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Performance Comparison of Radial Basis Function Networks and Probabilistic Neural Networks for Telugu Character Recognition

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Received: 10 January 2011 Accepted: 4 February 2011 Published: 16 February 2011

Abstract

The research on recognition of hand written scanned images of documents has witnessed several problems, some of which include recognition of almost similar characters. Therefore it received attention from the fields of image processing and pattern recognition. The system of pattern recognition comprises a two step process. The first stage is the feature extraction and the second stage is the classification. In this paper, the authors propose two classification methods, both of which are based on artificial neural networks as a means to recognize hand written characters of Telugu, a language spoken by more than 100 million people of south India(Negi et al. ,2001). In this model, the authors used Radial Basis Function (RBF) networks and Probabilistic Neural Networks (PNN) for classification. These classifiers were further evaluated using performance metrics such as accuracy, sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and F measure. This paper is a comparison of results obtained with both the methods. The values of F measure are quite satisfactory and this is a good indication of the suitability of the methods for classification of characters. The values of F-Measure for both the methods approach the value of 1, which is a good indication and out of the two, RBF is a better method than PNN.

Index terms— Classification, sensitivity, specification, F-measure, PPV, NPV.

1 Introduction

haracter recognition is a form of pattern recognition [2]. Any pattern feature recognition system consists of two major steps, extraction and classification. The main focus in this paper is on classification. Classification is one of the important decision making factor for many real world problems. In this model authors used the classification techniques for identifying similar shaped Telugu characters.

classifiers. RBF neural networks have fast training and learning rate because of their locally tuned neurons. They also exhibit a universal approximation property and good generalization ability. Probabilistic neural network integrates the characteristics of statistical pattern recognition and Back Propagation Neural Network (BPNN) and it has the ability to identity boundaries between the categories of patterns. In this research work the aforementioned two classifiers have been chosen for identification of Telugu script and then compared their performance.

2 II. Literature Review

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In the present work, authors used radial basis function network and probabilistic neural network as Considerable amount of research has occurred in identifying methods suitable for character recognition Nawaz et al. [3] developed a system for recognition of Arabic characters with RBF network and Hu invariant moments are used as predictor variables. Ashok and Rajan, [4] designed a system for writer identification with handwriting using Radial Basis function. The efforts published by Vijay and Ramakrishnan, [5] described a system for the recognition of Kannada text where they used the wavelet features as attributes and RBFN as a classifier. Birijesh , [6] designed the system for the hand written Hindi characters and in this work the performance of Multi Layer Perceptron (MLP) and RBF networks were compared and it was shown that RBF is superior to MLP. Kunte and Samuel [7] developed a neural network classifier with Hu invariant moments, Zernike moments as predictor variables and RBF network as a classifier. Vatkin and Selinger [8] used RBF neural network for the classification of hand written Arabic numerals using Legendre moments as predictor variables. Romera et al. [9] described an advanced system of classification using probabilistic neural networks and they used the classifier for optical Chinese character recognition. Khatatneh et al. [10] proposed a new technique in developing a recognition system for handling Arabic hand written characters with probalistic neural networks, which yields a significant improvement. The work published by Koche [11] compared the classification results of template matching, probabilistic neural network, and feed forward back propagation neural network where the performance of PNN was superior. Jeatrakul and Wong [12] compared the ©2011 Global Journals Inc. (US)

3 III. Problem Statement

Application of neural networks for optical character recognition is the problem domain. The goal of this paper is to construct classifiers with radial basis function networks, probabilistic neural networks and to compare the performance.

4 IV. Proposed System

The model proposed in this paper builds a pattern recognition system. Any pattern recognition comprises of two steps, feature extraction and classification. As the main aim of the paper is for classification a brief review of feature extraction is given.

5 1) Feature Extraction

As predictor variables used in the classification play a major role in increasing the accuracy of the classifier, the feature extraction is an important step. The system proposed by us is for the classification of Telugu hand written letters. The Telugu characters are neither available commercially nor available on the net. So the authors collected images from 60 people covering different educational back grounds and different age groups. Sample set of characters collected from one person and the corresponding Telugu alphabet and the class label are shown in figure **??**.

