Grape Leaf Disease Classifier and remedy recommendation system

Jitendra Singh Thakur[1], Satakshi Dubey[1], Vanshita Bansal[1], Himani Gupta[1], Mansi Gupta[1]

[1] Dept. of Computer Science, Jabalpur Engineering College, Jabalpur

Abstract. Grapes, grown in a subtropical climate, are considered one of the most important commercial crops grown in Indian agriculture. It has been considered as one of the lucrative farming activities in India. Grape cultivation in India is affected by several insect pests and diseases that lead to about 40% downfall in economical crop production and degrade crop quality. To detect the diseases at the initial stage is utterly important for diagnosis else it can inadequately affect the plant and reduce the production rate. The foremost objective of our system is to detect the diseases at the initial stage of crop cultivation. In our system, we have proposed a Deep Learning model named Convolutional Neural Network to detect the diseases affected areas of our leaf. The system involves the following steps like image acquisition, pre-processing, image segmentation, and feature extraction.

Keywords: *Convolution Neural Network, Grape leaf disease, Image processing techniques.*

1. Introduction:

In India, a major landmass is used for agriculture and cultivation. Agriculture plays an important role in India's economy, so it is important to determine the diseases of a plant in the field of agriculture. Grapes are very commercial and commonly cultivated crops throughout the world. It has been used for several purposes like wine production, brandy, raisins, and even fresh. However, grapes are unguarded to different types of diseases like Grape Black Rot, Grapevine Black Measles, Isariopsis Leaf spot of grapes. For the detection of the type of disease, several methods can be used. The experts used the basic method to look at the plant leaf from the naked eye and after identification, their observation of plant disease was done. But to do this, they needed a team of experts so that they could monitor the plant from time to time. Most of the Indian farmers don't have that provision or any intention of contacting any expert. Manual detection takes a lot of time, so there is a need to have automatic detection of leaves to cure the grape leaf in an early stage so that early detection of disease and early control can help the farmer to have less loss. For this, we will be using the CNN model for automatic leaf disease detection.

2. Literature Survey:

In [1], an automatic system is proposed for detecting diseases in the grapevines using image processing and machine learning techniques. This system is segmenting the leaf from the background image using the grab cut segmentation method. From the segmented leaf part, the diseased region is further segmented based on two different methods such as global thresholding and using the semi-supervised technique. The features are extracted from the segmented diseased part and it has been classified as healthy, rot, esca, and leaf blight using different machine learning techniques such as Support Vector Machine (SVM), AdaBoost, and Random Forest tree. Using SVM we have obtained a better testing accuracy of 93%.

In [2], the detection of disease is done by various sensors like temperature, humidity, leaf wetness. For wireless data transmission, ZigBee is used between the farmer and the sensor. The Hidden Markov Model is used to assess and predict the disease at an early stage.

In [3], the authors have proposed a system in which they were segmenting the leaf using our thresholding and were classifying the leaf disease using a decision tree by extracting different features.

In [4], The author aims to assist in the identification and classification of grape leaf diseases Convolutional Neural Network (CNN). CNN consists of 3 stages, namely Data Input, Feature Learning, and Classification. In this paper, four types of grape leaves have been identified. The implementation of CNN in this study uses Keras libraries that use the python programming language. The CNN training process results in an accuracy rate of 91.37%.

In [5], Pomegranate leaf disease detection was done by using color-based segmentation and features like color, morphology, and texture for classifying the leaves.

In [6], S. S. Sannakki et al. used image processing and artificial intelligence techniques g to diagnose the diseases on images of grape plant leaves. He deployed thresholding to mask green pixels and the image is processed to remove noise using anisotropic diffusion. Then grape leaf disease segmentation is done using K-means clustering. The diseased portion from segmented images is identified. Best results were observed when Feed forward Back Propagation Neural Network was trained for classification.

