Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 10, October 2021: 2790-2802

A Learning Techniques of Convolutional Neural Network (CNN) for Pest Diagnosis in Grapes Crop

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Abstract:. As India is an Agricultural based country, its economic stability depends on agriculture. Now a days due to technological advances in the digital world, production of crops has also increased, and along with this disease infection in crops has also grown. Manual detection of pests using plants parts like leaves, stem, roots is time consuming and non-availability of timely help from experts which is time consuming and costly. Also spraying the pesticides cannot be the all-time solution as pesticides leave behind many adverse effects, such as reduction in the fertility of soil as well as health issues to the workers. To overcome these problems has led to the early detection of pests using an expert system is need of an hour. In this paper researcher has presented review of research articles based on pest detection using Image Processing, machine learning and deep learning techniques such as Convolution Neural Networks which is best suitable to extract features from the diseased leaves images and classify them.

Index terms :Image processing, machine learning, deep learning, Convolutional neural network, pest diagnosis

I. INTRODUCTION

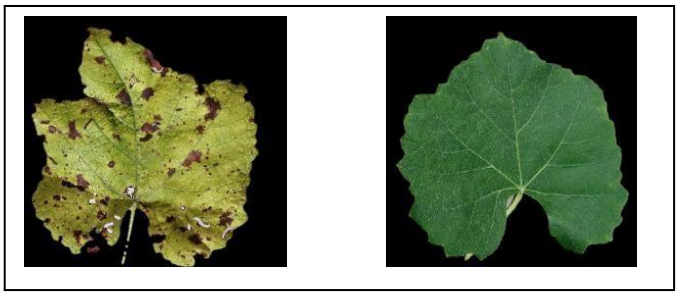
In India, grape production is most significant fruit crop and Maharashtra state is the leading grape-growing state. Though they are grown all over the world for the production of wines and raisins, they are mostly consumed fresh in India. Grapes may also be used as natural remedies for a variety of health issues due to their high nutrient content. Grape cultivation has proven to be very lucrative due to their widespread use and benefits, as well as their ease of cultivation in a variety of climates. Various types of fruit diseases reduce yield. Microorganisms such as fungi, bacteria, and other microbes also reduce the yield. Grapes are vulnerable to various different types of diseases, such as black rot, downy mildew, powdery mildew, esca, leaf spot, etc.

In this paper researcher present an algorithm developed using image processing, machine learning and deep learning techniques that can automatically classify the pest affected grapes leaves in the early stage. Grapes leaves are infected and also it is easier to identify the pest infection and therefore

the researcher prefer on grape leaf pest detection so that timely action can be taken by the farmers to avoid further losses of the yield. An automatic identification method for grape disease on urge of society.

The researcher focuses on to present a novel framework approach for the development of a plant disease recognition model based on leaf image classification and deep convolutional networks for detection of pest infected grapes plant leaves images. Further the training method used allow for system practical application. The proposed layout can distinguish different types of grapes plant leaves diseases for example Black rot, Esca (black measles), Leaf blight, etc. from healthy leaves. The framework for implementing crop disease recognition model using convolution neural network architecture is detailed in our paper. The figure 1: below shows the 4 types of leaves images which are downloaded from kaggle.com.

(a) Black (b) ESCA



(c) Leaf Blight (d) Healthy Leaf

Fig1: Grapes infected leaves[52]

II. LITERATURE REVIEW

A. Common classification techniques used for pest diagnosis in crops-

In this paper the researcher has surveyed common classification techniques which are as mentioned below:

a) **k-Nearest Neighbor:**

In machine learning techniques, k-Nearest Neighbor is a basic classifier where the classification is accomplished by defining the nearest neighbors to a query example and then using those neighbors to evaluate the query class. [5]

b) Support Vector Machine:

Support Vector machine (SVM) is a non-linear Classifier, in which the input data is non-linearly mapped to linearly separated data in some high dimensional space providing good classification performance. SVM is designed by determining the hyper plane to divide two classes to function with just two classes and the Class division is carried out with different kernels, by maximizing the margin between the two classes of the hyper plane. The samples closest to the margin are selected to determine the hyper plane and referred to as support vectors. Multiclass classification is also applicable and is essentially constructed to solve the problem by multiple two class SVMs, either by using one-versus-all or one versus-one. [5]

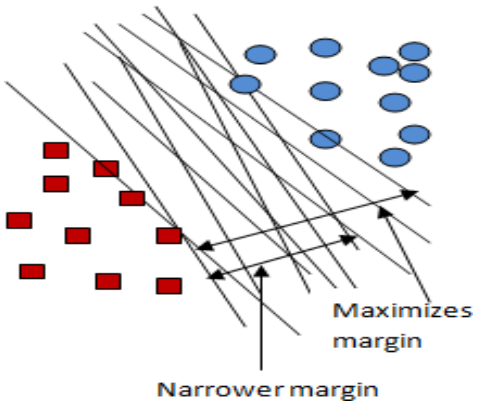


Fig: 2 Support vector machine [5]

c). Artificial Neural Network (ANN):

An Artificial Neuron may be a biological approach, there are number of nodes called neurons in ANN. Usually, neural networks are structured into layers. Back propagation is an algorithm for neural network learning that's utilized in layered feed-forward Artificial Neural Networks. One among the feed forward neural networks with one or more layers between the input and therefore the output layer is that the Multi-Layer Perceptron (MLP). Feed forward implies that data flows from input to output layer in one direction (forward). The network is in a position to find out nonlinear and linear relationships between input and output vectors via multiple layers of neurons with nonlinear transfer functions, therefore a really common option for several researchers is multilayer perceptron's (MLPs), which may be trained employing a back propagation algorithm. [5]

d). Self-Organizing Map

One of the neural network models, focused on unsupervised learning, is that the Self-Organizing Map. It vary from other artificial neural networks within the sense that they use an area function to take care of the input space's topological properties. A map from a better dimensional input space to a lower dimensional map space is defined within the self-organizing map. [5]

e). Probabilistic Neural Networks :

In Probabilistic Neural Networks, the operations are grouped into a four- layer multilayered feed forward network. The primary layer is that the input layer, which measures the space between the

input vector and therefore the vectors of the training input. For every class of inputs, the second layer sums up the contribution and generates internet output as a probability vector. The Third Pattern layer includes one neuron within the training data set for every event. It stores, alongside the target value, the values of the predictor variables for the scenario. The output layer compares the weighted votes accumulated within the pattern layer for every target category and uses the most important vote to predict the target category. As PNNs are much quicker than multilayer perceptron networks, just one undergo the training patterns is required in their training process. [5]

f). Fuzzy logic :

Fuzzy Logic classifiers are classification systems that use fuzzy sets or symbolic logic through the utilization of membership functions to rework real-world data values into membership degrees, in order that these rules can then be used for the classification process. This is often achieved for every of the attributes by identifying "categories."

The processing of fuzzy images is split into three main steps: image fuzzification, membership values adjustment, and image defuzzification. [5]

B. Convolutional Neural Network (CNN)

One of the foremost popular deep neural networks is that the Convolutional Neural Network (CNN). The name is derived from a mathematical linear operation between matrices called a convolution. CNN has many levels; Convolutionary layer, non-linearity layer, pooling layer and fully connected layer. The convolutional and fully connected layers have parameters but pooling and non-linearity layers do not have parameters. The foremost beneficial aspect of CNNs is reducing the amount of parameters in ANN which has helped to solve complex tasks. The CNN shouldn't have features which are spatially dependent. The foremost important layer in CNN is convolution layer which takes most of the time within the network. Network performance also depends on the amount of levels within the network. [11] Deep learning techniques are capable of identifying pests and diseases with high precision if enough data is out there for training so as to enhance classification accuracy.[49][50][42] Using machine learning techniques, we will classify the disease that affects the leaf, stem, root and fruit.

