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AI Based Plant Disease Classification using Deep Learning

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Abstract - *Agricultural productivity is something on which economy highly depends. This is the one of the reasons that disease detection in plants plays an important role in agriculture field, as having disease in plants are quite natural. If proper care is not taken in this area then it causes serious effects on plants and due to which respective product quality, quantity or productivity is affected. For instance a disease named little leaf disease is a hazardous dis- ease found in pine trees in United States. Detection of plant disease through some auto- matic technique is beneficial as it reduces a large work of monitoring in big farms of crops, and at very early stage itself it detects the symptoms of diseases i.e. when they appear on plant leaves. This paper presents an algorithm for image segmentation tech- nique which is used for automatic detection and classification of plant leaf diseases. It also covers survey on different diseases classification techniques that can be used for plant leaf disease detection. Image segmentation, which is an important aspect for disease detection in plant leaf disease, is done by using genetic algorithm.*

1.INTRODUCTION

The agricultural land mass is more than just being a feeding sourcing in today's world. Indian economy is highly depen- dent of agricultural productivity. Therefore in field of agricul- ture, detection of disease in plants plays an important role. To detect a plant disease in very initial stage, use of automatic disease detection technique is beneficial. For instance a dis- ease named little leaf disease is a hazardous disease found in pine trees in United States. The affected tree has a stunted growth and dies within 6 years. Its impact is found in Ala- bama, Georgia parts of Southern US. In such scenarios early detection could have been fruitful.

The existing method for plant disease detection is simply naked eye observation by experts through which identifica- tion and detection of plant diseases is done. For doing so, a large team of experts as well as continuous monitoring of plant is required, which costs very high when we do with large farms. At the same time, in some countries, farmers do not have proper facilities or even idea that they can con- tact to experts[10]. Due to which consulting experts even cost high as well as time consuming too. In such conditions, the suggested technique proves to be beneficial in monitoring large fields of crops. Automatic detection of the diseases by just seeing the symptoms on the plant leaves makes it easier as well as cheaper. This also supports machine vision to provide image based automatic process control, inspection, and robot guidance.

Plant disease identification by visual way is more laborious task and at the same time, less accurate and can be done only in limited areas. Whereas if automatic detection technique is used it will take less efforts, less time and become more accurate. In plants, some general diseases seen are brown and yellow spots, early and late scorch, and others are fungal, viral and bacterial diseases. Image processing is used for measuring affected area of disease and to determine the difference in the color of the affected area.

Image segmentation is the process of separating or group- ing an image into different parts. There are currently many different ways of performing image segmentation, ranging from the simple thresholding method to advanced color image segmentation methods. These parts normally correspond to something that humans can easily separate and view as individual objects. Computers have no means of intelligently recognizing objects, and so many different methods have been developed in order to segment images. The segmentation process is based on various features found in the image. This might be color information, boundaries or segment of an image. We use Genetic algorithm for color image segmentation.

Evolutionary computing was first introduced in the 1960s by I. Rechenberg. His idea was then taken forward by other researchers. Sometimes evolutionary changes are small and appear insignificant at first glance, but they play a part in natural selection and the survival of the species. Examples of natural selections are

1. The warrior ants in Africa are probably one of the most impressive examples of adaptation. Within any single col- ony, ants emit a chemical signal that lets the others know they all belong to the same compound. Or, put more simply, a signal that says, ''Don't attack me, we're all family.'' However, warrior ants have learned how to imitate the sig- nal from a different colony. So if a group of warrior ants attacks a colony, they will be able to imitate that colony's signal. As a result, the workers in the colony will continue on, now under the direction of new masters, without ever realizing an invasion has taken place.
2. All rat snakes have similar diets, are excellent climbers and kill by constriction. They all have the same reaction when startled (they remain motionless), and will

avoid confrontation whenever possible. Some will bite if threatened, although they are non-venomous. However, rat snakes come in a wide variety of colours, from yellow striped to black to orange to greenish. This is because rat snakes are found all over the Eastern and Midwestern states, and are subjected to all types of weather and terrain. Rat snakes are common in urban areas, but they can also be found in wooded areas, mountains or coastal regions. As a result, rat snakes have had to adapt to their local environments in an effort to avoid detection and hunt more effectively.

