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CLASSIFICATION OF DISEASED PLANT LEAVES USING NEURAL NETWORK ALGORITHMS

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ABSTRACT

Agriculture is the mother of all cultures. It played a vital role in the development of human civilization. But plant leaf diseases can damage the crops there may be economic losses in crops. Without knowing about the diseases affected in the plant, the farmers are using excessive pesticides for the plant disease treatment. To overcome this, the detected spot diseases in leaves are classified based on the diseased leaf types using various neural network algorithms. By this approach one can detect the diseased leaf variety and thus can take necessary steps in time to minimize the loss of production. The proposed methodology uses to classify the diseased plant leaves using Feed Forward Neural Network (FFNN), Learning Vector Quantization (LVQ) and Radial Basis Function Networks (RBF) by processing the set of shape and texture features from the affected leaf image. The simulation results show the effectiveness of the proposed scheme. With the help of this work, a machine learning based system can be formed for the improvement of the crop quality in the Indian Economy.

Keywords: neural network classification, performance evaluation, accuracy, precision, recall ratio, F_ measure

INTRODUCTION

Agriculture is the mother of all nations. Research in agriculture domain is aimed towards increase the quality and quantity of the product at less expenditure with more profit. The quality of the agricultural product may be degraded due to plant diseases. These diseases are caused by pathogens viz.., fungi, bacteria and viruses. Therefore, to detect and classify the plant disease in early stage is a significant task. Farmers require constant monitoring of experts which might be prohibitively expensive and time consuming. Depending on the applications, many systems have been proposed to solve or at least to reduce the problems, by making use of image processing and some automatic classification tools.

Al-Bashish et.al, developed K-means-based segmentation and neural networks based classification for plant leaf disease classification [1].The proposed masking technique is a robust technique for the detection of plant leaf diseases. The developed algorithms efficiency can successfully detect and classify the examined diseases [2]. Arivazhagan S, Newlin Shebia R, developed automatically detect the symptoms of diseases as soon as they appear on plant leaves [3]. The automated pixel wise classification used to classify the sugar beet leaf diseases such as k-nearest neighbour and bayes classification technique [4]. The ANN classification is calculated by giving different type of features i.e. size, color, proximity and average centroid distance [5]. The texture features are extracted using Run length Matrix. These extracted features are then used for classification purpose using ANN classifier [6]. Plant leaf images are classified based on two different shape modelling techniques, the first based on the Moments-Invariant (M-I) model and the second on the Centroid-Radii (C-R) model [7]. Phadikar S proposed an automated system has been developed to classify the leaf brown spot and the leaf blast diseases of rice plant based on the morphological changes of the plants caused by the diseases [9]. Sanjeev S Sannakki., et al, in paper titled Diagnosis and Classification of Grape Leaf Diseases Using Neural Networks; proposed Feed forward back propagation neural network was trained for classification [14]. The color feature extraction from RGB color model where the RGB pixel color indices have been extracted from the identified region of interest [15].

Proposed Method

The proposed work involves four modules: Image collection, Feature extraction, diseased plant leaves classification and Performance evaluation.

The below Figure 1 explains the proposed work flow method for the diseased leaf classification. The step by step process is explained below.

1. The diseased leaf images collected from various agricultural fields.
2. Extract the texture and shape feature of diseased leaf.
3. Classification of diseased plant leaves done by following artificial neural networking algorithms.

- Feed forward neural network algorithm
- Learning vector quantization algorithm
- Radial basis function algorithm

4. Performance metrics for diseased plant leaves classification evaluated. There are four performance metrics are calculated to evaluate the performance such as Accuracy, Precision, Recall ratio, F_measure.

