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Plant Disease Detection Using Fuzzy Classification

[1]Sutha P, [2]Nandhu Kishore AH ,[3]Jayanthi VE, [4]Periyanan A, [5]Vahima P

[1]Assistant Professor / Biomedical Engineering, PSNA College of Engineering and Technology, Dindigul
[2]Associate Professor / CSE, PSNA College of Engineering and Technology, Dindigul
[3]Professor / BME, PSNA College of Engineering and Technology, Dindigul
[4]Associate Professor,/ECE, Sri Ranganathar Institute of Engineering and Technology, Coimbatore
[5]UG Scholar / Biomedical Engineering, PSNA College of Engineering and Technology, Dindigul

ABSTRACT

The economic growth of a nation mainly depends on agricultural productivity. This is the one of the reasons that early prediction of plant diseases plays a crucial role in agricultural field, as acquiring disease in plants is quite natural. Proper care has to be taken in this area to prevent serious effects on plants in earlier stages by which respective product quality, quantity and/or productivity can be improved. Automatic disease detection techniques are highly valuable for reducing the tedious work of monitoring in big farms of crops by detecting disease symptoms appearing on the plant leaves in a very earlier stage. Therefore, a new algorithm is proposed for automatic detection and classification of plant leaf diseases using fuzzy classification technique. Image segmentation forms an important aspect for disease detection in plant leaf disease, which is done by using K-means algorithm. Using the Fuzzy membership function, structure relationships between vertices are viewed in the terms of degree for detecting the plant disease. A test image is compared with database image and then dissimilarity is calculated with extracted parameters like skewness, extract mean and deviation. The accuracy of 93% is achieved by the proposed system, which is more as compared with that of the existing system.

1. INTRODUCTION

Globally, it has been found that there are more than 8.7 million species of living organisms (human beings, plants and algae) on Earth, out of which, plants species plays a vital role in human life [1]. Plants are one of the essential resources for human well-being and can exist everywhere. Most of the plants carry significant information for the development of human society and are considered as essential resource for human well-being. Plant Identification is the determination of the identity of an unknown plant species in comparison with previously collected specimens. The process of recognizing the specimen is done by referring its botanical name. Once this connection is established, most of the related details of that plant species like name and other properties of the plant can be easily obtained.Plant classification is therefore done by placing the known plants into groups or categories to exhibit some relationship. They use the related features that are used to categorize the plants into a known hierarchy [2].

The following section deals with the preliminary concepts that are essential for plant disease detection.

1.1 DIGITAL IMAGE PROCESSING

The image processing techniques can be applied to analyze a picture by identifying shapes, colours and relationships that cannot be normally observed by the human eye [3]. It helps to detect abnormalities in the leaves and other parts of the plants. It involves a series of steps like acquiring the images of plant or its parts, pre-process the images for performing enhancement, extracting the necessary features and then applying the classification / matching algorithms for plant disease identification [4]. All the above steps involved are highly essential for achieving high accuracy and efficiency of the plant disease identification. Jayme Garcia ArnalBarbedo presented a survey on several methods that use image processing approaches to detect, quantify

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and classify plant diseases from the images [5]. Although disease symptoms can take place in any part of the plant, the system performs disease detection, severity quantification, and classification.

1.1.1. Acquisition of Leaf Image

The first stage in any plant disease identification starts with capturing of pictures of whole plant or its specific parts and preparing a database collection. The images are acquired by scanners or digital cameras [6]. As classification is a complex operation that needs high memory usage, the images are compressed using any one of the compression techniques like JPEP, BMP or GIF.

1.1.2. Pre-processing

The pre-processing step involves two main tasks, namely, enhancement and segmentation. Real world input data always contains some amount of noise that hinders the identification and recognition process from fulfilling its respective task [7]. Therefore, employing efficient image enhancement techniques are always desirable to reduce its effects. Enhancement techniques also include operations that can improve image properties which help to increase the overall performance of the identification system. Image enhancement is an art and an algorithmic challenge by applying image processing algorithms to improve the quality of an image. The goal of image pre-processing operation is to increase the quality of the image and image data so as to improve segmentation, feature extraction and classification processes.