Genetic algorithms belong to the evolutionary algorithms which generate solutions for optimization problems. Algorithm begins with a set of solutions called population. Solutions from one population are chosen and then used to form a new population. This is done with the anticipation, that the new population will be enhanced than the old one. Solutions which are selected to form new solutions (offspring)[11] are chosen according to their fitness – the more appropriate they are, the more probability they have to reproduce.
Some advantages of genetic algorithm are

- Genetic algorithm optimizes both variables efficiently, continuous or discrete.
- It searches from a large sampling of the cost surface.
- Large number of variables can be processed at the same time.
- It can optimize variables with highly complex cost surfaces.
- Gives a number of optimum solutions, not a single solution. So different image segmentation results can be obtained at the same time

The basic steps of genetic algorithm are as follows:

(1) [Start] Generate random population of n chromosomes (suitable solutions for the problem).
(2) [Fitness] Evaluate the fitness f(x) of each chromosome x
in the population.
(3) [New population] Create a new population by repeating following steps until the new population is complete.
(a) [Selection] Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected).
(b) [Crossover] With a crossover probability cross over the parents to form a new offspring (chil- dren). If no crossover was performed, offspring is an exact copy of parents.
(c) [Mutation] With a mutation probability mutate new offspring at each locus (position in chromosome).
(d) [Accepting] Place new offspring in a new population.

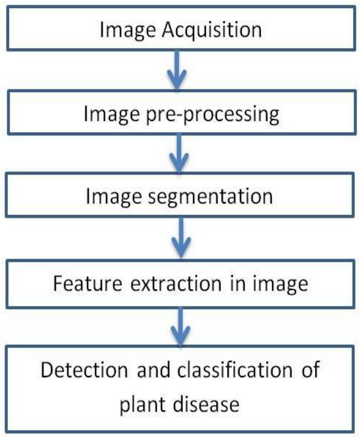
(4) [Replace] Use new generated population for a further run of algorithm.
(5) [Test] If the end condition is satisfied, stop, and return the best solution in current population.
(6) [Loop] Go to step 2.

2.Literature review

In this section, various method of image processing for plant disease detection is discussed.
The vegetation indices from hyper spectral data have been shown for indirect monitoring of plant diseases. But they cannot distinguish different diseases on crop. Wenjiang Huang et al developed the new spectral indices for identifying the winter wheat disease. They consider three different pests (Powdery mildew, yellow rust and aphids) in winter wheat for their study. The most and the least relevant wavelengths for different diseases were extracted using RELIEF-F algorithm. The classification accuracies of these new indices for healthy and infected leaves with powdery mildew, yellow rust and aphids were 86.5%, 85.2%, 91.6% and 93.5% respectively [1]. Enhanced images have high quality and clarity than the original image. Color images have primary colors red, green and blue. It is difficult to implement the applications using RGB because of their range i.e. 0 to 255. Hence they convert the RGB images into the grey images. Then the histogram equalization which distributes the intensities of the images is applied on the image to enhance the plant disease images.
Monica Jhuria et al uses image processing for detection of disease and the fruit grading in [3]. They have used artificial neural network for detection of disease. They have created two separate databases, one for the training of already stored disease images and other for the implementation of the query images. Back propagation is used for the weight adjustment of training databases. They consider three feature vectors, namely, color, textures and morphology [3]. They have found that the morphological feature gives better result than the other two features.
Zulkifli Bin Husin et al, in their paper [4], they captured the chilli plant leaf image and processed to determine the health status of the chilli plant. Their technique is ensuring that the chemicals should apply to the diseased chilli plant only. They used the MATLAB[12] for the feature extraction and image recognition. In this paper pre-processing is done using the Fourier filtering, edge detection and morphological operations. Computer vision extends the image processing paradigm for object classification. Here digital camera is used for the image capturing and LABVIEW software tool to build the GUI.
The segmentation of leaf image is important while extracting the feature from that image. Mrunalini R. Badnakhe, Prashant R. Deshmukh compare the Otsu threshold and the k-means clustering algorithm used for infected leaf analysis in [5]. They have concluded that the extracted values of the features are less for k-means clustering. The clarity of k-means clustering is more accurate than other method.
The RGB image is used for the identification of disease. After applying k-means clustering techniques, the green pixels is

