Deep Neural Network Systematic Computation on Plant Disease Detection

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Abstract. Automatic detection techniques of disease in plants are very important in the field of agriculture for balancing the yield and population of the country. It assures food security of the country and helps to avoid agricultural economic losses. Many of us think that farmers are always suffering only from problems like unexpected rainfall, Natural Disaster, soil erosion and nutrient imbalance, but there are various other problems among them the major key problem is Plant Disease. Most of the plant diseases are classified and detected using the leaves part of the plant. The images of the Leaves always play an important role in Plant Disease Detection Automation. Image classification and detection are implemented by ML and DL algorithms. Especially in the plant disease images many authors have implemented ML and DL techniques. This paper has listed various techniques and methodologies used by ML and DL algorithms in detection of diseases in plants and Deep Neural Network implementation is explained in the experiment and result section.

Keywords: *ML, DL, Convolutional Neural Network.*
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1 Introduction

Basically, India is an agricultural country since pre-historical times. Entire country depends on agriculture for the production of food materials with quality and quantity. More than 80% of the population of India are depending on agriculture as the main source of income for their livelihood. India has achieved significant growth in agriculture. Many factors are responsible for these achievement like proper government policies, agricultural higher education institutions and farmer responsibilities. One of the regular problems faced by the farmers is the plant diseases. Plant disease is the major threat to farmers for it challenges the crop yield. Traditional methods for finding plant disease required manual inspection of farms by old traditional method known experts who are now almost nil in most villages. Especially for the large farms, this process is to be a continuous one and therefore very expensive. More over in rural areas farmers are completely unaware of the agricultural expert's awareness. Automatic detection using computer vision and current popular analysis of RGB images are most required automation in agriculture for identification of plant disease[19]. Image classification and detection can be analyzed by ML or DL approach. Sample images of different plant diseases are illustrated in the following figures.


Fig. 1 Barley yellow dwarf


Fig 2. Stem Rot


Fig 3. Powdery mildew

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Fig 4. Bacterial Black Spot


Fig 5. Late blight


Fig 6. Leaf Curl


Fig 7. Early blight


Fig 8. Rust


Fig 9. Yellow Mosaic

ML and DL are emerging technological approach that helps in prediction, diagnosis of plant disease. Various Machine Learning algorithms like RF (Random Forest), ANN (Artificial neural network), Naive bayes, decision trees, Support Vector Machine (SVM), Fuzzy Logic, K-Means Method & CNN of Deep Learning etc. are deployed to increase the classification and the accuracy of the result [20].

2 Machine Learning

ML algorithms are basically represented by the parent set of AI, always referred as ML is a subset of AI and focused on the use of various algorithms to produce the improved accuracy results of the entire data in the way of human intelligence. Prediction and classification are implemented based on some data referred as an input, which are gathered in two forms as labelled or unlabeled. The machine learning algorithms will produce an evaluation about a pattern in the data. Three categories of ML are i) Supervised Learning ii) Unsupervised Learning iii) Reinforcement Machine Learning.

ML algorithms with labeled inputs are required to train the supervised machine learning algorithms to reach the desired output. In Supervised machine learning classifications, when the data is divided into two groups, it is by binary classification, if choosing more than two types, it is by using multi-class classification. Regression technique is used for continuous value prediction. Unsupervised ML algorithms require the data to be in unlabeled format.

The following are some examples of unsupervised machine learning: clustering is the grouping

of dataset based on similarities, anomaly detection is used to point the unusual data in the dataset, association mining is finding the frequently occur data item in the dataset and Dimensionality reduction is used to reduce the number of variables in the dataset.

Reinforcement learning works by programming an algorithm with a distinct result and frames the set of rules for accomplishing the desired result.

