Performance analysis of Handwritten Devnagari Character Recognition using Feed Forward , Radial Basis , Elman Back Propagation, and Pattern Recognition Neural Network Model Using Different Feature Extraction Methods

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Abstract— This paper describes the performance analysis for the four types of neural network with different feature extraction methods for character recognition of hand written devnagari alphabets. We have implemented four types of networks i.e. Feed forward , Radial basis, Elman back propagation and Pattern recognition neural network using three different types of feature extraction methods i.e. pixel value, histogram and blocks mean for each network. These algorithms have been performed better than the conventional approaches of neural network for pattern recognition. It has been analyzed that the Radial Basis neural network performs better compared to other types of networks.

Keywords- *OCR, Devnagari Script, Feature Extraction, Feed forward , Radial basis, Elman Back propagation, Pattern Recognition Neural Network .*

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I. Introduction

One of the primary way by which computers are able with humanlike abilities is through the use of a neural network. Neural networks are mainly useful for solving problems that cannot be expressed as a series of steps. Pattern recognition is possibly the most frequent use of neural network. The concept of learning in neural networks is used to a large scope in developing an OCR system to recognize characters of various fonts and sizes, and hand written characters. Parallel computational capability of neural network helps to reduce recognition time which is essential in a commercial perspective.

During the past 40 years, significant research effort has been dedicated to OCR for the Devanagari script. R.M.K. Sinha and V. Bansal[1-7] has done widespread work in Devnagari Optical character Recognition (DOCR). Handwritten DOCR is more difficult than English characters due to the complexity of devnagari script i.e. modifiers , compound characters, shape similarity[8]. Artificial neural network (ANN) [9-10] can be used for classification purpose.

Performance of the handwritten Devnagri character recognition system can be analyzed by using various performance measures like mean square error (MSE), percentage error , performance characteristics, recognition percentage etc.[11]. The feature extraction step of optical character recognition is the most important. A poorly chosen set of features will yield poor classification rates by any neural network.[12]
It has been analysed by NilayKarade et al. [13] that the number of hidden layer, number of neurons in hidden layer, validation checks and gradient factors of the neural networks models are taken into consideration during the trainingof a neural network.

The performance of the neural network is much accurate and convergent for the learning with the hybrid evolutionary algorithm[14].The feed forward neural network by using Evolutionary algorithms makes better generalization accuracy in character recognition problems[15].

In this paper we have implemented four different neural network models using three different feature extraction techniques i.e. we have implemented total twelve neural networks using 30 handwriting samples of Marathi alphabets having 44 characters in each sample for training and 5 for testing

II. OPTICAL CHARACTER RECOGNITION (OCR)

Optical character recognition (OCR) is becoming an essential part of document scanners, and is also used normally in banking and postal applications. Printed characters can now be accurately recognized. Optical character recognition is needed when the information should be readable both to humans and to a machine. Optical character recognition is unique because it does not require control of the process that produces the information.

Optical Character Recognition deals with the problem of recognizing optically processed characters. Optical recognition can be performed in two ways either offline or online. In off-line it is performed after the writing or printing has been completed, opposite to this in on-line recognition the computer recognizes the characters as they are drawn. Both hand printed and printed characters may be recognized, but the performance is directly dependent upon the quality of the input documents. Fig.1 shows the different types of character recognition [1] .It is difficult to develop a OCR for unconstrained handwriting. But we can improve the performance of OCR by using the constrained input .The basic steps involved in Optical Character Recognition are

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A. Data Acquisition
B. Preprocessing
C. Segmentation
D. Feature Extraction
E. Classification
F. Post Processing

