

# Tomato Leaf Disease Detection and Classification with Severity Estimation using Convolutional Neural Networks

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**Abstract**—Agriculture is undoubtedly the backbone of our nation. India is the second-largest producer of agricultural products globally. There are plenty of problems that a farmer faces in their field of work. When plants and crops are affected by pests, weeds, heat stress, cold stress, soil salinity, and acidity stress, drought, and flood, it affects the country's agricultural production. Usually, farmers observe the plants by their eye for detection and identification of disease. But this method can be time processing, expensive, human resources and inaccurate, etc. This proposed work is concerned with a new approach to detect the tomato plant diseases recognition model based on leaf image classification using the deep Convolutional Neural Networks (CNN) method. Automatic detection using image processing with deep learning techniques provides fast and accurate results. This technology helps the farmer identify what type of diseases the plant is being affected and suggests some medicine to be given to the affected plant. CNN techniques classified a few types of tomato diseases such as septoria leaf spot, leaf mold, bacterial spot, early blight, late blight are trained and fine-tuned to fit accurately into a plant's leaves gathered independently for diverse plant diseases. Disease severity is estimated using the dataset of infected leaf samples and output images to show the three types of severity level stages are low, medium or high levels in the MATLAB software.

**Index Terms**— Disease detection, Feature extraction, CNN, Tomato leaf, Severity Estimation and Deep Learning, MATLAB.

## I. INTRODUCTION

India is a country that is mainly based on agriculture, and about 70% of our population depends on agriculture. One-third of our country's income comes from agriculture. The outline specifies that almost half of the yield losses are principally due to pests and diseases [2]. To guarantee the least losses to the cultivated crop, it is decisive to look after its growth [5]. The crop losses caused by pests, diseases, and weeds are approximately assessed, ranging from 10% to 30%. So disease detection plays an important role in the agricultural field. Bacteria, fungi, viruses, etc., cause the maximum of plant diseases. If respective care is not taken in this area, it may seriously affect plants and affect productivity and quality. To detect plant diseases, we need a quick automatic way. The professional farmer's capability also depends on his/her physical condition, like fatigue, eyesight, work pressure, climate, etc. So this type of method is time-consuming and less efficient. The

manipulation of the computer with deep learning methods allows finding the premature identification, less time consuming and more efficient [4]. Here, a project is proposed with the idea of detecting plant leaf diseases using image processing. The image processing toolbox of MATLAB is used to calculate the affected area of disease and determine the difference in the color of the disease-affected area. Deep CNN is used to recognize the plant-based on wavelength and RGB channels [6]. Deep CNN has attained great success in the classification of various plant diseases. Here we are using a deep CNN model consisting of 10 convolution layers, 4 max-pooling layers, and 1 fully connected layer for classification built for pedestrian detection. CNN techniques are trained accurately into the database of a plant's leaves gathered independently for diverse plant diseases.

## II. METHODOLOGY

The system architecture for the tomato leaf disease detection and classification is shown in figure 2.1.