The second part of pre-processing technique is segmentation which subdivides the input leaf image into various parts with meaningful entities. Segmentation techniques use the various features extracted like gray or colour features or texture features to separate the various regions of the input image. Apart from these methods, several researches were carried out in the past decades to find an optimal segmentation solution.

JagadeeshDevdas Pujari et al presented segmentation using threshold techniques, region growing, K-means clustering and watershed to determine anthracnose affected lesion region in healthy fruit. Then quantification of affected area is calculated. The extraction of texture features is performed using Run length Matrix. These features are used in classification using ANN. The classification accuracy still needs to be improved [8].

Ouyang C et. al developed a segmentation algorithm for the real-time online images of diseased strawberry in greenhouse. First, pre-processing of images is performed to eliminate the impact of uneven illumination using “top-hat” transformation, and noise removal is done by median filtering. After comprehensively applying the methods of gray morphology, logical operation, OTSU and mean shift segmentation, the extracted Eigen values are normalized. Using eigenvectors of part of the samples, the Back Propagation (BP) neural network and Support Vector Machine (SVM) is implemented and executed. Results show that SVM have a higher recognition rate than the BP neural network [9].

Anusha Rao designed a hybrid approach for plant leaf disease detection and classification by combining the digital image processing and neural networks. Image enhancement and image conversion scheme are employed to overcome the illumination issues and reduction of noise. Features are extracted and a Neuro-Fuzzy Logic classifier is trained with the extracted features [10].

The main disadvantages of the existing segmentation techniques are the performance of the system degrades when the input image size is huge; most of the techniques are resolution or context based; accuracy of segmentation degrades when the system is provided with noisy or degraded images; most of the existing segmentation techniques do not meet the standard speed required by real time classification and recognition systems.

1.1.3. Feature Extraction

A successful plant disease identification system requires a set of features that best describe the images and which can provide maximum discrimination between the normal and abnormal parts of a plant. The quality of a feature vector lies in its ability to categorize the given input samples into different classes. The

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images of same class should have similar feature values whereas examples from different classes have different feature values. The feature extraction task consists of three sub-tasks namely the feature construction, feature selection and dimensionality reduction.

Feature construction is one of the key steps in the data analysis process which in turn conditions the success of the subsequent machine learning process to endeavour disease identification process. In particular, care should be taken not to lose any essential information in the feature construction phase. This task combines various existing features of a plant or plant parts image to form a feature vector.

Dimensionality reduction is another form of feature selection that focuses on reducing the number of attributes required to represent a plant or leaf image. These techniques mainly need to handle the 'curse of dimensionality'. As the dimensionality of feature space increases, the accuracy of the system increases but leads to sparseness of training data that decreases the performance of classification. Thus, the design should seek a balance between the dimensionality and number of training vector to improve the performance of the classification algorithm used for leaf recognition.

1.1.4. Matching Algorithm

Following the feature extraction process, the most crucial phase in the process of plant disease detection is matching and classification. The operation of the classification is simplified by transforming quantitative input data to qualitative output information. The output of the classifier may either be a discrete selection of one of the predefined classes or a real-valued vector expressing the likelihood values that the pattern is originated from the corresponding class.

Classification which is also known as pattern recognition, discrimination, supervised learning or prediction is a task that involves a construction of a procedure that maps data into one of several predefined classes. It applies a rule, a boundary or a function with sample's attributes to identify the classes. A classifier works to partition the feature space into decision regions that are identified using pre-defined labels.

An efficient classifier should be able to differentiate these partitions with precise decision boundaries (borders between decision regions). The efficiency of a classification technique depends on various factors such as whether learning method of the classifier is a supervised or unsupervised method, the type of output label (binary or multiple) and whether they are statistical or non-statistical in nature. Examples of some classifiers include Artificial Neural Network, Decision Tree Classifiers, Support Vector Machines, Naïve Bayes Classifiers and Rule-Based Classifiers etc. The classification model generated by the learning algorithm should fit the input data as well as it should correctly predict the class labels of the input records it has never seen before.