3. Implementation

3.1 Convolutional Neural Networks

Feature Extraction is in itself a daunting task, most of the papers suggest one or other way of using image processing for feature extraction for grape leaf disease classification. Although necessary, it increases system complexity. Convolutional Neural Networks (CNNs) are from the class of deep learning classifiers which are most commonly used for visual imagery analysis. CNNs, like neural networks, are made up of neurons with learnable weights and biases. CNNs are artificial neural networks involving a deep feedforward architecture with successive layers of convolution, pooling, and a fully-connected output layer. The basic entity in CNNs is neurons, just like all other neural nets with trainable weights and biases. For CNNs the input data is volumetric which differs from other conventional nets since the input data comprises images. An image usually has multiple channels and thus is a volumetric input.

3.1.1 Convolution Layer - Convolution layer extracts features from an input image. From mathematical origins, the term convolution alludes to combining two functions to generate a third function. So, basically, the convolution operation combines two different sets of information (image matrix and a filter). In ConvNets, various filters (also called kernels or activation maps) are used to perform convolution on the input data to perform operations such as edge detection, sharpening, etc. This operation generates a number of feature maps which signifies feature learning. To perform a convolution operation, the filter is slid all over the input and matrix multiplication is performed followed by summing up the result onto the activation map for every location. Convolution preserves the relationship between pixels by learning image features using small squares of input data.

3.1.2 Pooling Layer - CNNs involve a lot of computations and parameters and thus it might take a lot of time and resources to handle and process parameters. The pooling layer performs dimensionality reduction to reduce the number of parameters involved and speed up computation while preserving information. This optimizes the training time and controls overfitting thereby providing increased accuracy. Pooling layers are inserted between successive convolutional layers and they reduce the feature map dimensions simultaneously retaining significant information. The window size for pooling operation is to be defined beforehand. MaxPooling is the most widely used pooling method which picks up the maximum value out of each window. Types of pooling are -

- Max Pooling
- Average Pooling
- Sum Pooling

3.1.3 Fully Connected Layer - The layer we call the FC layer, we flattened our matrix into a vector and fed it into a fully connected layer like a neural network. Fully connected layers form the last block of the Convolutional Neural Network. The fully-connected layers have full connections to all activated values coming from the previous layers. The working principle for the fully-connected layers remains the same as the conventional neural network.

3.1.4 Training - Training for the Convolutional Neural Networks goes in the same way as other neural networks. A loss function is associated with the network which calculates how accurate the classification is. The model can be trained with methods such as back-propagation and gradient descent.

3.1.5 Training and Validation

All the training was performed on Python 3 Google Compute Engine Linux backend (RAM 12GB) hosted on Google Colab. The above model was subjected to the four classes of grape leaves and then the model was fit to train over that dataset with the following training parameters.

Training parameters -

- Learning rate = 1e-3
- Epochs = 40
- Optimizer = Adam Optimizer.
- Loss function = Categorical cross entropy

4. Proposed System:

In our project, we proposed a deep learning model to detect the grape leaf diseases at the untimely stage and recommend solutions for the recovery of the diseases. We design an application that uploads the image in the dataset and predicts the diseases subsequently showing the affected area of the leaf by using feature extraction methods.

4.1. Dataset:

The dataset used in this proposed system consists of 2000 grape leaf images consisting of 1892 images to train the model and 100 images for testing data is assembled from Github[7]. The dataset is classified into four different classes. Out of which three classes comprises of the three different types of diseases infected grape leaves, i.e.,

- Grape Black Rot
- Grapevine Black Measles
- Isariopsis Leaf Spot

The remaining class is of Healthy leaves.

Table 1. Image Dataset of Grape Leaf

Class	Number of Images	Training images	Testing images
Black Rot	592	566	26
Black Measles	451	427	24
Isariopsis Leaf spot	585	560	25
Healthy Leaves	361	361	25

4.2 Leaf diseases fundamentals:

The dataset used has mainly three categories of the diseased leaf images and they are:

4.2.1 Grape Black Rot: It is a fungal disease caused by Guignardia bidwellii, an ascomycetous fungus. It attacks the grape wine during warm and wet seasons. It’s harmful to the green parts of the vine such as leaves, shoots, leaf and fruit stems, tendrils, and fruit. The most affected region is the fruit of the plant. It starts with reddish-brown circular spots on the upper surface of the leaves and rapidly grows to form irregular blotches. As soon as the flower petal falls it starts affecting the fruit and within 48 hours the spot grows and covers half of the berry. Hence to save the fruit it needs to be controlled within the initial phase.

