Classification of Diseased Plant Leaves using Feed Forward Neural Network and Learning Vector Quantization Algorithm

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***Abstract*- Agriculture plays important role in human civilization. Research in agriculture domain is aimed towards increase the productivity and food quality at reduced expenditure with increased profit. But due to plant diseases, the quality of the agricultural products may be degraded. Disease in plants, that interrupts its vital functions such as photosynthesis, fertilization etc. To avoid this, the detected spot diseases in leaves are classified based on the diseased leaf types using feed forward neural network and learning vector quantization algorithm by processing the set of shape and texture features from the affected leaf portion. 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 simulation results of classification shows the effectiveness of the proposed system. 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.**

Key words - classification, feed forward neural network, learning vector quantization, performance evaluation, accuracy, precision, recall ratio, F_measure.

I. INTRODUCTION

Agriculture is the mother of all cultures. It plays a vital role in the development of human civilization. But plant leaf diseases can harm the crops and there may be economic loss in crops. Without knowing about the diseases affected in the plant, the farmers are using excessive pesticides for the plant disease treatment. 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[10]. 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 [15]. The color feature extraction from RGB color model where the RGB pixel color indices have been extracted from the identified region of interest [16].

II. *PROPOSED METHOD*

The proposed system includes four modules to classify the diseased plant leaves. The modules are Image collection, Feature extraction, diseased plant leaves classification and Performance evaluation.

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

1. The disease affected leaf images are collected from various agricultural fields.
2. Extract the texture and shape feature from diseased leaf.
3. Classification of diseased plant leaves processed by the following algorithms.
   - Feed forward neural network algorithm
   - Learning vector quantization algorithm
4. Performance metrics for diseased plant leaves classification calculated. There are four performance metrics are calculated to evaluate the performance of the classifier such as Accuracy, Precision, Recall ratio, F_measure.

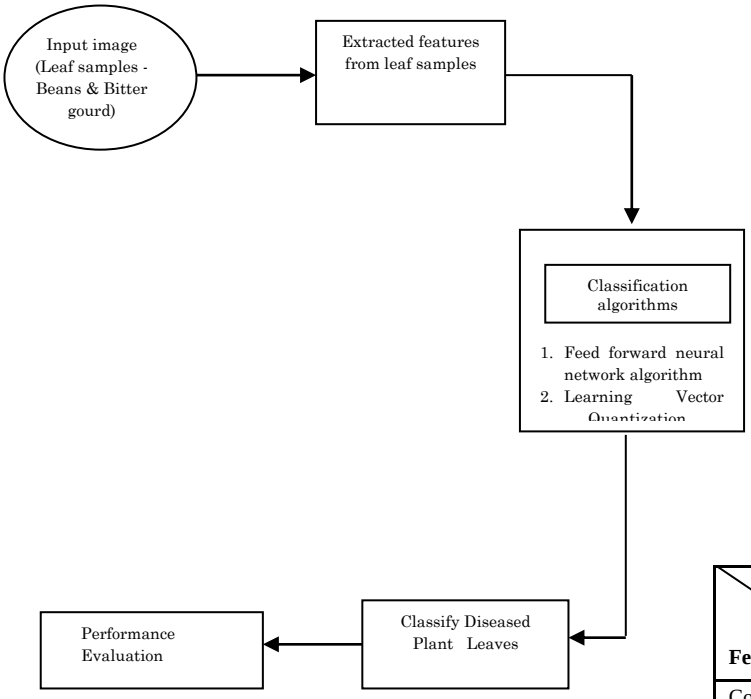

Fig 1. Workflow model for the proposed system

A. Image collection

The various plant leaf images are collected directly from the agricultural field using digital camera (20 Megapixel). The white background is set to take the flash of each leaf images to provide better result. In this two different agricultural plant leaves are considered. (i.e.) Bean and Bitter gourd leaf. The input sample images are shown below

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

B. *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.

The data for this work have been collected from 118 plant leaves (Bean leaf- 63, Bitter gourd- 55) which have symptoms of leaf disease. The data have been standardized so as to be error free in nature. Here various texture and shape features of an image extracted by the following formulas.

