature of visual representation. The methods for extracting color features from the image are:

i. **Color histogram:** It is a global descriptor which analyses the statistical color frequency of an image. All the color bins frequency distribution is represented using this method.

ii. **Histogram intersection:** It is a global descriptor which calculates the minimum value when a pair of histograms is given with k bins. The main advantage of this method is robust to geometrical modifications.

iii. **Color histogram for K-means:** The K-means clustering algorithm is used to segment the color pixels.

iv. **Color Correlogram:** It is a spatial correlation of color changes with concerning distance change.

v. **Color co-occurrence matrix:** It calculates the probability of the same color pixel, by subtracting the adjacent pixels.

vi. **Chromaticity:** In this mechanism, only a small set of features which represent spectral content will be stored.

**Classification**

The process of labeling the images to the predefined categories is known as “Classification”. The image classification can be done either by using supervised machine learning algorithms or unsupervised machine learning algorithms. The recent trends state that the supervised or unsupervised algorithm in combination with genetic algorithms will yield better results. A Supervised algorithm is the process of finding the labels of test data based on the tagging available for trained data. The supervised machine [X] learning algorithms are linear regression, nearest neighbors, decision trees and support vector machine. An Unsupervised algorithm is the process of labeling the data without any prior knowledge.

i. **Linear Classifier**

Linear Classifier is a process in which classification takes place by dividing the feature space, which is known as object characteristics, into a collection of regions that are labeled according to their target values. These classifiers are mainly used for document classification. They appear in two forms, first one is based on conditional density function, this includes naïve bayes [VII] and LDA algorithms. The Second one is based on discriminative models; this includes logistic regression.
ii. **Kernel Estimators**

This is used to estimate the random variable probability density function in a nonparametric way. K- Nearest Neighbor algorithm is the best example of this category, which is popularly used in both classification and regression. It finds similar things based on the distance in its neighborhood.

iii. **Support Vector Machine**

The major task of the SVM algorithm is to find the best hyperplane that can divide the dimensional space. This can be achieved by choosing the maximum margin. The maximum margin is obtained by finding the nearest points to it. The type of the SVM function is based on the kernel function chosen. The kernel function plays an important role in building the high dimensional feature space.

![Diagram of Classifiers](image)

**Fig. 3:** Types of Classifications

iv. **Decision Trees**

This is a graph based algorithm, which is constructed with the help of an algorithm by identifying the best split dataset conditions. The main aim of this algorithm is to predict the target value with simple rules, it is observed from the data features. It is best known decision system [XI].

v. **Neural Networks**

It is a computational learning system that translates one form of input into another form of output by using a network of functions. The major components of neural networks are:
i. Convolutional layer: It converts pixels into dot products by using the set of learnable filters. Each pixel represents a neuron.

ii. Activation functions [XXIV]: These are used to learn features from the images. These can determine the output, accuracy, and efficiency of the system. These are connected to every neuron in the model and they decide the status of the neuron. In deep learning mechanisms, we have 3 linear and 7 nonlinear activation functions.

iii. Pooling Layer: It is used to reduce the spatial representation of the feature space that is obtained as the output from the convolutional layer. It can be achieved by three approaches i.e. max-pooling, mean-pooling and random pooling.

Performance Measures

The models developed should be evaluated. Various parameters can evaluate the model. The performance measures are evaluated based on the confusion matrix. The model evaluates Accuracy, Precision, Recall, F1Score, ROC Curve

Fig.4: System Architecture for Image Processing

III. Literature Review

Various authors had applied various techniques to identify diseases in the plants. This section elaborates a few authors’ techniques:

Shuli Xing [XL] developed a simple and effective convolution neural network (CNN) to identify pests and leaf diseases by increasing the cross channel operation and by adapting feature reuse. The paper addresses the overfitting problem that occurred due to the usage of ImageNet dataset. It resolves the problem by: a) creating an image dataset of pests and diseases in citrus plants. b) Designing a light weight neural network to recognize types of pests and leaf diseases, to extract features it takes the entire feature map as input and a DenseNet is employed to reduce the number of input features in a dense block. Finally, a network is constructed to improve parameter utilization. c) Developing a novel data augmentation method to reduce the similarity between the images, it includes combination of any three operations namely, rotation, width shift, height shift, shear, zoom, and horizontal flip. Aitor Gutierrez [III]
suggested a comparative study for pest detection and identification using a machine learning based approach and deep learning based approach. In this study an infected tomato dataset is considered as a case study and a popular computer vision library known as “HALCON” is used to detect and identify pests on plants. In machine learning based approach the entire process is divided into two steps namely pest detection and pest classification. In pest detection step: firstly it checks the quality of the images, then it does background subtraction and finally, different pests are identified using a feature extraction algorithm. In pest classification step: either by using KNN or by Using MLP, the process extracts some model features and decides whether it is a pest or not. In deep learning based approach tensorflow library is selected for the entire process.