Machine learning techniques like Convolutional Neural Networks (CNN) and Mobile Net are wont to retrieve and categorize the diseased part's characteristics [45]. The accuracy of CNN's image classification is above other algorithms. [43][44][45][46][47][50][49]

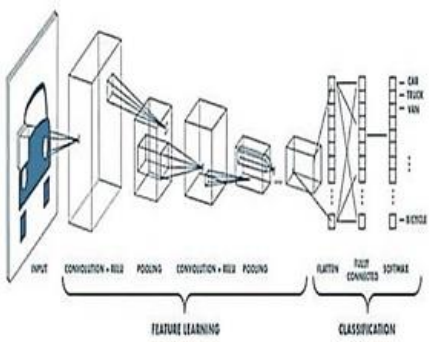


Fig 3: Architecture of CNN [18]

In the above figure Architecture of CNN the layers are divided into two sections Feature Learning and Classification. Feature Learning has three layers Convolution Layer, Re LU and Pooling layer. Classification Layer has three layers Flatten, Fully Connected and SOFTMAX.

What is Convolutional neural networks (CNN?)

The Convolutional Neural Network (CNN) is a type of adaptive image processing system that bridges the gap between normal feed forward neural networks and adaptive filters. One or more layers of two-dimensional filters, with non-linear activation functions and/or down-sampling, are wont to create two-dimensional CNNs. [2][6][7] Convolutional neural networks are a superb illustration of a biologically based concept that has resulted in competitive engineering solutions that outperform other approaches. [4][6][7] Convolutional Neural Networks (CNN) are biologically inspired variations of Multi-Layer Perceptron (MLPs). Multiple arrays are wont to represent many data modalities: 1D for signals and sequences, including language; 2D for images or audio spectrograms; and 3D for video or volumetric images. [7][47]The deep CNN with large dataset which contained thousands of various classes, it could achieve spectacular results, with the efficient use of GPU's, ReLUs , and a replacement regularization technique called dropout, and techniques to get more training examples by deforming the prevailing ones. [7]Recurrent Neural Networks are often preferred for tasks requiring sequential inputs, like speech and language. [7]

CNN stands for Convolutional Neural Network and is formed from three layers: the Reference layer, the center layers, and therefore the Output layer. The input layer is that the first layer, and it's this layer that recognizes the features as input, in other words, it's this layer that gives the pictures as input. The second layer, or middle layer, is formed from the specified number of nodes supported the program. [41]The deeper Alex Net network, which first appeared in 2012, marked the beginning of the fashionable convolutional neural network era and its performance demonstrates the importance of convolutional neural networks. [47]

C. Working of the convolution layer [Layers of CNNs]

The learning abilities of the human brain, which is formed from neurons linked by synapses, are the inspiration for artificial neural networks. [8][25] Due to the dimensions of the image, ANNs are unsuitable for images because they cause over-fitting. the most difference between a standard Artificial Neural Network (ANN) and a CNN is that during a CNN, only the last layer is totally connected, while in an ANN, each neuron is connected to each other neuron The Convolution Neural Network (CNN) is a type of adaptive image processing system that bridges the gap between normal feed forward neural networks and adaptive filters. One or more layers of two-dimensional filters, with non-linear activation functions and/or down-sampling, are wont to create two-dimensional CNNs. [2] [6] [7] Convolutional neural networks are a superb illustration of a biologically based concept that has resulted in competitive engineering solutions that outperform other approaches. [4][6][7]

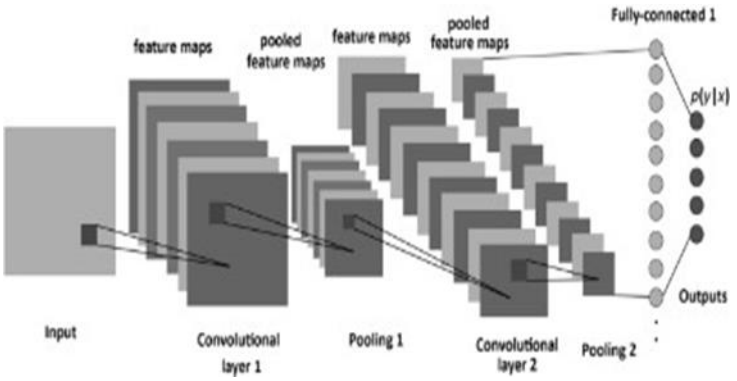


Fig 4: Artificial Neural Network [ANN] [24]

