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A Robust Approach for Identification and Classification of Turmeric Plant Leaf Diseases Using LDA-ANFIS Algorithm

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Abstract: Agriculture is the backbone of a country and it plays a very important role in the economy. In the field of agriculture, it is very important to identify the disease of crops and its nature. Turmeric plant is a significant plant used in turmeric production, and turmeric powder is used as medicine for certain diseases and as an antiseptic. There are several pests and diseases with significant effects on turmeric yields and leaf spot disease (Curcuma longa) among the most significant ones. Leaf spot disease leads to large damages to the leaves. The disease initially emerges as small circular spots, then evolves instantly and spreads over the entire leaf surface. The disease ultimately ends up with complete die out of the leaves. The data base of different leaf images was created and processed using SFCM segmentation, and leaf images textural analysis was carried out using GLCM. The LDA-ANFIS classifier is used for classification method and it helps to improve the detection rate and reduce the entropy loss. It is highly efficient and accurate to detect the disease image with different number of categories (Leaf Spot, Leaf Blotch Disease and Bacterial Wilt Disease etc.). Experimental analysis is done to calculate the performance metric like as Accuracy, Precision, F measure, Recall, Sensitivity and Specificity. Then, the comparative analysis of the existing parameters is compared to the proposed algorithm parameters. The proposed system LDA-ANFIS algorithm performance value of accuracy is 98%.
Keywords: Leaf Diseases, Agriculture, LDA-ANFIS algorithm.

I. INTRODUCTION

Agriculture plays a vital role in India's economy. 70% of the population is engaged in agriculture and allied activities. Research in agriculture is focused on improving the production, and eliminating food and plant disease. Nowadays, farmers are facing a lot of problems due to various plant diseases. The plants are easily vulnerable to various diseases due to climatic change and polluted environment. The plants are commonly infected by fungi, bacteria and virus. Generally, farmers are monitoring these diseases in plant by naked eye's continuous observation. This existing method is insufficient to detect the diseases in leaves, because, most of the foliar ailments have similarities in shape, size and color. Leaves are highly important sources compared to others. Detection of plant leaf disease is a challenging task in the agricultural sector. Plant leaf disease spreads through open environment and affects the other plants in a short period of time. So, it is necessary to introduce automatic, fast and accurate detection of foliar diseases in plants.

Turmeric is popularly known as Manjal in Tamil, and also commonly known as Haldi or Hardi in Hindi. Turmeric is the common name for Curcuma longa in biology. It is a southern Asia native. Based on its size, turmeric is divided into numerous types. Turmeric is the third largest spice produced by India and it accounts for about 80% of the world's production and 60% of world exports. Turmeric is grown in more than 100 different types all over the world. About 40 of these different turmeric cultivars are grown in India.

Globally, Indian turmeric is described as the best medicinal herb because of its implicit qualities and the presence of major bioactive compound which is Curcumin. Certain disorders can be treated using turmeric powder, which is also used as an antimicrobial. Turmeric is commonly grown in the states of Tamil Nadu, Uttar Pradesh, Bihar, Maharashtra, Karnataka, West Bengal, Andhra Pradesh and Kerala. The most widely cultivated types in Tamil Nadu are Erode local, Salem local, PTS-10, BSR-1, Roma and Suguna. For this research, the cultivars Erode local, Salem local and PTS-10 Turmeric are taken into consideration.

Diseases are one of the main issues that affect the quantity of turmeric harvested in turmeric production. Rhizome Rot Disease, Leaf Spot Disease, Leaf Blotch Disease, Dry Rot Disease, and Bacterial Wilt Disease are the major diseases that affect Turmeric plants. The colour and look of turmeric leaves alter when they become infected with such a disease.

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The growers of turmeric are unable to detect these changes earlier and take preventive measures. However, they can only see these alterations once an infection has reached a mature level; at that point, no amount of diagnosis can rescue the turmeric plant. By examining the microscopic change in the colour and appearance of the turmeric leaves, the proposed research effort uses digital image processing techniques to identify the Rhizome Rot Disease, Leaf Spot Disease, Leaf Blotch Disease, Dry Rot Disease, and Bacterial wilt Disease.