Pantazi, X.E. [XXXIV] designed a one class classifier to identify the diseases in the plants. In this approach, image segmentation with HSV transformation is done first to find the region of interest and subtract the background from the image. Then, the Local binary patterns process is defined for texture analysis and pixel labelling. One class classification is used to find the target class and outliers, OCSVM is used for conflict resolution and finally, nearest support vector strategy is applied to find the labels according to the proximity. Eftekhar Hossain [XVIII] proposed colour and texture based approach for detecting and classifying plant leaf disease using KNN. The process is divided into two phases: In the first phase i.e., training phase there are 6 stages namely a. image acquisition: The images are collected from Arkansas and Reddit-plant leaf disease b. colour space conversion: All the RGB colour images are converted into lab colourspace. The chromaticity layer will provide colour information about different axes. c. colour segmentation: the segmentation is done by finding the similarity of pixels based on the Euclidean distance. In this paper, the KNN algorithm assumed k value as 3 to segment red, green and blue regions. d. Disease detection using morphology: Along with morphological operations, dilation and erosion are applied to the binary image for separating the affected part from a leaf. Dilation is used to remove the noise from the image. e. Feature Extraction: From the segmented image, six features are extracted like mean, standard deviation, energy, contrast, homogeneity, and correlations. f. classification: using KNN classifier, the plant diseases are classified into 5 classes. It finds the class labels of unknown data by the maximum voting policy. In the second phase i.e., testing phase, unlabeled leaf images are given and the algorithm finds the k nearest data points.

S. Poornima [III] presented a Multi-SVM classifier for plant disease identification. In this study, pre-processing is done by subtracting the background from the image, applying the filter to remove noise in the image. During the segmentation process, the Sobel edge detector finds the number of edges and boundaries. Color based segmentation with the help of K-means clustering determines the diseased region. From the segmented region, Hough transform extracts the shape of affected leaf spots. Finally, on the extracted features multi-SVM classifier is built by training the images on the dataset. S. Anubha Pearline [XXXV] proposed a model on plant species identification and type of diseases by considering the shape as a classifying object. The texture information is extracted by local binary patterns and haralick methods. Shape features are extracted using Hu moments. A deep learning CNN
A model is developed by training on the ImageNet dataset, the model assumed the pre-trained model weights as initial weights and using various classification algorithms like LDA, LR and so on the model predicted the plant.

Vippon Preet Kour [XXVI] designed a model to identify the various diseases in apple based on fuzzy rule-based classification. The model used blob analysis to extract features and to find the region of interest. During classification, it uses a trapezoidal membership function to detect the condition of the plant (Poor, Average, Good, and Excellent). Marko Arsenović [V] focused on developing a plant disease identification system based on real-time environment rather than using the PlantVillage dataset to increase the accuracy of the system in the real-world. This work collected the healthy and diseased leaves from the field in various environments with a wide variety of plants labeled manually. Using two types of augmentation techniques namely traditional and GANs they produced syntactic data. To identify diseases in the plant, they designed a two-stage object detector algorithm. In the first stage, the regional proposal finds the location of candidates. In the second stage using various neural network architecture like YOLOv3, SSD training has been given by splitting the dataset.

Jayasankar [XLII] defined deformable algorithms for identifying diseases in wheat plants. The images are converted into different colour spaces. The images are segmented using a canny edge filter, the main advantage of the canny edge filter is it produces better results and the features are extracted by the K-means clustering algorithm. The statistical patterns are obtained by the principal component analysis.

Saraansh Baranwal [VIII] developed a system to identify the diseases in apple leaves. The system is developed using the GoogLeNet CNN architecture, the main advantage of this system is it is available in inception modules. The dataset consists of three disease classes and one healthy class. In this system, the augmentation of data is taken care of by Keras library. Images are normalized by subtracting the mean and dividing with standard deviation. New images are generated by a predefined function in keras, which performs simple transformation operations. This system contains four layers in which two are convolutional layers that are operated on the basis of ReLu activation function and maxpool layer. The remaining two layers are fully connected. The output layer neurons are used for the classification of the image.