4.2.2 Grapevine Black Measles: This is also called esca or black measles. The affected regions are leaves, trunks, cranes, and berries. On leaves ‘tiger stripe’ like patterns appear as interveinal striping. The ‘measles’ refers to the superficial spots found on the fruit. And later these spots may coalesce making berries appear black. Fruits affected by these fungal diseases will have an acrid taste in the season. There is no effective method to control this disease to date. To control it removes the infected berries, leaves, trunk and destroys them.

4.2.3 Isariopsis Leaf Spot: It is also named Leaf blight. It causes irregularly shaped lesions on the surface of leaves and the trunk. Cynthiana and Cabernet Sauvignon are susceptible to this pathogen. In berries, it shows the symptoms same as black rot but in severe conditions, it collapses the cluster.

4.3. System overview:

In our application the user uploads images from the gallery. As soon as the image uploads they are cropped into a specific dimension, accompanying, the image data is converted to numerical data. Further, the image is sent to the server where the deep learning CNN model is trained on the Grapes Leaf dataset. Now, the server receives the image metadata. The numerical data images are sent to the pre-trained CNN model which returns the predicted output. Finally, the output is printed on the user console window.

4.4. Software and Hardware requirements:

8GB RAM is recommended to train the CNN model.The model is trained on Python 3 Google Compute Engine Linux backend hosted on Google Colab. The application is built on languages HTML, CSS, Bootstrap. To build CNN model 'Tensorflow' library is used. Other Python libraries like Numpy, OpenCV are used for feature extraction and other image processing techniques.

5. Results and discussions:

Cross-entropy loss increases as the predicted probability diverges from the actual label. We achieved a training accuracy of 99.60% and a validation accuracy of 93.80%. The total loss 0.01716 and the validation loss 0.31 are shown in figure and figure respectively.

6. Conclusion and Future Work:

For the given scenario, we achieved a training accuracy of 99.60% and a validation accuracy of 93.80% which supports the fact that our model is not suffering from overfitting. The training time for the complete process was around 8 minutes and 48 seconds with 40 epochs and 1392 iterations in each. Our model has surpassed other latest state of the art proposals in the same domain. The best thing is we have used our own CNN architecture for the same and not any established standard architecture. This work uses a CNN model to do multiclass grape leaf classification and achieves an impressive accuracy of 99.60%.

We have utilized the Plant Village dataset from crowdAI for this work. We further look forward to doing two things; one is to prepare the CNN model for other plant leaf diseases as well and incorporate them into our application. Secondly, we will build our models in the future taking into consideration the noisy images as well.

8. References:

[1].S.M. Jaisakthi, P. Mirunalini, D. Thenmozhi, SSN College of Engineering Chennai, India, Second International Conference on Computational Intelligence in Data Science (ICCIDS-2019)

[2] Suyash S. Patil, Sandeep A. Thorat. “Early Detection of Grapes Diseases Using Machine Learning and IOT”, 2016 Second International Conference on Cognitive Computing and Information Processing (CCIP)

[3] H.Sabrol, K.Satish: Tomato plant disease classification in digital images using classification tree. In: 2016 International Conference on Communication and Signal Processing (ICCSP), pp. 1242–1246 (2016)

[4] Moh. Arie Hasan, Dwiza Riana , Sigit Swasono , Ade Priyatna , Eni Pudjiarti, Lusa Indah Prahartiwi. “Identification of Grape Leaf Diseases Using Convolutional Neural Network”. Journal of Physics: Conference Series in 2020

[5] Khot. S.T, Supriya, P., Gitanjali, M., Vidya, L.: Pomegranate disease detection using image processing techniques 5(1), 2248 – 2251 (2016)

[6]] S. S. Sannakki, V. S. Rajpurohit, V. B. Nargund, and P. Kulkarni, “Diagnosis and classification of grape leaf diseases using neural networks,” 2013 4th Int. Conf. Comput. Commun. Netw. Technol. ICCCNT 2013, no. September 2015, pp. 2–7, 2013, doi: 10.1109/ICCCNT.2013.6726616.

[7]Dataset collected “github.com/spMohanty/PlantVillage-Dataset/tree/master/raw/color”.