Performance Analysis of Handwritten Marathi Character Recognition with RBF, Cascade, Elman and Feed Forward Neural Networks

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Abstract- Character recognition of handwritten Marathi curve scripts is one of the most challenging areas of research in neural networks due to high variability in writing styles. Marathi characters have shirolekhas and spines. This seriously affects many of the performance recognition parameters and much more.In this paper, we are performing the performance analysis of RBF neural network, Cascade Neural network, Elman Neural network and Feed forward neural network for the character recognition of handwritten Marathi curve scripts. For the experiment, we have taken in to account the six samples each of 48 Marathi characters. For every sampled character, the 'Edge detection and dilation method of Feature extraction'with a set of image pre-processing operations have been performed. Here to study and analyze the performance of these four neural networks, firstly we have created the network, trained the network, simulated the network and plotted the regression plots. It has been analyzed that RBF neural networks has a high regression value as compared to the rest of the methods for the training set.

Keywords- *RBF neural network; Cascade neural network; Elman neural network; feed forward network; Pattern Recognition.*

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I. INTRODUCTION

An Artificial Neural Network (ANN) is information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information [1]. The key element of this paradigm is the novel structure of the information processing system. ANN models can detect patterns that relate input variables to their corresponding outputs in complex biological systems for prediction[2].The neural network consists of an input layer of nodes, one or more hidden layers and an output layer.

It has been investigated widely that the ANN has been used for pattern recognition. It has been also found that ANN is successfully applied for the pattern recognition of handwritten characters.Handwritten Devnagari Characters are more complex for recognition than corresponding English characters due to many possible variations in number, order, direction and Shape as well as writing style of the constituent strokes [3].

Kauleshwar Prasad, Devvrat C. Nigam, AshmikaLakhotiya and DheerenUmre [12] haveconverted the character image into a binary image, and then applied character extraction algorithm in which it has empty traverse list initially. A row is scanned pixel by pixel and on getting black pixel, it is checked if it is already in the traverse list. It is checked that if it is already there then it is ignored, otherwise added to the traverse list using edge detection algorithm. They have claimed to have good results by using feed-forward Back propagation neural network and also stated that poorly chosen feature extraction method gives poor results.

Ankit Sharma and Dipti R Chaudhary [13] have achieved the accuracy of 85%, using feed forward neural network. The special form of Reduction is used which includes the noise removal and edge detection for the feature extraction of gray scale images.

NilayKarade et al. [14] have come to the conclusion that the generalized neural network trained with radial basis function approximation for the second method of feature extraction yields the highest rate of recognition i.e. 85% for randomly chosen 10 lower case and 10 uppercase characters.

The feed forward neural network consists of an input layer of units, one or more hidden layers, and an output layer. Each node in the layer has one corresponding node in the next layer, thus creating the stacking effect. The input layer's nodes have output functions that deliver data to the first hidden layer nodes. The hidden layer(s) are the processing layer, where all of the actual computation takes place. Each node in hidden layer computes a sum based on its input from the previous layer (either the input layer or another hidden layer). The sum is then "compacted" by a sigmoid function (a logistic transfer function), which changes the sum to a limited and manageable range. The output sum from the hidden layers is passed on to the output layer, which produces the final network [14].

Elman neural network architectures are proposed by Jeffrey Elman. These networks were recurrent and designed to learn sequential or time-varying patterns. In this way, the algorithms could recognize and predict learned series of values or events. Elman's primary interest in this architecture was for language processing algorithms, but he suggested it's usefulness for just about anything involving sequences.

Cascade-forward networks consist of Nl layers. These are similar to feed forward networks with a small change. The first layer has weights coming from the input. Each subsequent layer has weights coming from the input and all previous layers. All layers have biases. The last layer is the network output.

The one essential subset of ANN is Radial Basis Function Network and its generalization. The important aspect of the RBFN is the distinction between the techniques of updating the first and the second layers weights. There are numerous variants of back propagation algorithm which can be used for handwritten character recognition. Choice of a correct algorithm has much more importance since, the error surface may have several flat regions; the back propagation algorithm with fixed learning rate may be inefficient.

In this paper, we are investigating the performance of RBF, Elman back propagation, Cascade, and Feed forward models for handwritten character recognition of Marathi curve scripts through edge detection and dilation method of feature extraction.

II. RBF NEURAL NETWORK

An RBF neural network, is a three layer feed forward network that consists of one input layer, one radial layer and one output layer, each input neuron corresponds to a component of an input vector x.Generally, these classifiers are used for interpolation in multidimensional space [5].