Kumari et. al detected the plant leaf disease using Fuzzy C-Means clustering algorithm. Athanasios Anagnostis developed Anthracnose infected Walnut tree leaf disease identification by implementing a robust Convolution Neural Networks (CNN)to classify images of Walnut leaves depending on whether or not these leaves are infected by anthracnose, and therefore determine whether the Walnut tree is infected [11].

Sibiya et. al implemented CNN deep learning models by applying threshold-segmentation on images of diseased maize leaves with common rust disease to extract the percentage of the diseased leaf area which was then used to derive fuzzy decision rules for the assignment of Common Rust images to their severity classes. [12].

2. OVERVIEW OF PLANT DISEASES

Sri SilpaPadmanabhuni made an extensive study on existing plant disease detection systems [13]. It is identified that plants usually suffer from bacterial, fungal and viral diseases. It includes leaf spots, blights, canker, wilts and scabs etc.The following section will illustrate some of the diseases that affect the plants and plant parts like leaves, flowers, fruits etc.

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2.1. Powdery Mildew

Fig.2.1 Powdery Mildew disease of mango flower and leaf

The distinguishing symptom of this disease is the surface with white powdery fungal development on leaves, stalks of panicles, flowers and fruits. The affected flowers and fruits drop pre-maturely and reduce the crop yield considerably or might even prevent the fruit set. The fungus parasitizes the young tissues of all parts of the inflorescence, leaves and fruits. Young leaves are attacked on both the sides of the leaves. The powdery mildew survives in winters in dormant buds. During favourable time for growth spores are produced and originate new infections affecting the entire yield and productivity. Rains or mists with the cold weather during flowering stage forms the favourable conditions and are congenial for the occurrence of this disease.

2.2. Phoma blight

The symptoms are noticeable on mature leaves. Initially, the lesions areas are irregular and show yellow to light brown in colour which is speckled over the leaves. The disease spots can be noticed with dark margins and dull grey centres. In case of severity, the spots coalesce and form patches resulting defoliation of infected leaves. Fungi present in the seeds forms the source of infection. This fungus survives both on fruits as well as other plant parts. Rainy season is the most conducive to the expansion of disease.

Fig.2.2. Phoma blight disease of mango leaf

2.3. Bacterial canker

The disease is visible on leaves, stalks, twigs and stems, branches and in fruits of mango crop, at first seems to be water soaked lesions, later turned to typical canker. The affected area of canker has a light yellow colour, later it enlarges to irregular patches showing dark brown in colour. These lesions regions on plant parts survive for long period in diseased tissues. Spring session is very ideal

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Fig.2.3. Bacterial canker disease of mango fruit and leaf

3. METHODOLOGY

Food is one of the basic needs of human being. World population is increasing day by day. So it has become important to grow sufficient amount of crops to feed such a huge population. But with the time passing by, plants are affected with various kinds of diseases, cause great harm to the agricultural plant productions. Beside that many countries economy greatly depends on agricultural productivity and it's also a need for a country to attain agricultural productivity of basic agricultural product for the people of that particular country. Detection of plant disease through some automatic technique is beneficial as it requires a large amount of work of monitoring in big farm of crops, and at very early stage itself it detects symptoms of diseases means where they appear on plant leaves.

Automated identification of plant species using leaf images is a worthwhile goal because of the current combination of rapidly dwindling biodiversity and the shortage of suitably qualified taxonomists. This is particularly important in geographic locations that currently have a huge number of species and those with the largest number of species restricted to that geographic area. Development of crops often depends on the incorporation of genes from wild relatives of existing crops and hence it is important to keep track of the distribution of all plant taxonomy. In addition, with the deterioration of environments, even though many of the rare plant species are already dead, still many more of the rare plant species are at the margin of extinction. So, the investigation of plant recognition can contribute to environmental protection. The recognition of plant leaves is a vital process in botany and in tea, cotton and other industries and is also used during early diagnosis of plant detects like diseases.