identified and then using otsu's method, varying threshold value is obtained. For the feature extraction, color co-occurrence method is used. RGB image is converted into the HSI translation. For the texture statistics computation the SGDM matrix is generated and using GLCM function the feature is calculated [6].
The FPGA[13] and DSP based system is developed by Chunxia Zhang, Xiuqing Wang and Xudong Li, for monitoring and control of plant diseases [7]. The FPGA is used to get the field plant image or video data for monitoring and diagnosis. The DSP TMS320DM642 is used to process and encode the video or image data. The nRF24L01 single chip 2.4 GHz radio transmitter is used for data transfer. It has two data compress and transmission method to meet user's different need and uses multi-channel wireless communication to lower the whole system cost.
Shantanu Phadikar and Jaya Sil uses pattern recognition techniques for the identification of rice disease in [9]. This paper describes a software prototype for rice disease detection based on infected image of rice plant. They used HIS model for segmentation of the image after getting the interested region, then the boundary and spot detection is done to identify infected part of the leaf.

3. BASIC STEPS FOR DISEASE DETECTION



4.METHODOLOGY

- The usage of image processing technology for plant disease degree grading eliminates the subjectivity of traditional classification methods and human-induced errors.
- The correct recognition and classification of the plant disease is very essential for the successful cultivation of the Plant and this can be done by using image processing.
- MATLAB is used for colour feature extraction and image recognition. Here digital camera is used for image capturing.

A] Image Acquisition

The images of the plant leaf are captured through the camera. This image is in RGB (Red, Green And Blue) form. color transformation structure for the RGB leaf image is created, and then, a device-independent color space transformation for the color transformation structure is applied [6].

B] Image Pre-processing

To remove noise in image or other object removal, different pre-processing techniques is considered. Image clipping i.e. cropping of the leaf image to get the interested image region. Image smoothing is done using the smoothing filter. Image enhancement is carried out for increasing the contrast.
the RGB images into the grey images using colour conversion using equation (1).
f(x)=0.2989*R + 0.5870*G + 0.114.*B (1)
Then the histogram equalization which distributes the intensities of the images is applied on the image to enhance the plant disease images. The cumulative distribution function is used to distribute intensity values [2].

C] Image Segmentation
Segmentation means partitioning of image into various part of same features or having some similarity. The segmentation can be done using various methods like otsu' method, k-means clustering, converting RGB[14] image into HIS model etc.

1] Segmentation using Boundary and spot detection algorithm:
The RGB image is converted into the HIS model for segmenting. Boundary detection and spot detection helps to find the infected part of the leaf as discussed in [9]. For boundary detection the 8 connectivity of pixels is consider and boundary detection algorithm is applied [9].

2] K-means clustering:
The K-means clustering is used for classification of object based on a set of features into K number of classes. The classification of object is done by minimizing the sum of the squares of the distance between the object and the corresponding cluster.

The algorithm for K –means Clustering:
1. Pick center of K cluster, either randomly or based on some heuristic.
2. Assign each pixel in the image to the cluster that minimizes the distance between the pixel and the cluster center.
3. Again compute the cluster centers by averaging all of the pixels in the cluster. Repeat steps 2 and 3 until convergence is attained.