The radial layer consists of K neurons and one bias neuron. Each node in the radial layer uses an RBF denoted with $\phi(r)$, as its non-linear activation function.

The hidden layer performs a non-linear transform of the input and the output layer. This layer is a linear combiner which maps the nonlinearity into a new space. The biases of the output layer neurons can be modeled by an additional neuron in the hidden layer, which has a constant activation function $\phi_0(r)=1$. The RBFN can achieve a global optimal solution to the adjustable weights in the minimum MSE range by using the linear optimization method. Thus, for an input pattern x, the output of the jth node of the output layer can define as;

$$y_j(x)=\sum_{k=1}^{K} w_{kj}\phi_k(\|x_i-\mu_k\|)+w_{0j} \quad (1)$$

. The Radial Basis Function $\phi(.)$ is typically selected as the Gaussian function that can be represented as:

$$\phi_k(x_l)=\exp(-\frac{\|x_l-\mu_k\|^2}{2\sigma_k^2}) \quad (2)$$

for $k=(1,2,.....,,K)$

and 1 for $k=0$ (bias neuron) Where x is the N-dimensional input vector, μ_k is the vector determining the centre of the basis function ϕ_k and σ_k represents the width of the neuron. The weight vector between the input layer and the kth hidden layer neuron can consider as the centre μ_k for the feed forward RBF neural network.

III. CASCADE NEURAL NETWORKS

Cascade Forward models are similar to feed-forward networks, but include a weight connection from the input to each layer and from each layer to the successive layers. While two-layer feedforward networks can potentially learn virtually any input-output relationship and feed-forward networks with more layers might learn complex relationships more quickly [6]. For example, a three layer network has connections from layer 1 to layer 2, layer 2 to layer 3, and layer 1 to layer 3. The three-layer network also has connections from the input to all three layers. The additional connections might improve the speed at which the network learns the desired relationship. In cascade networks, the output of the *h*thhidden unit is given by

$$y_{i,N+h}=f_j\left(\sum_{k=1}^{N}x_{i,k}\theta_k+\sum_{j=N+1}^{N+h-1}y_{i,j}\theta_j\right), \quad (3)$$
$$i=1,\dots,M, h\geq 1,$$

Where$f_j()$ is a nonlinear activation function[7] .

$\{\theta_k$, k =1, • • • ,N$\}$ are the weights that connect the input units to thehth hidden unit, and $\{\theta_j$, j = N + 1, • • • ,N + h − 1$\}$ arethe weights that connect pre-existing hidden units to the hthhidden unit.

IV. ELMAN NETWORKS

Elman's definition of a context revolved around prior internal states, and thus he added a layer of "context units" to a standard feed forward net. In this way, the states of the hidden units could be fed back into the hidden units during the next stage of input. Elman (1990) best describes it. Both the input units and context units activate the hidden units and then the hidden units feed forward to activate the output units. The hidden units also feedback to activate the context units.This constitutes the forward activation.

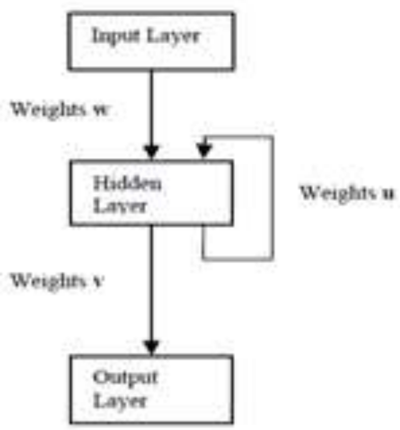

Figure 1. Block diagram of Elman Network

Elman networks are two-layer back propagation neural networks, with the addition of a feedback connection from the output of the hidden layer to its input. This feedback path allows Elman networks to learn to recognize and generate temporal patterns, as well as spatial patterns [4].

Output of the hidden layer is given by [4].

$$y_j(t) = f(net_j) \quad (4)$$

$$net_j(t) = \sum_i w_{ji} x_i(t) + \sum_h u_{jh} y_h(t-1) \quad (5)$$

The final output is given by [4].

$$y_k(t) = g(net_k) \quad (6)$$

$$net_k(t) = \sum_j v_{kj} y_j(t) + \vartheta_k \quad (7)$$

Where $V_{kj}$is the weight vector from layer k to layer j. $y_j(t)$ is the input vector and$\theta_k$is the bias.