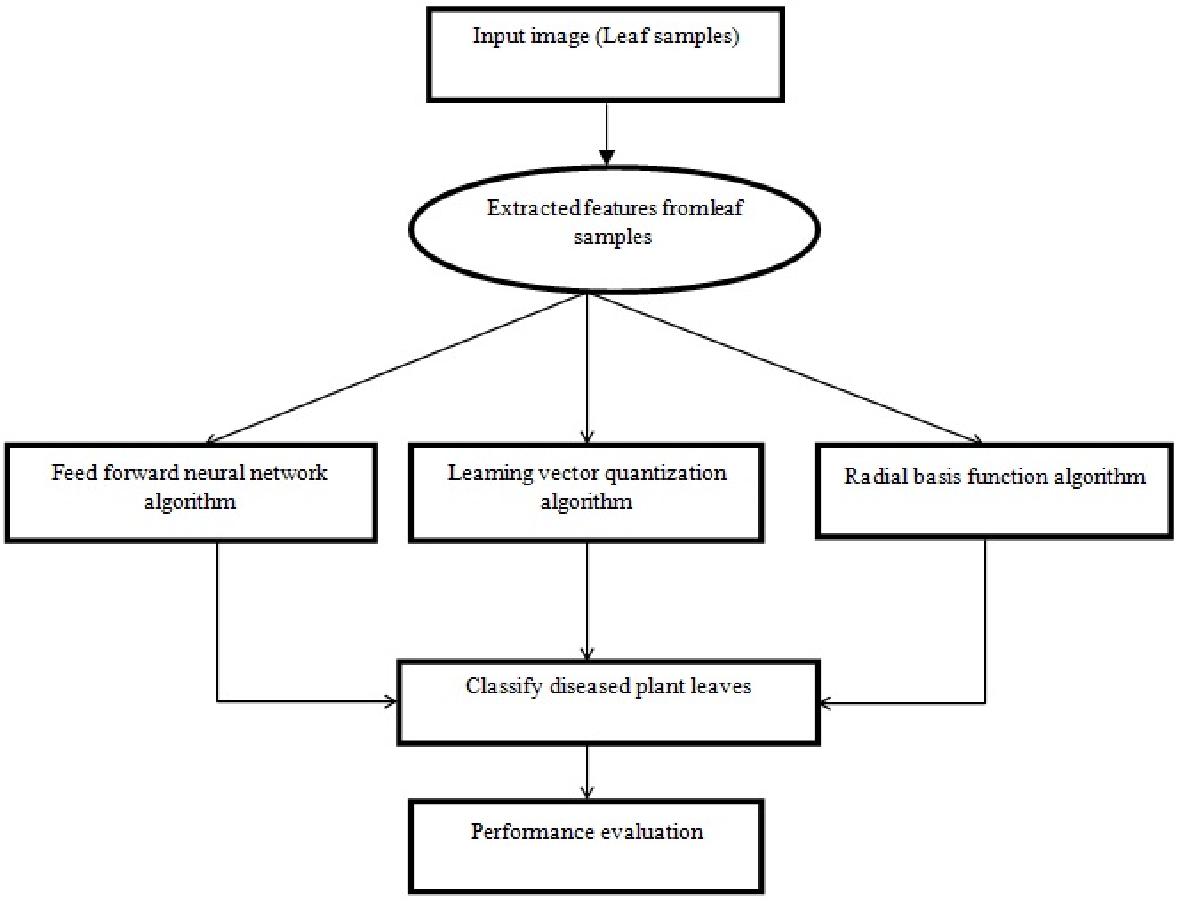

Figure-1. Workflow model for the proposed system.

A. Image collection

The various plant leaf images are collected directly from the agricultural field using digital camera. The white background is set to take the flash of each leaf images for better result. In this two different agricultural plant leaves are considered. (i.e.) Bean leaf and Bitter gourd leaf. The input sample images are shown below

Figure-2. Input Image Samples: a) Bean leaf b) Bitter gourd leaf.

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Feature Extraction

Feature extraction is a superior form of dimensionality reduction. When the input data to an algorithm is too large to be processed and it is suspected to be notoriously redundant then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction.

In this work, we considered 118 diseased leaf samples (Bean leaf- 63, Bitter gourd- 55) are considered. Here various texture and shape features of an image extracted by the following formulas.

$$Energy = \sqrt{\sum_{i,j=0}^{N-1} P_{i,j}^2}$$

$$Contrast = \sum_{i,j=0}^{N-1} P_{i,j}(i-j)^2$$

$$Correlation = \sum_{i,j=0}^{N-1} \left[\frac{(i-m_r)(j-m_c)P_{i,j}}{\sigma_r \sigma_c}\right]$$

$$Homogeneity = \sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+|i-j|}$$

Table-1. Extracted features for bitter gourd leaf.

Features \ Samples	Image 1	Image 2	Image 3	Image 4
Contrast	0.070772	0.06781	0.04272	0.04686
Homogeneity	0.965022	0.96619	0.97986	0.97710
Energy	0.237069	0.26042	0.38959	0.36436
Correlation	0.988418	0.98719	0.98273	0.98377
Area	43015	42081	58344	56846

The extracted feature values of some sample diseased leaf images are given below

Table-2. Extracted Features for Bean Leaf Samples.

Features \ Samples	Image 1	Image 2	Image 3	Image 4
Contrast	0.10602	0.05640	0.05790	0.0839
Homogeneity	0.94999	0.97179	0.97104	0.95849
Energy	0.13919	0.18739	0.20086	0.19052
Correlation	0.9848	0.98772	0.98476	0.97339
Area	38187	43563	43204	39013

Thus the shape and texture features of 118 diseased leaf samples are extracted and given as the input to the classifier.

Image classification

In this proposed method the classification techniques are used to classify the diseased plant leaves. Here artificial neural networking (ANN) technique is used. The ANN classification techniques as Feed forward neural network algorithm (FFNN), Learning vector quantization

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(LVQ) and Radial basis function networks (RBF) techniques are used.