Fig. 1 Various images of turmeric foliar disease

Fig. 2 Farmer shows disease affected leafs in farmlands

In the proposed work, several image processing methods and algorithms are used for the detection of two main turmeric leaf diseases namely Leaf Spot and Leaf Blotch and the results obtained were classified using LDA-ANFIS classifiers.

II. OVERVIEW OF EXISTING ALGORITHM FOR LEAF DISEASE DETECTION

A. Support Vector Machine

A non-linear classifier is the Support Vector machine (SVM). This is a recent development in machine learning that is applied to a variety of texture classification difficulties as well as pattern recognition issues in general. SVM offers superior classification performance, because, the input data is non-linearly transferred to linearly separated data in a high-dimensional space. The marginal distance between various classes is maximised via SVM. Class division is carried out using various kernels. By choosing the hyper plane to separate two classes, SVM is made to function with just two classes. By increasing the margin from the hyper plane to the two classes, this is achieved.

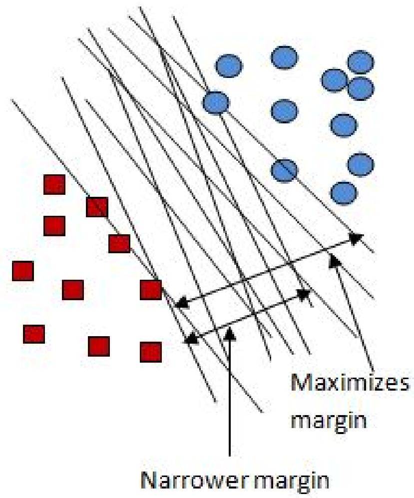

Fig. 3 Support Vector Machine

1) *Advantages of SVM Are*
a) Its prediction accuracy is excellent,
b) Its working is robust when training examples contain errors,
c) Its simple geometric interpretation and a sparse solution, and
d) Like neural networks, the computational complexity of SVMs does not depend on the dimensionality of the input space.

2) *Drawbacks of SVM Are*
a) This classifier includes long preparation time,
b) In SVM it is hard to understand the learned function (weights), and
c) The large number of support vectors used from the training set to perform classification task.

B. Artificial Neural Network (ANN):

An artificial neuron is essentially a biological neuron modified by engineering. Many nodes, referred to as neurons, make up an ANN. Usually, layers are used to arrange neural networks. Each neuron in the hidden layer of a neural network gets signals from every neuron in the input layer. Through the training phase, weights and constants are determined to represent the biases and the strength of each signal. The result is then translated by a transfer function into the output following the addition and weighting of the inputs. Sigmoid, hyperbolic tangent or step transfer functions are employed.

ANNs were first conceptualized as a single neuron in the McCulloch and Pitts model of the 1940s (McCulloch & Pitts, 1943). The simplest single layer network, called Perception, was suggested by Frank Rosenblatt in 1958. Its weights and biases could be trained to generate the right target vector when given the associated input vector. Just input neurons and output neurons are present in this network. It can only address linear issues.

III.THE PROPOSED WORK FOR PLANT LEAF DISEASE DETECTION AND CLASSIFICATION

The proposed work mainly classifies the diseases in the turmeric leaves. The dataset of 100 turmeric leaves are collected for processing the data. The work includes different phases of image processing techniques.

The steps included are:-

1) Initially, for pre-processing state, the input images are to be converted from one color space which is RGB to HSI color space and only the hue component is processed through other phases,
2) Then Spatial Fuzzy C-Means Clustering Segmentation has been used for extracting the diseased part of the leaf,
3) The output of the segmentation phase is then processed to feature extraction phase where GLCM texture analysis is used, and
4) The features are trained and using Linear Discrimination Analysis - Adaptive Network Based Fuzzy Inference System classifier, the diseases are classified.