6 Figure1: Sample set of Characters

As handwriting varies from person to person and from time to time with the same person, the following preprocessing steps are required before extracting the features.

7 1.1) Normalization

All the scanned images are brought to a common size by identifying the tight fit rectangular boundary around the image and they are scaled to 32x32 image.

8 1.2) Binarization and Thinning

The aim of this process is to separate the character from the back ground in the grey image color to black and white and then the image is thinned down to skeleton of unitary thickness.

After preprocessing a set of 41 features are extracted from the skeletal images covering the local, global and statistical features. A brief description of the features is given in Table **??**.

Table **??**: Description of Features

9 V1

The number of pixels in skeletal image that are in excited state V2

The number of pixels in skeletal image that have one exited neighbor V3

The number of pixels in skeletal image that have two excited neighbors V4

The number of pixels in the skeletal image that have three excited neighbors V5

The number of pixels in the skeletal image that have two exited neighbors which are 180 degrees apart V6 ,V7 ,V8

The densities of pixels in the exited state when the image is divided into three regions horizontally V9,v10.v11 The densities of the pixels in the exited state when the image is divided into three regions vertically V12

Total number of crossings i.e., changes from 1's to 0's and from 0's to 1's as the image scanned horizontally V13

Total change in the horizontal crossings V14

Total number of crossings i.e., changes from 0's to 1's and from 1's to 0's as the image is scanned in the vertical direction V15

Total change in the vertical crossings V16

The number of connected components in the image V17 Euler number the binary matrix i,e., the skeletal image V18 entropy: is a statistical measure of the randomness that can be used to characterize the texture of the input image Entropy=-sum (p*log 2 (p)); V19 Energy: is the sum of squared elements in the grey level co occurrence matrix. Energy= ? p(I) 2 for all i and j V20 Contrast: returns a measure of the intensity contrast between a pixel and its neighbor over the whole image Contrast = ? | i-j| 2 p(i,j) for all I and j V21

Correlation: is measure of how correlated a pixel to its neighbor over the whole image. Correlation=?((i-µi)(j-µj)p(I,j))/? i ? j

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Volume XI Issue IV Version I

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performance of classifiers developed using RBF and PNN and according to them the performance of RBF was found to be superior.

From the literature survey it has been observed that the recognition systems were developed for Arabic and Kannada and Chinese script using RBF and probabilistic work. Not much work had been reported for Telugu script using RBF and PNN. This literature review reveals a dearth in information regarding recognition of Telugu hand-written characters. It inspired us to develop a classifier for Telugu script using RBF and PNN and compare the performance of the networks.

11 V22

Cluster tendency: Measure of the grouping of the pixels that have similar gray level values. Cluster tendency= ? ? (I+j -2µ) k p(I,j) V23

Standard deviation of the binary matrix V24 Maximum value of the gray level co occurrence matrix V25,V26

Co ordinates of the centroid of the binary skeletal image V27 ,V28

Number of crossings at the centroid in horizontal and vertical directions V29 Eccentricity: scalar that specifies the eccentricity of an ellipse that has same second moments as the region of the image V30 Orientation: scalar (in degrees) between the x axis and the major axis of the ellipse ,that has the same second moments as the image V31 Scalar that specifies the number of pixels in the convex area of the image V32 Diameter: scalar that specifies the diameter of the circle as the region of the image V33 Solidity: scalar specifying the proportion of pixels that are in the region of the image.

12 V34

Extent: scalar that specifies the ratio of pixels to the total in the bounding box V 35 to v41 Hu invariant moments: seven moment based features which are invariant to size and orientation of the character As the data obtained for different features are with different scales, standardization of the data is required before proceeding with any classification task. The standardization is performed withX 1 S X - X = X 2) Classification

Classification is a data mining technique used to predict group membership for data instances. The objective of the data classification is to analyze the input data and to develop an accurate description or model for each class using the features present in the data. The model is used to predict the class label of unknown records and such modeling is referred as predictive modeling. The methodology used in the paper uses predictive modeling and developed using neural networks. As the goal of this work is to compare the performance of a classification model and is based on the counts of test samples correctly and incorrectly predicted by the model.

3) Performance Metrics of records from class i predicted to be of class j.