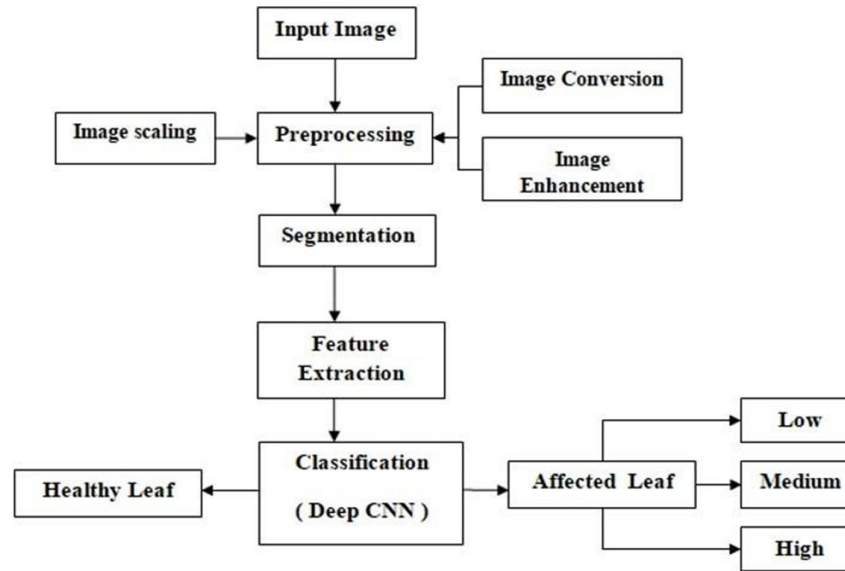


Figure 2.1. System Architecture for Image Processing

Capturing tomato plant leaf as high-quality images through the camera. Image pre-processing is the technique of enhancing data images before computational processing. This pre-processing image commonly involves removing low-frequency background noise, normalizing the individual particles' intensity, removing reflections, RGB-Gray process, contrast improvement, resizing an image, color enhancement, and masking portions of images and then the processed image. It is done by the process of splitting-up a digital image into multiple fragments. Feature extraction is the process of extracting the values of energy, entropy, standard deviation, color enhancement, etc., and then the extracted images are classified.. Tomato leaves are classified by using the convolutional neural networks algorithm. If the processed data is normal, then the output will be shown as a healthy leaf, or else processed data is abnormal, then the output will be shown as an unhealthy leaf.

The steps followed, as depicted above, include the following

### A. Image acquisition

Obtain the high quality captured tomato plant leaf image through the camera from the internet or agriculture field and are put in the database for further activities

### B. Image Pre-processing

In pre-processing, the images of the tomato leaf are applied to remove the noise from the image. The image is enhanced in the pre-processing step by image clipping to remove the background, image smoothing using a smoothing filter, and image enhancement for increasing contrast.

### C. Image Segmentation

Image segmentation means partitioning an image into various parts of the same features or having some similarity using the k-means clustering method.

### D. Feature Extraction

In Feature extraction, the highlights are removed. Picking the entire arrangement of pixels can pick just those that are important and adequate to depict the entire segment. Feature extraction is the process of extracting the values of energy, entropy, standard deviation, color enhancement, etc., and then the extracted images are classified below.

$$\begin{aligned} (1), \text{Mean} \quad , x' &= \frac{1}{n} \cdot \sum_{i=1}^n x_i \\ (2), \text{Variance} \quad , \sigma^2 &= \frac{1}{N} \sum_{i=1}^N (x_i - x')^2 \\ (3), \text{Standard Deviation} \quad , \sigma &= \sqrt{\frac{1}{N-1} \sum_{i=1}^N (x_i - x')^2} \\ (4), \text{Skewness} \quad , \gamma_1 &= \frac{1}{N} \sum_{i=1}^N [(x_i - \mu) / \sigma]^3 \\ (5), \text{Kurtosis} \quad , \gamma_2 &= \frac{1}{N} \sum_{i=1}^N [(x_i - \mu) / \sigma]^4 - 3 \end{aligned}$$

### E. Image classification and clustering

In some existing systems, it contains the RGB image of the leaf and applies color for transformation techniques. By using the application of a K-means clustering algorithm it carried out the infected clusters. In image classification, analyzes the numerical properties of various image features and organizes data into categories. Tomato leaves are classified by using the Convolutional neural networks algorithm. If the processed data is normal then the output will be shown as a healthy leaf or else processed data is abnormal then the output will be shown as an unhealthy leaf.

#### Convolutional Neural Networks

A Convolutional neural network can have even tens or hundreds of layers that each learn to detect different features of an image. Filters are applied to each raw image at different resolutions, and the output of first convolved image is used as the input to the next layer. The filters can start as very simple features, like brightness and edges, and increase in complexity to features that uniquely define the object.

#### Feature Learning, Layers, and Classification

A CNN is composed of an input layer, an output layer, and many hidden layers in between like other neural networks.

Wsm-reboot-cnn-super-disc-neural-network: These three layers perform operations that alter the data with the intent of learning features specific to the data. The most common layers are: convolution, activation / ReLU, and pooling.

- Convolution layer: sets the input images in a set of Convolutional filters, each of which activates certain features from the images.
- Rectified linear unit (ReLU): allows for faster and effective training by mapping negative values to 0 and maintaining positive values. This is sometimes cited as activation, because only the activated features are carried forward into the next layer.
- Pooling layer: clarifies the output by performing nonlinear down sampling, by lowering the number of parameters that the network needs to learn.

These operations are repeated over hundreds of layers, with each layer learning to identify different features.

Filters are applied to each training image at different resolutions, and the output of each convolved image is used as the input to the next layer this is an example of a network with many convolution layers.

#### Classification Layers

After learning features in many layers, the architecture of a CNN comes to classification. The next-to-last layer is a fully connected layer that gives outputs a vector of K dimensions where, K is the no. of classes that the network

will be able to forecast. This vector contains the expectation for each class of any image being classified. The final layer of the CNN architecture uses a classification layer such as softmax to give the classification output.