So, the identification of disease in the vegetables and fruits is done by the proposed system given as block diagram in figure 1.

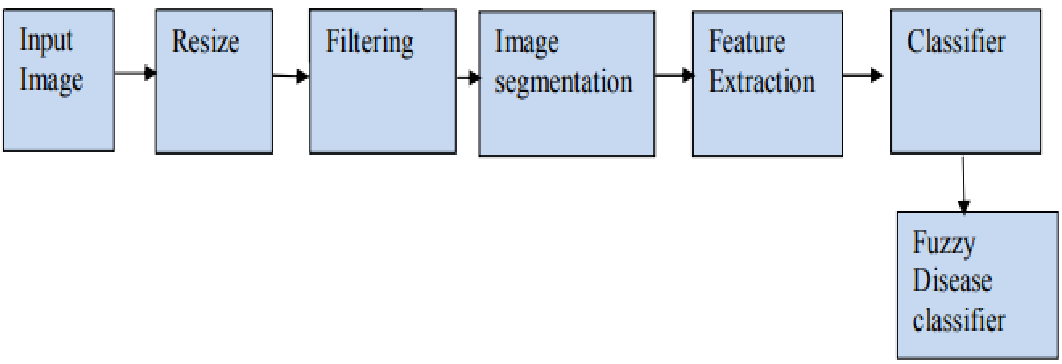

Fig. 4.1 Block diagram for the disease diagnosis in vegetables and fruit using images

Initially, the vegetable images are acquired by scanners or digital cameras. For identification process, the vegetable recognition system is made by collecting database using 20 samples. As classification is a complex

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operation that needs high memory usage, a lossy compression format like JPEG / BMP / GIF is normally used.

To find out whether the leaf is diseased or healthy, certain steps must be followed. i.e., Pre-processing, segmentation, Feature extraction, Training of classifier and Classification.

Pre-processing is a common name for operations with images at the lowest level of abstraction both input and output are intensity images. The aim of pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing. Image segmentation is a crucial process for most image analysis consequent tasks. Especially, most of the existing techniques for image description and recognition are highly depend on the segmentation results. Segmentation splits the image into its constituent regions or objects. In that image segmentation technique by using Otsu's thresholding method detect the disease. First level of segmentation only detect defected area of leave then second level of segmentation detect the leaf disease part.

In machine learning, pattern recognition and in image processing, feature extraction starts from an initial set of measured data and builds derived values (features) intended to be informative and non-redundant, facilitating the subsequent learning and generalization steps, and in some cases leading to better human interpretations. Feature extraction is related to dimensionality reduction. Here, we are using the fuzzy logic for the classification purpose. In recent years, the number and variety of applications of fuzzy logic have increased significantly. The applications range from consumer products such as cameras, camcorders, washing machines, and microwave ovens to industrial process control, medical instrumentation, decision support systems, and portfolio selection.

In input acquisition , 5 types of plant leaf diseases are acquired to meet accuracy. Images captured might be of various forms and of various dimensions, hence the images are pre-processed and brought to same dimension. Segmentation is done to get the areas of interest using K-Means Clustering algorithm. Features are extracted using feature extraction techniques based on colour, shape and textural features. Such as colour co-occurrence, Skewness, contrast, correlation etc. are used to extract the desired set of features. Random forest (RF) is used for classification.

4. RESULTS AND DISCUSSION

4.1 Image acquisition

The vegetable images are acquired by scanners or digital cameras. For identification process, the vegetable recognition system is made by collecting database using 20 samples. As classification is a complex operation that needs high memory usage, a lossy compression format like JPEG / BMP / GIF is normally used.

Fig. 4.1. Input image of unhealthy plant

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4.2. Pre-processing

The important goal of image pre-processing is to increase the quality of the image and image data, so as to improve segmentation, feature extraction and classification processes. The main pre-processing steps done here are image thresholding and edge detection. In image thresholding, otsu's method is used which uses the histogram of the image for threshold searching process. This algorithm returns a single intensity threshold that separate pixels into two classes, foreground and background.