3] Otsu Threshold Algorithm:

Thresholding creates binary images from grey-level images by setting all pixels below some threshold to zero and all pixels above that threshold to one. The Otsu algorithm defined in
[5]is as follows:

i. According to the threshold, Separate pixels into two clusters
ii. Then find the mean of each cluster.
iii. Square the difference between the means.
iv. Multiply the number of pixels in one cluster times the number in the other

The infected leaf shows the symptoms of the disease by changing the color of the leaf. Hence the greenness of the leaves can be used for the detection of the infected portion of the leaf. The R, G and B component are extracted from the image. The threshold is calculated using the Otsu's method. Then the green pixels is masked and removed if the green pixel intensities are less than the computed threshold.

D] Feature Extraction

Feature extraction plays an important role for identification of an object. In many application of image processing feature extraction is used. Color, texture, morphology, edges etc. are the features which can be used in plant disease detection.

In paper [3], Monica jhuria et al considers color, texture and morphology as a feature for disease detection. They have found that morphological result gives better result than the other features. Texture means how the colour is distributed in the image, the roughness, hardness of the image. It can also be used for the detection of infected plant areas.

i] Color co-occurrence Method :

In this method both color and texture are taken into account to get an unique features for that image. For that the RGB image is converted into the HSI translation.

$$H = \begin{cases} Theta & if\ B \le G \\ 360 - Theta, & B > G \end{cases} \text{ ------- (2)}$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)] \text{ ------- (3)}$$

$$I = \frac{1}{3}(R+G+B) \text{ ----------- (4)}$$

For the texture statistics computation the SGDM matrix is generated and using GLCM function the feature is calculated.

ii) Leaf color extraction using H and B components:

The input image is enhanced by using anisotropic diffusion technique to preserve the information of the affected pixels before separating the color from the background [8]. To distinguish between grape leaf and the non-grape leaf part, H and B components from HIS and LAB color space is considered. A SOFM with back propagation neural network is implemented to recognize colors of disease leaf.

E] Classification

i) Using ANN:

After feature extraction is done, the learning database images are classified by using neural network. These feature vectors are considered as neurons in ANN [3]. The output of the neuron is the function of weighted sum of the inputs. The back propagation algorithm, modified SOM; Multiclass Support vector machines can be used.

ii) Back propagation:

BPNN algorithm is used in a recurrent network. Once trained, the neural network weights are fixed and can be used to compute output values for new query images which are not present in the learning database.

