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Tomato Leaf Disease Detection Using Deep Learning Techniques

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Abstract - Early Detection of Plant Leaf Detection is a major necessity in a growing agricultural economy like India. Not only as an agricultural economy but also with a large amount of population to feed, it is necessary that leaf diseases in plants are detected at a very early stage and predictive mechanisms to be adopted to make them safe and avoid losses to the agri-based economy. This paper proposes to identify the Tomato Plant Leaf disease using image processing techniques based on Image segmentation, clustering, and open-source algorithms, thus all contributing to a reliable, safe, and accurate system of leaf disease with the specialization to Tomato Plants.

Keywords— Leaf disease detection, image processing, convolutional neural networks, feature extraction, deep learning

I. INTRODUCTION

India is a growing economic giant and more than 65% of the population is either directly associated with agriculture or agriculture products. [1] The crops are suffered the major losses due to plant diseases and insect damage. In the approximate figures, the worldwide annual production tonnages lost due to various pests at the start of the 21st century. [2] The Losses due to plant diseases contribute to around 15 to 17% of the total accumulated losses over the annual production range and this is highly alarming is shown in Figure 1. A total of 68% average annual loss of crop production is spoilt as loss that is being caused by several factors such as pests, weeds, and plant leaf diseases [3]. This causes a big blow to the economy.

Crop enhancement and protection results, based on paramount global practices and the new technologies available are the answer. [13][14]There are many emerging trends and promising solutions for sustainable crop protection which include fustigation, agronomy, chemicals, seed treatment, and bio-technology growth and use of sustainable expertise to identify the crop disease at the earliest.

In the country, [16] the next generation of agriculture has to include all possible promising solutions using in a specified situation. The sector has enormous unrealized possible for growth and incredibly low-level application of crop protection chemicals, as compared to the universal norms joined with the class for educated farming, fast increasing the awareness in young, etc.

The best solution to the problem is to identify the disease of the plant so that precautionary steps can be taken to safeguard the same. This paper implements the concept of applying convolutional neural network implementation to the detection of leaf disease in the tomato plant and suggests a suitable solution to the farmer to recover the same.

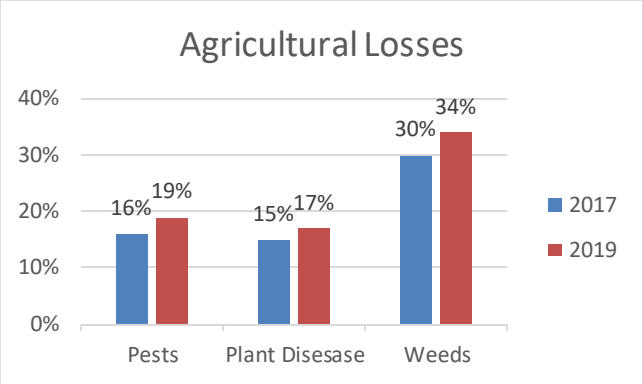

Figure 1. Graph for agricultural losses due to Pests, Plant Disease, and Weeds [3]

II. RELATED WORKS

Many research works have been done on the detection and prevention of plant leaves in general and tomato leaves in particular. But there are some restrictions on the same. Most of the previous researches use only the principal component analysis, i.e. only one sample leaf is taken into consideration for comparison, and the same is maintained as reference filter value throughout the whole process of the detection of the disease. Moreover, during the segmentation process, only the texture-based segmentation techniques [4] [5] [6] are deployed during the detection process. This may have produced the desired results, but the accurate prediction of disease detection [7] [8] will not be the same when the same is applied in real-time scenarios. This may lead to diversion and wrong pesticide or medical suggestions to the farmers, thus resulting in chaos. Mostly [9] [10] [15] K Means Clustering is being used for detection purposes. There are many other techniques available, hence it is necessary to make a detailed study by implementing the same and making comparisons on the level of accurate prediction of the said implementation.

Some research works have been implemented in MATLAB [11] [12]. Statically the measures of this detection system that are processed in terms of reactivity, specificity, and accuracy need to be designed and implemented in a much more sophisticated, user-friendly environment, to achieve the

desired detection levels. Figure 2 is shown sample tomato leaf images with different types of disease?