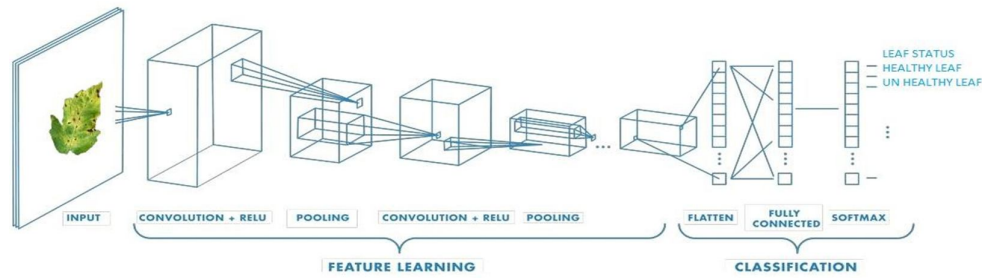


Figure 2.2. CNN Function

### Severity

Disease severity is estimated using the dataset of infected leaf and output images to show the three types of severity level stages: low, medium, or high levels.

### III. RESULT

The input image, as shown in figure 3.1, is loaded, and the pre-processing is performed. By using Matlab, the contrast of the image is improved in the enhanced leaf image, and it is shown in figure 3.2.

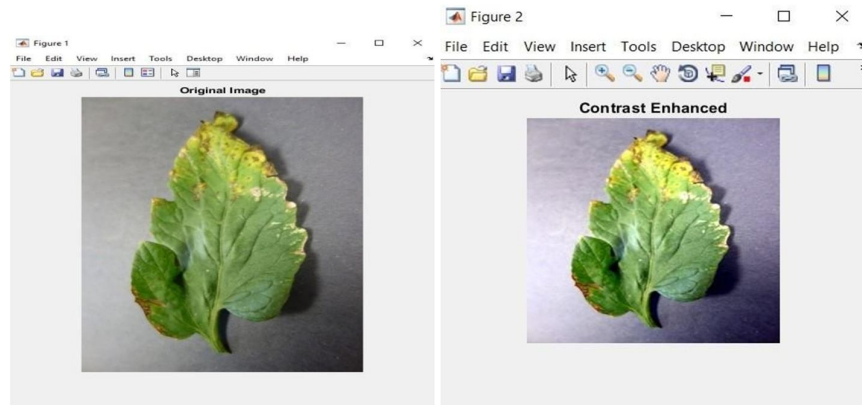


Figure 3.1. Original Image

Figure 3.2. Enhanced Image

Figure 3.3 shows the original Image and its Enhanced Image are shown in the enhanced pair image to differentiate contrast after enhancement. The histogram of the enhanced pair image shows the number of pixels in an image with different intensity values found in that image shown in the figure.

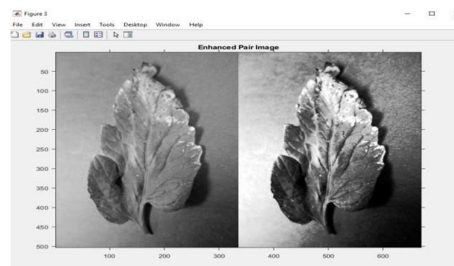


Figure 3.3. Enhanced Pair Image

The OTSU and HIS segmentation were performed in figures 3.5 and 3.6 to classify the leaf segments for detecting the leaf's status.

