Neural network based Numerical digits Recognization using NNT in Matlab

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ABSTRACT

Artificial neural networks are models inspired by human nervous system that is capable of learning. One of the important applications of artificial neural network is character Recognition. Character Recognition finds its application in number of areas, such as banking, security products, hospitals, in robotics also. This paper is based on a system that recognizes a english numeral, given by the user, which is already trained on the features of the numbers to be recognized using NNT (Neural network toolbox) .The system has a neural network as its core, which is first trained on a database. The training of the neural network extracts the features of the English numbers and stores in the database. The next phase of the system is to recognize the number given by the user. The features of the number given by the user are extracted and compared with the feature database and the recognized number is displayed.

KEYWORDS

Steepest Descent algorithm, Back propagation network, Artificial neural network, Feature extraction, Least mean square

1. INTRODUCTION

The handwriting recognition refers to the identification of written characters. Handwriting recognition has been become a very important and useful research area in recent years for the ease of access of many applications. Numerous approaches have been proposed for character recognition and considerable success has been reported [1]. Numeral recognition refers to the process of translating images of handwritten, typewritten, or printed digits into a format understood by the user for the purpose of editing, indexing, searching and reduction in storage size .Number recognition can be online or offline. In online number recognition, data are captured during the writing process with the help of special pen and an electronic interface. Offline documents are scanned images of prewritten text, generally on sheet or paper [2]. Offline number recognition is significantly different from online number recognition, because here, stoke information is not available [3, 4]. In this paper, we work with offline numerals. In this paper artificial neural network is used for recognition of numerals. Back propagation network is used for training of artificial neural network. The learning rule used here is Steepest Descent algorithm with adaptive learning capabilities.

1.1. STEEPEST DESCENT ALGORITHM

Steepest Descent algorithm calculates the gradient of function. Gradient means change of error energy with respect to weight value. This algorithm is used to calculate the error. Training in neural networks involves finding the minimum of a complicated non linear function (called error

function).This algorithm describes the error that a neural networks makes in approximating or classifying the training data. The error that mainly occurs in training of network is mean square error (mse). Mse is a network performance function. It measures the network performance according to mean of squared errors.

1.2. ARTIFICAL NEURAL NETWORK

Artificial neural networks have been developed as generalizations of mathematical models of biological nervous systems. A first wave of interest in neural networks emerged after the introduction of simplified neurons by McCulloch and Pitts (1943). The basic processing elements of neural networks are called artificial neurons [5] or simply neurons or nodes. In a simple mathematical model of neuron, the effects of the synapses are represented by connection weights that modulate the effect of associated input signals and the non linear characteristics exhibited by the neurons that are represented by transfer function [6]. The neuron impulse function is calculated as the weighted sum of input signals, with the help of the transfer function. The Learning capability of artificial neurons is achieved by adjusting the weights in accordance with chosen learning algorithm. The artificial neural network can be trained into two main groups that are supervised and unsupervised learning. In supervised learning, the network learns by example with help of some training algorithm and a target value is set, whereas in unsupervised learning, no target value is set or no example is given. Unsupervised learning is very complex and difficult to implement [7].

