An Automatic Apple Grading System using Levenberg-Marquardt Neural Network (LMNN)

[1]Amitabh Wahi, [2]Karishma Nageshwaran, [3]Pavithra R., [4]Ravi Shankar Mishra,
[5]Sundaramurthy S., [6]Gopalakrishnan B
[1,2,3,5,6] Dept. of IT, [4] Dept. of CSE
BannariAmman Inst. of Tech., Sathyamangalam. Erode District, Tamil Nadu- 638401

Abstract:

In computer vision grading of fruits is a complex problem. The farming community gets a better price of the agriculture produce based on the grading of the products. The image processing and artificial neural networks play an important role in recognizing the different types of fruits and grading of same fruits among its subsets. In the proposed work, two different classes of apples are segregated into respective categories. The shape based features were extracted from the two classes of the apples. The features were presented to the artificial neural networks to classify the apples into respective categories. The two different neural networks based classifiers: Levenberg-Marquardt neural Network (LMNN) and Back Propagation neural network (BPNN) were selected for the purpose. The neural classifiers were trained on the training dataset of the apples. After successful training of the networks, its performances were measured on the test data set and the results of two classifiers were compared. It is found that LM based neural network performance was better than the BPNN in terms of classification accuracy and speed.

Keywords: Two class problems, Feature extraction, artificial neural classifiers, Classifications, LMNN , BPNN

Introduction:

The recognition of apples of different shapes using image processing and artificial neural networks comes under the category of non-destructive inspection method which promotes agricultural quality produce for the users. The authors in [1] developed an automatic system to classify cooked fork ham by application of image processing and artificial neural network. They obtained about 86.1% of classification rate. The authors [2] have proposed a fruit classification system using color – based, shape - based and size - based and achieved best classification results. The researchers applied moment features to recognize 3D objects by using back propagation neural network and object better classification rate compared to other methods [3]. In [4] a low cost fruit harvesting system was developed using image processing technique. The researchers have developed a novel method to recognize mature fruit and locate cluster positions for greenhouse automatic harvest applications [5].

Methodology:

The colored images of apples were taken from the dataset named Fruits 360 from Kaggle [6]. The grayscale images were obtained from the colored images of the apples. The images were resized into 128 x 128. The grayscale images of the apples were enhanced to get better pictorial representation by Gamma correction method. The features were extracted from the samples.

Each feature vector were stored in a [1xN] where N is the total number of columns in the matrix. The features were normalized by min-max normalization method such that each feature vector component will be in the range of [0,1]. The feature date set is divided into two groups - training and testing data sets. The artificial neural networks were trained on the training data sets. The trained network was presented with the test data set to evaluate the performance of the neural classifiers.A simple diagram of two hidden layers artificial neural network is shown in Fig 1. The complete process of the automatic apples classification system is given below in Fig.2.

Sample Collection:

Two different neural networks – based classifiers were applied to detect defects on the surface of apples. The colored images of apples were taken from the dataset named Fruits 360 from Kaggle [6]. The images of the apples were depicted in the Fig1 (a) and (b). The grayscale images were obtained from the colored images using conversion algorithm. The grayscale images were of large size. Hence, sample images were resized into small size as 128 x 128.

Classification of Apples:

Supervised neural classifiers are used to identify the apples in a fast and real-time method. The objective of classification is to sort out all pixels in a digital image into one of several classes. By adopting the method of supervised classification, we identify samples of the classes containing different pixels. There are various methods for this purpose [7-8]. Two class recognition in apples is one of the identified cases which can become a classification problem. Based on the shape of the apple classification accuracy was achieved by the neural networks.