Abhishek Dey [XV] developed an automated multi-class classification of beetle pests. In this paper, the entire process is divided into 4 stages. They are a. Preprocessing: In this, all the images should be of the same size if no, they are resized to a fixed size. The noise in the image is removed by using a Gaussian filter and finally, the quality of the image is improved by contrast enhancement technique. b. Segmentation: segmentation aims to find the region of interest. The exact location of the insect is automatically detected with the help of a modified K-means clustering algorithm. The main aim of the K-means clustering algorithm is to classify the colors and based on these k number of images are generated to find the diseased segment. c. Feature Extraction: The text features are extracted from the statistical method i.e., GLCM, a probabilistic texture feature and a total of 24 features are extracted by measuring the difference between two different gray levels. d. Classification: A supervised machine
learning algorithm known as SVM is used to classify 12 classes. The kernel function will create an optimal hyper plane and divide the entire data points into positive classes and negative classes.

Siddharth Singh Chouhan [XIII] designed the BRBFNN network for the identification and classification of plant diseases. In this novel approach, for feature extraction, region growing algorithm is used. This technique initially starts with a set of seeds and these seeds rapidly increase by covering the adjacency locations. The regions can be identified by either by using 4-neighborhood or 8-neighborhood. For training the network, bacterial foraging optimization is implemented. It includes four steps namely, chemo taxis, swarming, reproduction, dispersal, and elimination. The neural network with three layers: input, hidden and output layer. The hidden layer radial basis as activation function along with radial kernel function. The output layer compromises of linear neurons; with the help of this network segmentation is performed.

Ziaur Rahman [XXXVI] designed a framework for fast automatic image cropping based on deep saliency map detection and Gaussian filter. In this model, a saliency map with maximum and minimum rectangle window is used to detect the region of interest. Gaussian filter is implemented to smoothen the image and extract the information from the image.

Melike Sardogan [XXX] developed a system based on CNN and LVQ algorithm. Learning Vector Quantization is a heuristic algorithm, which consists of 3 layers. Input layers collect the information and each neuron represents a class. The reference vector helps in finding the learning mechanism, which represents the similarity between the values. Rutu Gandhi [XXXVII] used an augmented approach to identify the diseases in the plant. The training of the model is taken care of by DCGAN, to achieve a good accuracy rate. The Inspection model helps in selecting the best convolution. It was trained on ImageNet database. The second type of architecture developed is MobileNet, to avoid the heavy computation problems that are occurred in inspection models. In this, the first layer is fully connected, it is completely normalized and ReLu function can identify the non-linearity. The Softmax pooling layer can classify the diseases.

Konstantinos P. Ferentinos [XV] compared five different CNN architectures with the help of Torch framework and training algorithms were implemented in GPUs of an NVIDIA. The dataset is divided into training and test. All the models are trained with different parameters. The Learning rate is achieved using annealing schedule starting from 0.01 to 0.001 within 20 epochs. After the successful completion of epochs, the data is classified more accurately than the others. Shanwen Zhang [XXXIX] discussed color based CNN architecture to identify plant disease. TCNN model is proposed in this paper, by integrating different color components. The main advantage of this system is, it can automatically learn the high end features for performing classification. The system consists of three fully connected layers with different colors, a softmax layer, and an output layer. The dropout normalization function is applied for eliminating the overfitting problem. The ReLu activation helps in finding the non-linearity in properties. The major component in this system is
discrete information to the backpropagation algorithm, which can increase the recognition rate and also reduces the intra-class distance problem.

**Sukhvir Kaur [XXII]** discussed various reviews conducted on plant disease systems and the techniques involved in them. It mainly focused on the limitations of availability systems. Most of the available systems failed in training the datasets correctly. So it is better to design hybrid adaptive systems. It also suggested that stage based disease detection will increase the productivity of crops. **Juncheng Ma [XXVIII]** discussed a decision based segmentation method for identifying foliar disease. A decision tree was built using classification and regression algorithm with a feature subset, in which the features are selected by a person’s rank correlations. The tree was optimized using the pruning mechanism, which is done through pixel by pixel classification.