Feed forward neural network algorithm

Artificial neural networks are the very versatile tools and have been widely used to tackle many issues. Feed-forward neural networks (FFNN) is one of the popular structures among artificial neural networks. These efficient networks are widely used to solve complex problems by modelling complex input-output relationships.

Learning vector quantization algorithm

Learning Vector Quantization (LVQ) is a supervised version of vector quantization that can be used when we have labeled input data.

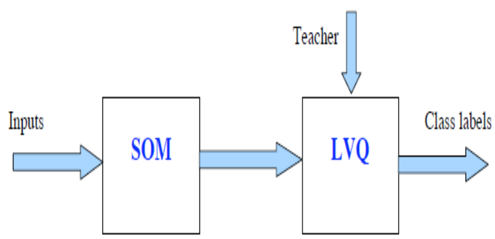

Figure-3. Block diagram for LVQ.

It is a two stage process – a SOM followed by LVQ: This is particularly useful for pattern classification problems.

1. The first step is feature selection – the unsupervised identification of a reasonably small set of features in which the essential information content of the input data is concentrated.

2. The second step is the classification where the feature domains are assigned to individual classes.

Radial basis function networks

A radial basis function (RBF) is a real-valued function whose value depends only on the distance from the origin. The normally used measuring norm is Euclidean distance. RBF's are the network where the activation of hidden units are based on the distance between the input vector and a prototype vector.

RBF training algorithm is a two step process.

1. The centre vectors of the RBF functions in the hidden layer are chosen by k-means clustering.
2. The second step simply fits a linear model with coefficients to the hidden layer's outputs with respect to some objective function.

Performance analysis

To measure the quality of the classified diseased leaf images the performance is analysed by using four parameters, which includes Accuracy (AC), Recall ratio, Precision and F_measure.

Accuracy

The accuracy (AC) is the proportion of the total number of predictions that were correct. It is determined using the equation

$$\text{Accuracy (AC)} = \frac{tp+fp}{tp+tn+fp+fn} \quad (1)$$

Recall ratio

The recall or true positive rate (TP) is the proportion of positive cases that were correctly identified, as calculated using the equation

$$\text{Recall ratio} = \frac{fp}{tn+fp} \quad (2)$$

Precision

Precision (P) is the proportion of the predicted positive cases that were correct, as calculated using the equation

$$\text{Precision (P)} = \frac{fp}{fn+fp} \quad (3)$$

F_measure

The F-measure computes some average of the information retrieval precision and recall metrics.

$$F = \frac{(\beta^2+1)*P*TP}{\beta^2*P*TP} \quad (4)$$

Where,
tp is number of correct classified bean leaves
tn is number of misclassified bean leaves
fp is number of correct classified bitter gourd leaves
fn is number of misclassified bitter gourd leaves

Experimental Results and Analysis

The classification of diseased plant leaves performance of various neural network techniques which have been analyzed for the 118 input leaf images. The performance evaluated for the neural network techniques which have been used in this paper from the confusion matrix of their respective classifier.

The Figure-3 shows the confusion matrix for feed forward neural network classification results for 118 input leaf samples.

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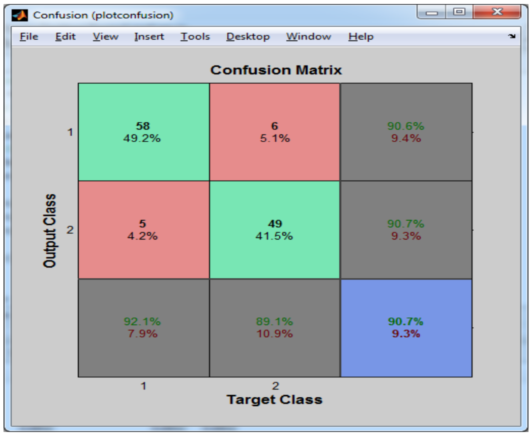

Figure-4. Confusion matrix for FFNN.

From Figure-3, the feed forward neural network classification was explained. Here totally 118 diseased leaf samples are taken. That is 63 bean leaves and 55 bitter gourd samples considered to extract the feature.

In FFNN classification, 58 bean leaf samples are correctly classified and misclassified samples are 5.The correct classification rate for beans samples 92.1%. For bitter gourd, 49 samples are correctly classified out of 55.The correct classification for bitter gourd leaves is 89.1%.The overall system classification rate for the above leaf samples are 90.7% and the error rate of the system is 9.3%.