V. FEED-FORWARD NETWORKS

A feed forward neural network is an artificial neural network wherein connections between the units do not form a cycle [8].

In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes (if any) and to the output nodes. There are no cycles or loops in the network. The best example of feed forward network is a multi-layer perceptron. This type of networks consists of multiple layers of computational units, usually interconnected in a feed-forward way. Each neuron in one layer has directed connections to the neurons of the subsequent layer. In many applications the units of these networks apply a sigmoid function as an activation function.

Multi-layer networks use a variety of learning techniques, the most popular being back-propagation. Here, the output values are compared with the correct answer to compute the value of some predefined error-function. By various techniques, the error is then fed back through the network. Using this information, the algorithm adjusts the weights of each connection in order to reduce the value of the error function by some small amount. After repeating this process for a sufficiently large number of training cycles, the network will usually converge to some state where the error of the calculations is small. In this case, one would say that the network has learned a certain target function. To adjust weights properly, one applies a general method for non-linear optimization that is called gradient descent. For this, the network calculates the derivative of the error function with respect to the network weights, and changes the weights such that the error decreases (thus going downhill on the surface of the error function). For this reason, back-propagation can only be applied on networks with differentiable activation functions.

Here, the error is given by..

$$\varepsilon_k = \frac{1}{2}\sum_{j=1}^{p}\left(d_j^k - \delta(y_j^k)\right)^2 = \frac{1}{2}E_i \quad (8)$$

Where $\varepsilon_k$is summed squared error, $d_j^k$is the desired output and $\delta(y_j^k)$ is the actual output.

$$\varepsilon = \frac{1}{Q}\sum_{k=1}^{Q}\varepsilon_k \quad (9)$$

The hidden to output layer weight update is given by

$$w_{hj}^{k+1} = w_{hj}^k + \Delta w_{hj}^k \quad (10)$$

The input to hidden layer weight update is given by

$$w_{ih}^{k+1} = w_{ih}^k + \Delta w_{ih}^k \quad (11)$$

Where Δw_{hj}^k and Δw_{ih}^k are the weight changes

VI. FEATURE EXTRACTION

In this experiment, we have used 'Edge detection and dilation method' of feature extraction.The data set used in the present research work comprises of 288 handwritten characters of Marathi language. The said set is created by collecting six samples of 48 characters each from six different people on paper. Out of these 288 characters, 192 characters (4 samples of each character) are used as training samples. Here we do apply a series of preprocessing operations on scanned images. Firstly we convert the images of RGB characters into gray scale. Then gray scale images are converted to binary form by thresholding. Morphological dilation operation is performed next to fill the gaps in characters, followed by edge detection operation to get the boundary of the character. The exact portion of image is cropped so as to apply the further operation. In this experiment, we have the P as the training pattern which is nothing but all the characters which are converted into a matrix form. T is the testing pattern with which we have to perform the recognition.

VII. RESULTS AND DISCUSSION

In our experiment, we are analyzing the performance of all of the four neural network models for the created training pattern (192) and corresponding test pattern vectors which are already created from the selected feature extraction method. We have applied the four neural network methods – Cascade, Elman, Feed forward and RBF. For every method, we have created the network, trained the network, simulated the network and plotted the regression plots. The performance of these neural network models is presented in Table 1 which contains the method and regression value of all of the four networks. Actual regression plots RBF network is presented in Fig. 2b and performance is expressed in Fig 2a. Regression plot for Cascade neural network is represented in Fig. 3a. and Fig 3b. Regression plot for Elman network is represented in Fig 4. Regression plots for feed forward neural network are expressed in Fig 5a and Fig 5b. Also a graph presenting the comparison of

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regression values of all the four methods is plotted. From the graph, it is clear that the RBF networks show a good regression value which is equal to 1.

Method	Regression value
Cascade NN	0.46994
Elman BP NN	0.48278
Feed Forward NN	0.47774
RBF NN	1.00000