**Yang Lu [XXVII]** designed a system for rice disease identification using a deep convolution neural network. The main purpose of this system is to early identification of disease because CNN are the best resources for pattern recognition. In this system, a hierarchical architecture containing three layers is proposed. The first layer is used to extract the low level features like edges, lines, and corners. The other two layers are used to extract high level features and the activation functions are sigmoid and tanh. The Stochastic pooling layer used in this model can find the maximum value of a specific feature. The main advantage of this layer avoids overfitting. In this layer first it computes the probabilities for all the possible regions, and then a particular region is computed using multinomial distribution. Finally, soft max regression activation function is applied to the solve multi-class classification problems. The training is done in stages with the help of the gradient descent algorithm. During the first stage i.e., feed forward phase the training is done for different classes with different patterns. During the second stage, i.e., backpropagation phase using recurrence function the model is trained with back propagated error from the higher layer to the lower layer.

**TallhaAkram [IV]** suggested surveillance for disease classification. In this system, the image is transformed into three color space namely Luminance chrominance color space for efficiently separating the color and light components, YCrCb and HSV. Image enhancement is done with the help of contrast stretching because it mainly enhances the foreground color channels. Then it processed using a sobel edge filter for finding the gradients with fixed size kernel and a cumulated weighted gray value is computed for all the blocks. The segmentation is performed with Otsu thresholding along with dilation and erosion is performed. The entire model is constructed by designing a parallel architecture known as ANoC. **Alessandro dos Santos Ferreira [XVI]** discussed weed detection using neural networks. The texture features are extracted by gray level co-occurrence matrix. The frequencies obtained by this method will represent relation and distance between the neighboring pixels. This method can extract 36 features of the images. The shape is extracted using a Histogram of oriented Gradients algorithm and the color is extracted using local binary patterns. The classification is done using the convolution neural network. The training for this neural network is given by famous architecture known as “CaffeNet”. It is developed.
using a superpixel segmentation algorithm. The algorithm groups the pixels based on their color similarity and spatial proximity. The parameter for the algorithm is a number of super pixels that can be segmented into the same size. Finally, the results are evaluated by comparing with various classifiers like a combination of Adaboost and C4.5, Random Forest and SVM.

**Aboul Ella Hassanien [XVII]** proposed a moth flame algorithm for automatically detecting the diseases. Gabor filter can efficiently extract the texture features, which is a product of cosine and Gaussian functions. In this paper, for minimizing the feature subset, this is achieved by moth flame based rough set attribute reduction in combination with SVM. The main advantage of this method requires minimal prior knowledge. **Everton Castelao Tetila [XLI]** suggested segmentation based Simple Linear Iterative Clustering to detect different diseases in soybean. The algorithm generates regions known as super pixels. The algorithm controls the shape and size of super pixels by adjusting the parameters. Each super pixel can be classified into various classes. In this paper, the color features are extracted using color statistics. The textures are extracted using GLCM and local binary patterns. The shape of the image is extracted with Hue’s moment and central moment. The classifications of the images are done using various classifiers like Adaboost, J48, Sequential minimal optimization. **Dhiman Mondal [XXIX]** discussed soft computing with image processing techniques to identify disease symptoms in leaf images. The Pearson correlational coefficient, which is a statistical parameter to measure relation between to variables, is used to identify the key features depending on the image. In this, the feature class correlation value of each feature is calculated. The values which are greater than the specified threshold value are selected as dominating feature set. The crucial element in this paper is image gradation to extract the features. This can be done as follows: 1. Structuring element was selected to perform morphological operations 2. Bottom hat transformation is applied to the gray scale image to extract the external boundary. 3. Top hat transformation is applied to obtain the internal boundary. 4. Calculation of both transformations to get the final gray scale image. 5. Finally, compare the gray scale image with the original image. The disease is identified with Naïve Bayesian classifier with entropy based discretization. The classifier calculates the entropy for each potential split of the bin. The split with the highest entropy gain is selected. This process continues until the termination condition is satisfied. On the selected splits, the K-means clustering algorithm is applied and posterior probability is calculated to identify the class label name.

**Ehsan Kiani [XXIII]** presented an experimental model to detect diseases in the plant using color processing detection algorithms and fuzzy logic classification algorithm. In this paper, the fungal diseases are identified by filling the holes of the binary image of green pixel and then subtraction is performed over the binary image and then finally, pixel matching is performed to identify whether it is a healthy plant or infected plant. The fuzzy classification algorithm is used to identify the type of disease. The number of green pixel images and the number of matched pixels between red and green were supplied as input to the fuzzy logic algorithm and the mean value is calculated to find the type of disease. **R.P. Narmadha [XXXI]** proposed an image processing method to identify the paddy plant diseases. In this, all
the images are converted into gray scale image, and then the noise in the images is removed using the K-means clustering algorithm. The shape of the image is extracted using object pixel count. To check whether a plant is infected or not, the author used the SVM classification algorithm. If it is infected, the type of the disease is identified using the ANN algorithm.