There are biologically induced variations of the convolution neural network (CNN) multi-layer perceptron (MLP). Multiple arrays are wont to represent many data modalities: 1D for signals and sequences, including language; 2D for images or audio spectrograms; and 3D for video or volumetric images. [7][47]The deep CNN with large dataset which contained thousands of various classes, it could achieve spectacular results, with the efficient use of GPU's, ReLUs , and a replacement regularization technique called dropout, and techniques to get more training examples by deforming the prevailing ones. [7]Recurrent Neural Networks are often preferred for tasks requiring sequential inputs, like speech and language. [7]

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D. Layers of Convolution :

1) Input Layer-The first layer of every CNN used is that the –'input layer,' which takes images and resizes them before moving them on to subsequent layers for feature extraction.[16]It is that the first layer in Convolution, and it's wont to extract the features of an input image. It defined the connection between pixels by learning image features from input file using small squares. [44] Convolutional Layer is formed from variety of filters that extract various features from the input image.[16][43]Every filter's main goal is to make a feature map that detects basic structures like boundaries, lines, and squares, then group them into subsequent layers to make more complex shapes. To find out and detect patterns from the previous layer, convolution computes dot products

between the input file and therefore the entries of the filters. [43]A generalized linear model (GLM) for the underlying local image patch is employed in simple CNNs because the convolution filter. [14]

The local association between an individual neuron within the next layer and a few neurons within the previous layer is understood because the receptive field. Receptive field is employed to extract local features from the input image. [17] 2.Pooling (subsampling) layers. The main idea of pooling is down-sampling so as to scale back the complexity for further layers. [25][44] Within the image processing domain, it are often considered as almost like reducing the resolution. Pooling doesn't affect the amount of filters. It strengthens the features' resistance to noise and distortion. Pooling are often wiped out two ways: maximum pooling and average pooling. The input is separated into non-overlapping two-dimensional spaces in both cases. [16][12][11] Max-pooling is one among the foremost common sorts of pooling methods. It partitions the image to sub-region rectangles, and it only returns the utmost value of the within of that sub-region. One among the foremost

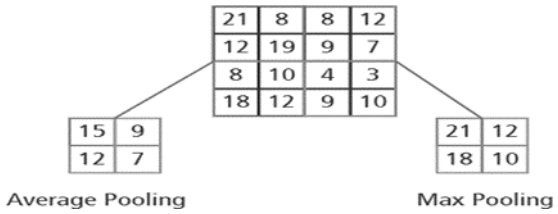

Fig 5: Pictorial representation of Average Pooling and Max pooling [16]

common sizes utilized in max-pooling is 2×2.[12][11][16] The pooling operator maps sub region to its maximum value in peak pooling and to its average value in average pooling. [11] CNN emphasizes the thought of pooling. It reduces the amount of connections between convolutional layers, which reduces the computational load. [14]The exact location of a feature becomes smaller once it's been detected. Hence, the convolution layer is followed by the pooling or sub-sampling layer. [17][43] The main advantage of using the pooling technique is that it significantly reduces the number of training parameters and changes the translation. [25]

The Pooling layer simply down samples or compresses the input image's dimensions. [25]A stride, like 2x2 or 5x5, is chosen. The dimension matrix obtained from the Convolution Layer is added to the stride after it's been selected. Each stride's highest value is saved during a new matrix. Pooling are often either Max Pooling or Minimum Pooling, counting on the stride. Maximum Pooling is employed when the stride is long, while Minimum Pooling is employed when the stride is brief. [25][44][43]During testing, we note that models with overlapping pooling have a harder time over fitting. [3]The pooling mechanism is further illustrated within the diagram below. The size of the input is 4x4. A 4x4 image is split into four 2x2 matrices for 2x2 subsampling. The utmost value of the four values within the 2x2 matrix is that the contribution within the case of max pooling. The sum of the four values is employed which may be a fraction rounded to the closest integer when average pooling is employed. [16]