4.2.1 OTSU method

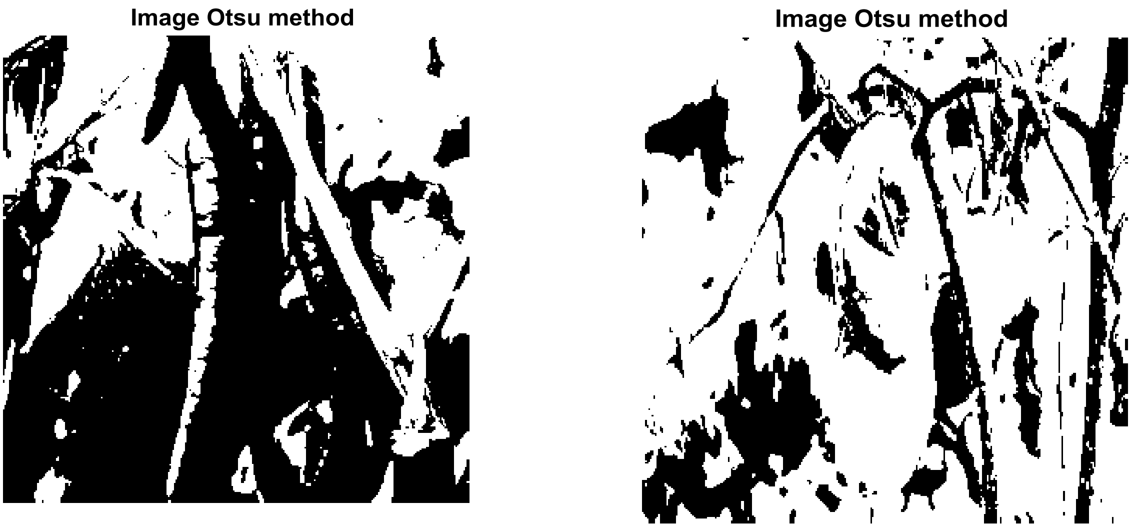

Fig. 4.2 Image after otsu'sthresholding

4.2.2 Edge Detected Image

Edge detection includes a variety of mathematical methods that aim at identifying points in a digital image at which the image brightness changes sharply or more formally has discontinuities. Edge detection method extracts the data and finds the boundaries of an object within an image.

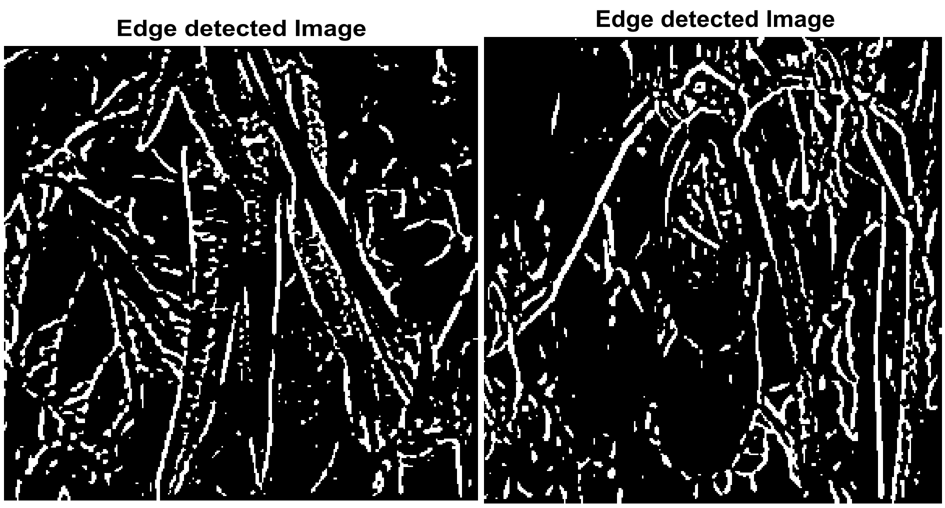

Fig. 4.3. Edge detected image

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4.3. Feature extraction

Contrast enhancement is a process that makes the image features stand out more clearly by making optimal use of colors available on the display or output device. Contrast manipulations involve changing the range of values in an image in order to increase contrast.