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

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

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

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

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

TABLE I. EXTRACTED FEATURES FOR BITTER GOURD LEAF SAMPLES

Samples / Features	Image 1	Image 2	Image 3	Image 4
Contrast	0.05810	0.04209	0.07349	0.04033
Homogeneity	0.97115	0.97905	0.96732	0.98130
Energy	0.21825	0.38706	0.40597	0.52695
Correlation	0.99066	0.98602	0.98225	0.99314
Area	39966	53973	65031	46919

TABLE II. EXTRACTED FEATURES FOR BEAN LEAF SAMPLES

Samples / Features	Image 1	Image 2	Image 3	Image 4
Contrast	0.06643	0.11205	0.09106	0.02866
Homogeneity	0.96739	0.94487	0.95507	0.98566
Energy	0.20725	0.14031	0.15453	0.37750
Correlation	0.98636	0.98330	0.98627	0.98826
Area	48289	16000	40890	47016

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

C. 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 (LVQ) techniques are used.

1) 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.

2) 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.

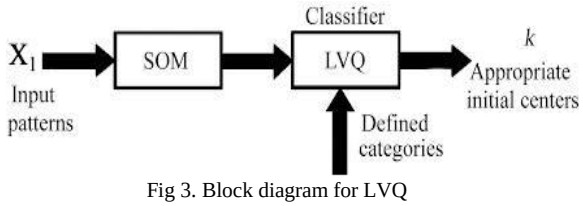

Fig 3. Block diagram for LVQ

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.

D. 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.

1) Accuracy

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

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

2) Recall ratio

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

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

3) Precision

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

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

4) 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

III. EXPERIMENTAL RESULTS AND DISCUSSION

The classification of diseased plant leaves performed by using feed forward neural network and learning vector quantization techniques which have been analyzed for the 118 input leaf images. From the confusion matrix of the respective classifier the performance metrics evaluated.

Here four performance metrics had been calculated to measure the efficiency of the classification results.

(i.e.) Accuracy, Precision, Recall ratio, F_measure.

Figure 3 shows the confusion matrix for feed forward neural network classification for 118 input leaf samples. Here 63 bean and 55 bitter gourd samples are considered to extract the feature.

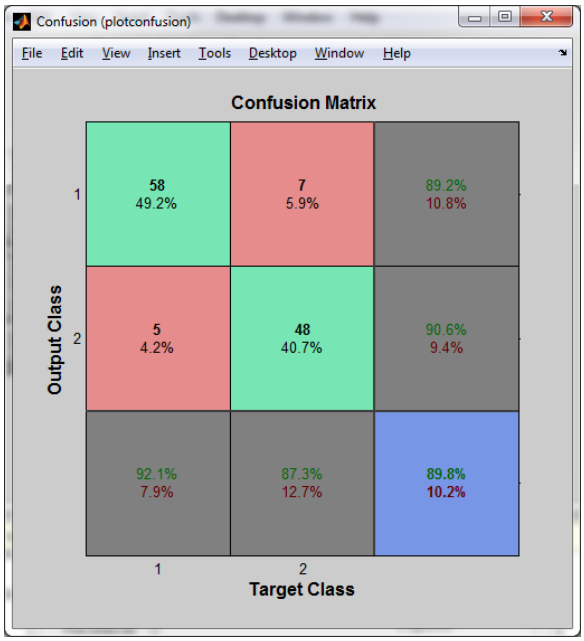

Fig 4. Confusion matrix for FFNN

From the above confusion matrix, 58 bean leaf samples are correctly classified and 5 bean leaf samples are misclassified. The correct classification rate for beans samples 92.1%. For bitter gourd, 48 samples are correctly classified out of 55.The correct classification rate for bitter gourd leaves is 89.1%.