IV. Conclusion

Some of the diseases can be identified with naked eyes at early stages while a few take some time to identify. This type of detection based on observation is time taking process and decreases the productivity of crops. So, to solve this problem image processing plays an important role in the detection of diseases. In the olden days, traditional approaches have been implemented, but in recent years computer vision with deep learning techniques has gained a lot of improvement in classifying the diseases at a faster rate at the early stages of the plant life cycle. In this paper, we have studied various plant disease detection systems that have been developed in recent years. During this study, we have identified that some important factors are to be concentrated on designing a detection system.

i. Most of the authors developed their system either based on the standard dataset known as “PlantVillage” or they implemented based on the predefined architectures. All the images are taken from a controlled environment, but in real situation, external factors like lightening conditions, angle of the capturing devices and other factors will impact the quality of the image.

ii. The quality of the images also determines the accuracy of the system. Noisy images adversely impact the system.

iii. The selection of image processing techniques during preprocessing and segmentation plays a crucial part in the development process. Lack of technical knowledge may lead to choosing the wrong algorithm.

iv. Deep learning algorithms require a huge amount of time for performing operations. The processing speed must also be taken into consideration.

References

I. Humeau-Heurtier, "Texture Feature Extraction Methods: A Survey," in IEEE Access, vol. 7, pp. 8975-9000, 2019. doi: 10.1109/ACCESS.2018.2890743.

II. AIP Conference Proceedings 2095, 030018 (2019); https://doi.org/10.1063/1.5097529. Published Online:09 April 2019.

III. Aitor Gutierrez, Ander Ansuategi, Loreto Susperregi, Carlos Tubio, Ivan Rankic, and Libor Lenza, “A Benchmarking of Learning Strategies for Pest Detection and Identification on Tomato Plants for Autonomous Scouting Robots Using Internal Databases,” Journal of Sensors, vol. 2019, Article ID 5219471, 15 pages, 2019.
IV. Akram, Tallha&Naqvi, Syed & Kamran, Muhammad & Kamran, Muhammad. (2017). Towards real-time crops surveillance for disease classification: exploiting parallelism in computer vision. Computers & Electrical Engineering. 59. 15-26. 10.1016/j.compeleceng.2017.02.020.

V. Arsenovic, M.; Karanovic, M.; Sladojevic, S.; Anderla, A.; Stefanovic, D. Solving Current Limitations of Deep Learning Based Approaches for Plant Disease Detection. Symmetry 2019, 11, 939.

VI. Azad, Dr&Hasan, Md & K, Mohammed. (2017). Color Image Processing on Digital Image. International Journal of New Technology and Research. 3. 56-62.

VII. Banchhor, C. & Srinivasu, N. 2018, "FCNB: Fuzzy Correlative Naive Bayes Classifier with MapReduce Framework for Big Data Classification", Journal of Intelligent Systems.

VIII. Baranwal, Saraansh&Khandelwal, Siddhant&Arora, Anuja. (2019). Deep Learning Convolutional Neural Network for Apple Leaves Disease Detection. SSRN Electronic Journal. 10.2139/ssrn.3351641.

IX. B. Dhruv, N. Mittal and M. Modi, "Analysis of different filters for noise reduction in images," 2017 Recent Developments in Control, Automation & Power Engineering (RDCAPE), Noida, 2017, pp. 410-415.

X. BOMMADEVARA, H.S.A., SOWMYA, Y. and PRADEEPINI, G., 2019. Heart disease prediction using machine learning algorithms. International Journal of Innovative Technology and Exploring Engineering, 8(5), pp. 270-272.

XI. Chandana, K., Prasanth, Y. & Prabhu Das, J. 2016, "A decision support system for predicting diabetic retinopathy using neural networks", Journal of Theoretical and Applied Information Technology, vol. 88, no. 3, pp. 598-606.

XII. Chen, Jiansheng&Bai, Gaocheng& Liang, Shaoheng& Li, Zhengqin. (2016). Automatic Image Cropping: A Computational Complexity Study. 507-515. 10.1109/CVPR.2016.61.

