

Comparative Analysis of Deep Learning Models for Accurate Detection of Plant Diseases: A Comprehensive Survey

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Abstract

Agriculture plays an important role towards the economic growth of any nation. It also has a significant effect on global GDP. The enhancement in agro production helps in controlling greatly the inflation. Today a large percentage of population from rural India is still dependent on agriculture. But every year there is a huge loss happen in agriculture due to different plant diseases. A farmer does not able to recognise any plant disease at its beginning stage due to insufficient knowledge. Sometimes they take help of agriculture officers in this process. However, if the infection level has grown by that point, it typically leads to a significant crop loss. Also the diagnosis made by the agriculture officer based on their past experience, is always not accurate. Computational vision-based solutions can be used to deal with this great disaster to a large extent. Computer vision mainly deals with different algorithms that enable a computer to identify a hidden pattern for recognition using image or video data. In this work a detailed investigation has been performed on the different computer vision based solutions proposed by different authors to detect various crop diseases.

Keywords: Plant diseases, Transfer learning, Densenet (DN), Efficientnet (EN), Convolutional Neural Network (CNN), Resnet (RN)

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1. Introduction

Agriculture is always considered as the strongest pillar for the economy of any country. As per World Bank report in some underdeveloped countries agriculture contributes more than 25% towards the GDP [1]. Around 58% population of India are dependent on farming as their source of income. India is having massive area for planting Rice, wheat, cotton, Potato, Tomato among all countries in the world [2]. But today in reality a farmer faces a number of practical challenges in farming such as lack of rainfall, crop disease, insufficient knowledge about pesticides, unawareness about modern tools and techniques etc. The major reason for the economic crisis recently came in Srilanka was due to the heavy loss in agriculture [3]. In India also every year many farmers commit suicide due to loss in Agro production. Farmers are not able to recognize any plant infection due to insufficient domain knowledge

[4]. Sometimes farmers take help of Agriculture officers to assess the condition of different plants. But by the time if the amount of infection has gone to a significant level, then it is very difficult to recover the plant from the stage. The leaf of any plant is generally being considered as the best indicator about any plant infection. Hence any plant pathological process mostly begins with the examination of the leaf [5]. The most common plant disease infects any plant is early blight, septoria leaf spot, leaf curl etc. Hence to avoid such a great loss in agriculture there is a need of any solution that can easily identify the occurrence of the disease from its visual appearance in advance [6]. Once the disease can be identified at its early stage then any kind of precaution can be used to save the crop loss. Now a days different computer vision-based systems are used to solve any complex problem based on visual analysis. Computer vision is an emerging area under Artificial Intelligence that enables a computer to classify different objects by understanding complex patterns from any visual input [7].

Computer vision methods are implemented using different Deep learning-based models. Deep learning comprises of different Artificial Neural Network based models that create intelligence within a computer by mimicking human brain structure. In case of Neural Network intelligence can be developed in a computer artificially by performing training using a number of image samples. A Neural network comprises of a number of hidden layers in between the input and output layer. During the process of training the model understand different image features that helps in classification. The input image is given in the input layer and the object identification is done in the output layer [8]. These kinds of systems can not only help the farmers to identify any infection but also assist the agriculture officers to take any clinical decision quickly. In this study a detailed investigation has been performed on different of computer vision-based solutions proposed by different authors for the diagnosis of various plant diseases. At present for better image classification task advance transfer learning models such as VGGnet (VN), Resnet (RN), Efficientnet (EN) and Densenet (DN) are mostly used.

2. Literature Review

Andrew et al. [9] applied different transfer learning models for the prediction of different plant diseases. The data augmentation method was used to create more image samples by small modification in the image orientation. Out of all the models Densenet-21 has shown the best performance during evaluation. Wei et al. [10] used four different pre-trained models for leaf disease identification. The models were created and evaluated in different heterogeneous computing environments such as CPU, GPU and VPU. Out of all the models Densenet121 has shown promising accuracy. After that the performance of the model is assessed by changing the environment to pytorch. Sunil et al. [11] applied hybrid method using machine learning and deep learning for tomato plant leaf disease prediction. Initially the leaves size is enhanced. After that histogram equalization method is used to alter the color properties of the leaf image. The boundaries of the leaf are identified using contour plot. Multiple descriptors were used for feature extraction. Finally, the extracted features are given to the convolutional neural network for classification. Mehedi et al. [12] applied a different transfer learning approach followed by explainable AI for the detection of 38 types of leaf diseases. At first the image samples are scaled up followed by an augmentation operation for resampling. Then the images are given to various models for the training. In the next phase the validation set is used for evaluating the model performance calculated using accuracy. The efficientnet has shown the best accuracy during validation. To have an insight into the working the models LIME is used. Tejaswini et al. [13] implemented a classical CNN based approach for the classification of Rice leaf disease. The dataset contained a total of 3 unhealthy and 1 healthy classes of rice leaf images. The