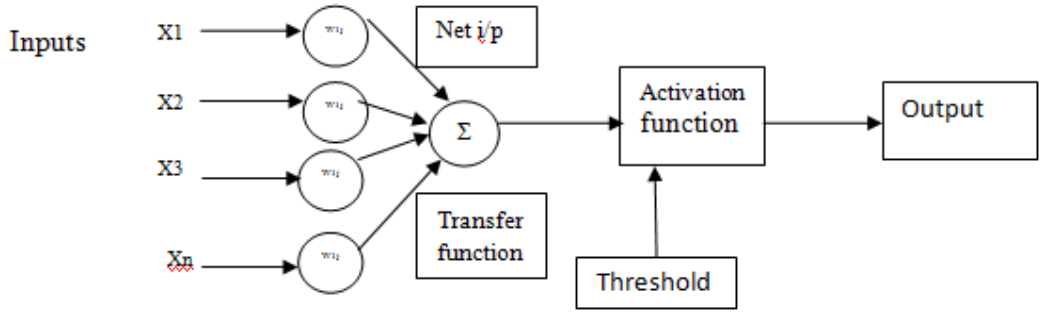


Figure 1.shows artificial neural network

1.3. BACK PROPAGATION NETWORK

Back propagation, an abbreviation for 'backward propagation of errors', is a method used for training of artificial neural network. From the desired or actual output, the network learns from number of inputs, similar to the way a child learns to identify a car from group of toys. It is supervised learning method. It requires a dataset of desired output from set of many inputs, making up the training set. A back propagation network consists of three layers of units- input layer, hidden layer and output layer as shown in figure 2. These units are connected in feed forward manner with input units fully connected with units in hidden layer and units in hidden layer fully connected with units in output layer. When back propagation network is cycled, an input pattern is propagated forward to the output units through input to hidden and hidden to output weights. Back propagation is an iterative process that starts with last layer and moves backward through the layers until the first layer is reached. This algorithm is based upon Widrow hoff delta learning rule in which the weight adjustment is done through mean square error of output response to sample input. The rest of these sample patters are repeatedly presented to the

network until the error value is minimised. Weights are adjusted according to the error present in the network.

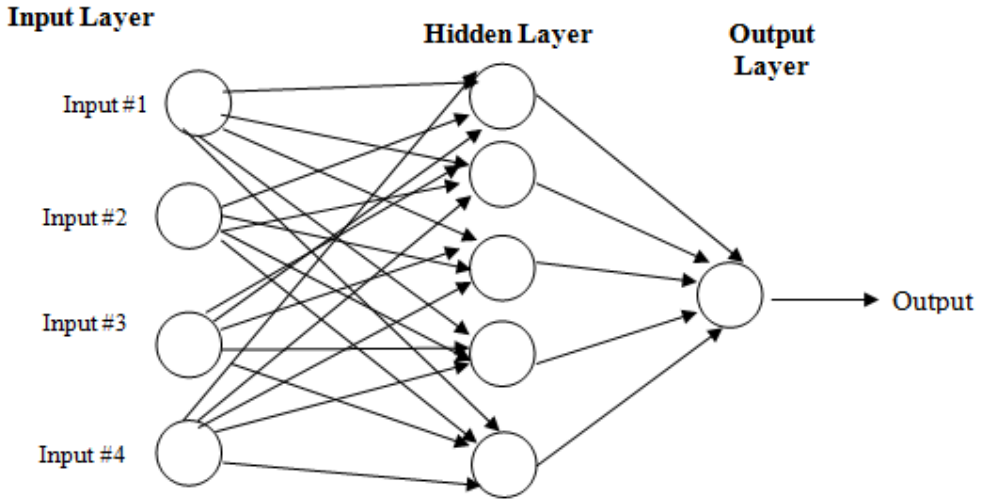


Figure 2. shows Back Propagation Network

2. ADAPTIVE LEARNING RATE

The back propagation algorithms are basically of two types, gradient descent and gradient descent with momentum. With standard steepest descent, the learning rate is held constant throughout training. The performance of this algorithm is dependent on the proper setting of learning rate. If the learning rate is set too high, the algorithm can starts oscillate and becomes unstable. If learning rate is kept small, algorithm takes long time to converge. The performance of steepest learning can be improve if learning rate is allowed to change during training process. An adaptive learning rate has an advantage of keeping the learning step size as large as possible while keeping learning process stable. The learning rate is made sensitive to the complexity of mean square error. This process can increase the learning rate, but up to the extent that the network can learn without having large number of errors.

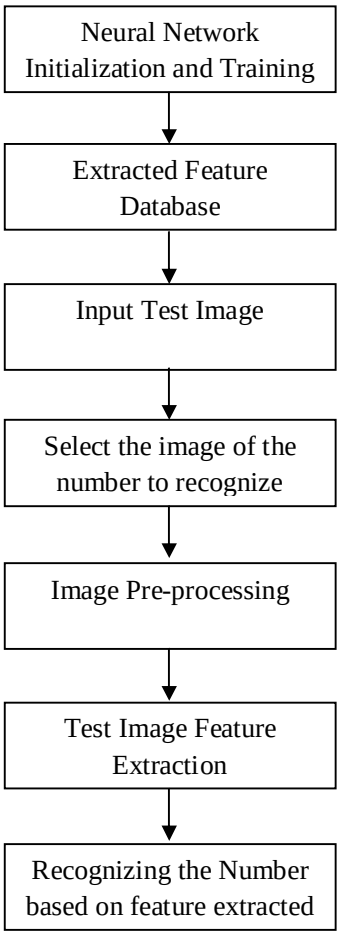
One of the most popular algorithms in adaptive learning is least mean square (LMS) algorithm of Widrow and Hoff. The LMS algorithm has been used here because of its robustness and simplicity. Key parameter in this algorithm is step size. If the step size is made larger, the rate of convergence of LMS algorithm is fast but on the other side, mean square error is increased. But, if the step size is made smaller, the convergence rate of LMS algorithm is slow. Thus step size provides a trade off between convergence rate and MSE. An intuitive way to improve the performance of LMS algorithm is to make the step size variable rather than fixed, choose large step size values during the initial convergence and use small step size values when the system is close to its steady state , which results in variable step size (adaptive learning rate) LMS algorithms. By using such approach both fast convergences rate and least MSE can be obtained. In the VSSLMS algorithm, the step size μ is replaced with variable parameter μ(n) and coefficient vector w(n) is updated as:

$$w(n+1) = w(n) + \mu(n)\, e(n)\, x(n)$$

Where e(n) is error and x(n) is input to network.

3. METHODOLOGY USED

This paper recognizes the English numerals given as an image to the system automatically using the intelligence of the two layered neural network. The neural network applied in the system utilizes the Steepest Descent Algorithm with Adaptive Learning Rate as the learning rule, which is used for the training of the neural network. The basic flow of the system is shown as below:



The methodology used here can be explained as:

3.1. Neural Network Initialization and Training

In the Ist step, neural network is initialised and trained with the help of back propagation network. Once the network has been initialised, the network is ready to train. Some issues that need to address upon training the network are: What should be the values of- learning rate, sigmoid shape, gradient, weight bias and how many values of Iterations (Epochs) are to be taken for the training of network for given set of inputs. Here the network learns what we have taught to it.

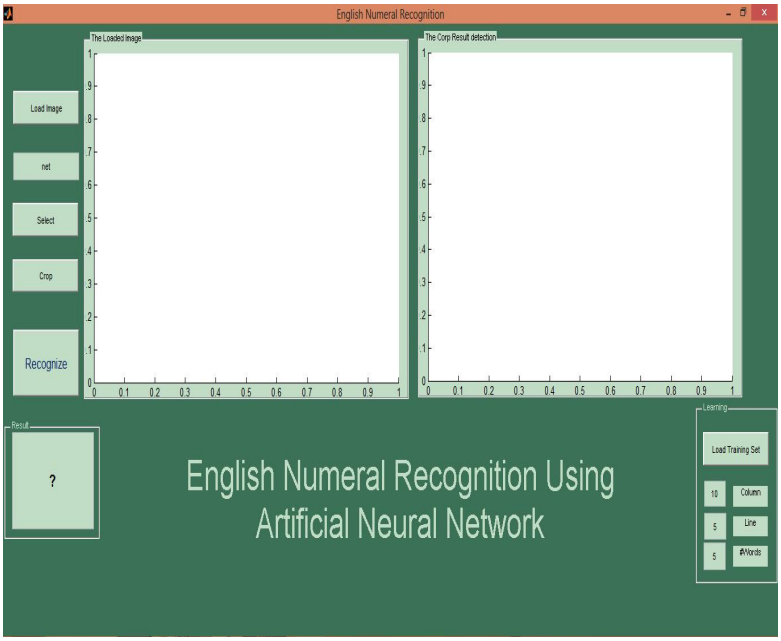


Figure 3.shows NN toolbox for English numeral recognition

Neural network is trained as shown in fig.4. Here we have set 5000 iterations for the network to train. Following figure.5 shows that our performance goal is met with only 313 iterations out of 5000 iterations. Other parameters of network are also displayed. Time taken for training of network is displayed as 0:05:26 as well as performance and gradient are also displayed here.