XIII. Chouhan, Siddharth&Koul, Ajay & Singh, Dr. Uday& Jain, Sanjeev. (2018). Bacterial foraging optimization based Radial Basis Function Neural Network (BRBFNN) for identification and classification of plant leaf diseases: An automatic approach towards Plant Pathology. IEEE Access.

XIV. Chouhan, Siddharth& Singh, Dr. Uday& Jain, Sanjeev. (2019). Applications of Computer Vision in Plant Pathology: A Survey. Archives of Computational Methods in Engineering. 10.1007/s11831-019-09324-0.
XV. Dey, Abhishek & Bhomik, Debasmita & Dey, Kashi. (2019). Automatic Multi-class Classification of Beetle Pest Using Statistical Feature Extraction and Support Vector Machine: Proceedings of IEMIS 2018, Volume 2. 10.1007/978-981-13-1498-8_47.

XVI. Ferreira, Alessandro & Freitas, Daniel & Silva, Gercina & Pistori, Hemerson & Folhes, Marcelo. (2017). Weed detection in soybean crops using ConvNets. Computers and Electronics in Agriculture. 143. 314-324. 10.1016/j.compag.2017.10.027.

XVII. Hassani, Aboul Ella & Gaber, Tarek & Mokhtar, Usama & Hefny, Hesham. (2017). An improved moth flame optimization algorithm based on rough sets for tomato diseases detection. Computers and Electronics in Agriculture. 136. 86-96. 10.1016/j.compag.2017.02.026.

XVIII. Hossain, Eftekhar & Hossain, Md & Rahman, Mohammad. (2019). A Color and Texture Based Approach for the Detection and Classification of Plant Leaf Disease Using KNN Classifier. 1-6. 10.1109/ECACE.2019.8679247.

XIX. I. M. Krishna, C. Narasimham and T. B. Reddy, "Image super resolution and contrast enhancement using curvlet's with cycle spinning," 2016 International Conference on Communication and Electronics Systems (ICCES), Coimbatore, 2016, pp. 1-6. doi: 10.1109/CESYS.2016.7889926.

XX. I. Murali Krishna, Dr. Challa Narasimham and Dr. A. S. N. Chakravarthy Published a paper on "A Novel Feature Selection based Classification Model for Disease Severity Prediction on Alzheimer's Database", 2018, JARDCS, Volume-10, Issue-4 Page no: 245-255 ISSN: 1943023X.

XXI. Jha, Kirtan & Doshi, Aalap & Patel, Poojan & Shah, Manan. (2019). A comprehensive review on automation in agriculture using artificial intelligence. Artificial Intelligence in Agriculture. 2. 10.1016/j.aiia.2019.05.004.

XXII. Kaur, Sukhvir & Pandey, Shreelekha & Goel, Shivani. (2018). Plants Disease Identification and Classification Through Leaf Images: A Survey. Archives of Computational Methods in Engineering. 26. 10.1007/s11831-018-9255-6.

XXIII. Kiani, Ehsan & Mamedov, Tofik. (2017). Identification of plant disease infection using soft-computing: Application to modern botany. Procedia Computer Science. 120. 893-900. 10.1016/j.procs.2017.11.323.

XXIV. Kishore, P. V. V., Kumar, K. V. V., Kiran Kumar, E., Sastry, A. S. C. S., TejaKiran, M., Anil Kumar, D. & Prasad, M. V. D. 2018, "Indian Classical Dance Action Identification and Classification with Convolutional Neural Networks", Advances in Multimedia, vol. 2018.
XXV. Konstantinos P. Ferentinos, Deep learning models for plant disease detection and diagnosis, Computers and Electronics in Agriculture, Volume 145, 2018, Pages 311-318, ISSN 0168-1699, https://doi.org/10.1016/j.compag.2018.01.009.

XXVI. Kour, Vippon & Arora, Sakshi. (2019). Fruit Disease Detection Using Rule-Based Classification: Proceedings of ICSICCS-2018. 10.1007/978-981-13-2414-7_28.

XXVII. Lu, Yang & Yi, Shujuan & Zeng, Nianyin & Liu, Yurong & Zhang, Yong. (2017). Identification of Rice Diseases using Deep Convolutional Neural Networks. Neurocomputing. 267. 10.1016/j.neucom.2017.06.023.