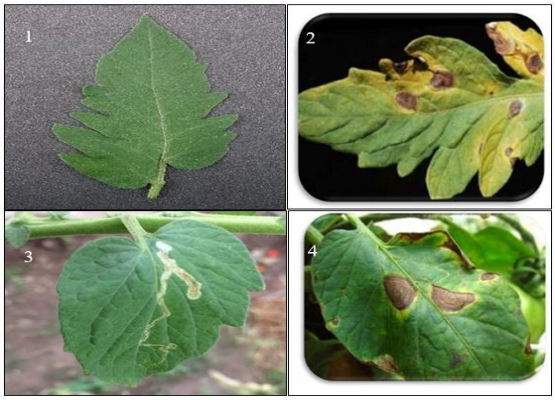

Figure 2. Sample Tomato leaf images with four disease conditions. 1. Healthy 2. Phoma Rot 3. Leaf Miner 4. Target Spot.

III. PROPOSED METHOD

The objective of the paper is to propose a methodology that could classify the tomato leaf diseases and suggest the best solution to overcome the same. This has been implemented effectively using image processing technique and the latest niche algorithms and using the open source programming language Python. The process of the proposed method is shown in Figure 3.

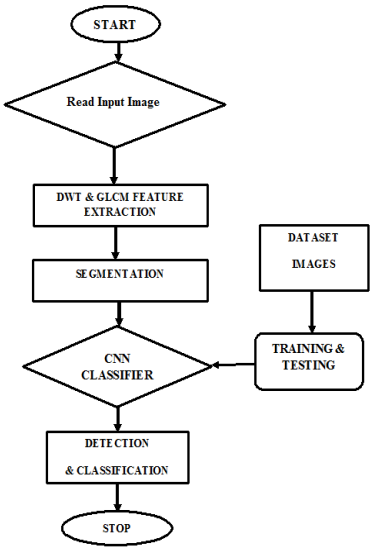

Figure 3. Process diagram of the proposed method

The image is preferably taken from the plant. Dataset Images are the ones that are taken and stored already in the database for comparison. The images to be detected cannot be compared directly to the dataset images, as that may mislead the process of the detection system. The images are processed with a series of feature extraction mechanisms and are then segmented to determine the affected portion of the leaf to be compared using the CNN Classifier. Then results are used to detect and classify the tomato plant disease and suggest a suitable solution to the farmers as a precautionary step. The steps that are done are pre-processing, feature extraction for both the input image and dataset images to increase the accuracy level of prediction.

A) Pre-processing

The image pre-processing is the initial step. During the pre-processing step, the Gaussian filter with a smoothened approach is applied to tomato leaf for reduce the noise and remove the blur from the image to improve the enhancement of tomato leaf image. The representation of this filter is defined as,

$$G(x,y) = 1/2\pi(\sigma^2)\left(e^{-\left(\frac{x^2+y^2}{2e^2}\right)}\right) \quad (1)$$

Figure 4 is shown that the enhancement of tomato leaf using Gaussian Filter with smoothened approach during the pre-processing stage.

Figure 4. Steps for pre-processing using Gaussian Filter with smoothened approach for enhancement of tomato leaf

B) Feature Extraction

The most important step in image recognition is feature extraction. This feature extraction is done by using the DWT and GLCM. For feature extraction, DWT utilizes the coefficients with sub-bands and computed correlation of GLCM is used to classify the leaf image or the segment of a leaf image depending upon various luminous levels.

I. DWT: Discrete Wavelet Transform (DWT) is applied on the improved enhancement of tomato leaf image as shown Figure 5 and implies can take the discrete wavelet transform of the tomato leaf and utilizes the coefficients to generation of the same to a numerical precision. The wavelet features are extracted by using DWT form tomato leaf healthy and affected images and the DWT transformation convert digital signal into

wavelet signal. The DWT descriptor can be extracted features for all directions like vertical, horizontal, and diagonal from sub-bands of tomato images and can be retrieve the detailed content of the tomato leaf image by using low and high pass filter technique. The DWT is defined as,

$$\varphi(t) = \begin{cases} 1, for\ t\epsilon\left(0, \frac{1}{2}\right) \\ -1, for\ \epsilon\left(\frac{1}{2}, 1\right) \\ 0, otherwise \end{cases} \quad (2)$$

II. GLCM: The image made out of pixels each with a luminous level and the GLCM is used to classify the leaf image or the segment of a leaf image depending upon various luminous levels. For each GLCM can be extracted the spatial coordinates with common correlation statistical property and the find probability of occurrence between each pixel value with adjacent pixel value. The correlation is defined as the following equation,

$$Correlation = \sum_i \sum_j \frac{(x_i - \mu_x)(y_j - \mu_y)h(x_i, y_j)}{\sigma_x \sigma_y} \quad (3)$$