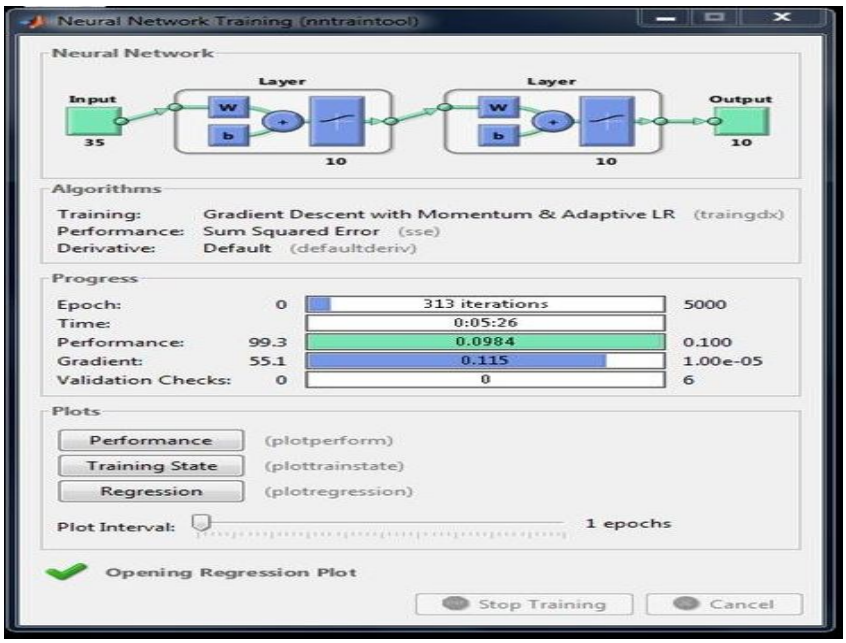


Figure 4.shows training of ANN

3.2. Feature Extraction

Feature Extraction is used to extract relevant features for recognition of characters. First features are computed and extracted and then most relevant features are selected to construct feature vector which is used for recognition. The computation of features is based on statistical, structural, directional, moment, transformation like approaches. Feature extraction is extracting information from raw data which is more relevant for classification purpose and that minimises the variation within a class and maximizes the variations between classes[8].

3.3. Input Test Image

Input the image which is to be tested. Input images maybe any numerals between 0 to 9. It may be 0,1,2,3,4,5,6,7,8,9 as well as combination of two or three numbers. The arrow indicates to load image by which image can be loaded into the system. Here we take an image of 5*7 matrixes which is displayed in fig.6.

