

Deep Learning Techniques used in Detecting and Classifying Images of Multi Crop Leaf Diseases

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Abstract—Health is very important factor in the life of human beings. Qualitative or healthy food is also playing an important role in healthy human beings. Healthy food which rich in healthy nutrients will get only from healthy crop fields. so indirectly different crop plants have important role in human beings' life. We all human beings require food for living our daily life. Food grains production quality and quantity both may affected by bad weather conditions, heavy rain, floods, drought, aridity and plant diseases. We can't control different bad weather conditions which affect the quantity and quality of crop productions. Skilful farmers rarely notice plants with the opened eye whereas disease, but this method is often indefinite and can take a long time. Controlling damaged leaves while crops are developing is a critical step. Early disease identification, categorization and analysis of sick leaves, as well as potential remedies, can boost crop productivity. Farmer understood the importance and use of artificial intelligence in agriculture field. Several machine learning (ML) as well as deep learning (DL) techniques are developed & explore by many researchers, and oftentimes they also got significant results in both cases. By Inspiring those existing work, here this paper studied and compared different deep learning techniques from different researchers for studying further better result in multi crop leaf disease classification and detection.

Index Terms— Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Support Vector Machine (SVM), Convolution Neural Network (CNN).

I. INTRODUCTION

Now days, in our country the use of technology in agriculture is creatively approached. Various crop grains are the part of our daily routine. Increased population of our country requires huge amount of crop production. Different bad weather conditions already affect the quantity and quality of crop productions. In addition to it different leaf diseases of crops reduce the crop production. Controlling damaged leaves while crops are developing is a critical step. Early disease identification, categorization and analysis of sick leaves, as well as potential remedies, can boost crop productivity. That is why disease detection and categorization of many crops leaf at initial stage of curing will directly help to increase the agricultural food production. Presently many more farmers understood the use of internet of things and artificial intelligence. During the past decade, adoption of

DL and AI accomplished the principal at the back of advancement in Natural Language Processing (NLP), robotics, computer vision. Different researcher studied, developed and examined various DL techniques with different kind of result. Literature review will provide overview of all of that deep learning techniques. In the literature review part, we will study various techniques used for different types of crop leaf disease classification and detection.

II. REVIEW OF LITERATURES

In their proposal Hybrid Feature-Based Disease Detection in Plant Leaf, Ashutosh Kumar Singh et al. [1] Their study uses two approaches, and the results of their simulations are compared for performance assessment. The photos from the Plant Village data set for apple, potato, maize, rice and tomato plants are enhanced with data in the first section, and CNN are used to extract the deep characteristics of the plants' deep features (CNN). Using a Bayesian optimal support vector machine classifier categorise these characteristics also the outcomes are measured in relation to sensitivity, precision, f-score and resolution. Second section used photos from the data set are preprocessed, and histograms of oriented gradients (HoG), GLCM, and color moments to extract the images' texture and color properties. The color, deep features and texture these three categories of characteristics are combined to create mongrel features in this instance. This choice of mongrel features was made using binary particle swarm optimization, and the simulation results were then classified using a random forest classifier.

During the feature extraction stage, Maryam Saberi et al. [2] suggested a very efficient framework for identifying different fruit and plant leaf diseases. Their suggested model makes use of an altered deep transfer learning strategy. Classification is continually constrained by issues like overfitting and poor accuracy when potential illnesses appear on plant leaves. The authors tested their proposed algorithm on datasets from Plant Village and UC Irvine that included six leaf photo sets of healthy and sick leaves from apple, maize, cotton, grape, pepper, and rice.

A Hybrid Metaheuristic Enabled Approach for Botanical Leaf disorder disclosure was put out by Mohapatra et al. [3]. Preprocessing, picture segmentation, feature extraction, and illness categorization are all part of their suggested methodology. Initially, they use histogram equalization and contrast enhancement to improve the picture of mango leaves. The separation process is therefore completed activity using a lines mean-located neuromorphic accompanying fuzzy c-means. The critical aspects, in the way that the Upgraded Local Binary Pattern (ULBP), color, and pel attributes, are then gleaned from the separate pictures. The disease labeling aspect, which is shaped utilizing a CNN, taken these traits towards the end (CNN). A novel mixture addition model named the Cat Swarm Updated Black Widow Model (CSUBW) is further applied to raise categorization veracity.