Figure 5. Input tomato leaf image

C) Segmentation

Segmentation is the process of categorising the leaf image into smaller portions of texture, containing similar characteristics is shown in Figure 8. The proposed method is used to segmentation process to determine the boundary of the tomato leaf and label it into pieces. There are two properties with pixel intensity such similarity and dissimilarity and used to stop the process of segmentation. To obtain similarities, use color-based thresholding and it can be realized by setting the range of intensity value of pixel in the original tomato image that chosen the foreground pixel values. The procedure for segmentation with color-based thresholding is defined in the following equation,

$$|g(x,y)| = \begin{cases} 0, f(x,y) < T \\ 1, f(x,y) \geq T \end{cases} \quad (4)$$

The overall framework for tomato leaf detection method is shown Figure7.

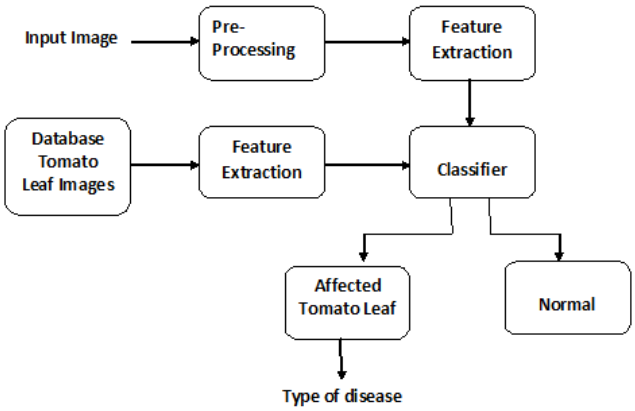

Figure 7. The overall framework for Tomato Leaf Disease Detection method

D) Convolutional Neural Network

A convolutional Neural Network algorithm used in this proposed method is a hierarchical feature extraction that maps the pixel values and evaluates the same with the trained dataset image. It classified by several fully connected layers in the subsequent step and all adjustable parameters of the leaf portions are optimized by reducing the error over the training set. The compared image is classified into disease affected and normal leaf as the image classifier technique that has been deployed. The results of the same are stored into the database for further detection and analysis.

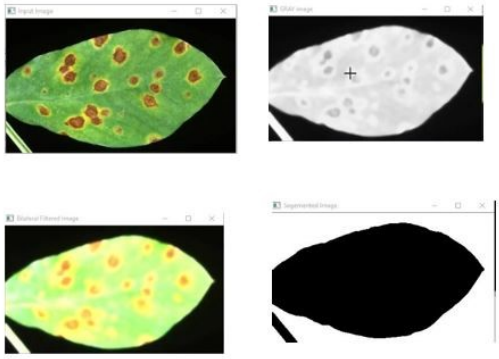

Figure 8. Processing segmentation technique on tomato leaf

IV. EXPERIMENTS

The proposed method tested on OpenCV is one of the most widely used libraries for computer vision applications. OpenCV-Python is the API for OpenCV and fast and also the best choice for implementing the Image Processing concepts of leaf disease detection. This paper gives the detection of tomato leaf disease for the prediction of affected and normal leaf. More number of samples needs to be tested survey on

different diseases classification. The tomato leaf image datasets and associated with relevant diseases were taken for detection and classification for the proposed method. The proposed method is very less computational and very efficient optimum results were obtained, which also shows the efficiency of the proposed method of tomato leaf disease detection produced high accuracy rate for classification and recognition of the tomato leaf diseases detection method. A furthermore, the benefit of the proposed method can be detected the tomato plant diseases at beginning stage.

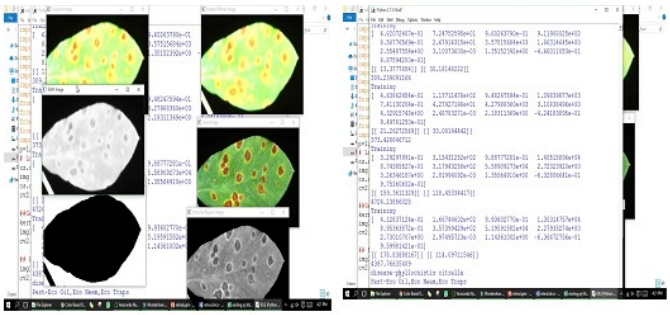

Figure 9. Results for Tomato leaf disease detection method (affected and normal)

Table I. Average performance measures of Tomato leaf disease detection (proposed method)

S.No	Different types of tomato leafs disease	Accuracy (%)
1	Healthy	98.75
2	Phoma Rot	96.67
3	Leaf Miner	96.88
4	Target Spot	97.23

The proposed method, the ability of the algorithm shows clear improvement due to represents deep convolutional neural network and classified tomato leaf accurately with minimum error rate. From the analysis, the efficiency of the proposed method of tomato leaf disease detection produced high accuracy rate with 98.12% is shown in Figure 9 and Table I. The average performance measures of tomato leaf disease detection as shown in Table I and Figure 10.