Although confusion matrix provides the information needed to determine how well a classification model performs, summarizing this information with a single number would make it convenient to compare the performance of different models. This can be done by using the performance metrics such as sensitivity or recall, specificity, precision or positive predictive value, negative predictive value, F-measure and accuracy.

13 3.5) F-measure

It can be used as a single measure of performance of the test. The F measure is the harmonic mean of precision and recall

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Where X is the median and Sx is the standard deviation. To ensure accurate classification a large number of features are extracted in our models, which are to be characteristic of each individual character. Different researchers used different number of variables to suit their purposes like Huette et al. [13] who used about 124 and Patra et al. **??**14] who used only 17 and the authors used 41 variables. As the number of features increases, the complexity of the pattern recognition system increases, so we reduced the dimensions by using factor analysis. Predictor variables are reduced to 18 variables from a total of 41 variables.

Several criteria may be used to evaluate the performance of a classification algorithm in supervised learning. A confusion matrix is a useful tool for analyzing how well a classifier can identify test samples of different classes [15], which tabulates the records correctly and incorrectly predicted by the model. Each entry Cij in the confusion matrix denotes the number 4) Radial Basis Function Approach Radial basis function network which is a feed forward network consists of three layers input layer, hidden layer and the output layer. The architecture of RBF is shown in Figure **??**. The RBF is different from the ordinary feed forward networks in calculating the activations of hidden neurons. The activations at the hidden neurons are computed by using the exponential of distance measures.

Each node in the input layer corresponds to a component of the input vector x. The second layer, the only hidden layer in the neural network applies non linear transformation from input space into hidden space by employing non-linear activation function such as Gaussian kernel. A linear node at the output layer corresponds to the classes of the problem. A simple way to choose the number of radial basis functions is to create a hidden neuron centered on each training pattern. However, this method is computationally very costly and takes up huge amount of memory. In our model, the training patterns are clustered into a reasonable number of groups using K-means clustering algorithm.

15 INPUT LAYER HIDDEN LAYER OUTPUT LAYER Figure 2: Radial Basis Function Network

Then a neuron is assigned to each cluster centre. The output of each hidden neuron is calculated by using the Gaussian radial basis function? ? ? ? ? ? ? ? ? ? = 2 2 2 || i µ - x || - exp ||) i µ - x || (? G

Where, x is the training sample, µi is the centre of the hidden ith neuron and ? is the width of the neuron. The width of the basic functions are set to a value which is a multiple of the average distance between the centers. This value governs the amount of smoothing.

The activation at the output neurons is defined by the summation( ) ? + = i G w x Y b ||) µ - x || (* i T T 1 ?

In our model, we fixed the number of centers as 100 and width as 2.4 which is a multiple of the average width 0.6 of the hidden neuron. The percentages of characters correctly classified for different number of centers and for different widths (? values) are shown in Table 2 and table 3 respectively. With the above results, the authors fixed the parameters, the number of hidden neurons as 100 and width of the basis function as 2.4. With these parameters the confusion matrix obtained as shown in Figure **??**. The input layer does not perform any computation and simply distribute the input to the neurons in the pattern layer which has one node for each training example. On receiving the pattern x from the input layer, the neuron xij of the pattern layer computes its output as

16 Number of Centers

( ) ( ) ( ) ( ) ? ? ? ? ? ? ? ? ? ? ? ? = 2 2 / 2 exp 2 1 ? ? ? ? ij T ij d d ij x x x x x

Where, d denotes the dimension of the pattern vector x, ? is the smoothening parameter and xij is the neuron vector. The summation layer neurons compute the maximum likelihood of pattern x being classified into Ci by summarizing and averaging the output of all the neurons that belong to the same class,

17 Results and Discussions

In this paper the authors compared the classification models developed using radial basis function network and probabilistic neural network. The summary of the confusion matrix for both the methods is shown in table 5 and table 6 respectively.