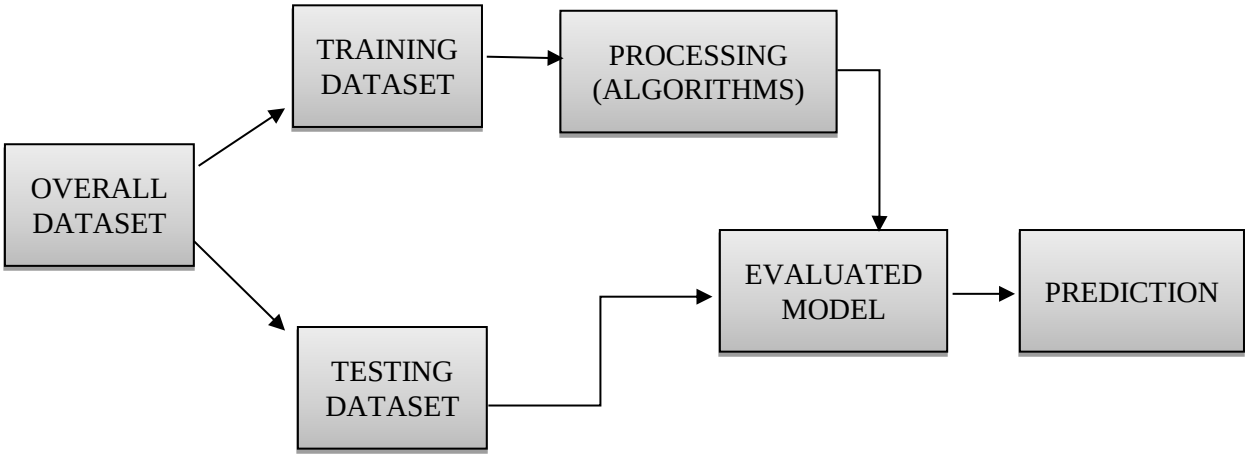

Fig 10. Machine Learning Block Diagram

3 Deep Learning

Deep learning is a subdivision of machine learning. DL algorithms are used for extracting features and classification of its own according to the supplied input. Learning and thinking of artificial neural networks of deep learning imitate the human brain to produce the desired output. An entire neural network of various layers nodes is much like a neuron of the human brain, the signals are received from other neurons. Nodes of each layer are linked to the nodes of the adjacent layers. The signal transfers among the nodes and assigns the proportional weights. The final layer is responsible to produce output for compiled weighted inputs. The below diagram depicts about deep neural network architecture [17].

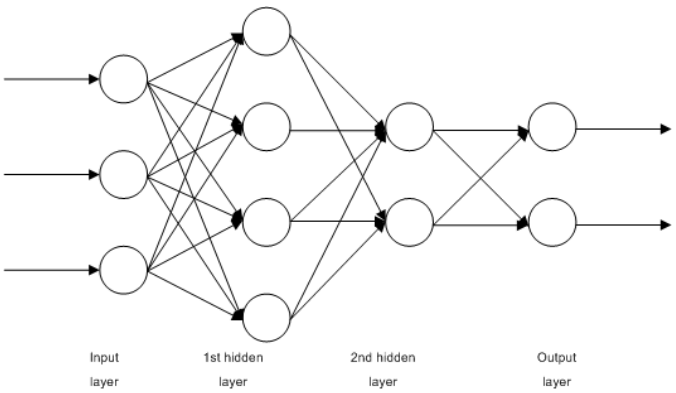

Fig 11. Deep Learning Block Diagram

Convnet architecture consists of three layers: convolutional layer, pooling layer and fully connected layer. Convolutional Layer: Majority of feature extraction implementation to identify image is done in this layer. The Kernel or Filters of convolutional layer moving across the various portion of the image to find out the required features are present in the image or not. Final output from the feature map, which is ultimately the numerical form of the image used for CNN to interpret and extract relevant information of image. Pooling Layer: pooling layer improves convolutional layer efficiency and reduces the complexity using the technique of reducing the feature parameters from the input but the loss of information in positive side, which reduces the complexity and improves efficiency of CNN. Fully Connected Layer: Feature maps are flattened into a vector and passed through FC Layer. This layer is responsible for making final classification or prediction.

4 Literature Review

[1] Kusumo et al. (2018), proposed "Corn-Plant Diseases automatic detection using Image Processing". In this work, they used a number of features based on image processing for the detection of corn diseases. Scale-Invariant Feature Transform (SIFT), Speeded Up Robust Features (SURF), Oriented FAST and Rotated BRIEF (ORB), and (HOG) used to detect RGB color. Support Vector Machines (SVM), Decision Tree (DT), Random Forest (RF), and Naive Bayes (NB) evaluated the performance of these features. Finally, RGB is the feature with the best accuracy for most classifiers.

[2] Orillo et al. (2014), proposed "Rice plant (oryza sativa) using back propagation ANN", In this work they detected the following diseases of rice plant, which were brown spot, bacterial leaf blight and rice blast. Totally 134 images were involved in the network and Back propagation was used to improve the accuracy and performance.