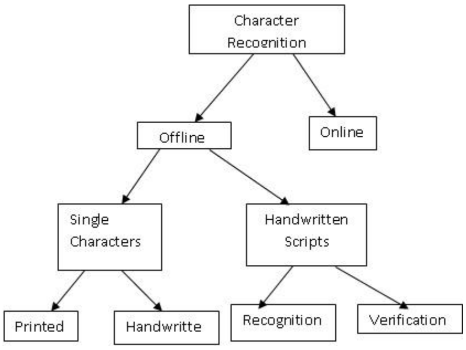

Figure 1. Types of Character Recognition

A. Data Acquisition

It is the first and most important step in OCR In this step we have to collect data i.e. samples of handwritten or printed documents .The collected documents has to be scanned in order digitize the data. The image should have a specific format such as jpeg, bmp etc. The images can be acquired through a scanner, digital camera or any other suitable digital input device. Data samples for the experiment have been collected from different individuals so that more diverse data can be collected.

B. Preprocessing

This step is used to reduce the noise and remove the unwanted data if any. We can also decrease the variation and transforms the data in specific format so that the data can be processed more easily and efficiently .There are various ways through which preprocessing can be done like Binarization, Noise reduction, Stroke width normalization, Skew correction, Slant removal, Filtering, Morphological Operations, Noise Modelling, Skew Normalization, Size Normalization, Contour Smoothing, Compression, Thresholding, Thinning etc

C. Segmentation

It is also an import step in OCR. In this step the document is segmented into Lines, words and the characters. We can to use various segmentation techniques like projection profile, bounding box etc. The accuracy of segmentation affects indirectly on the accuracy of recognition i.e. accuracy of character recognition closely depends upon segmentation. Segmentation promise the effectiveness of classification and recognition.

D. Feature Extraction

Feature extraction means taking out the raw data from the information which is most relevant for classification. There are three types of feature extraction methods a i.e. Statistical, Structural and Global. We can create feature vectors by extracting the significant features from the alphabets. These feature vectors are then used by classifier to recognize the input with target output.

E. Classification

The classification step is the decision making part of the recognition system. There are many existing Classical and soft computing techniques for handwriting classification.

- Classical Techniques: Template matching Statistical techniques Structural techniques

- Soft Computing Techniques: Neural networks (NNs) Fuzzy- logic technique Evolutionary computing techniques

The performance of a classifier depends on various factors like the size of training data set, segmentation technique , types of features etc.

F. Post Processing

In this step the results of classifier are converted into the required format. Post processing can also improve the recognition rate .

III. CHALLENGES IN HANDWRITTEN DEVNAGARI CHARACTER RECOGNITON

Optical Character Recognition (OCR) deals with automatic recognition of characters in a document image. A lot of research is done for English Character Recognition (CR).Various OCR software for English languages are also available. Indian languages are more complicated in terms of structure and computations it is difficult to develop a OCR for them. Devnagari is the most popular script in India. Hindi,Marathi, Nepali etc. languages use devnagari script for writing .Thus, the work on Devnagari script is very useful. The alphabet of the Devnagari script consists of 14 vowels and 33 consonants. The basic characters of Devnagari script are shown in Fig.2.

In Devnagari script a vowel following a consonant takes a modified shape. Depending on the vowel , its modified shape is placed at the left, right (or both) or bottom of the consonant. These are called as modifiers. In character segmentation the modifiers are most difficult to segment . Due to the presence of header line called shirodhara it is difficult to separate the characters in devnagari script. Compound characters can be combinations of two consonants as well as a consonant and a vowel. Recognition of compound characters is also a difficult problem. we have considered only basic characters of Devnagari script.

The complexity of a handwritten character recognition system increases mainly because of various writing styles of different individuals. Most of the errors in such system arise because of the confusion among the similar shaped characters. In Devnagari there are many similar shaped characters. it can be seen that shapes of two or more characters are very similar due to handwritten style of different individual and such shape

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similarity is the main reason of low recognition rate. The modifiers , compound characters and shape similarity are the major reasons of complexity in Devanagri Character Recognition .