18 VI. Conclusion

In this paper, the authors presented two classification models, one is radial basis function networks and the other is probabilistic neural networks and both being implemented using MATLAB. The accuracy of all the classes is above 90% with both the methods. But the overall accuracy of the RBF network is found to be better from the results. In

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Building a model that maximizes both precision and recall is a key challenge in classification algorithm [16]. Precision and recall can be summarized into another metric known as F measure as explained in performance metrics. The F measure for both the classes is shown in the form of a graph in figure **??**. With the first method

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Figure 1: 3. 1 3) 4)

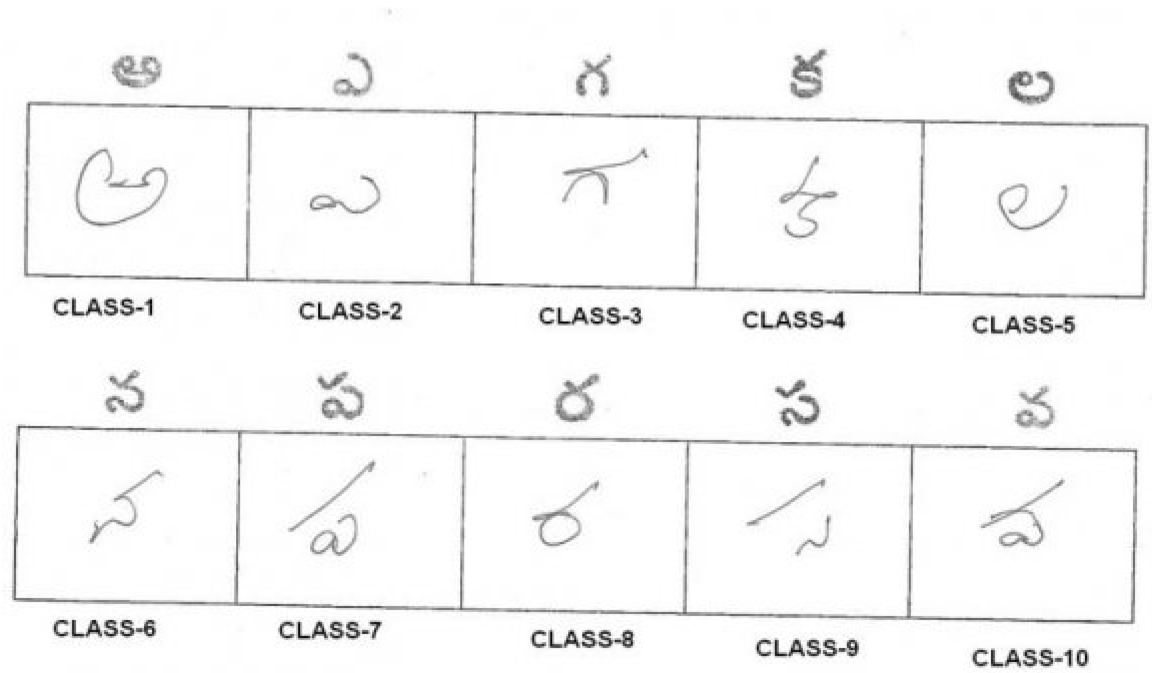
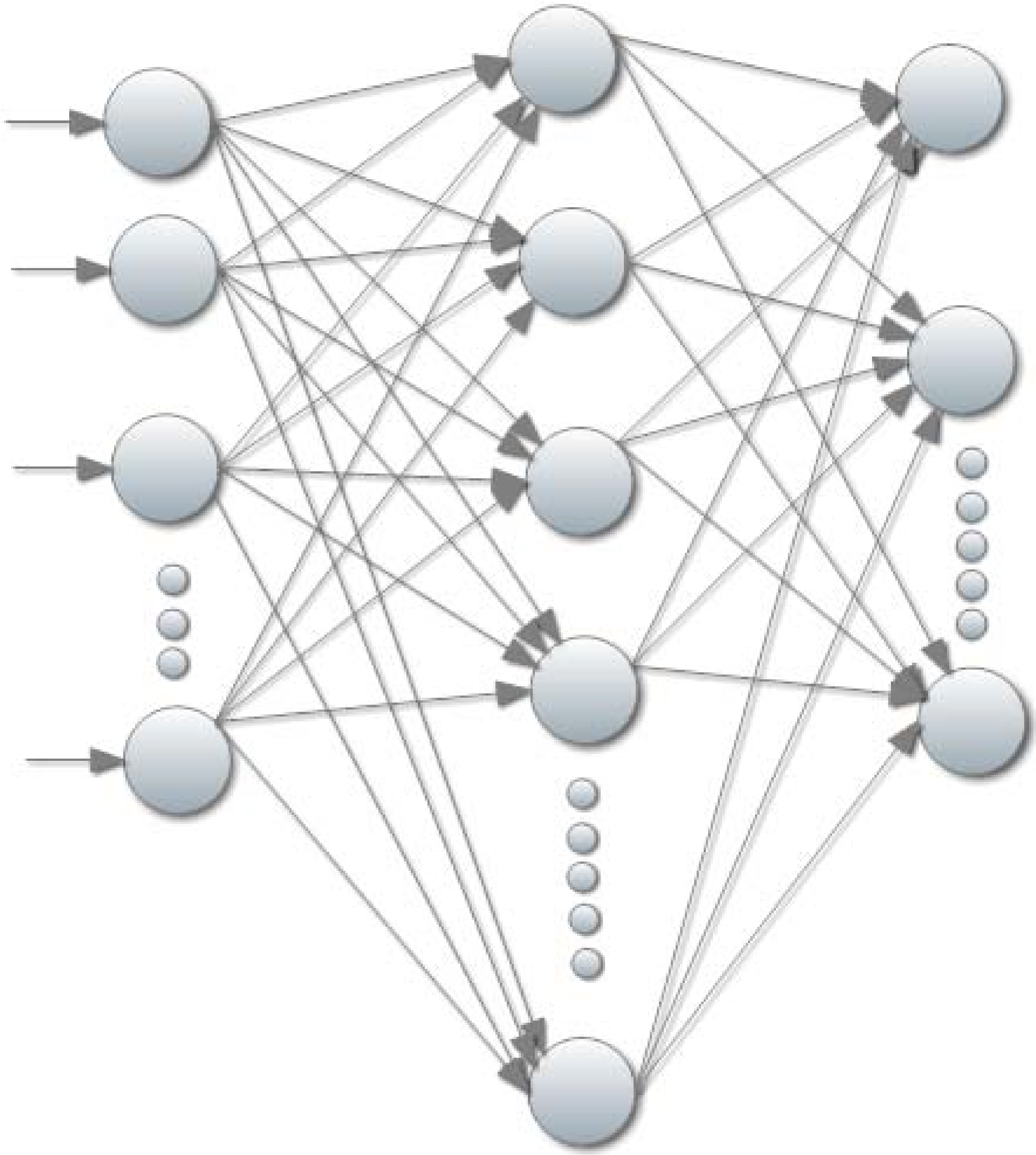