4. 3.1. Contrast Enhancement

Fig. 4.4. Contrast enhanced image

4.4. Image segmentation

Image segmentation is the classification of an image into different groups. K-means clustering is done to cluster an image which identifies k number of centroids and then allocates every data point to the nearest cluster, while keeping the centroid as small as possible.

4. 4.1. Cluster Output

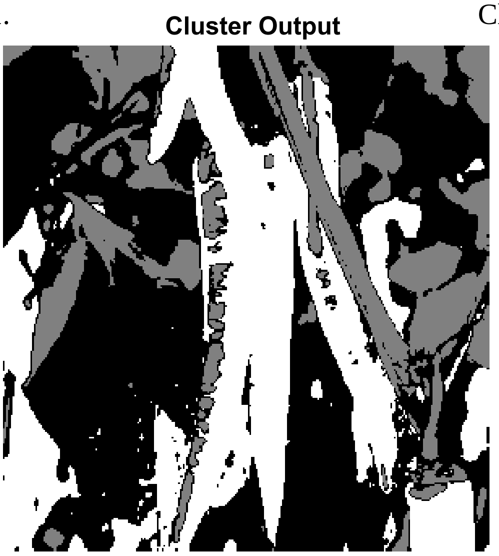

Fig. 4.5. Clustered output

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4.5. Image classification

In image classification, fuzzy classifiers are used which a method of reasoning that resembles the human is reasoning. Fuzzy classification is done to group the individuals having the same characteristics into a fuzzy set.

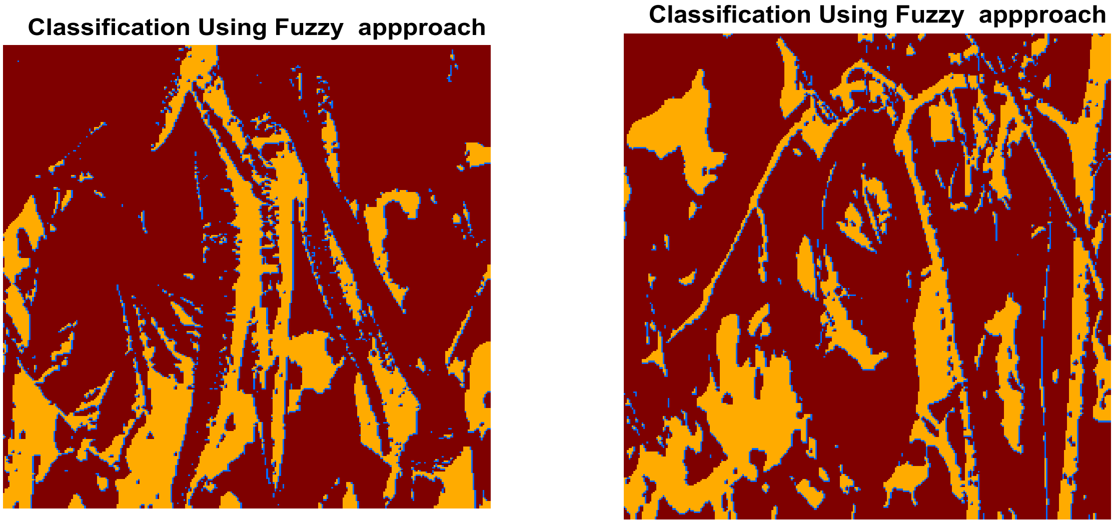
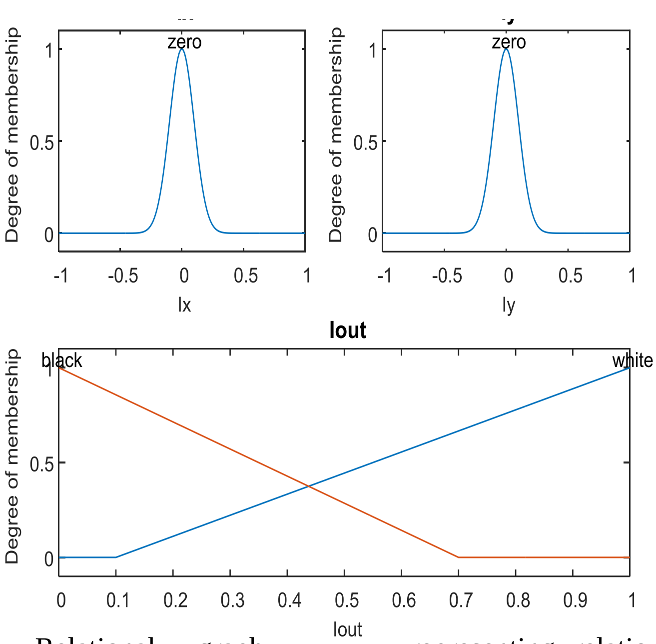