For the purpose of detecting leaf disease, Sunil S et al. [4] created a model based on ML and IP methods. For the purpose of detecting leaf ailment, their submitted model integrates DWT+PCA+GLCM+CNN joining calculating fantasy and machine intelligence methods. Author focuses on the ailment of attractive woman leaves. The dataspace was detached into Voronoi containers utilizing K-way grouping, and the border of the leaf sample samples was therefore renewed utilizing profile following. The appropriate traits of the leaf samples are derived utilizing a consolidation of descriptors, containing the Discrete Wavelet Transform, Principal Component Analysis, and Grey Level Co-incident Matrix. In the end, ML methods like KNN, SVM, and CNN are used to categorize the recaptured facial characteristics (K-NN). On attractive woman tumbled samples, the veracity of their submitted model is determined utilizing SVM (88%), K-NN (97%), and CNN (99.6%).

The study by Dhivyaa et al. [5] used an enlarged complexity network and additional dense blocks to pick the suitable characteristics based on Bi-LSTM to identify plant illnesses. Data from the Plant Village dataset and the cassava disease have shown the viability of their suggested model. Their results presented that the submitted model for the disease of cassava leaf ailment had a maximum F1 score of 95.49 portion.

By using You Only Look Once algorithm to upskill the applicable network the author Sachin C. et al. [6], passed various pre-processed vegetable images into the network. They drew bounding boxes around the vegetable before training. They have used various vegetables dataset like cucumber, green apple, green capsicum and compared in different parameter. They achieved output with accuracy of 61.6 %. After passing preprocessed image of vegetable to the network, the network identifying the vegetable and it also displayed labeled predicted class category around bounding boxes.

Surampalli Ashok et al. [7], they have detected tomato leaf disease images by using support vector machine technique. Also, they described how to use oriented gradient histogram and SVM to compute shape feature in early stages of infected lead. Their experiment validated for Swedish and Flavia leaf dataset and combined dataset.

The article by Kirtan Jha et al. [11] provides a brief overview of how AI, IoT and ML are currently being utilized to robotize traditional agricultural practices, particularly those related to plant illness, inadequate warehouse administration, pesticide control, controlling weeds, and inadequate irrigation and water control. To lessen human interaction and effort, they suggested employing ML, AI, DL, NN, and fuzzy logic. The usage of RNN, CNN or any other computational network may be utilized to identify plant illness or other undesired weed in a farm, further extending the idea that artificial intelligence approaches are expanding quickly.

Convolution Neural network have been used by Dimitris G. et al. [35], for performing feature extraction and segmentation for categorizing different images of leaf into smaller portion of surface. They discover the border of leaf of tomato and labeled it.

For the purpose of diagnosing illnesses in diverse plant leaves, L. Sherly Puspha Annabel et al. [12] studied several plant diseases and various categorization approaches used in machine learning. In order to detect a specific sort of illness, they have conducted a comparative research of disease detection in different plant leaves using various machine learning algorithms. Further, this paper summarized the overall performance of supervised and unsupervised classification algorithms for disease detection. Accuracy of each classifier is given along with pros and cons of each classifier are reviewed.

K-nearest neighbour (KNN) classifier was suggested by Eftekhari Hossain et al. [16] as a procedure for plant leaf infection discovery classification. For categorization, the leaf disease photos' textural characteristics are retrieved. In this study, a KNN classifier will categorise several plant species' illnesses such as alternate, alternaria, anthracnose, leaf spot, canker, bacterial blight. The suggested method has a 96.76% accuracy rate for correctly identifying and diagnosing the chosen illnesses. Image capture, color conversion, color segmentation, feature extraction and morphological operation are the five key processes that make up the proposed model. There are 237 photos of leaves representing five different plant diseases in the collection. The $L^*a^*b^*$ color space utilized to change over an image's color space in order to discern the colors in a leaf picture. Three neighbors are used for color picture segmentation instead of the K-nearest neighbor classifier. The leaf, disease, portioned portion and background portions are spoken to by the colors green, red, and blue appropriately. The binary picture is used to separate the disease region from the original leaf image based on green color using morphological opening, dilation, and erosion. The plant infection has been divided into five categories by using KNN classifier. The execution calculation between the KNN division yield and the manual division yield has evaluated the dice similarity coefficient (DSC), minimal square error (MSE), and structural similarity index measurement (SSIM) variables. The disarray lattice and ROC bend have been utilized to evaluate the prepared classifier's execution, exactness, review, exactness and f1-score parameters were produced in arrange to assess the execution of the created classifier show on the testing dataset utilizing the perplexity network.