Figure 2. Basic Characters of Devnagari Script

IV. ARTIFICIAL NEURAL NETWORKS (ANN)

A neural network can perform computations at a higher rate compared to the classical techniques. It can easily adapt to changes in the data and learn the input signals characteristics, because of its adaptive nature. A neural network is consists of many nodes. Neural network architectures can be classified into two major groups, feed-forward which have no loops and feedback (recurrent) networks in which loops occur because of feedback connections. The most familiar neural networks used in the character recognition are systems are the multilayer perceptron of the feed forward networks and the kohonen's Self Organizing Map (SOM) of the feedback networks(Fig.3).

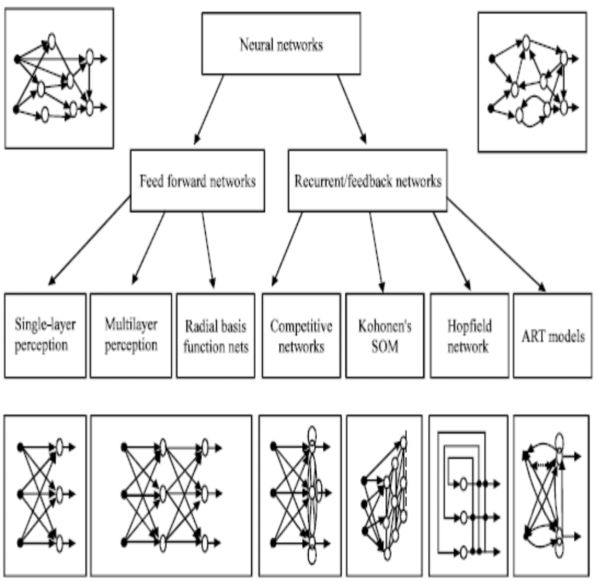

Figure 3. Taxonomy of feed forward and feedback network architectures

A. *Feed Forward Neural Network*

Feed-forward networks have perceptron which are arranged in layers. The first layer takes the inputs and the last layer producing outputs. The middle layers have no connection with the external world, and hence are called hidden layers.
These networks are called feed-forward networks because information is constantly "fed forward" from one layer to the next it is possible because the perceptron in one layer is connected to every perceptron in the next layer i.e. the information flows in only one direction. There is no connection among perceptron in the same layer.
Classification can be done more precisely by varying the number of nodes in the hidden layer, the number of layers, and the number of input and output node. Hence feed-forward networks are commonly used for classification.
Feed-forward networks belongs to the supervised learning, in which pairs of input and output values are fed into the network for many cycles, so that the network learns the relationship between the input and output. Back propagation is the most popular learning technique in feed forward networks. These networks apply a sigmoid function as an activation function.

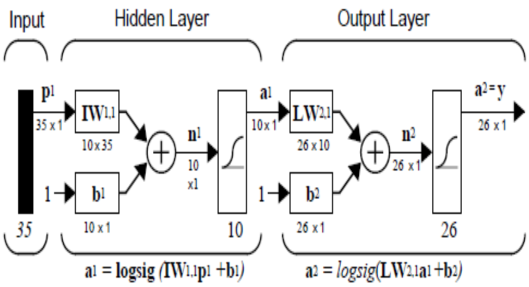

Figure.4 Feedforward NN Architecture

Every time a neural network is trained using input vector of a training sample, the output vector o is compared to the desired value d. The comparison is done by calculating the squared difference of the two.

$$E=(\delta-o)^2 \qquad (1)$$

The value of Error tells us how far we are from the desired value for a particular input. The goal of back propagation is to minimize the sum of error for all the training samples, so that the network behaves in the most desirable way.

$$\text{Minimize} \sum E=(d-o)^2 \qquad (2)$$

Decreasing the value of w in the direction of the gradient leads to the most rapid decrease in error, we update the weight vectors every time a sample is presented using the following formula:

$$W_{new} = W_{old} - n^* (\delta E/\delta W) \qquad (3)$$

where n is the learning rate (a small number ~ 0.1). Using this algorithm, the weight vectors are modified so that the value of error for a particular input sample decreases a little bit every time the sample is presented. When all the samples are presented in turns for many cycles, the sum of error gradually decreases to a minimum value.