2) Non-linear layers ReLUs (Rectified Linear Units) :

The next layer after the convolution is non-linearity which may be wont to adjust or cut-off or limiting the generated output. [11] CNN relies on a non-linear "trigger" function to signal the different identification of potential features on each hidden layer. To effectively implement this non-linear triggering, CNNs can use variety of functions, like rectified linear units (ReLUs) and continuous trigger (non-linear) functions. [8] The advantage of a ReLU over other non-linear functions utilized in CNNs is that the network trains much faster. Figure 9 shows ReLU's features, with its transfer function plotted above the arrow. [8][11]

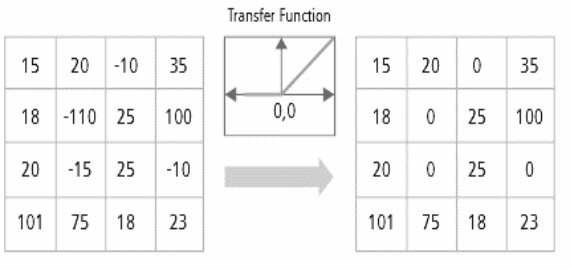

Fig 6:Pictorial representation of ReLU functionality [8]

The implementation of ReLU to exchange sigmoid may be a major improvement in CNN, because it greatly reduces the complexity of learning CNN parameters and increases accuracy. [11]The pixels that are not required are deactivated within the ReLU layer, leaving only the important pixels active. The pixel is converted to either 0 or 1 by the ReLu sheet. If a pixel's value is negative, it's converted to 0; otherwise, it maintains its value. [16][25][44][43] ReLU, on the opposite hand, doesn't leave the disappearance of gradients. [17]

3) Fully Connected Layer: The fully connected layer transforms high-level filtered images into groups with labels. [16]The final layers of a CNN are usually completely linked layers. [8] The fully-connected layer may be an almost like the way that neurons are arranged during a traditional neural network. Therefore, each node during a fully-connected layer is directly connected to each node in both the previous and within the next layer and every of the nodes within the last frames within the pooling layer are connected as a vector to the primary layer from the fully-connected layer. [12] [17] [25] [44]The aim of Fully Connected Layer (FC) is to require the values from the previous layer and get them organized in order that one vector of probabilities are often wont to drop out the category to which the input belongs.[43]

III. ARCHITECTURE / METHODS :

AlexNet has more complex structure then LeNet-5 [34][37] another approaches are more advanced than AlexNet viz. ZFNet, VGGNet, GoogleNet and ResNet,VGGNet. [20][22][43] for normal computing environments Dense-Net201[35][50], ResNet-101, and Inception v2,Inception v3 are best suitable methods.[35][43][50] And for mobile and embedded applications, ShuffleNet and SqueezeNet are used[35][36][46][50]

The loss function is that the measurement criterion for the whole network model during neural network training. [34]It's critical to settle on the proper loss feature for the work. Hinge loss, Softmax loss, Contrastive loss, and Triplet loss are common loss functions. [14] Different loss

functions were used for the bounding box regression layer and classification layer [20]

Optimization Techniques for CNN [Reducing Overfitting] the 2 main ways we fight overfitting are Data Augmentation and Dropout are some key techniques for optimizing CNNs.[3][14].Data augmentation may be a common technique in deep learning to make more data. The offline augmentation method is applied when the collected dataset is little. The most methods are rotation, translation, flipping, shearing, zooming, brightness adjustment and other corresponding changes. [3][14][31] [39][44] to spice up classification accuracy, often utilized in conjunction with conventional machine learning or deep learning algorithms.[39][43] the Keras deep learning library in Python was used for analysis.[39]Online augmentation may be a better option for enormous datasets. The advantages of knowledge augmentation are twofold.1. CNN models have better generalization potential, and 2.Adding more data to the model improves its robustness. [31] Regularization techniques effectively reduces overfitting, which is an unavoidable issue in deep CNNs. [14]

IV. BENEFITS OF USING CNN

1] Ruggedness to shifts and distortion within the image

2] Memory requirements are reduced.