Fig1.(a): Class 1- Apple Crimson Snow

Fig 1(b): Class 2- Apple Pink Lady

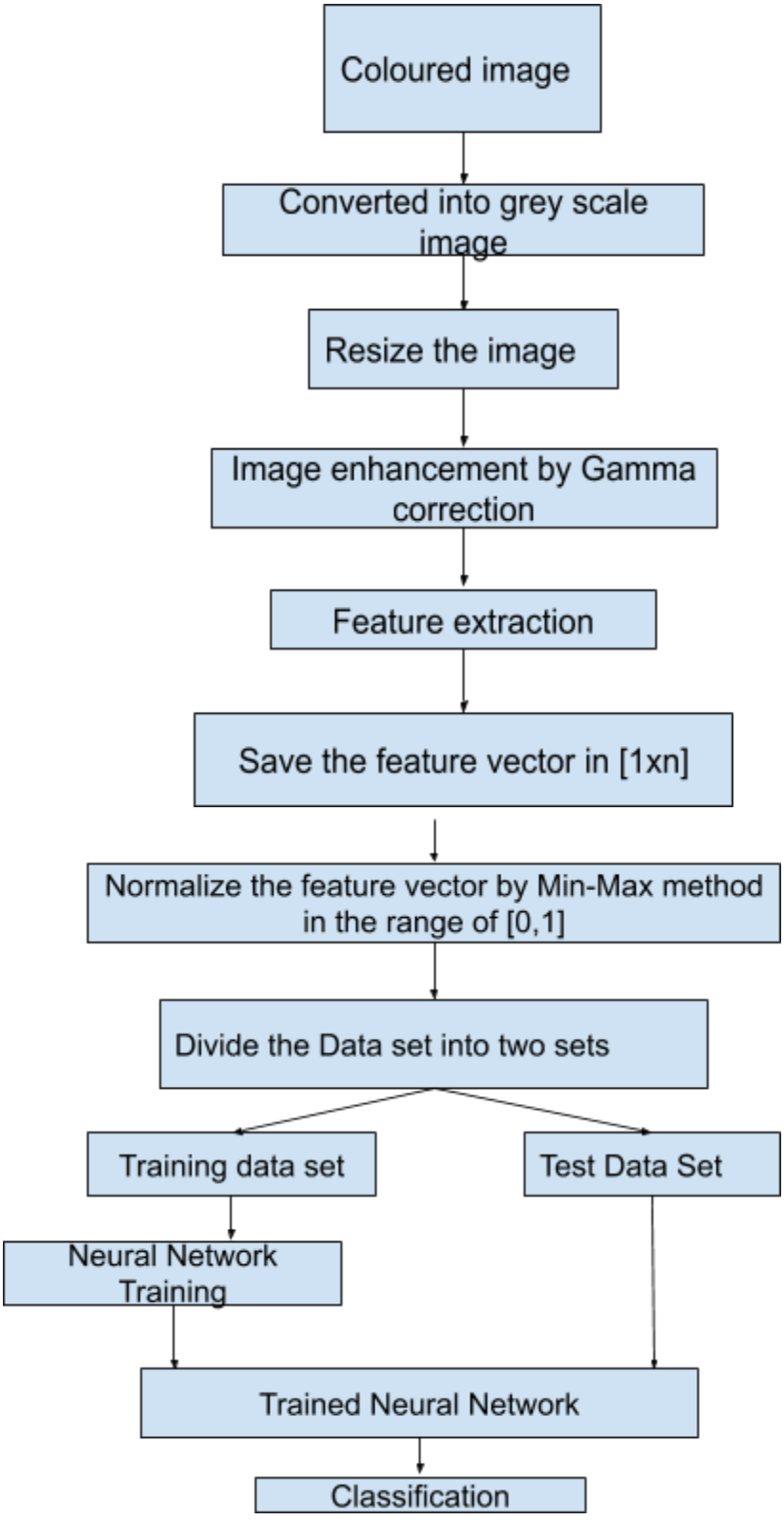

Fig 2.The complete diagram of the process

Feature Extraction: The type of feature extraction methods from the given apple images play a significant role in the classification process. Moment methods [9] were applied to extract the features from the images of the apples. The features from one apple was stored in [1 x N] where N is the number of columns in the matrix. Min-max method was applied to normalize the feature data in between [0,1]. The same process was followed for all the images of two classes of apples. The feature database was created for the two different shapes of the apples. Total number of 6 moment features were extracted from each sample. The moment features are given below from [9].

$M00$= zero order moment = $\sum \sum (x, y)\, x\, y$

$M10$ = first order moment X = $\sum \sum (x, y)\, x\, y$

$M01$ = first order moment Y = $\sum \sum (x, y)\, x\, y$

$M20$ = Second order moment X= F= $\sum \sum x\, 2\, (x, y)\, x\, y$

$M02$ = Second order moment Y = $\sum \sum y\, 2\, (x, y)\, x\, y$

$M11$= First order moment XY = $\sum \sum (x, y)\, x\, y$

Where I(x,y) is the intensity value of each grey level pixel. x and y are coordinates of that pixel.