XXVIII. Ma, Juncheng & Du, Keming & Zheng, Feixiang & Zhang, Lingxian & Sun, Zhongfu. (2018). A Segmentation Method for Processing Greenhouse Vegetable Foliar Disease Symptom Images. Information Processing in Agriculture. 6. 10.1016/j.inpa.2018.08.010.

XXIX. Mondal, Dhiman & Kole, Dipak & Roy, Kusal. (2017). Gradation of yellow mosaic virus disease of okra and bitter gourd based on entropy based binning and Naive Bayes classifier after identification of leaves. Computers and Electronics in Agriculture. 142. 10.1016/j.compag.2017.11.024.

XXX. M. Sardogan, A. Tuncer and Y. Ozen, "Plant Leaf Disease Detection and Classification Based on CNN with LVQ Algorithm," 2018 3rd International Conference on Computer Science and Engineering (UBMK), Sarajevo, 2018, pp. 382-385. doi: 10.1109/UBMK.2018.8566635.

XXXI. Narmadha, R. & Arulvadivu, G., (2017). Detection and measurement of paddy leaf disease symptoms using image processing. 1-4. 10.1109/ICCCI.2017.8117730.

XXXII. Narottambhai, Mitisha & Tandel, Purvi. (2016). A Survey on Feature Extraction Techniques for Shape based Object Recognition. International Journal of Computer Applications.137.16-20.10.5120/ijca2016908782.

XXXIII. Padmaja Grandhe, Dr. E. Sreenivasa Reddy, Dr. D. Vasumathi. (2016). An Adaptive Cluster Based Image Search And Retrieve For Interactive Roi To Mri Image Filtering, Segmentation, And Registration (Vol. 94,, No.1). Journal of Theoretical and Applied Information Technology.

XXXIV. Pantazi, X. E., Moshou, D., & Tamouridou, A. A. (2019). Automated leaf disease detection in different crop species through image features analysis and One Class Classifiers. Computers and Electronics in Agriculture, 156, 96–104.
XXXV. Pearline, Anubha & Kumar, Sathiesh & Harini, S. (2019). A study on plant recognition using conventional image processing and deep learning approaches. Journal of Intelligent & Fuzzy Systems. 36. 1-8. 10.3233/JIFS-169911.

XXXVI. Rahman, Ziaur & PU, Yi-Fei & Aamir, Muhammad & Ullah, Farhan. (2018). A framework for fast automatic image cropping based on deep saliency map detection and gaussian filter. International Journal of Computers and Applications. 1-11. 10.1080/1206212X.2017.1422358.

XXXVII. R. Gandhi, S. Nimbalkar, N. Yelamanchili and S. Ponkshe, "Plant disease detection using CNNs and GANs as an augmentative approach," 2018 IEEE International Conference on Innovative Research and Development (ICIRD), Bangkok, 2018, pp. 1-5. doi: 10.1109/ICIRD.2018.8376321.

XXXVIII. Sandhu, Gittaly & Kumar, Vinay & Joshi, Hemdutt. (2017). Study of digital image processing techniques for leaf disease detection and classification. Multimedia Tools and Applications. 1-50. 10.1007/s11042-017-54458.

XXXIX. Shanwen Zhang, Wenzhun Huang, Chuanlei Zhang. Three-channel convolutional neural networks for vegetable leaf disease recognition, Cognitive Systems Research, Volume 53, 2019, Pages 31-41, ISSN 1389-0417, https://doi.org/10.1016/j.cogsys.2018.04.006.

XL. Shuli, Xing & Lee, Marely & Lee, Keun-kwang. (2019). Citrus Pests and Diseases Recognition Model Using Weakly Dense Connected Convolution Network. Sensors. 19. 3195. 10.3390/s19143195.

XLI. Tetila, Everton & Machado, Bruno & Belete, Nicolas Alessandro & Guimaraes, David & Pistori, Hemerson. (2017). Identification of Soybean Foliar Diseases Using Unmanned Aerial Vehicle Images. IEEE Geoscience and Remote Sensing Letters. PP. 1-5. 10.1109/LGRS.2017.2743715.

XLII. Thangaiyan, Jayasankar. (2019). AN IDENTIFICATION OF CROP DISEASE USING IMAGE SEGMENTATION. 10.13040/IJPSR.0975-8232.10(3).1054-64.

XLIII. Yuheng, Song & Hao, Yan. (2017). Image Segmentation Algorithms Overview.