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The LDA-ANFIS intelligent detection system for leaf disease used in this study includes two phases. These phases are, Linear Discriminant Analysis (LDA) and Adaptive Network Based Fuzzy Inference System (ANFIS) classifier. The system overview of the above mentioned work is as follows

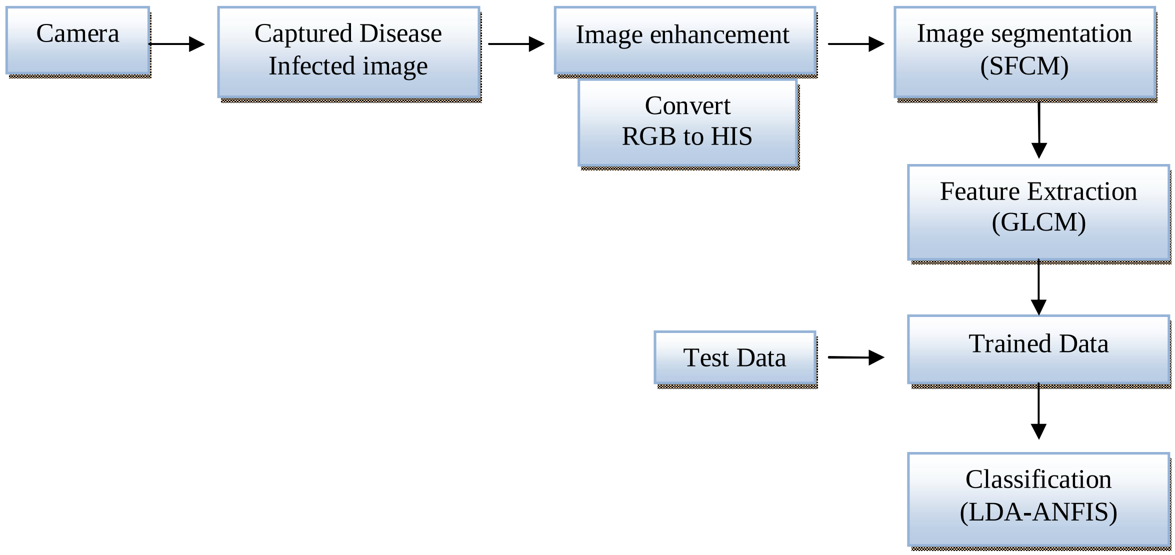


Fig. 4 Block diagram of Proposed work

A. Linear Discrimination Analysis

The Linear Discriminant Analysis (LDA) is a class explicit discriminative. This technique benefits supervised learning to find a set of base vectors. These base vectors are shown as wk. The wk vectors are ratio of the between and within class scatters of the training sample set, which is maximized. For find wk base vectors, the following generalized eigenvalue problem is solved:

$$W_{opt}=\text{argmax}_w \frac{|W^T Sc\, W|}{|W^T Sv\, W|}=[w_1,w_2,\ldots\ldots,w_L] \longrightarrow \quad (1)$$

Here {*wk* | 1 _ *k* _ *L*} are the LDA subspace base vectors. *L* is the dimension of the subspace. *SC* and *Sv* are the between and within class scatter matrices. These matrices can be given as below:

$$Sc = \sum_{k=1}^{a} Mk\,(\mu k-\mu)(\mu k-\mu)^T \longrightarrow \quad (2)$$

$$Sc = \sum_{k=1}^{a} \sum_{Xu \in XK} (Xu-\mu k)\,(Xu-\mu k)^T \longrightarrow \quad (3)$$

Here *a* is the number of classes and *x* ∈ *RN* is the data sample. *Xk* is the set of samples with class label *k*. *µk* is the mean fo$(x+a)^n$ the all the samples with the class label *k*. *Mk* is the number of samples in the class *k*. If *Sv* is non-singular, the base vectors ***wk*** sought in Eq. (1) are the first *L* largest eigenvalues {*ψk* | 1 _*k* _ *L*}. It can be obtained its representation in LDA subspace by a simple linear projection *WT x* for a given test sample *x* due to the LDA base vectors are orthogonal to each other.

B. Adaptive Network Based Fuzzy Inference System

In Adaptive Network Based on Fuzzy Inference System (ANFIS) classifier's structure used both artificial neural network and fuzzy logic. ANFIS classifier is formed if–then rules, couples of input–output and learning algorithms of neural network. These are used for training of ANFIS classifier. LDA-ANFIS intelligent detection system for leaf disease used in this study includes two phases. These phases are, Linear Discriminant Analysis (LDA) and Adaptive Network Based Fuzzy Inference System (ANFIS) classifier.

In the following sections, the obtained results of this LDA-ANFIS intelligent detection system for leaf diseases are demonstrated by using different performance evaluation techniques respectively. These techniques are, sensitivity and specificity analysis, classification accuracy and precision. The correct detection rate of leaf diseases calculated for obtaining of results of sensitivity and specificity analysis for LDA-ANFIS intelligent diagnosis system for leaf diseases in this study is given below.