The overall system accuracy for FFNN classification for the above leaf samples are 90.7% and the error rate of the system is 9.3%

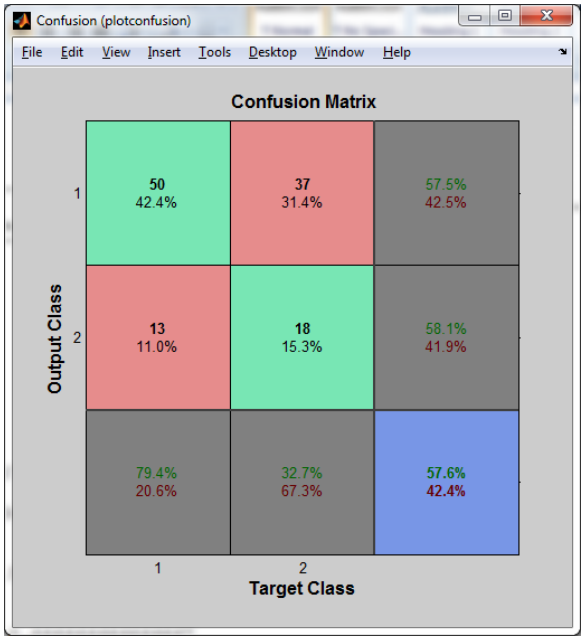

Fig. 5. Confusion matrix for LVQ

From Figure 4, learning vector quantization classification result was explained. From LVQ classification, 50 bean leaf samples are correctly classified out of 63 samples. The correct classification rate for beans samples 79.4%. For bitter gourd only 18 samples are correctly classified out of 55.The correct classification for bitter gourd leaves is 32.7%.

The overall system accuracy for the above learning vector quantization is 57.6% and the error rate of the system is 42.4%.

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

TABLE III. PERFORMANCE EVALUATION FOR CLASSIFICATION

Classifier / Performance metrics	FFNN	LVQ
Accuracy	0.8983	0.5762
Precision	0.8923	0.5747
Recallratio	0.9206	0.7936
F_Measure	0.9062	0.6666

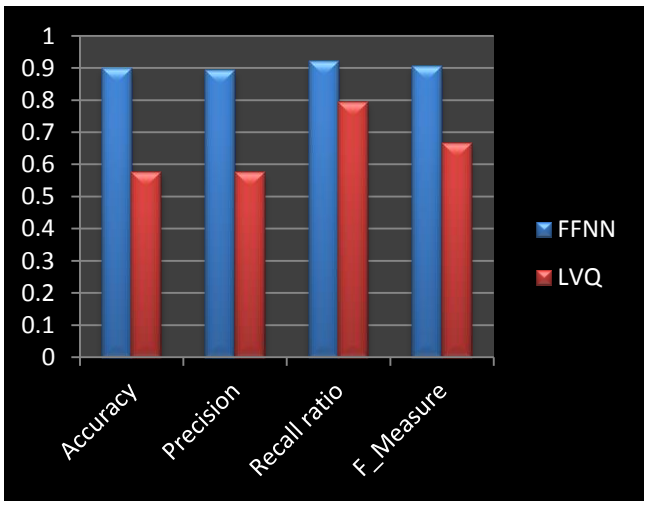

Fig 6. Performance analysis chart for classification

From figure6, the performance analysis chart reveals that the accuracy of FFNN is higher than

Learning Vector Quantization (LVQ). This indicates the feed forward neural network classification approach is better based on these parameters.

IV. CONCLUSION AND FUTUREWORK

In this paper, the neural network techniques such as feed forward neural network (FFNN) and learning vector quantization (LVQ) 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.

The feed forward neural network classification provides better result than learning vector quantization. The feed forward neural network provides 89.8% classification accuracy for bean and bitter gourd diseased leaves classification where as LVQ network provides 57.6% better result.

The future scope of this work will focus on developing hybrid algorithms for achieve better classification result. Genetic algorithm is combined with these neural network classification algorithms for the purpose of weight bias optimization to improve the accuracy of the classification result.

ACKNOWLEDGMENT

We sincerely thank our Principal Dr.K.Ramar and management of Einstein College of Engineering for providing full support and encouragement for preparing this paper.

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