Fig. 4.6. Fuzzy classified output

4.6.Relational graph of fuzzy classification



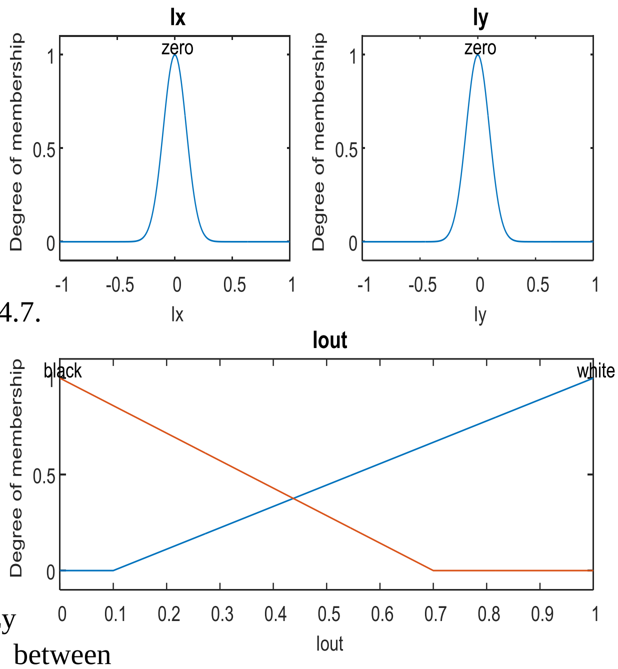


Fig. 4.7. Fuzzy Relational graph representing relationship between vertices

This relational graph shows the working accuracy of fuzzy classifier by representing the structure of relationships between vertices as a matter of degree, accuracy, specificity and sensitivity has been calculated.

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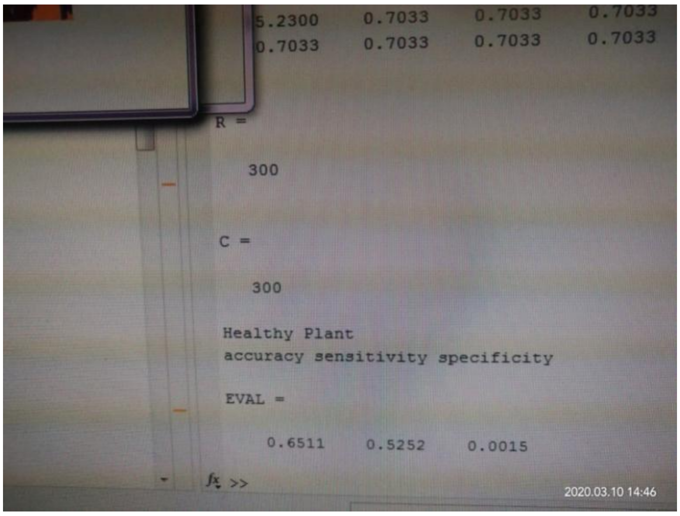
The result for the two different unhealthy plant images have been tested with the proposed system is given below