Vanitha [17] recommended a profound learning-based calculation to consequently categorise and recognize sicknesses of rice plants from leaf photographs. The made show was competent of recognizing the presence of takes off and separating between solid clears out and three major rice sicknesses, counting rice brown spot (RBS), rice sheath decay (RSR), and rice bacterial curse (RBB). Total 350 photos in the collection were acquired from various sources using a variety of enhance approaches. The dataset was trained using the VGG16, ResNet50, and InceptionV3 CNN architectures. The accuracy of ResNet50 is quite good at 99.53%.

A system based on AI networks was put into place by Nikhil Shah et al. [18] for the identification of illnesses affecting cotton leaves. Images of cotton are captured using an image capturing device and then pre-processed using techniques for image segmentation and feature extraction. Image improvement uses noise cancellation. The RGB and HSV components of the picture are utilized to categorise the grade of cotton leaf diseases using the MATLAB Artificial Neural Network (ANN) tool. Six distinct forms of illness were identified throughout the testing using 18 photos of leaves. Binary findings were recorded as "1" for diseased leaves and "0" for healthy leaves.

The stages of the common plant malady location framework and ML classification approaches for plant disease detection are compared, according to Shruthi U et al. [19]. In this study, it was shown that convolutional neural networks provide good accuracy and can identify a greater variety of agricultural illnesses. They also found that many studies employ SVM for categorization, with certain illnesses having an accuracy of 90% to 95%. In a survey, it was discovered that CNN classifiers are utilised to classify a variety of plant diseases with an accuracy rate of above 95%.

DL algorithms were suggested by M. Vengateshwaran et al. [24] to automatically identify and categorise the plant leaf disease using picture datasets. The study focused on processes including picture capture, preprocessing, segmentation, feature extraction, and classification. The study through graphical depiction produced by the proposed research leads to a better prediction method for symptoms with a high degree of similarity. A preprocessed dataset of various leaf pictures from agricultural and fruit plants, including sugarcane,

carrot, cotton, potato, wheat, rice, banana, and guava is chosen. Applying versatile Canny and Gaussian thresholding to a pre-processed picture will offer assistance find the locale of intrigued. Faster Region-Based CNN is used to classify the image after being segmented using the Canny edge detector approach. Along with the pesticide for the sickness, the disease's infection status in leaves.

For the reason of recognizing sound and harmed clears out from information sets via preprocessing, feature extraction, and classification, Shima Ramesh et al. [25] suggested Random Forest classifier. With the utilize of HOG, a highlight descriptor utilized for question acknowledgment, highlights of a preprocessed picture are recovered. Hu moments, Haralick Surface, and Color Histogram have been utilized as three attribute descriptors. The reality of HoG attribute extraction employs the created cells is one of its benefits. When connected as a classifier for photos of solid and debilitated takes off, the arbitrary timberland approach given more prominent precision with a littler collection of picture information. Utilizing the irregular forest approach, 160 photographs of papaya clears out were utilized to prepare the show. For exactness, the strategy was compared to other machine learning models. Concurring to comparisons, it has been appeared that utilizing a arbitrary forest classifier, the model can classify with an precision of around 70%, which is higher than that of other classifiers like calculated relapse, SVM, Gullible Bayes, and K-nearest neighbor.

Using scale-invariant feature transform (SIFT), accelerated robust features (SURF), Orientated FAST and rotated BRIEF (ORB), and histogram of oriented gradients as object detectors, Budiarianto Suryo Kusumo et al. [26] focused on the automated diagnosis of maize plant disease (HOG). They tested how well these characteristics performed using a variety of ML techniques, including SVM, DT, RF, and NB. Gray leaf spot (513 photos), common rust (1192 images), healthy (1162 images), and northern leaf blight (956 images) are four groups of categorization diseases that affect maize plants. Images are scaled down from their original (256*256) dimensions to 64*64 pixels for RGB characteristics, and they are left at their original dimensions for all other features. They employed k-fold cross validation with $k = 10$ to validate the findings for all features and classifiers, and the accuracy was used to assess the performance of the classifiers. The findings of the experiment suggest that color is the most informative aspect since changes in color or the presence of spots or rotting areas in the leaves are typically used by the naked eye to detect plant illnesses. Experimental analysis found that the RGB feature provides the greatest accuracy for classification purposes, and that SVM with Linear Kernels outperforms all other machine learning techniques. Additionally, experiments show that RF might yet be enhanced if the numbers of trees are larger.