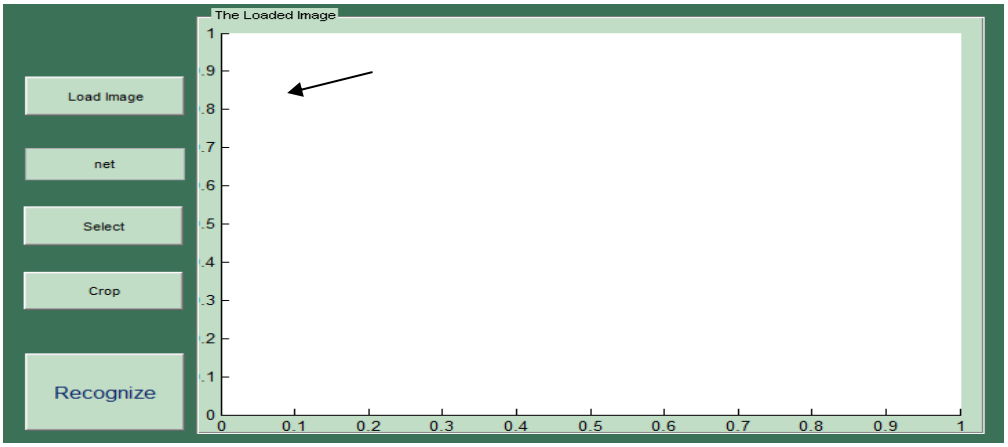


Figure.5 shows Ist step of loading of image in ANN

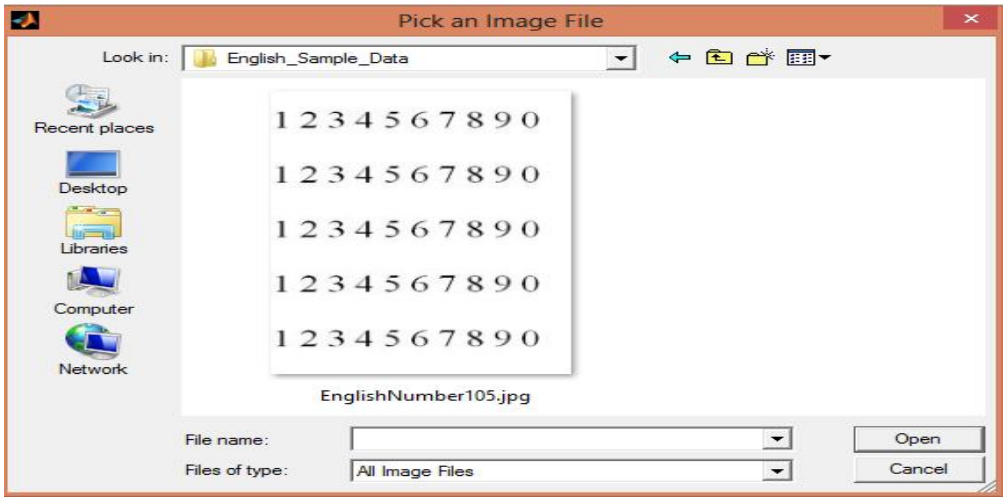


Figure.6 shows 2nd step of loading image in ANN

3.4. Image Pre-Processing

Raw image may carry some unwanted noise. In Pre-processing stage, we basically remove the unwanted noise and distortion of image. In Image pre processing, the input image is first converted into gray scale image and then to binary image. This process is called digitization of image. The scanned image has some noise, the noise is due to some unnecessary details present in the image. Image Pre processing is used for skeletonization (thinning) and noise reduction or removal .Skeletonization is necessary here as it decreases the line width of text from many pixels to single pixel. Noise removal is necessary as it remove unwanted details which do not play any important role. Image dilation and filling of holes are performed to produce the pre processed image suitable for segmentation [9]. In segmentation stage, an image consisting of sequence of characters is decomposed into sub images of individual character [10].In Segmentation, the position of the object that is the number in the image is find out and size of number is cropped as shown in figure.7.

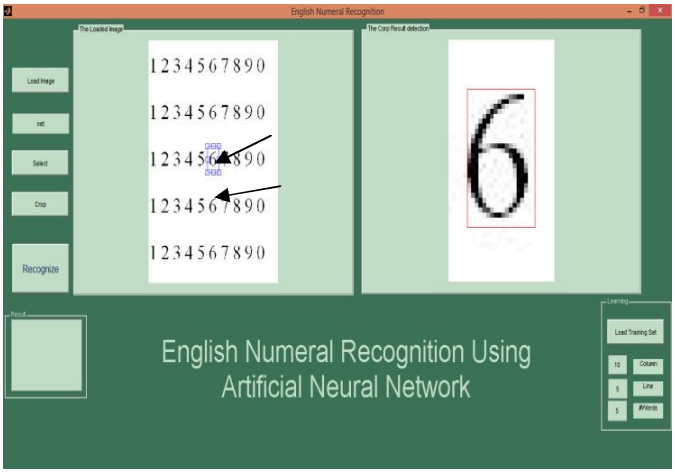


Figure.7 shows pre processing of image

3.5. Test image feature extraction

The image from the segmented stage is matched with all the number which is preload into the system. In this step, the nearest match of the stored and input number is finding out. Once, the matching is completed the number with maximum matching is declared as the number present in the image.

3.6. Recognizing the number

This is the final stage .Here the recognized number is displayed as shown: The number that is highlighted in blue is selected and is recognized. In figure 8, a single number '6' is selected and is displayed as shown. In figure 9, two numbers '67' is selected and is displayed as 67 shown in figure.9.

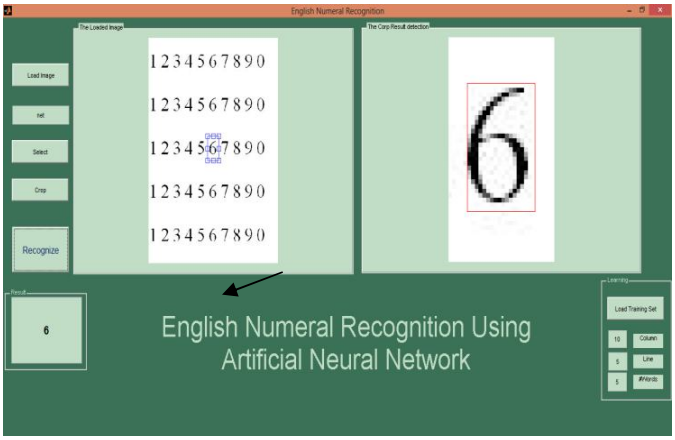


Figure.8 shows recognition of numeral '6'