Sensitivity and specificity:

Sensitivity = $\frac{TP}{TP+FN}$ %

Specificity = $\frac{TN}{FP+TN}$ %

- True Positive (TP)
- True Negative (TN)
- False Positive (FP)
- False Negative (FN)

The correct detection rate of leaf diseases, calculated for obtaining results of classification accuracy analysis for LDA-ANFIS intelligent diagnosis system for leaf diseases in this study, is given below.

Disease detection accuracy (A) = $\frac{\sum_{k=1}^{|C|} asses(c_k)}{|C|}$, $C_k €C$

IV. EXPERIMENTAL RESULTS AND DISCUSSION

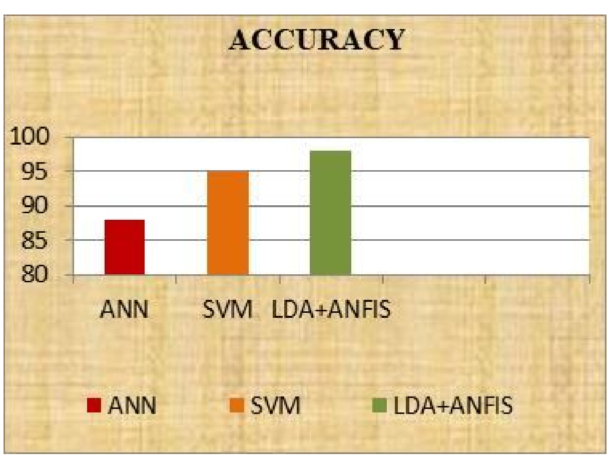
The efficiency of the proposed LDA-ANFIS method for image classification to detect leaf diseases and the results are analysed and shown with various evaluation measures such as classification accuracy, sensitivity, specificity, precision and f measure value and the execution time with less iteration.

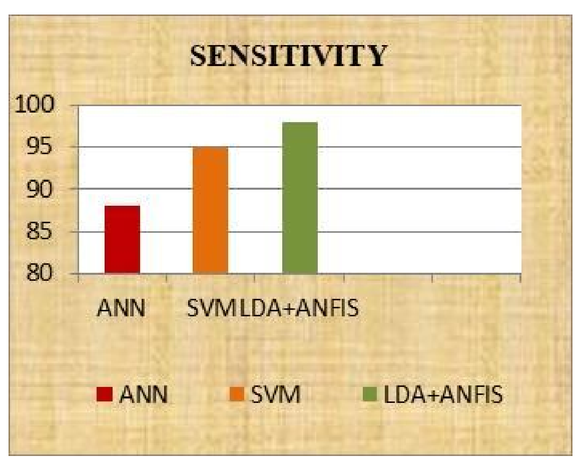
For a better classification algorithm, execution time must be less and accuracy value must be high. We showed our experimental results in Table.1, Table.2 and Table.3 for different turmeric leaf images and compared our results with existing method with less recall value, less execution time, higher sensitivity value and also accuracy.

Image Classification Metrics And Charts

TABLE I
IMAGE CLASSIFICATION METRICS – IMAGE SET 1

METRICS	ANN	SVM	LDA-ANFIS
ACCURACY	88	95	98
SENSITIVITY	88	95	98
SPECIFICITY	88	95	98
PRECISION	88	95	98
RECALL	88	95	98
F-MEASURE	88	95	98