Endang Suryawati et al. [27] looked studied how well deep CNN architectures performed at detecting plant illnesses. They compared these three designs to GoogleNet and assessed execution of basic two-layer CNN (operated as a guideline) and AlexNet (which has five layers), and VGGNet (which has thirteen convolutional layers). To test CNN architectures, a dataset from the tomato plant is used. They looked into how the network depth affected the model's precision. Comparative analysis reveals that VGGNet, with an accuracy of 95.24 percent, obtains the greatest accuracy among the other analysed designs, highlighting the significance of using deeper architectures for classification.

CNN technology was proposed by A. Blessy et al. [28] for the diagnosis of agricultural diseases using samples of leaf pictures. Segmentation of the afflicted leaf section, feature extraction, and classification are all part of the suggested methodology. Convolution Neural Networks are used to implement the final classification procedure. The sample leaf picture is first provided as input. The diseased area of the input picture is divided into segments to determine the disease's kind and assess its severity. Using the FCM Clustering Algorithm, the affected portion of the leaf picture is segmented. The Gray Level Co-Occurrence Matrix (GLCM) and Run Length Matrix are then used to uniquely identify the sickness name and severity using the traits derived from the affected area (RLC). The strings of data are represented using run-length encoding. CNN, which require less pre-processing than other classification methods, are then given these characteristics to categories the illness. On various leaf photos afflicted by various diseases and taken by actual cameras, experiments are conducted. Utilizing performance matrices like Classification Accuracy, Precision Rate, Recall Rate, and Error Rate, crop disease methods' effectiveness is assessed. According to performance evaluation, CNN's classification accuracy is 98%, which is higher than that of SVM and ELM.

Using IoT technology, Sona Pawara et al. [29] created a method for pomegranate plant disease monitoring and alerting farmers and specialists. In the presented study, several sensors are employed to collect real-time data on various agrometeorological parameters as temperature, leaf wetness, humidity, and moisture. Data is sent to the cloud from various sensors and is then retrieved by the base station. The base station comprises of a system with a Hidden Markov Model that is used to classify pomegranate plant illness and gives farmers real-time disease diagnosis and targeted pesticide application.

A deep learning-based approach was put up by Hang J. et al. [30] to recognize and categories plant leaf diseases. Their suggested approach utilizes the neural network's advantages to categories the target illness locations and extract the traits of sick sections. The authors improve the unoriginal convolutional neural network to understand; sicknesses by mixing a makeup of inception piece, a squeeze-and-excitement (SE) piece, and a global combining coating to address the troubles of long training union opportunity and also-abundant model parameters. Finally, to underrate the amount of model limits, the completely connected coating was substituted accompanying the all-encompassing average combining layer.

Rajleen Kaur et al. [34], they have developed enhanced model in SVM to improve plant leaf detection They used SVM to execute on two different datasets. First dataset utilized for practicing and second utilized for examining. In one part the capture images and preprocess them and in second they it returns back by separating parts of depictions with segmented background pixel of figures. They used neural network and PCA for classifying healthy part and diseased part of image.

Table I describes different agricultural leaf disease detection and classification techniques with different inputs datasets.

TABLE I. DETAILED ABOUT THE STUDIES OF VARIOUS DEEP LEARNING AND CLASSICAL LEARNING STRUCTURES USED IN VARIOUS LEAF DISEASE DETECTION AND CLASSIFICATION