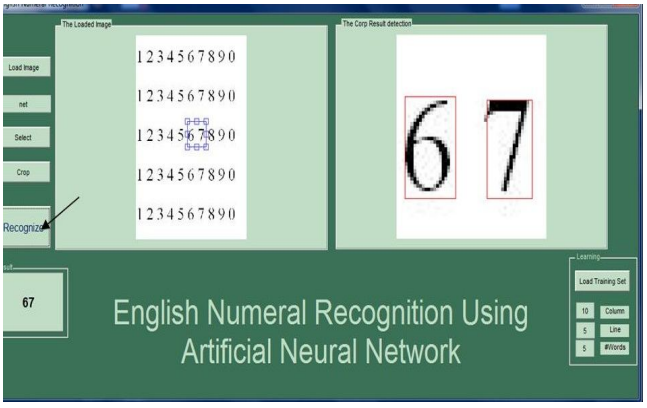
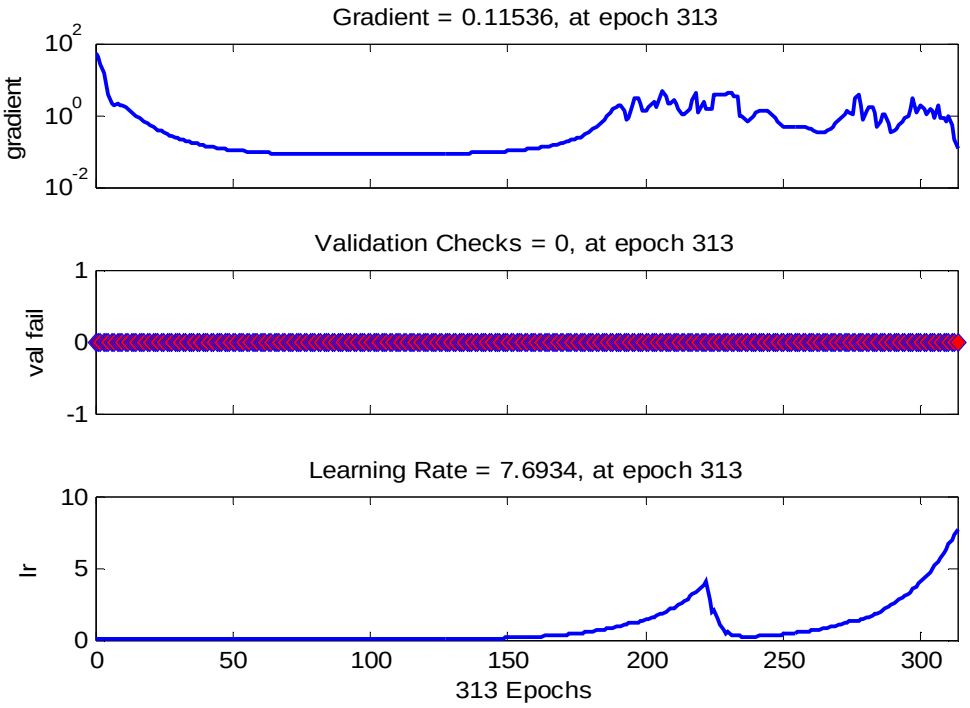
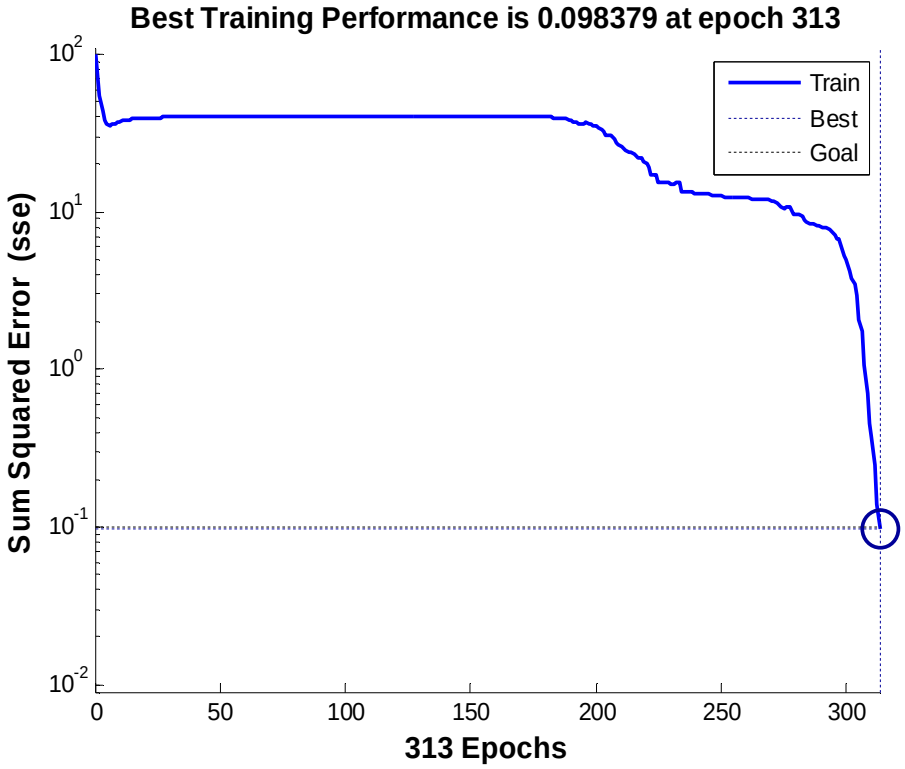