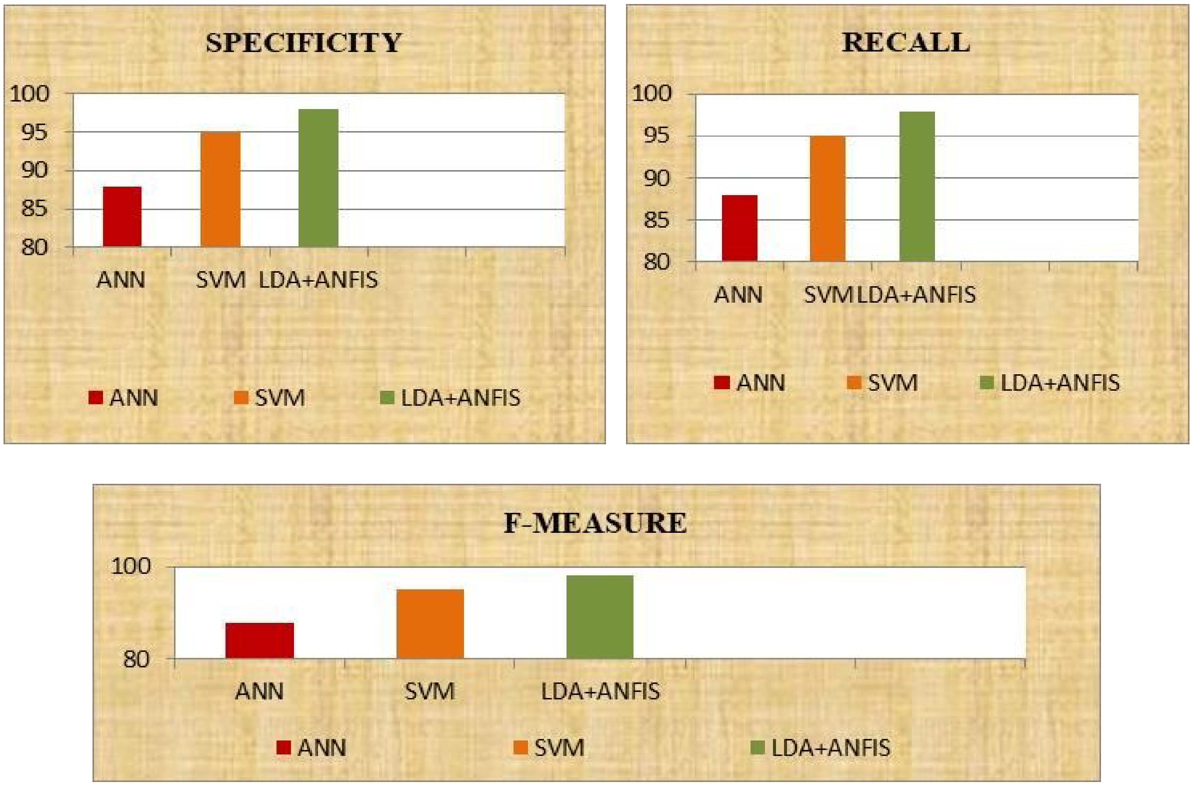
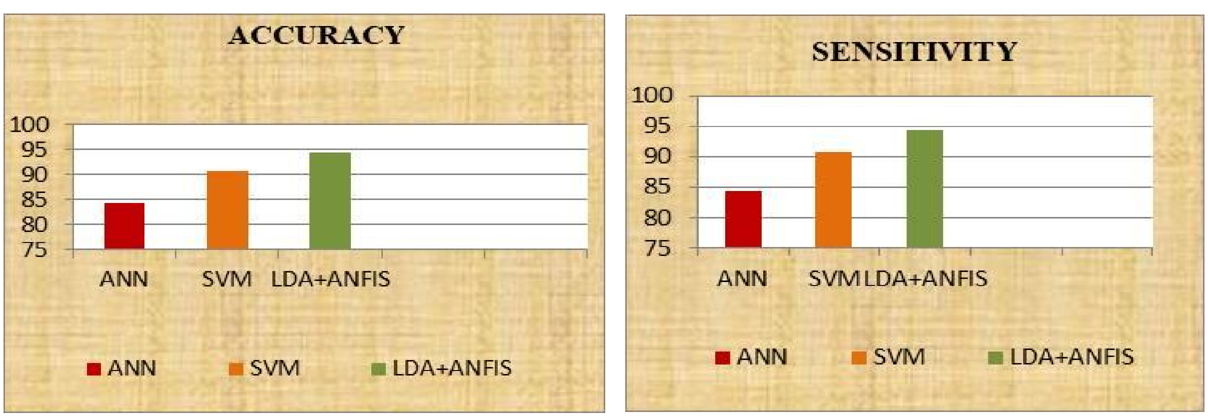
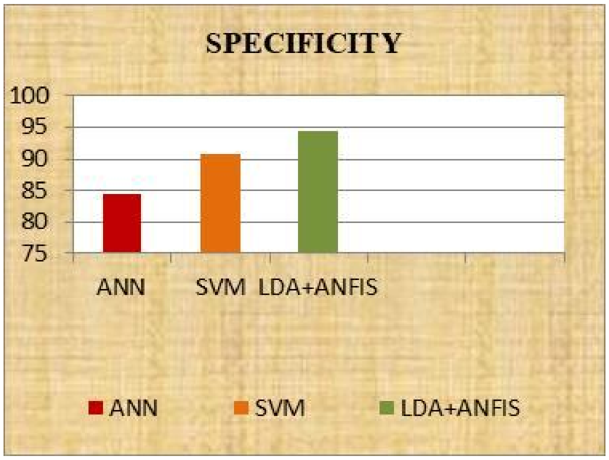