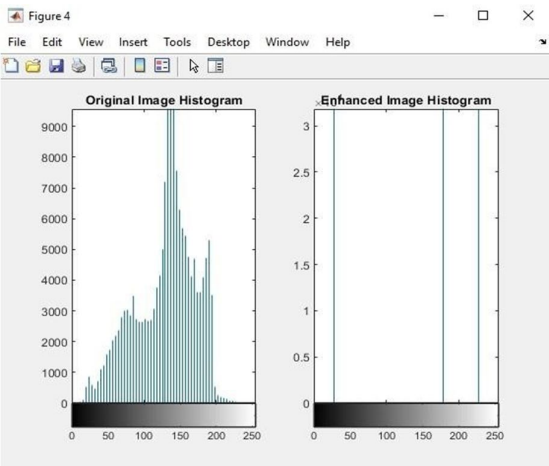


Figure 3.4. Image Histogram

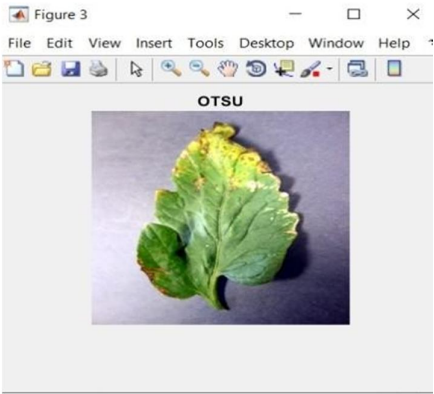


Figure 3.5. OTSU Image

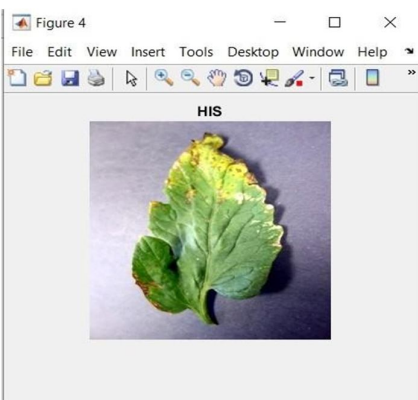


Figure 3.6. HIS Image

In the RGB segmented process, a Red-Blue-Green colour added together to produce an extensive range of colours is shown in figure 3.7.

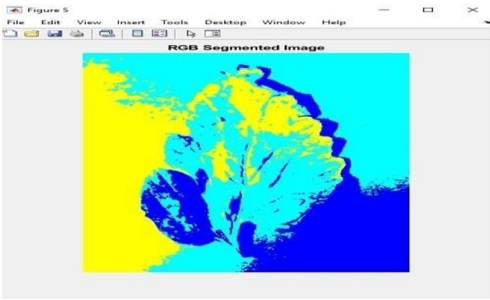


Figure 3.7. RGB Segmented Image

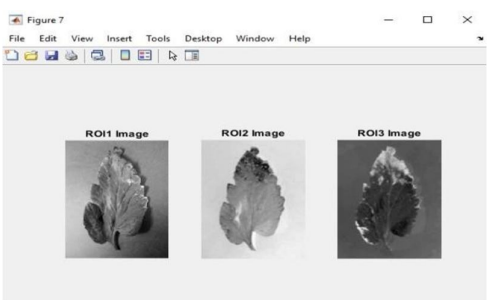


Figure 3.8. ROI Image

A ROI is a Region of Interest, It is processed to identify the affected portion of an image is shown in the figure 3.8.

Figure 3.9 shows the graphical representation of mean value of the input images.

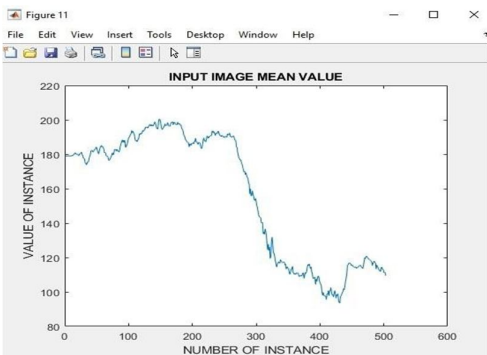


Figure 3.9. Input Image Mean Value

Figure 3.10 extracts features such as Standard Deviation, Maximum pixel, Entropy, and area from the segmented images.

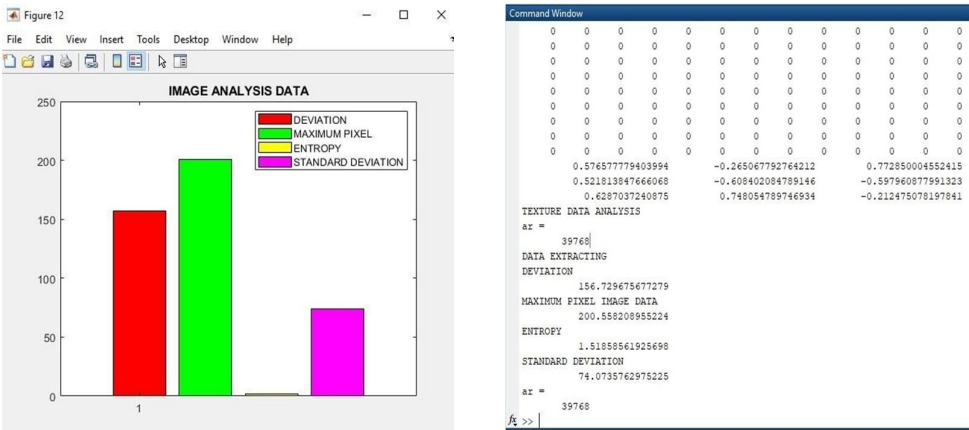


Figure 3.10. Image Analysis Data

In this analysis process, the original image is loaded, and it is set for the run. For data extraction, the steps from pre- processing to data extracting are shown in the test figure.