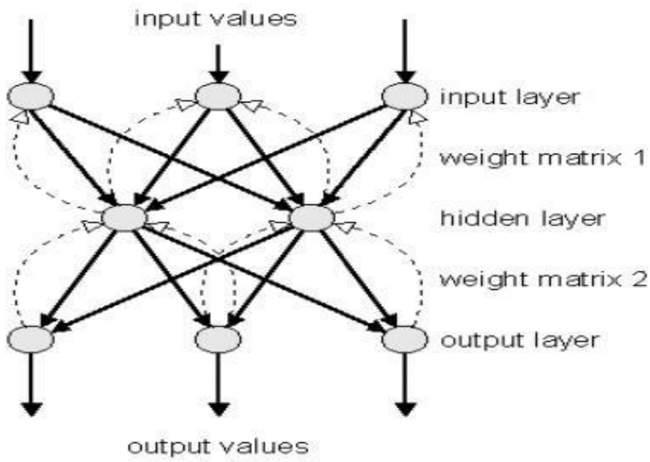


Fig -1: Back propagation Network

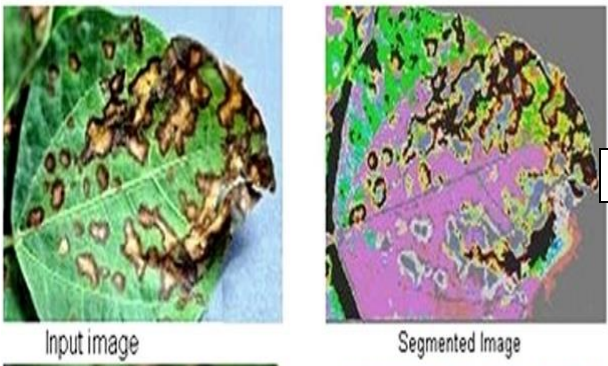


Fig 2

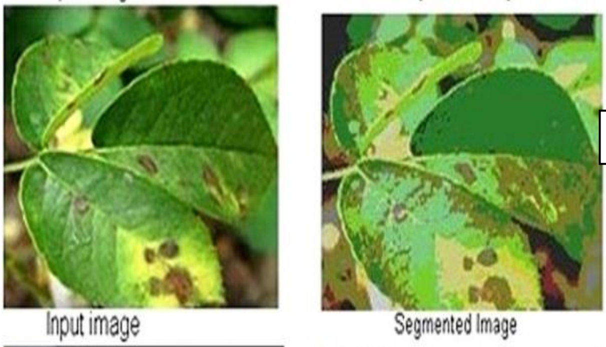


Fig 3

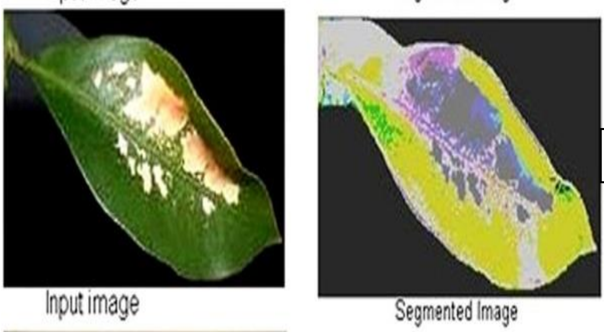


Fig 4

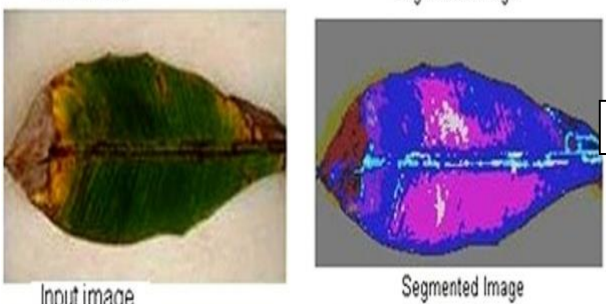


Fig 5

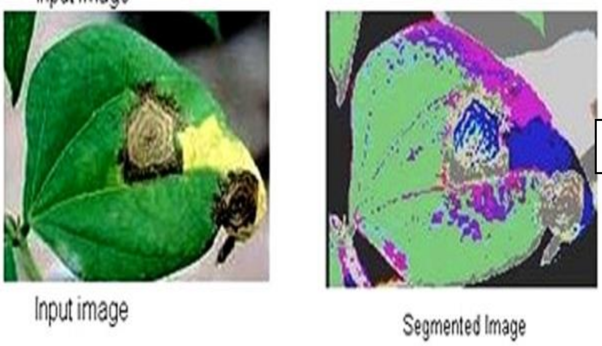


Fig 6

5.RESULTS

All the experiments are performed in MATLAB. For input data disease, samples of plant leaves like rose with bacterial disease, beans leaf with bacterial disease, lemon leaf with Sun burn disease, banana leaf with early scorch disease and fungal disease in beans leaf are considered. above shows the original images which are followed by output segmented images. Segmented image can be classified into different plant diseases. Fig. 2 shows the input and output image where input image is a banana leaf with early scorch disease and output image shows the classification of disease using feature extraction method.

In the same manner classification of diseases of other input plant leafs are shown in Figs. 3–6.

The co-occurrence features are calculated after mapping the R, G, B components of the input image to the thresholded images. The co-occurrence features for the leaves are extracted and compared with the corresponding feature values that are stored in the feature library. The classification is first done using the Minimum Distance Criterion with K-Mean Clustering and shows its efficiency with accuracy of 86.54%. The detection accuracy is improved to 93.63% by proposed algorithm. In the second phase classification is done using SVM classifier and shows its efficiency with accuracy of 95.71%. Now the detection accuracy is improved to 95.71% by SVM with proposed algorithm. The training and the testing sets for each type of leaf along with their detection accuracy is shown in Table 1.2 and Fig. 7. From the results it can be seen that the detection accuracy is enhanced by SVM with proposed algorithm compared to other approaches reported in [4,5,7].