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B. Radial Basis Function Networks

Radial basis function networks take a different approach to to the design of neural networks than that of Multi Layer Perceptron. They use a curve fitting approach in a high-dimensional space. Learning in this method is equivalent to finding a surface in this hidden space that gives a best fit to the training data. They have a single hidden layer which consists of Radial basis functions which translate the inputs, in a non-linear way to a high-dimensional space. Problems that are not linearly separable in the input space can be found to be linearly separable in the hidden space.

Radial Basis Function (RBF) networks can perform classification. They can be used as function approximators They use a set of radial basis functions, which have the same dimension as the input space. They have a single hidden layer. The solution to the weights can be performed by linear least squares.

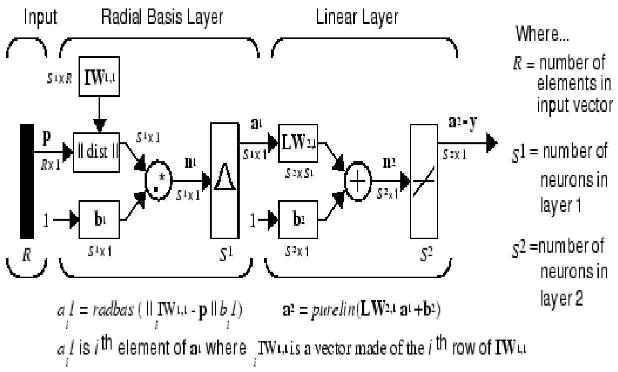

Figure 5. Radial Basis Function Network architecture

Transformation from the input space to the hidden-unit space is nonlinear while the transformation from the hidden-unit space to the output space is linear.Radial basis networks consist of two layers: a hidden radial basis layer of S1 neurons, and an output linear layer of S2neurons.

The || dist || box in this figure accepts the input vector **p** and the input weight matrix $\mathbf{IW}^{1,1}$, and produces a vector having S_1 elements. The elements are the distances between the input vector and vectors ${}_i\mathbf{IW}^{1,1}$ formed from the rows of the input weight matrix.

The bias vector b1 and the output of || dist || are combined with the MATLAB® operation .* , which does element-by-element multiplication.The output of the first layer for a feedforward network net can be obtained with the following code:

a{1} = radbas(netprod(dist (net.IW{1,1},p) ,net.b{1})) (4)

C. Elman Neural Network

The Elman network is a two-layer network with feedback from the first-layer output to the first layer input. This recurrent connection allows the Elman network to both detect and generate time-varying patterns. A two-layer Elman network is shown below(Fig. 6).

The Elman network has tansig neurons in its hidden (recurrent) layer, and purelin neurons in its output layer. This combination is special in that two-layer networks with these transfer functions can approximate any function (with a finite number of discontinuities)

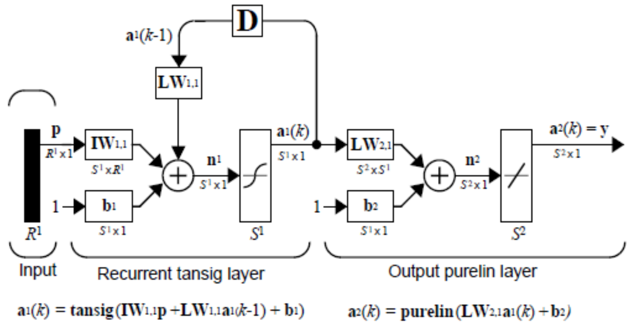

Figure 6. Elman Network Architecture

with arbitrary accuracy. The only requirement is that the hidden layer must have enough neurons. More hidden neurons are needed as the function being fit increases in complexity.

Note that the Elman network differs from conventional two-layer networks in that the first layer has a recurrent connection. The delay in this connection stores values from the previous time step, which can be used in the current time step. Thus, even if two Elman networks, with the same weights and biases, are given identical inputs at a given time step, their outputs can be different due to different feedback states. The network can store information for future reference hence it is able to learn temporal patterns as well as spatial patterns. The Elman network can be trained to respond to, and to generate, both kinds of patterns.