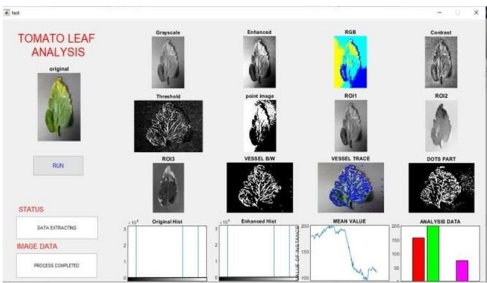


Figure 3.11. Tomato Leaf Analyses

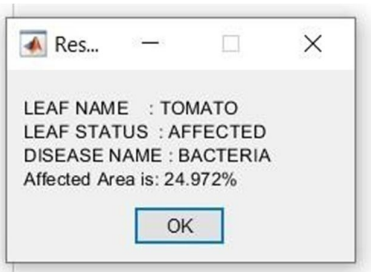


Figure 3.12. Result

After feature extraction, processed data is classified using Convolutional neural network techniques, as shown in figure 3.12.

#### IV. CONCLUSION

The proposed work deals with Early Blight, Septoria Leaf Spot, Bacterial Blight, and Leaf Mold; these diseases were detected using image processing with techniques in MATLAB. It involves loading an image, image pre-processing, image segmentation, feature extraction, and classification. The development of an automatic detection system using image processing facilitates to support the users in the identification of diseases at an early stage and supply helpful data for its management.

#### REFERENCES

- [1] Reva Nagi and Sanjaya Shankar Tripathy (2020) "Infected Area Segmentation and Severity Estimation of Grapevine Using Fuzzy Logic " Department of Electronics and Communication Engineering, Birla Institute of Technology Mesra, Ranchi, India, Springer.
- [2] Jay Trivedi, Yash Shamnani, Ruchi Gajjar (2020), "Plant Leaf Disease Detection Using Machine Learning", International Conference on Emerging Technology Trends in Electronics Communication and Networking, Springer.
- [3] Anakha Krishnakumar and Athi Narayanan (2019) "A System for Plant Disease Classification and Severity Estimation Using Machine Learning Techniques" Department of Computer Science and Engineering, Amrita Vishwa Vidyapeetham, Amritapuri, India, Springer.
- [4] Malusi Sibiya and Mbuyu Sumbwanyambe (2019) "An Algorithm for Severity Estimation of Plant Leaf Diseases by the Use of Colour Threshold Image Segmentation and Fuzzy Logic Inference: A Proposed Algorithm to Update a "Leaf Doctor" School of Engineering, College of Science, Engineering & Technology, University of South Africa.
- [5] José G.M. Esgaríoa , Renato A. Krohlinga , José A. Venturad (2019) "Deep learning for classification and severity estimation of coffee leaf biotic stress " Computers and Electronics in Agriculture, Elsevier.
- [6] Prajwala TM, Alla Pranathi, Kandiraju Sai Ashritha, Nagaratna B (2018), "Tomato Leaf Disease Detection using Convolutional Neural Networks", Eleventh International Conference on Contemporary Computing (IC3), 2-4 August, Noida, India.
- [7] Azeddine Elhassouny, Florentin Smarandache (2019), "Smart mobile application to recognize tomato leaf diseases using Convolutional Neural Networks", IEEE/ICCSRE2019, Agadir, Morocco.
- [8] Anjnaa, Meenakshi Sooda , Pradeep Kumar Singh,( 2019) "Hybrid System for Detection and Classification of Plant Disease Using Qualitative Texture Features Analysis" International Conference on Computational Intelligence and Data Science (ICCIDS), 1877-0509 © 2020 The Authors. Published by Elsevier B.V.
- [9] Prajwala TM, Alla Pranathi, Kandiraju Sai Ashritha, Nagaratna B. Chittaragi\*, Shashidhar G. Koolagudi (2018) "Tomato Leaf Disease Detection using Convolutional Neural Networks", Department of Computer Science and Engineering, National Institute of Technology Karnataka, IEEE.
- [10] Akshay Kumar, Vani M (2018) "Image Based Tomato Leaf Disease Detection", Department of Computer Science and Engineering National Institute of Technology Karnataka, IEEE