Authors Name	Type of Leafe	Techniques	Result/Accuracy(%)	Discussion
Ashutosh Kumar Singh et al.[2022]	Apple ,corn ,potato, tomato rice plant images	CNN, Bayesian optimizes SVM, HoG, GLCM	Developed Hybrid Feature based plant leaf disease detection	Deep features extracted by CNN and feature classified by Bayesian SVM classifier and feature extracted by Hog, GLCM and color moments.
Sachin C et al.[2020]	Various vegetable images like Cucumber,grren apple,green capsicum	Used You Only Look Once Algorithm	Recognising vegetable and labled class category with 61.6%	To train desired network author used You Only Look Once Algorithm
Surampalli Ashok et al.[2020]	Swedish and Flavia tomato leaves datasets	Used histogram of oriented gradients and SVM	Recognize and classified plant leaf	To compute shape feature used Zernik Moments and histogram of oriented gradients ,SVM
Vinod Kumar et al.[2020]	Open dataset of 15200 images of crop leaves	ResNet-34 approach	99.40% accuracy on test set	Compared ResNet results with SVM, decision tree, logistic regression , K-NN
Authors Name	Type of Leafe	Techniques	Result/Accuracy(%)	Discussion
Achyut Moberkar et al. [2020]	Cotton leaf	Neuro-fuzzy inference system	85% accuracy	Image processing and segmentation done for identifying spot leaf disease in 3 different cotton leaf images
Vijaykumar ponnusamy et al.[2020]	Real time plant leaf	K-mean, GLCM,SVM	Classification achieved using SVM	k-means used to determine defected area of plant leaves and GLCM used for texture and color feature extraction
Yunong Tian et al.[2019]	Pretrained dataset of leaves	PCA and neural style transfer	89% data manipulation through transfer learning	They used pretrained data model
Kirtan Jha et al.[2019]	Trained Plant leaf dataset	CNN,RNN	Given brief review	Review on CNN,RNN to detect plant images
L. Sherly et. al.[2019]	Different plant	ML	summarized the overall performance of supervised and unsupervised classification algorithms for disease detection	Diagnosing illnesses in diverse plant leaves

Shruthi et al.[2019]	Variety of Plant Diseases	SVM,CNN	Certain illnesses having an accuracy of 90% to 95%.	They discovered that CNN classifiers are utilized to classify a variety of plant diseases with an accuracy rate of above 95%.
Eftekhari Hossain et al.[2019]	237 leaf images of five various diseased plant.	KNN	Detect and identify the selected disease with 97.76%	KNN classifier used to classify plant disease into five classes
V. Vnitha et al.[2019]	350 Rice plant leaf images	Vgg16,ResNet50,Inception V3 for dataset training	ResNet50 achieved 99.53% accuracy	Developed model was able to detect healthy and diseased leaf among three rice leaf diseases
Nikhil Shah et al.[2019]	18 Cotton leaf images	ANN tool of MATLAB	Result stored in binary form '1' for leaf with disease and '0' for without disease	Developed system based ANN for cotton leaf disease detection among six different types of diseases
M. Vengateshwar et al.[2018]	Leaf images of crops, cereal crops, vegetable crops and fruits such as sugarcane,cotton,potato,carrot,chilly,brinjal,rice,wheat,banana, guava	Different deep learning algorithms, region- based CNN	Outcome presented through graphical visualization	Diseased leaves classified using faster region-based CNN. Organic pesticides also suggested for infected plant leaves.
Shima Ramesh et al.[2018]	160 images of papaya leaves	Hu moments, Haralick Texture, color histogram	Approximate 70 accuracy	They proposed Random Forest classifier healthy and disease leaf classification based on preprocessed data set
Budiariano Suryo Kusumo et al.[2018]	Corn leaf images	SIFT,SURF, ORB,HoG,SVM,D T,RF,NB	RGB feature gives best accuracy among various ML methods and SVM with linear kernels gives best performance	They indicate Random Forest could be improved if no of trees are larger.
Rajleen Kaur et al.[2015]	Different plant leaves two datasets	CNN with PCA	Modified SVM compared with existing old SVM	One dataset used for training and second used for testing leaves
Dimitris G et al.[2014]	Tomato leaf	DTW and GLCM	Detect and classified leaf disease	Convolution neural network used to detect and classify tomato leaves

III. CONCLUSION

The majority of past study work only used tiny datasets for classification, making it unable to identify and categorise newly infected leaf photos accurately. A larger dataset volume is needed for categorization. The kind of hand-crafted characteristics used determines how effective machine learning approaches are. Feature extraction must be done automatically is necessary for choosing and learning the best set of features for recognition. Furthermore, the DL network should be trained on a large number of images to ensure that the features are more generalizable. Less work is done using hybrid of two or more algorithms. Thus, in the future, the work can be done by using a combination of deep learning and machine learning algorithms with best feature extraction methods to improve classification efficiency and for decreasing time. Many deep learning techniques has been developed for different crops. But still there are scope in future for developing hybrid deep learning models to achieve more accuracy to improve crop production in sorghum, wheat and millet and many more which required in large amount and in good quality.

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