V. PROPOSED OCR SYSTEM

we have designed a form to collect the isolated characters and digits (Fig.7).We have provided printed samples of devnagari alphabets and asked the writers to write the same characters in the blank space provided in front of the printed characters . We have digitized the duly filled forms using scanner at 300 DPI in color mode and stored the scanned images in the jpeg format.

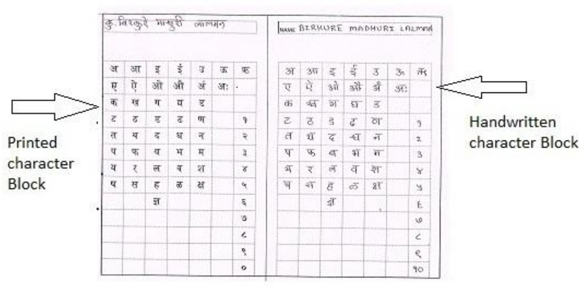

Figure 7. Sample of Handwritten Devnagari Characters

In this paper we have used three feature extraction methods

A. Pixel values
B. Histogram values
C. Block mean values

A. Pixel values

In this method we have used following steps to get the character pattern vector for each characters (digits and alphabets). Binaries the image using Otsu method. Remove noises (impression of other forms, salt and paper noise , corner folding , physically damaged paper , extra lines , stapler pin marks) that might have occurred during the digitization process . Perform the edge detection operation. Perform the hole filling operation to obtain the uniform connected components Perform the labeling operation on the connected components to find the bounding box for each character. Crop the bounding box and resize it into 15 X 15 matrix. (Fig.8) The character pattern is stored in column vector of size 225 X 1.

B. Histogram values

For creating a histogram of each character first we need to convert the color image into gray image using rgbtogray function. Then we draw the histogram of each character (Fig.9) and store the histogram count values in a column matrix of 256x1.

C. Block mean values

The block mean values can be calculated as follows. Convert the character image into black and white i.e. binary image. Then remove the blank space from left, right, upper and lower side of image .Resize the image into matrix of size 15x15 and after that divide the image into the blocks of 3x3 (Fig.10). Calculate the mean value for each block and Store mean values in to a column matrix of size 25x1 .

After creation of feature vectors we have to create one more file for storing the target values. It will be the six bit representation for each character ex. 000001, 000010, …….. , 101100. A target matrix of 6 X 44. The target matrix contains 44 binary values each having six bits for representation of each character. The input and target required to create a neural network is read from the files and store it in the variables P and T.

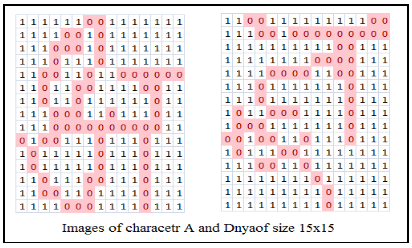

Figure 8. Character Pattern vectors

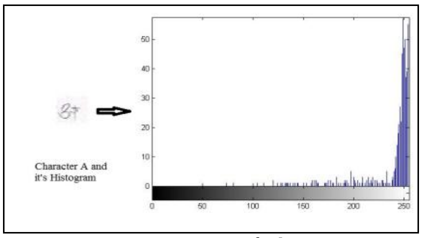

Figure 9. Histogram of Character A

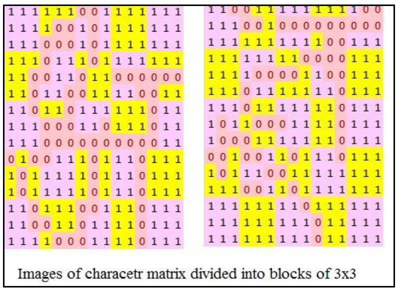

Figure 10. Characters divided into blocks

VI. RESULTS AND DISCUSSION

In this paper we have implemented four types of neural networks i.e. Feed forward , Radial basis, Elman back propagation and Pattern recognition neural network using three different types of feature extraction methods i.e. pixel value, histogram and blocks mean for each network. Totally twelve different networks we have trained using 1320 character samples of handwritten Marathi alphabets collected from 30 different persons and 220 character samples are used for testing purpose .