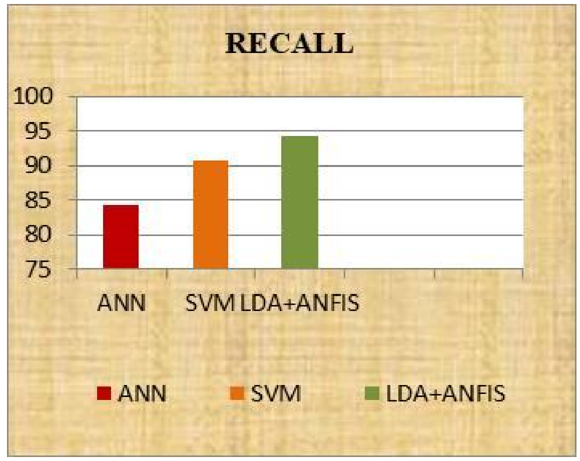
Fig 5. Image classification results of Image Set 1

TABLE II
Image classification Metrics – Image Set 2

METRICS	ANN	SVM	LDA-ANFIS
ACCURACY	84.4	90.8	94.3
SENSITIVITY	84.4	90.8	94.3
SPECIFICITY	84.4	90.8	94.3
PRECISION	84.4	90.8	94.3
RECALL	84.4	90.8	94.3
F-MEASURE	84.4	90.8	94.3







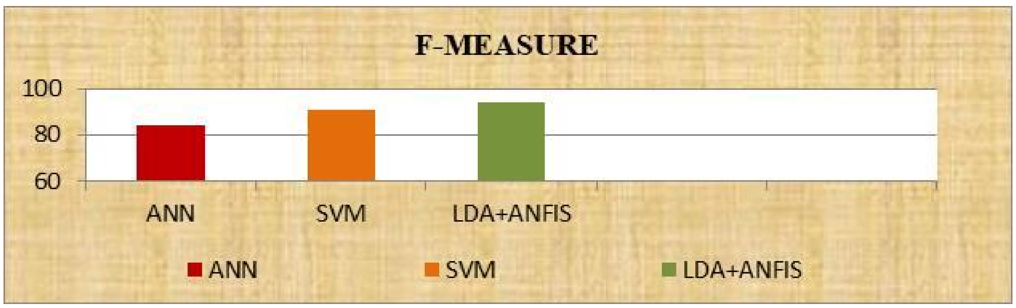
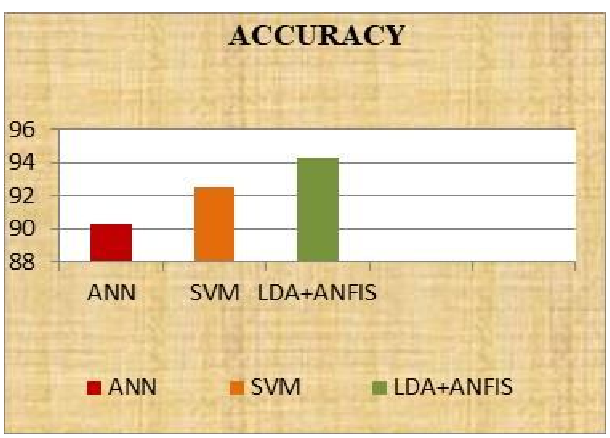
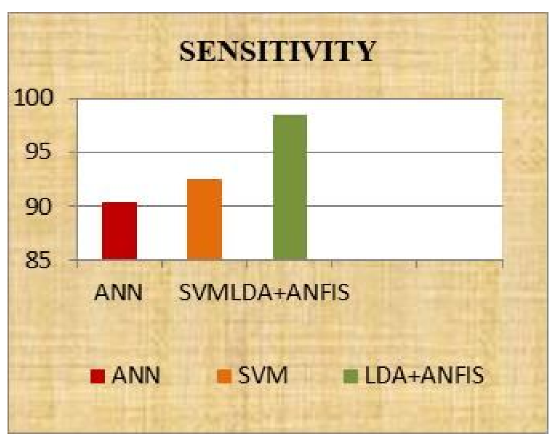