Table 1: The Method and Regression value

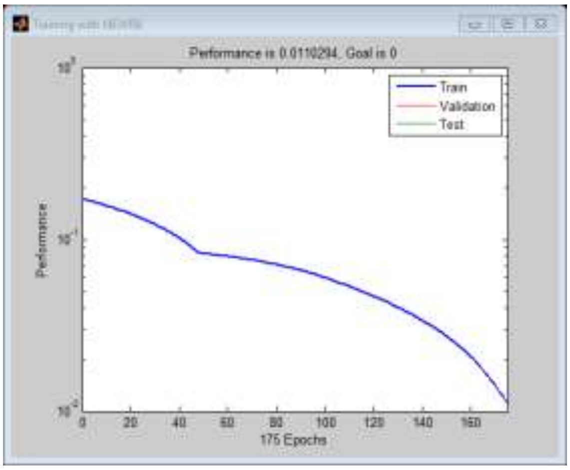

Figure 2a. PERFORMANCE PLOT FOR RBF NEURAL NETWORKS

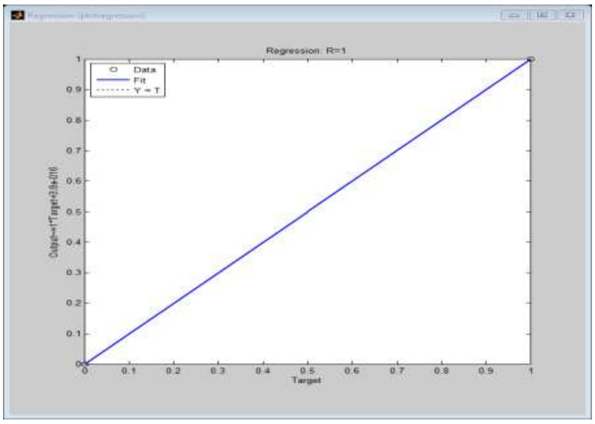

Figure 2b. REGRESSION PLOT FOR RBF NEURAL NETWORKS

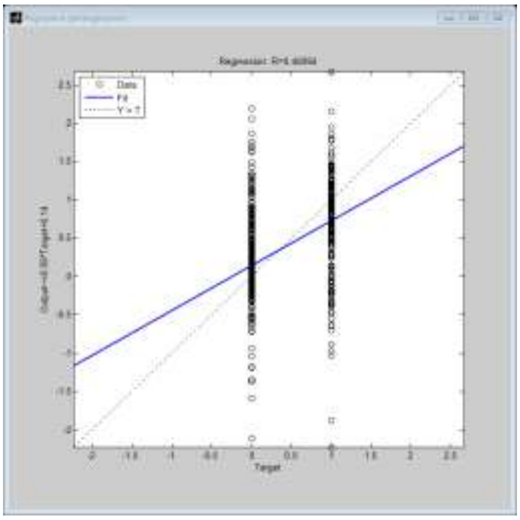

Figure 3a. REGRESSION PLOT FOR CASCADE NEURAL NETWORKS

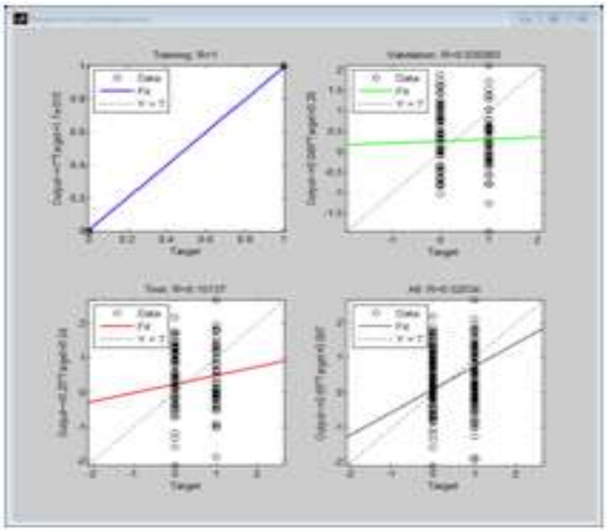

Figure 3b. REGRESSION PLOT FOR CASCADE NEURAL NETWORKS

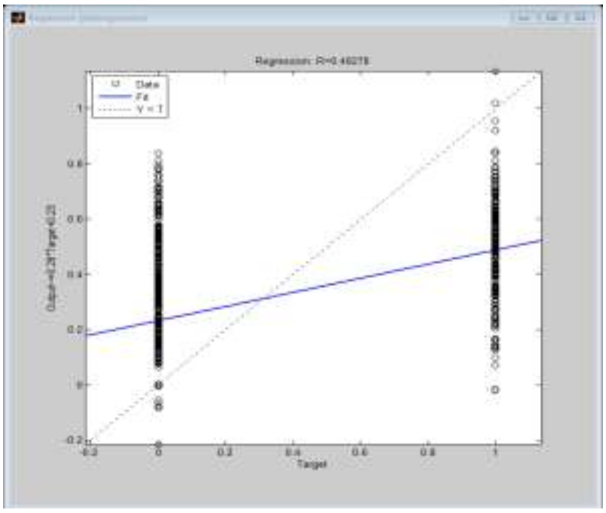

Figure 4. REGRESSION PLOT FOR ELMAN NETWORKS

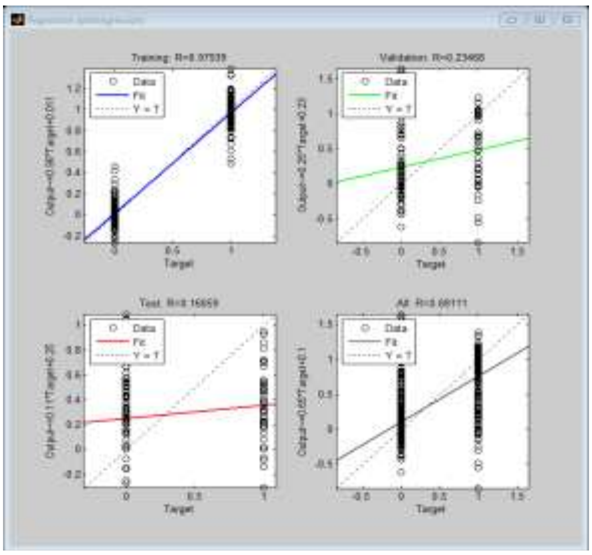

Figure 5a. REGRESSION PLOT FOR FEED FORWARD NEURAL NETWORKS

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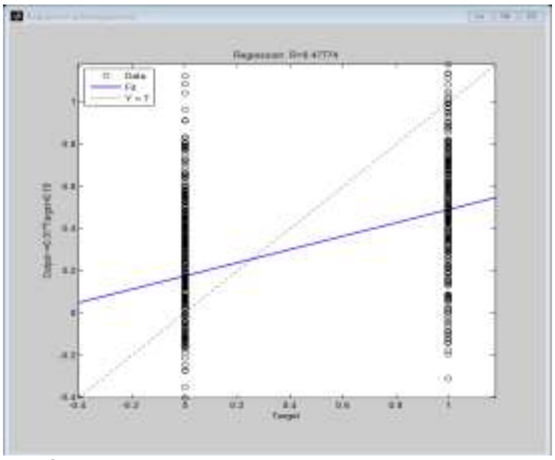
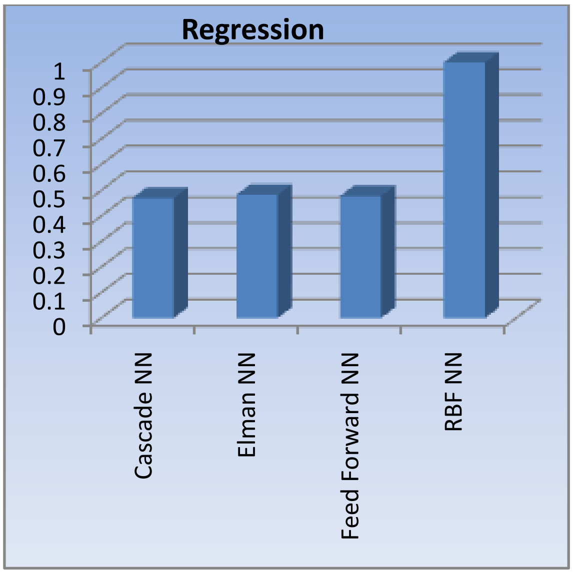


Figure 5b. REGRESSION PLOTFOR FEED FORWARD NEURAL NETWORK

VIII. COMPARATIVE CHART SHOWING THE REGRESSION OF ALL THE ABOVE METHODS APPLIED OVER THE HAND WRITTEN MARATHI CHARACTERS



IX. CONCLUSION AND FUTURE SCOPE

The results mentioned in this paper clearly exhibit the performance analysis of Cascade network, Elman BP network, Feed Forward network and RBF network. The experimental details obtained after applying these four techniques are explored in terms of regression in the form of plots. From the graph, it is clear that the value of RBF classifier is 1 and for rest of the classifiers, it lies between 0.4 to 0.5. The next step of research would be to enhance the performance of these methods so that proper results of regressions can be obtained.

ACKNOWLEDGMENT

The author thanks to Dr. Bharat Shinde, Principal, VidyaPratishthan's Arts, Science and Commerce College, Vidyanagari, Baramati, Dist-Pune (India) for his valuable guidance and encouragement for the research work.

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