[3] Meunkaewjinda, A. et al. (2008), proposed "Detection of grape leaf diseases", they used BPNN to extract the color variance from grape leaf, Gabor filters and features of grape leaf allowed the SVM to achieve very efficient identification of diseases.

[4] Masazhar et al. (2017), proposed "Palm oil leaf disease detection using multiclass SVM classifier". This work proposed to find oil palm diseases chimaera and anthracnose detection used k-means clustering and multiclass SVM classifier. Using this k-mean clustering process they extracted totally thirteen types of features. Multiclass SVM classifier achieved accuracy of 97% for Chimaera and 95% for Anthracnose.

[5] Monzurul Islam et al. (2017), proposed "Using image segmentation and SVM for Detection of potato Diseases", In this work, they used 300 leaf images to detect two blight diseases, late blight and early blight. The dataset of potato plant collected from 'plant village' public dataset and they used segmentation and SVM classifier to find the disease with the accuracy rate of 95%.

[6] Md. Selim Hossain et al. (2018), proposed "Tea Leaf's Diseases Using SVM", This proposed work recognized and classified brown blight disease and algal leaf disease as the two important tea leaf diseases. Eleven features were extracted and with the support of SVM classifier was used to detect the diseases with the accuracy of more than 90%.

[7] Yao et al. (2009), proposed "Rice Diseases Detected using Support Vector Machine", This proposed work implemented with the shape and colour feature of the leaf part of the rice plants. Leaf blight, sheath blight and blast diseases were detected using SVM. Bacterial spots were segmented, texture and shape features were extracted to produce accuracy rate of 97.2%.

[8] Gautham Kaushal et al. (2017), proposed "Level cooccurrence matrix (GLCM) and K nearest neighbor (KNN) based Algorithm for Plant Disease Detection". In this work, Multiple class classifier, KNN classifier was used to detect the plant diseases rather than SVM classifier. SVM classifier is compared with the performance of the KNN classifier.

[9] Diptesh Majumdar et al. (2015) , proposed "Rust disease of wheat plant using Fuzzy C-Means Clustering Method", Fuzzy Classifier in plant disease detection used the dataset, which was combination of healthy and unhealthy leaves part of the wheat plant. Classification of healthy and unhealthy leaves achieved 88% and recognition of disease was 56%.

[10] Maniyath et al. (2018), proposed "Papaya leaf diseases detected using ML algorithm", In this proposed work implement using RF (random forest) classifier, totally 160 papaya leaf images were used to develop a model. The produced model classified with the accuracy rate of 70%.

[11] Srdjan Sladojevic et al. (2018), proposed "Plant diseases were recognized and classified using DNN", peach, apple, pear, cherry and grape plants of thirteen different diseased leaves were involved to produce a model using CNN classification. Totally, more than 30000 images used in the model and performed with the accuracy above 91 percentage.

[12] Arnal Barbedo, Jayme Garcia (2019), proposed "Plant disease detection using DL algorithm for fining the individual lesions and spots", In this work, the entire process implemented only on the individual lesions and spots of the leaves. The exact region has its own features, to compare with the variable data and the result was achieved without the need of further images.

[13] Belal A. M. Ashqar et al. (2018), proposed "Image-Based Tomato Leaves Diseases Detection Using Deep Learning", Totally 9000 infected and healthy images were involved for research and trained deep convolutional neural network achieved good accuracy to identify 5 diseases.

[14] Albert Cruz et al. (2019), proposed "Detection of grape plant yellow symptoms with artificial intelligence", Convolutional neural network models utilized the Grapevine yellows (GY) disease of grapes leaf images were used in this system. The following six architectures AlexNet, GoogLeNet, Inception v3, ResNet-50, ResNet-101 and SqueezeNet involved to find the diseases. Finally, ResNet-50 produced the best accuracy.

[15] Mohanty Sharada P et al. (2016), proposed a "Using Deep Learning for Image-Based Plant Disease Detection", Totally 54,306 images from a public dataset of unhealthy and healthy images of plant leaves were used. Trained deep CNN model used to identify 14 crop species and 26 diseases. The required accuracy rate was achieved by the developed model.

[16] [18] S. Jeyalaksshmi et al.(2019), Proposed a "Data Mining in Soil & Plant Nutrient Management, Recent Advances and Future Challenges in Organic Crops", This work focused on soil supplements utilizing data mining gathering techniques, Data Mining in Soil & Plant Nutrient Management.