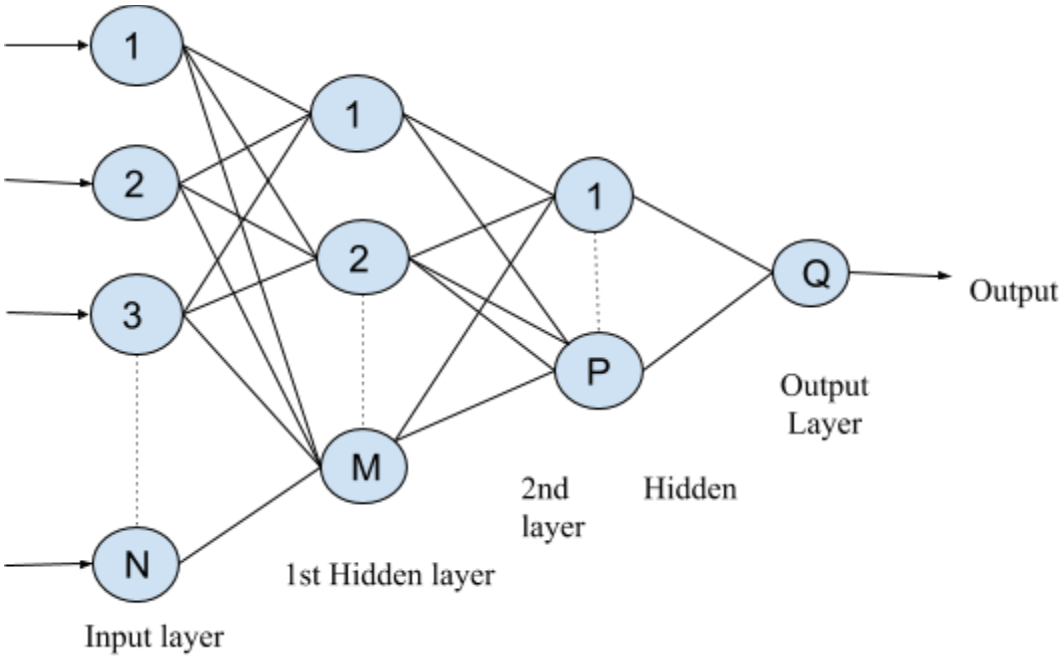

Fig 3: A basic diagram of supervised feed forward neural networks.

Experiments:

The apples single images were collected from [6]. The code was developed and executed in Matlab [10]. Two classes were downloaded from the [1]. Class 1 was Apple Crimson Snow and Class 2 was Apple Pink Lady. Class 1 and 2 had 122 images. 50% of each class was split into training and testing datasets. The images were converted into grayscale images. By applying the Gamma correction each image was enhanced to get more clarity of the objects in the images. The features were extracted by applying moments as represented in [2]. Two different neural networks based on back propagation algorithm: Perceptron and LM were considered for the classification purpose. The neural networks have two hidden layers and one output layer. The non-linear neurons were considered for the computation in the hidden layer and output layer. The number of neurons in the input layer and output layer were fixed and the number of neurons in hidden layer 1 and 2 were varied in each experiment until the best classification results were obtained. The feature data set was divided into two sets: the training set and the testing set. In the training set the data which is not present in the training set were presented to the networks for classification purpose. A large number of experiments were conducted to get outputs. The five best classification results on the same set of hidden neurons were gathered and reported here. Sixty percent of the data set was used for training and the forty percent of the data set was kept for testing. The Results obtained are shown in Fig 4 and 5.

Table 1: Two neural classifiers performance comparison on apple images dataset

Type of ANN	Network Architecture	Training Timing in Sec	Test Results	% Classification
Gradient based ANN	24:15:10:2	17	56	95.08%
LM based ANN	24:11:7:2	15	58	96.69%