Fig. 6 Image classification results of Image Set 2

TABLE III
IMAGE CLASSIFICATION METRICS – IMAGE SET 3

METRICS	ANN	SVM	LDA-ANFIS
ACCURACY	90.3	92.5	98.5
SENSITIVITY	90.3	92.5	98.5
SPECIFICITY	90.3	92.5	98.5
PRECISION	90.3	92.5	98.5
RECALL	90.3	92.5	98.5
F-MEASURE	90.3	92.5	98.5





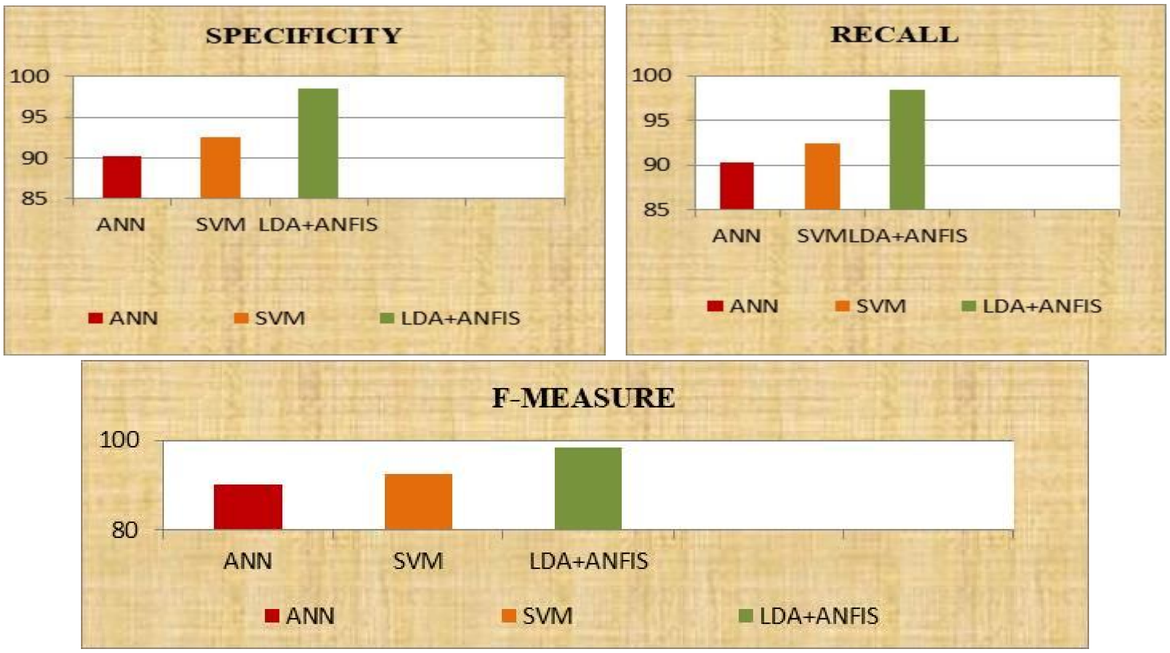


Fig 7. Image classification results of Image Set 3

V. CONCLUSION

In this paper, Linear Discriminant Analysis (LDA) and Adaptive Network Based on Fuzzy Inference System (ANFIS) classifier was applied to the task of classification in turmeric plant leaf diseases. The performance of the proposed LDA-ANFIS Classification method is compared with convention Artificial Neural Network and Support Vector Machine algorithm based on the parameter measures like classification Accuracy, Sensitivity, Specificity, Precision, Recall and F-Measure value. From the experiments results, it is seen that the proposed LDA-ANFIS algorithm has good classification accuracy and proved that the proposed classification algorithm is very effective compared with existing algorithm. From the results obtained, the LDA-ANFIS algorithm provides 98.50% in terms of accuracy. This system is a robust system, because, the results are having the high percentage of accuracy and low percentage of error. In future studies of leaf disease detection, different feature extraction and classifier methods may be used for increasing accuracy with large number of data set.