classical CNN consisted of 5 different types of layers including input and output layers. The accuracy of classification of CNN was found to be better than other pre-trained approaches used in the work. Azath et al. [14] developed an intelligent cotton plant leaf disease diagnosis system using CNN. The cotton leaves samples are collected from farms belong to different areas of Arab. The dataset is segregated into 3 different infected classes and 1 healthy class of images. As a part of data pre-processing augmentation operation is performed on the image samples. The implemented CNN contains 8 different layers including input and output layer. Hassan et al. [15] built an effective mobile device based deep learning solution for the better prediction of 14 different plant diseases. The system is mainly based on different pre-trained CNN models. The performance assessment of the models is done with respect to different model related parameters such as number of epochs, batch size, and dropout. The performance of the mobile net is found to be most effective due to its lighter weight. But by considering the accuracy the efficientnet was found to be more efficient during training and validation. Qi et al. [16] implemented a set of machine learning and deep learning model for Peanut-Leaf disease identification. The dataset contains the image samples of 5 classes including healthy samples also. Among the all-machine learning and deep learning models ResNet 50 has shown the most prominent result in terms of classification accuracy. Vaishnave et al. [17] applied K Nearest Neighbour (KNN) classifier for Groundnut leaf disease prediction. The classifier was trained with the images of 4 categories of leaf diseases. In the pre-processing phase masked images were prepared and sent for segmentation. After that the features were extracted from the segmented images. Finally, the extracted features were given to the classifier for classification of the leaf disease. Sangeetha et al. [18] created a CNN for the recognition of tomato leaf disease. Before classification the images were resized. There was a total of 8 layers consisting of 4-convolution layers and 4-pooling layers used in the model. Shima et al. [19] utilized Random Forest (RF) model for the leaf disease prediction. For extracting features from the image Histogram of an Oriented Gradient method was mainly used.

Ghosh et al. (2023) embarked on a comprehensive study to assess water quality through predictive machine learning. Their research underscored the potential of machine learning models in effectively assessing and classifying water quality. The dataset used for this purpose included parameters like pH, dissolved oxygen, BOD, and TDS. Among the various models they employed, the Random Forest model emerged as the most accurate, achieving a commendable accuracy rate of 78.96%. In contrast, the SVM model lagged behind, registering the lowest accuracy of 68.29% [20].

Alenezi et al. (2021) developed a novel Convolutional Neural Network (CNN) integrated with a block-greedy algorithm to enhance underwater image dehazing. The method addresses color channel attenuation and optimizes

local and global pixel values. By employing a unique Markov random field, the approach refines image edges. Performance evaluations, using metrics like UCIQE and UIQM, demonstrated the superiority of this method over existing techniques, resulting in sharper, clearer, and more colorful underwater images [21].

Sharma et al. (2020) presented a comprehensive study on the impact of COVID-19 on global financial indicators, emphasizing its swift and significant disruption. The research highlighted the massive economic downturn, with global markets losing over US \$6 trillion in a week in February 2020. Their multivariate analysis provided insights into the influence of containment policies on various financial metrics. The study underscores the profound effects of the pandemic on economic activities and the potential of using advanced algorithms for detection and analysis [22].

3. Comparative Analysis

In the previous section various deep learning based methods used for different plant leaf disease prediction is

discussed. It is clearly observed that resampling of existing data samples and use of transfer-learning based model really affects the performance to a large extent. In most cases, image regeneration augmentation method is used. To enhance accuracy and avoid overfitting issues in case of deep learning models a greater number of image samples is required. As the image samples belongs to specific type of classes of plants hence augmentation and Generative Adversarial network are used to generate more image samples artificially. It is clearly observed that as compared to classical CNN models transfer learning performs well for variety image classification problems. The transfer-learning based approach always helps to accumulate extra knowledge in addition to the existing knowledge. Hence it was found to be more efficient as compared to the classical deep learning models as well as machine learning models. The following table 1 shows the classification accuracy shown by the different models. Most of the authors have applied Densenet and Efficientnet in their work. In the case of Efficientnet the performance boosting happens by the use of scaling the depth, width and resolutions at one time. But in case of Densenet it provides connection between all preceding layer neurons with all succeeding layer neurons.

Table1: Comparative Analysis Table

Reference No.	Author	Model used	Plant name	Accuracy
9	Andrew	DN	Multiple	99.81%
10	Wei	DN	Multiple	96.41%
11	Sunil	CNN	Tomato	99.6%
12	Mehedi	EN	Multiple	99.6%
13	Tejaswini	CNN	Rice	78%
14	Azath	CNN	Cotton	96.4%
15	Hassan	EN	Multiple	99.5%
16	Qi	RN	Peanut	97.5%
17	Vaishnave	KNN	Groundnut	96%
18	Sangeetha	CNN	Tomato	94.6%
19	Shima	RF	Multiple	65%

4. Conclusion

In this study a detailed investigation was performed on different types of plant disease prediction using various deep learning based methods. The study concludes that boosting the performance of different models’ image sample count plays a major role. Also, the use of pre-trained models also improves the accuracy a lot. Other than augmentation, other resampling methods can also be used.

From this study it is concluded that efficientnet and densenet proved to be the most efficient neural network structures as compared to classical CNN structures as well as different machine learning based models while classifying the different leaf disease.

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