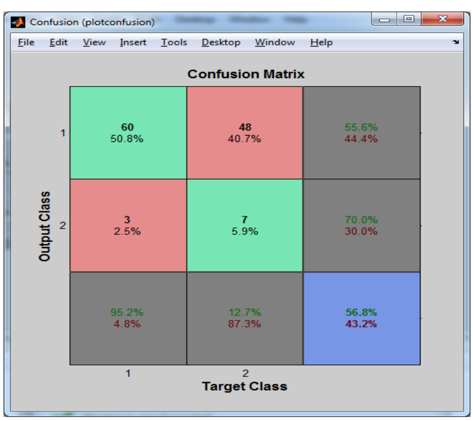

Figure-5. Confusion matrix for LVQ.

From Figure-4, classification of learning vector quantization was explained. In LVQ algorithm, 60 bean leaf samples are correctly classified out of 63 samples. The correct classification rate for beans samples 95.1%. For bitter gourd only 7 samples are correctly classified out of 55.The correct classification for bitter gourd leaves is 12.7%.

The overall system classification rate for the above leaf samples are 56.8.7% and the error rate of the system is 43.2%.

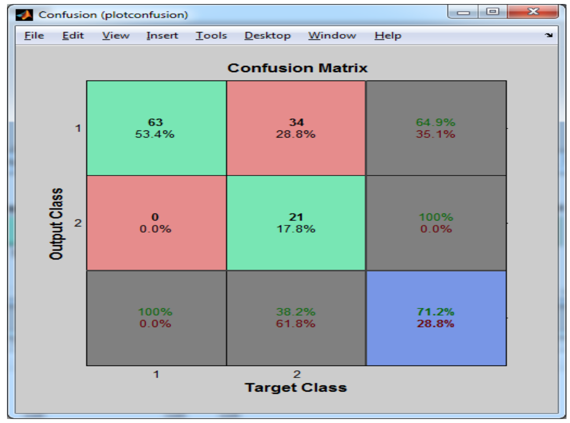

Figure-6. Confusion matrix for RBF.

RBF network correctly classified all diseased bean leaf samples. But in bitter gourd only, 2l leaf samples are correctly classified out of 55. The correct classification rate of bitter gourd leaf samples are 38.2%. The overall system performance of RBF classification is 71.2%.The error rate of RBF classification for the above plant leaf is 28.8%.

The performance evaluation for the above classification techniques using Accuracy, Recall ratio, Precision and F_measure tabulation is given below

Table-3. Performance evaluation for classification.

Methods	Accuracy	Recall	Precision	F_Measure
FFNN	0.9067	0.9365	0.8939	0.9147
LVQ	0.5677	0.9523	0.5555	0.7017
RBF	0.7118	1	0.6494	0.7875

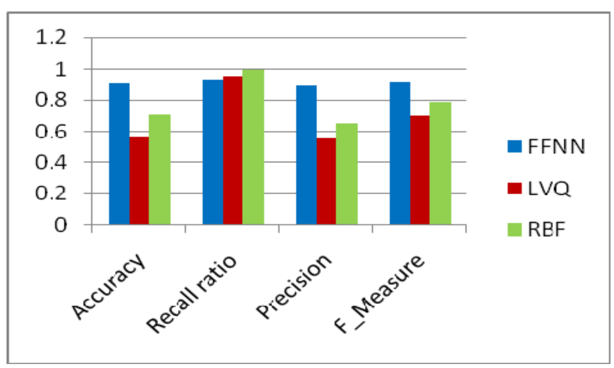

Figure-7. Performance analysis chart for classification.

The Figure-6 performance analysis chart reveals that the accuracy of FFNN is higher than others and also the Precision value and F_measure is higher than other algorithms. This indicates the feed forward neural network classification approach is better based on these three parameters.

CONCLUSIONS AND FUTUREWORK

In this paper the neural network algorithm is proposed for diseased plant leaf classification. The neural network techniques such as feed forward neural network (FFNN), learning vector quantization (LVQ) and radial basis function network (RBF) were tested for two different diseased leaf image classifications such as bean and bitter gourd leaves. The performance is measured using classification parameters such as Accuracy, Precision, Recall ratio and F_measure. With these four parameters the performance is analyzed and based on the analysis the FFNN classification approach provides better result.

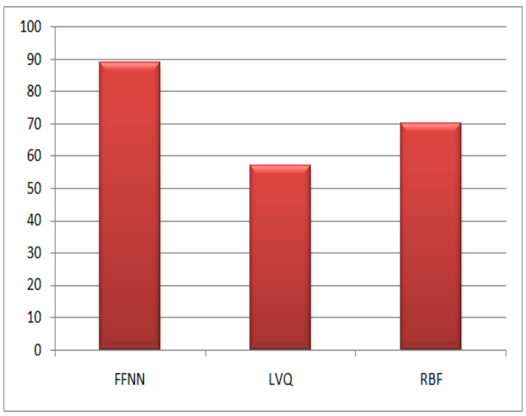

Figure-8. Success rate analysis

The future work of this project will focus on developing hybrid algorithms for achieve better classification result. The color features of leaf image can be taken as the input for better classification result in future.

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