3] Training would be easier and more efficient. [8]

Utilizing Multiple GPUs for Training, as current GPUs are particularly well-suited to cross-GPU parallelization since they will read and write to every other's memory without having to travel through the host machine's memory. [3]

V. FRAMEWORK [PROCESS DESCRIPTION [49]

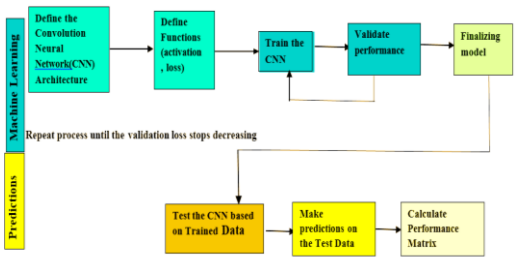

Fig 7: Framework process flowchart for the Learning and predictions stage

The process flowchart within the above framework figure are shown in two stages:

Before the pictures are input for learning stage, they're pre-processed. During which images are collected and sized as per requirement and filtered to get rid of noise then the dataset prepared is employed for learning.

In learning stage the dataset is split into 3 divisions as training set, validation set and testing set. Within the machine learning (ML) stage, during which images are wont to train a classifier and permit it to self-improve until it reaches its maximum potential; and therefore the predictions stage, during which characterized test images are fed into the classifier to gauge its actual performance.

Any crop disease are often outlined using framework as shown in figure 7. This may help us create a more comprehensive system which will be even more useful in meeting the social needs of farmers.

Furthermore, the algorithmic component of this study are going to be focused on the event and application of hybrid algorithms that use probabilistic mathematical symbols in convolutional neural networks to integrate experts' knowledge on this problem. The target is to grow the accurateness thereby giving generalizability to the classifier. [49]

1. Procedural learning

Network Architecture of CNN- during which trials and experimentation are used. And therefore the key factors effective in determining architecture of CNN are used like number, type and order of layers.

Definition of Functions - To optimize the networks weight, the activation function is chosen. Which defines the layer's output, and therefore the loss function.

Training the Dataset: The training data is employed by the algorithm to make a function that describes the specified relation which makes predictions before subsequent step.

Validation of Dataset: The function of the algorithm is validated against the validation dataset. The algorithm computes the prediction error and attempts to minimize it. This section defines the process's "learning." Finalizing the model: The training-validation cycle is repeated until the algorithm is not any longer ready to improve itself. We stop the procedure and finalize our model when the training and validation losses are nearly an equivalent, and before the validation loss begins to extend. [49]

2. Prediction

On the idea of trained data, put the CNN to the test: The validation accuracy of the finalized model is employed to assess its performance; that's, the accuracy it could achieve supported the info that was wont to train and evaluate it. This is often a sign of the model's performance, but truth performance is revealed only predictions on unknown data are made. Predict the category of every image using the test data: We use the testing data, which is totally unknown to the model, to form predictions on the category of every image. The classifier predicts a category for every image, which is saved alongside truth class. [49]

CONCLUSION

In this paper researchers have explained the role of deep learning techniques CNN for pest diagnosis in grapes crop leaves as leaves being the prime most part for the first detection of the pests on crops. This may improve fertility of soil and increase the assembly of crop. CNN are often wont to build an expert system which can fulfill the increasing demand of automated monitoring and management system. Hence saving the loss and reducing the dependency on the experts to a particular extent is feasible. It can provide help for an individual having less knowledge about the disease. Counting on these goals, we've to extract the features like the disease and classify them.

In future an Android app are often built which captures the pictures, tests the input images and displays the test result by identifying sort of pest infection on input images and suggests pesticides as an answer for treatment. The users i.e. farmers using the app can connect through the server implemented with python programing language.

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