The numbers of leaf disease samples that were classified into five classes of leaf disease using proposed algorithm [16]are shown in Table 1.3 and Fig.8. From the results it can be seen that only few samples from Frog eye leaf spot and bacterial leaf spot leaves were misclassified. Only two leafs with bacterial leaf spot disease are classified as frog eye leaf spot and one frog eye leaf spot is classify as bacterial leaf spot.

Table 1.2 – Comparison of results.

Disease samples	No. of images usedfor training	No. of images used for testing	Detection MDC with accuracy/ % K mean	MDC with proposed algorithm	SVM with proposed algorithm
Banana	15	10	80.00	90.00	90.00
Beans	15	14	92.85	92.85	92.85
Lemon	15	10	90.00	100.00	100
Rose	15	12	83.33	91.66	100
	Overall accuracy		86.54	93.63	95.71

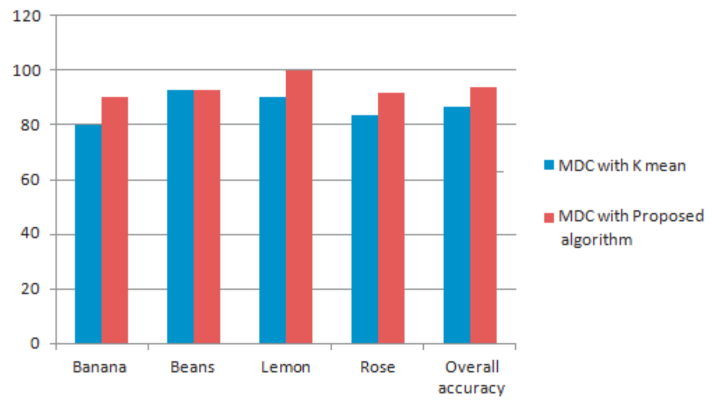


Fig. 7 – Comparison of results.

Table 1.3 – Classification results per class for proposed method.

Leaf disease	Bacterial leaf spot	Frog eye leaf spot	Sun burn disease	Fungal disease	Early scorch	Accuracy
Bacterial leaf spot	23	2	0	0	0	92
Frog eye leaf spot	1	24	0	0	0	96
Sun burn disease	0	0	25	0	0	100
Fungal disease	0	0	0	25	0	100
Early scorch	0	0	0	0	25	100
Average						97.6

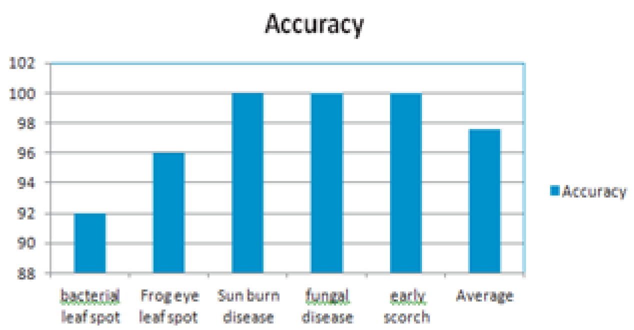


Fig. 8 – Classification results per class for proposed method.

6.CONCLUSIONS

This paper presents the survey on different diseases classification techniques used for plant leaf disease detection and an algorithm for image segmentation technique that can be used for automatic detection as well as classification of plant leaf diseases later. Banana, beans, jackfruit, lemon, mango, potato, tomato, and sapota are some of those ten species on which proposed algorithm is tested. Therefore, related diseases for these plants were taken for identification. With very less computational efforts the optimum results were obtained, which also shows the efficiency of proposed algorithm in recognition and classification of the leaf diseases. Another advantage of using this method is that the plant diseases can be identified at early stage or the initial stage. To improve recognition rate in classification process Artificial Neural Network, Bayes classifier, Fuzzy Logic and hybrid algorithms can also be used.

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