5 EXPERIMENTS AND RESULTS

Plant leaf images are used for implementation of Plant disease detection because leaf is a major part plant in the farmers life to find the plant diseases in early stage. The same fact is also involved to select the leaves dataset. Data are collected from the Kaggle village dataset and the following plants are involved for implementation which are Alstonia Scholaris, Arjun, Guava, Jamun, Jatropha, Lemon, Mango and Pomegranate. Collected inputs are fine tuning using rotation, flipping, zooming & color adjustments preprocessing techniques. The Proposed deep convolutional neural network involved to predict the plant diseases with 70 percentage of training data and 30 percentage of testing data. The following table depicts about Deep Convolutional Neural network architecture.

Layer (type)	Output Shape	Param #
conv2d_1 (Conv2D)	(None, 296, 296, 32)	2432
max_pooling2d_1 (MaxPooling 2D)	(None, 98, 98, 32)	0
conv2d_2 (Conv2D)	(None, 96, 96, 32)	9248
max_pooling2d_2 (MaxPooling 2D)	(None, 48, 48, 32)	0
conv2d_3 (Conv2D)	(None, 46, 46, 32)	9248
max_pooling2d_3 (MaxPooling 2D)	(None, 23, 23, 32)	0
conv2d_4 (Conv2D)	(None, 21, 21, 64)	18496
max_pooling2d_4 (MaxPooling 2D)	(None, 10, 10, 64)	0
flatten_1 (Flatten)	(None, 6400)	0
dense (Dense)	(None, 512)	3277312
dropout (Dropout)	(None, 512)	0
dense_1 (Dense)	(None, 128)	65664
dense_2 (Dense)	(None, 16)	2064
Total params: 3,384,464 Trainable params: 3,384,464 Non-trainable params: 0		

Table.1 Layers of Deep Neural Network

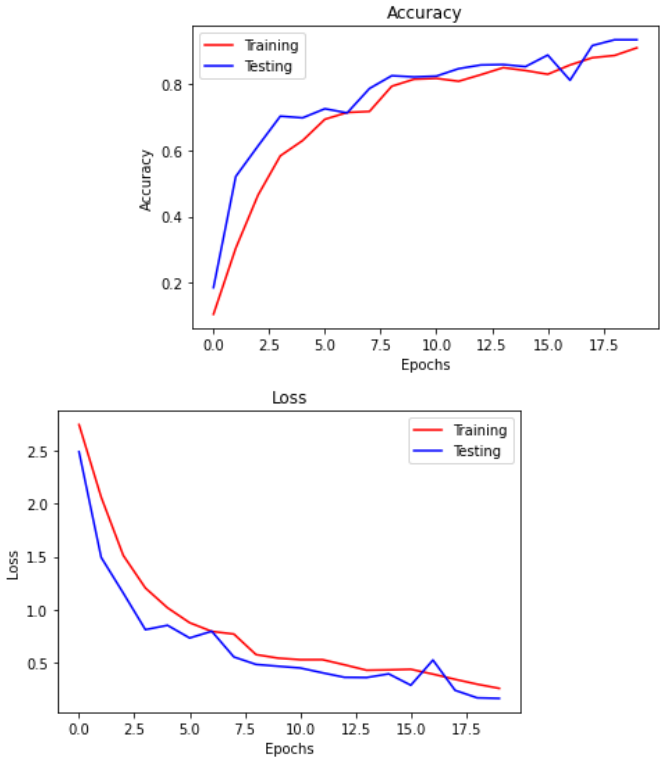

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Fig.12. Accuracy and Loss of Deep CNN

The training dataset consists of above-mentioned leaves images of 70 percentage data are involved to train a model. The combination of convolutional and max pooling layers is declared. Then 25% of data is to be dropped out and softmax activation function used in the last layer to reduce the loss. Totally, 20 Epochs involved to train a model and testing accuracy is 93% obtained as a result.

6 Conclusion

Agriculture field computational automation is mostly required for finding crop diseases to control the major threat to food security and yield for the country. Advances in computer vision and smart phone capturing techniques are made possible and easy for diagnosing and finding the appropriate plant diseases, so that the relative solutions can be done at the initial stage of the identified infection. This paper quoted various ML and DL models in the literature review section. Deep neural network of convolutional neural network model is involved to train and test a dataset, 93% accuracy is obtained during 20^{th} epoch. According to the analyzation the deep neural network models take leads in finding the plant disease diagnosis and detection with highest accuracy.

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