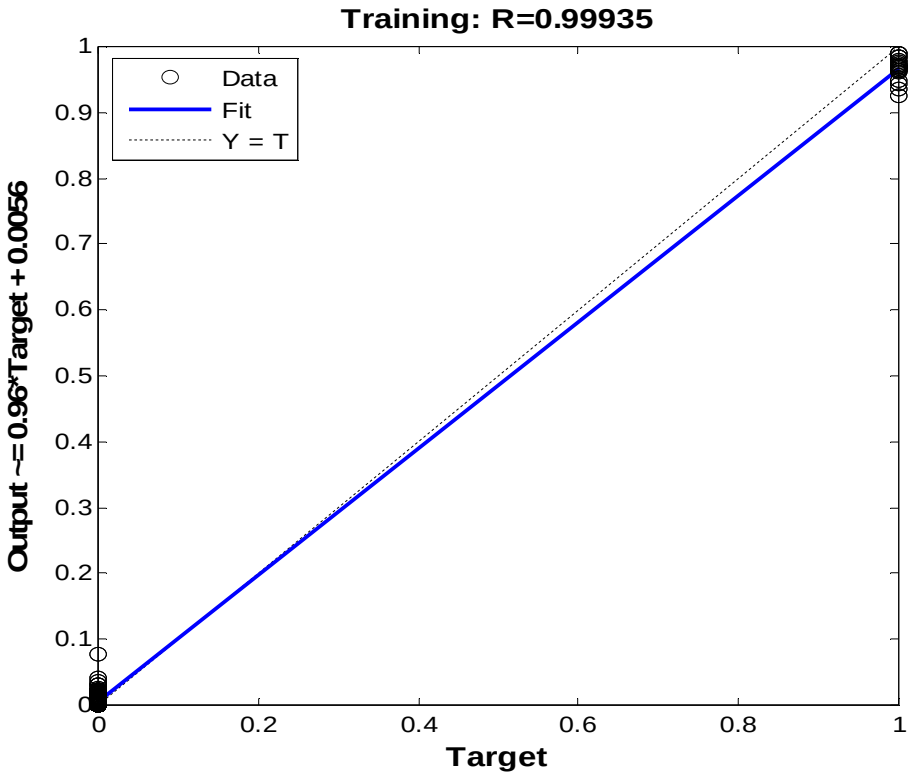
Figure.9 shows recognition of numeral '67'

4. PERFORMANCE PARAMETERS

The performance parameters show the accuracy of the system in terms of its parameters like gradient, validation, learning rate and training.


Gradient = 0.11536, at epoch 313
gradient
Validation Checks = 0, at epoch 313
val fail
Learning Rate = 7.6934, at epoch 313
lr
313 Epochs


Best Training Performance is 0.098379 at epoch 313
Train
Best
Goal
Sum Squared Error (sse)
313 Epochs



5. CONCLUSION AND FUTURE SCOPE

The application of neural network in character recognition has been a field of study recently. Neural networks are used to solve the tasks which are difficult for conventional computers or human beings to solve. This paper aims at recognition of English numeral recognition using gradient descent based back propagation training algorithm. The main aim of using this algorithm is to reduce the error which is difference between the computed value of neural network and desired value. By using artificial neural network methodology of English numeral recognition, 99% accuracy is achieved. The method used in this paper can be further extended to recognize multilingual characters.

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