First we have trained the network then we simulated the network to get the output values and after that we have plotted the regression. The regression values for the four networks i.e. Feed forward , Radial basis, Elman back propagation and Pattern recognition neural network are 0.5 , 1, 0.4, 0.6 respectively . The following figures (Fig.11 to Fig.14) shows the regression plots for all the four types of neural networks i.e. feed forward , Radial Basis, Elman, pattern recognition. which indicates that the performance of Radial basis neural network works is more effective. After getting the regression values we have drawn a bar chart for comparing the performance of these four networks(Fig.15 & Fig.16).

VII. CONCLUSION AND FUTURE SCOPE

In this paper we have done the performance analysis of Feed forward , Radial basis, Elman back propagation and Pattern recognition neural network which clearly mention that the performance of Radial basis neural network is better as compared to other networks . Here we have used three different types of feature extraction methods i.e. pixel value, histogram and blocks mean for each network. We can improve the results by combining these feature extraction methods. We have also not consider the modifiers with the character here so in future we can also use marathi characters with modifiers to train the network

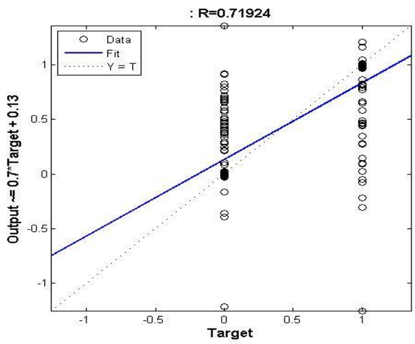

Figure 11. Regression plot for Feedforward Neural Network

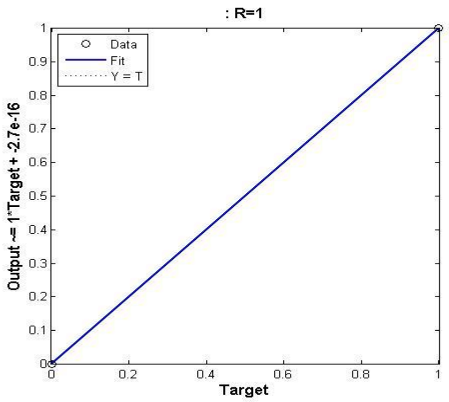

Figure 12. Regression plot for Radial basis Neural Network

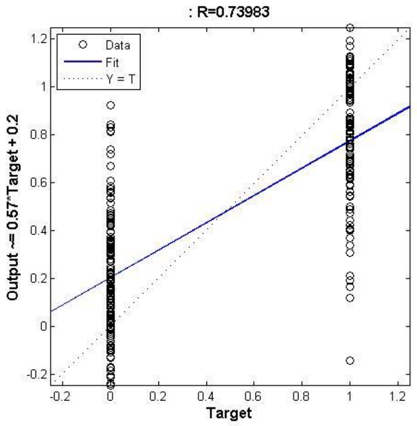

Figure 13. Regression plot for Elman Neural Network

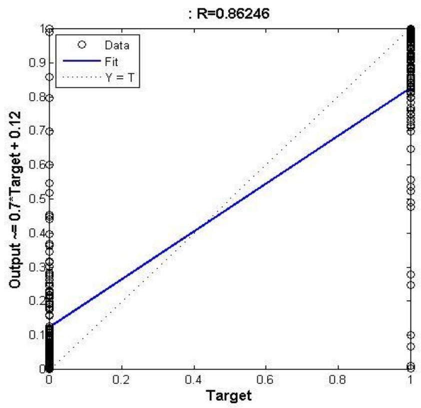

Figure 14. Regression plot for Pattern Recognition Neural Network

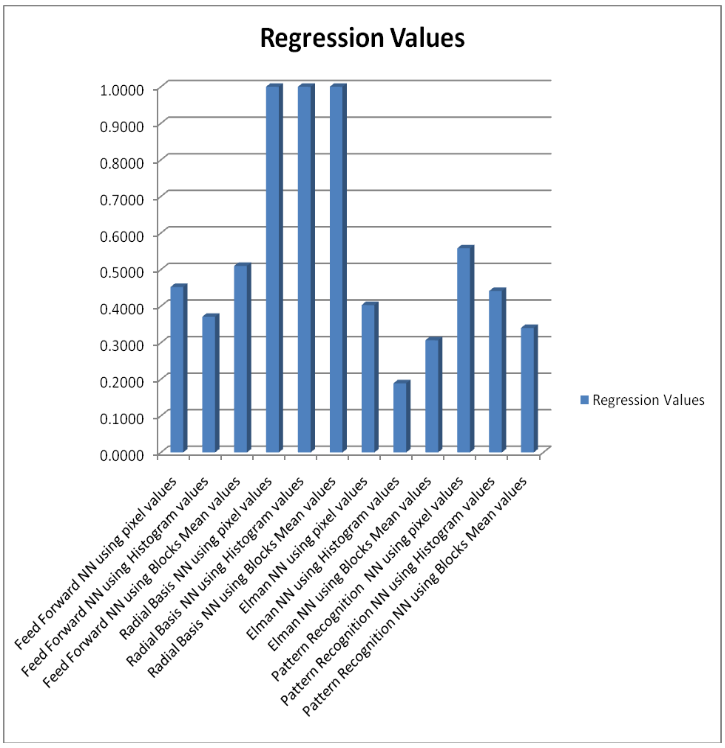

Figure 15. Comparative chart for the Regression values of all the Neural Network methods

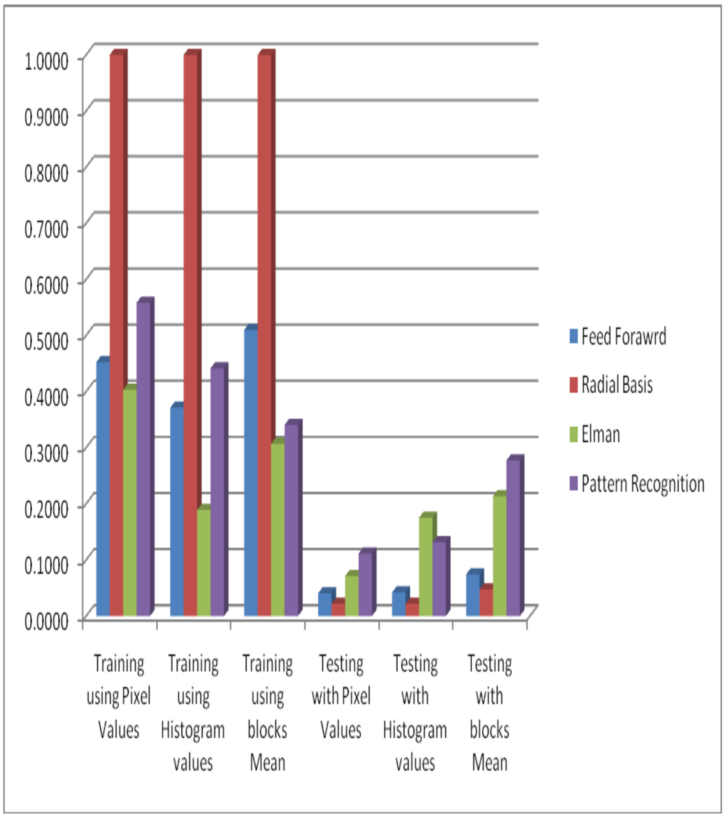

Figure 16. Comparative chart for the feature extraction methods

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