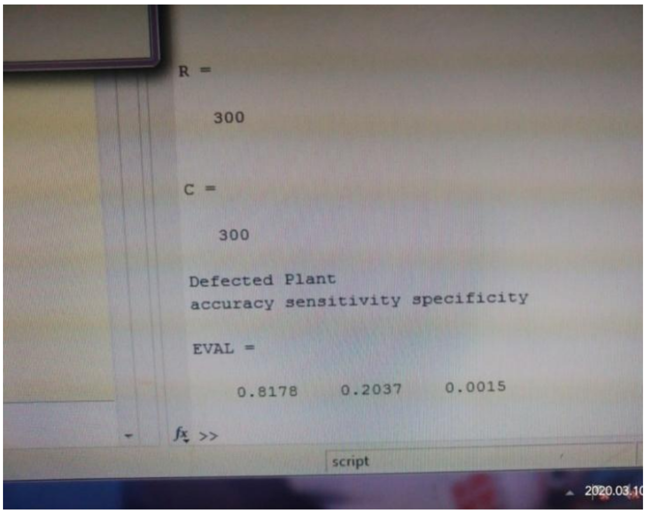


Fig. 4.8 Result from the proposed system for unhealthy plant images

Our proposed system is compared with the state of art and listed below

NO.	TITLE	METHODOLOGY	ACCURACY
1	Detection and classification of leaf disease using Artificial Neural Network	Feed Forward Neural Network (FFNN), Learning Vector Quantization (LVQ) and Radial Basic Function Network (RBF)	56.87
2	Cucumber disease detection using artificial neural network	Artificial Neural Network (ANN), GLCM (Gray level co-occurrence method)	80.45
3	Detection of Jute plant Disease using Image Processing and Machine Learning	Color co-occurrence methods, Multi SVM classifier	86
4	A Robust Deep-Learning Based Detector for real time tomato plant diseases and pest detection	Faster Region-based Convolutional Neural Network (Faster R-CNN), Region-based Fully Convolutional Network (R-FCN), and single shot Multibox Detector (SSD).	85.98
5	Plant Disease Classification Using Convolutional Networks and Generative Adversial Network	A deep learning framework developed by Berkley Vision and Learning Centre, was used to perform the deep CNN training.	80% in 5 epochs
6	Vegetable Disease Detection	Otsu method and Fuzzy classifier	90

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5. CONCLUSION AND FUTURE WORK

The methodology has been implemented successfully and performance tested on a real set of apple leaf data. The result is quite convincing and wide adaptability in developing countries, where such information plays an important role for improvement in yield. The proposed method uses mobile cams for capturing the diseased images and does not require any kind of special training and sophisticated capturing devices. The proposed method is (i) fully automatic for ROI calculation, background separation and parameter .evaluation (ii) disease independently, (iii) low cost and possibility for the wide usability in field conditions, (iv) simpler segmentation method and more advanced parameters are used. We have developed a fully automatic color image sensing based system for classifying the four most dangerous soya bean foliar infections, namely bacterial blight, frog's eye, brown spot, and soya bean rust. All four infections have similar color shades and are confusing for a non-plant pathologist. An algorithm was developed to find the refined lesion texture histogram and apply the DCT on statistical features of RLTH, followed by a normalization process.

We using local binary pattern feature descriptor for lesion areas, and proved the suitability of using the same for classifying the infections under consideration. In the classification based methods, first the system train a classifier with the feature descriptors of the training images and finally classify the test images to a category using trained classifier and feature descriptor of the test image. In this method, we have tested fuzzy classifier. From the experimental observation, we conclude that the LBP feature descriptor is having the better performance as compared to the other tested feature descriptors .In the future, the proposed methodology can be integrated with other yet to be developed, methods for disease identification and classification using color and texture analysis to develop an expert system for early plant foliar disease warning and administration, where the disease type can be identified by color and texture analysis and the severity level estimation by our proposed method since it is disease independent. The performance of the system can be improved in the future by using advanced background separation methods to separate the leaf object from a complex background.

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