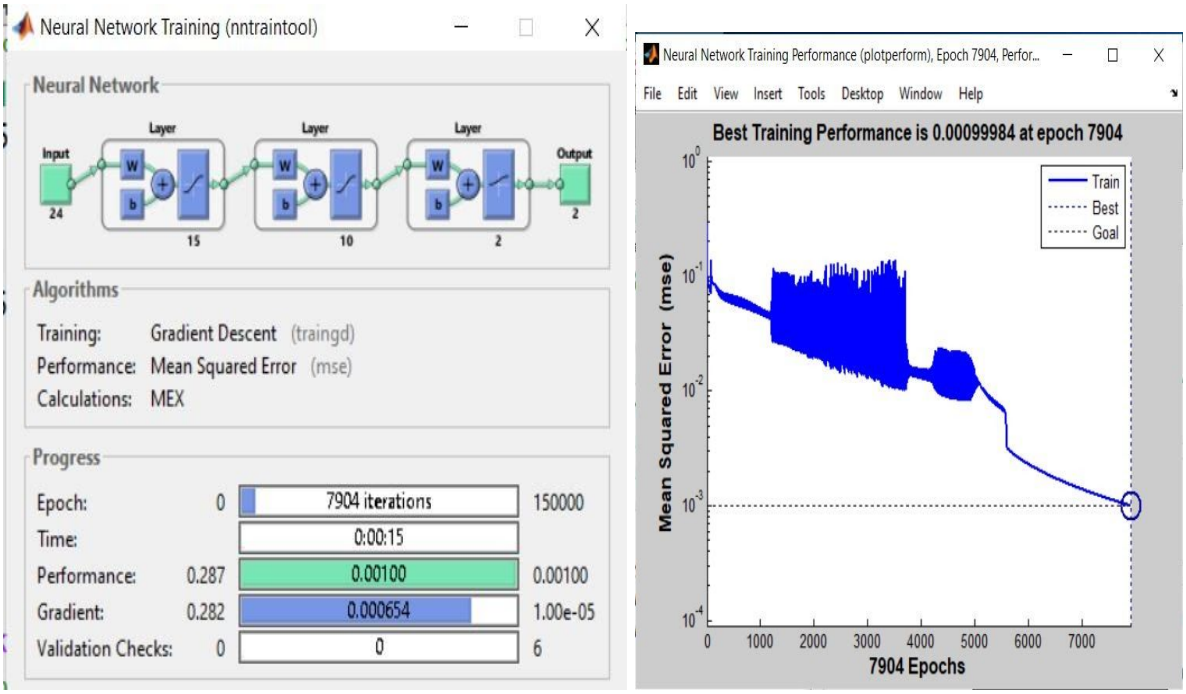

Fig 4(a)-(b): Results obtained using test data on LMNN

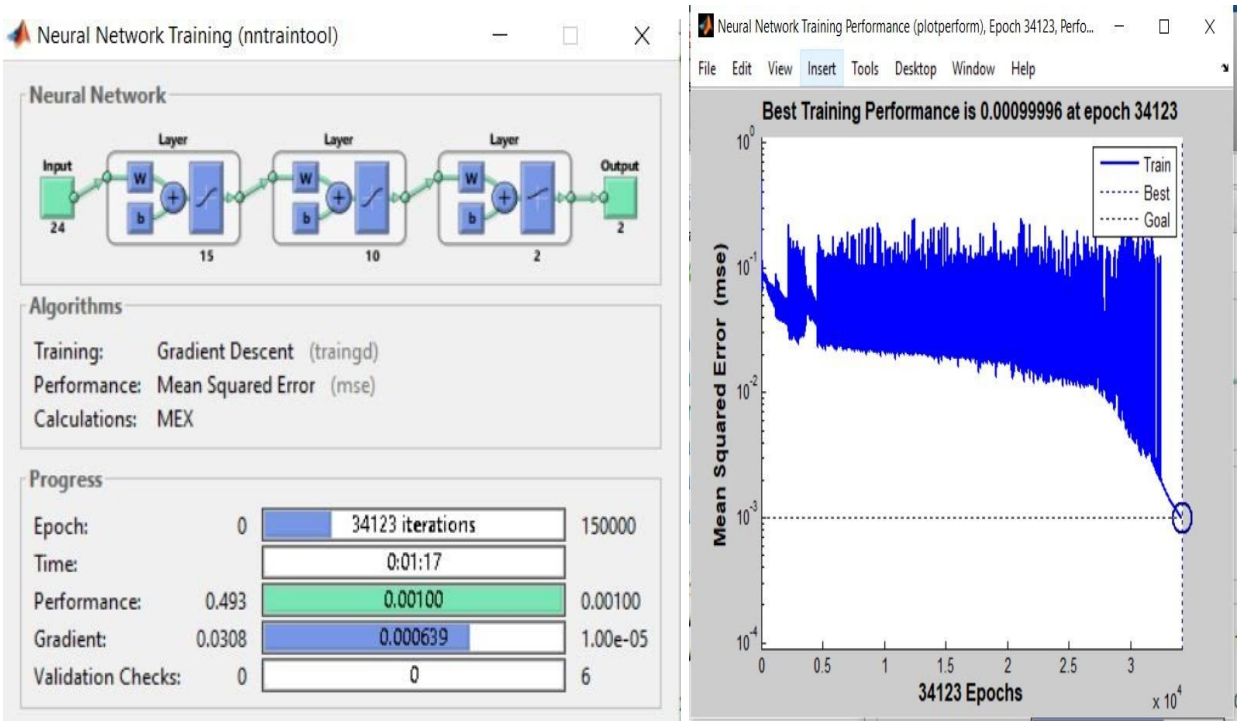

Fig 5(a)-(b): Results obtained using test data on BPNN

Conclusion:

The results revealed that image processing and techniques can be synergized to produce sorting of apple fruits at high speed and accuracy. In our case, feature extraction using moments of the shape produces better performance of the apples. Two different neural network approaches were introduced. BPNN and LMNN performances were measured after the successful training of the classifiers. It is found that LMNN performance is better than BPNN as shown in Table 1. Also LMNN takes less training time than BPNN. A single classifier architecture based on LMNN provides a better solution for classification compared to BPNN. In future work, a large database of other fruits may be used for training and testing to assess the accuracy of the result obtained from LMNN.

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