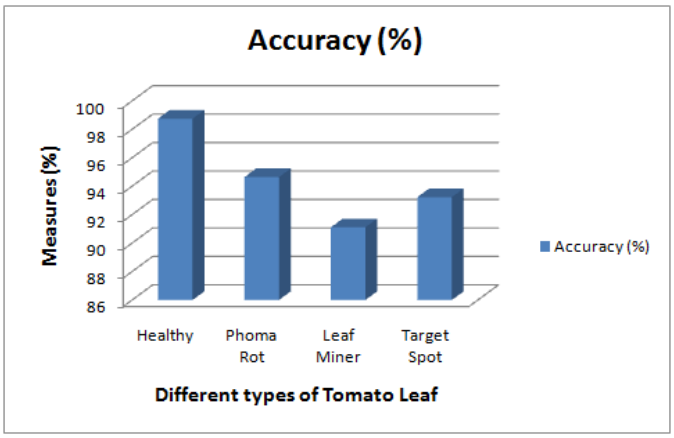

Figure 10. Average performance measures of Tomato leaf disease detection (proposed method)

The proposed method is compared with automated capturing systems using Deep Neural Networks (AlexNet) [17] and ANN technique. The performance of the proposed method produced high accuracy rate over the above mentioned method due to a hierarchical feature extraction that maps the pixel values and evaluates the same with the trained dataset image. It classified by several fully connected layers in the subsequent step and all adjustable parameters of the leaf portions are optimized by reducing the error over the training set as shown in Table II.

Table II. Comparison average performance measures of Tomato leaf disease detection

S.No	Method	Accuracy (%)
1	Deep Neural Networks (AlexNet) [17]	95.75
2	ANN technique [18]	92.94
3	Tomato leaf disease detection using CNN (**proposed method**)	98.12

Figure 11 is shown that comparison measures for proposed method and other method. It is concluded that the proposed method the ability of the CNN algorithm shows clear improvement due to represents deep convolutional neural network and classified tomato leaf accurately with minimum error rate. Table II is shown comparison average performance measures of Tomato leaf disease detection.

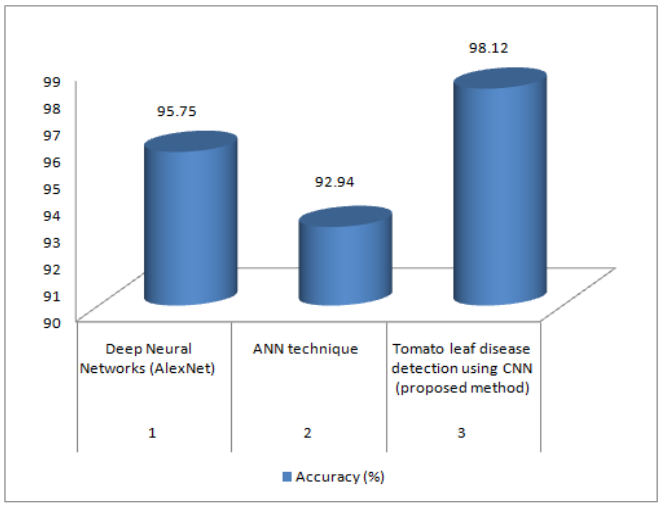

Figure 11. Comparison measures with the existing method

V. CONCLUSION

The proposed method is achieved an accuracy level of 98%. The proposed method is used as a CNN algorithm for hierarchical feature extraction that map input image pixel intensities and compare the same with the trained dataset image. All adjustable parameters of the leaf portions are optimized by reducing the error over the training set. The compared image is classified into disease-affected and normal leaf as the image classifier technique that has been deployed and also implemented artificial neural network, fuzzy logic, and hybrid algorithms can also be deployed. The proposed work can be further extended for various new algorithms to provide optimum results in context to existing techniques. Real-time application based plant disease categorization will be one of the main factors in the selection of the appropriate technique.

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