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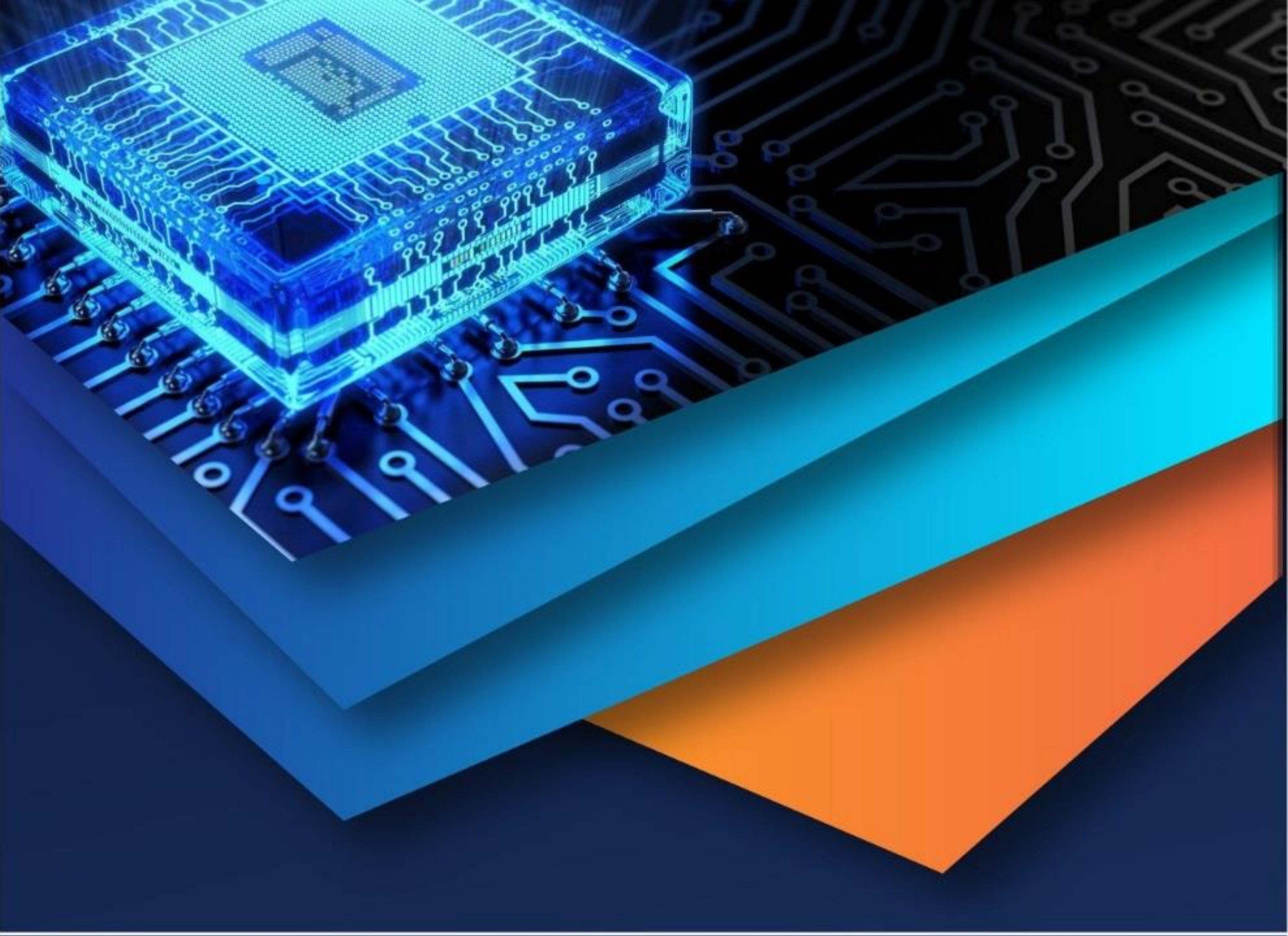

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