Figure 2:



34

Figure 3: Figure 3 :Figure 4 :

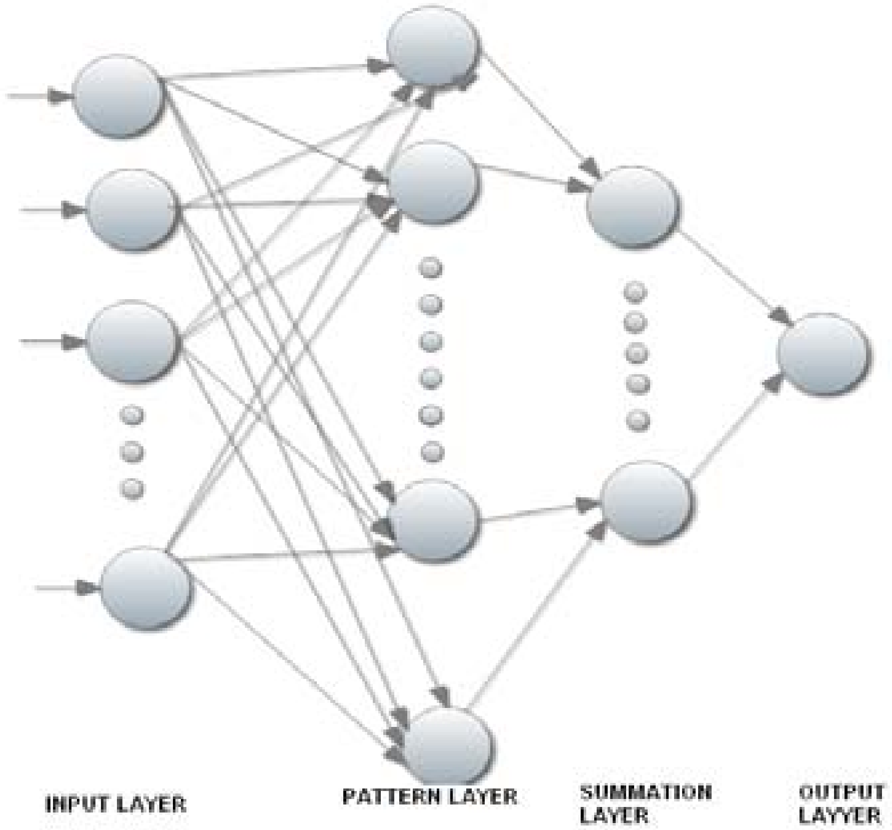


Figure 4:

the value of F is less than 0.7 for classes with the labels 8, 10 and with PNN the value is less than 0.7 for classes with labels 2, 6, 8 and 10. [1] [2] [3]

[1] March 2011Where, w is the weight vector.The weights are computed by W = (G G) G d Where d is the target class matrix. ©2011 Global Journals Inc. (US)

[2] March 2011©2011 Global Journals Inc. (US)

[3] March 2011This page is intentionally left blank

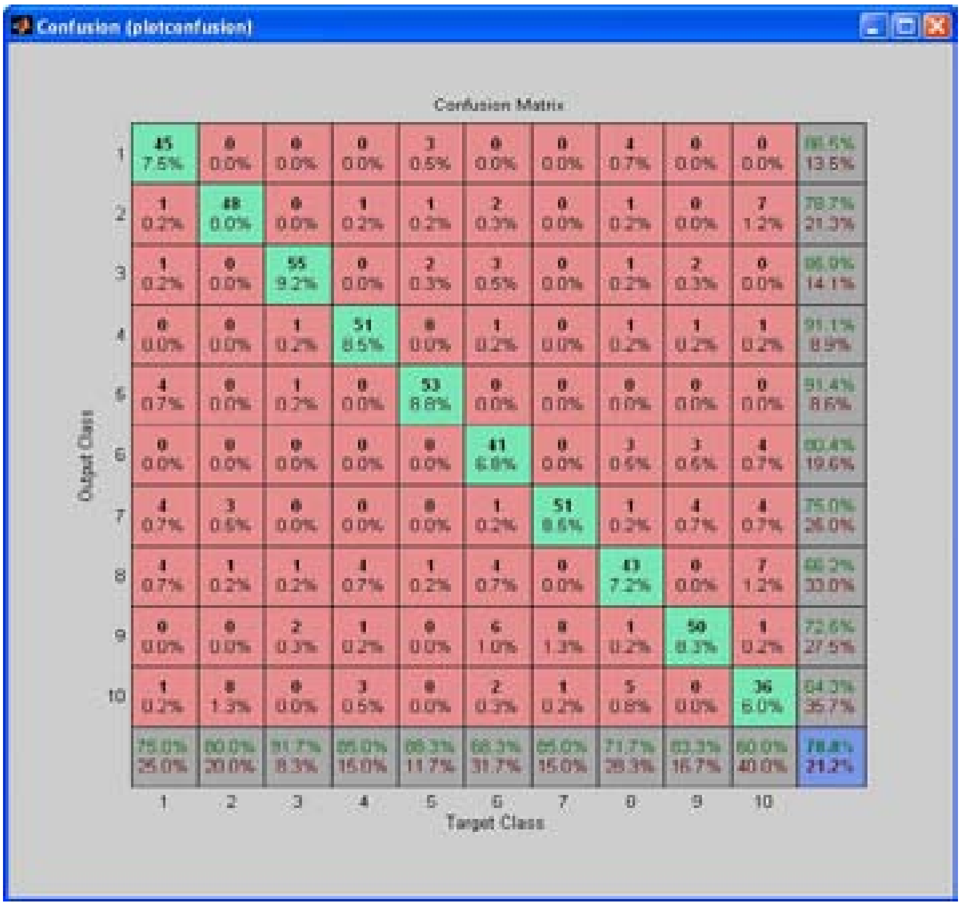

Confusion (plotconfusion)
Confusion Matrix
Output Class
Target Class

Figure 5:

4

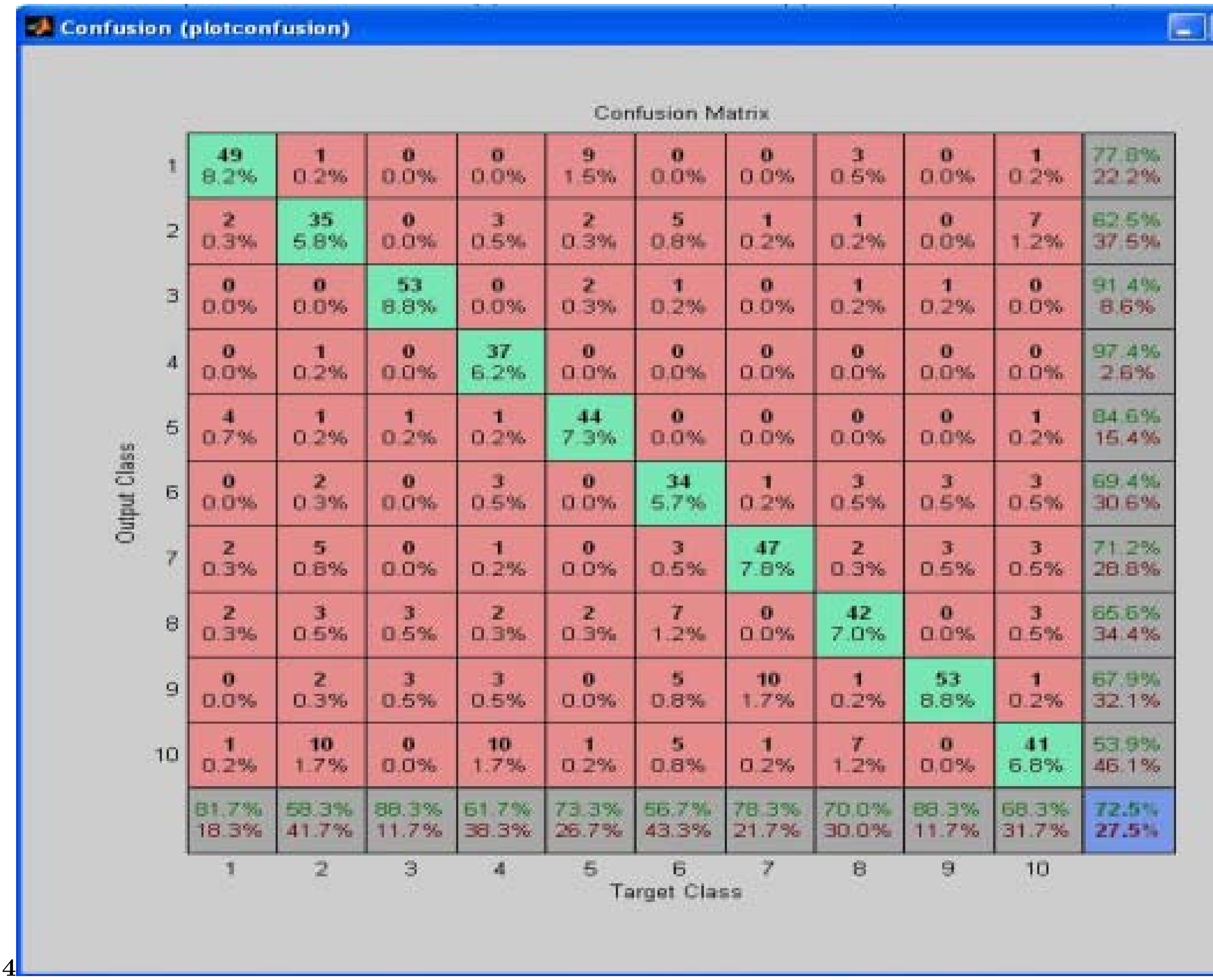


Figure 6: Figure 4 :

5

Class	Accuracy	Sensitivity	Specificity	Precision	NPV	F Measure
1	96.33	75	98.70	86.53	97.26	0.8
2	95.83	80	97.59	78.68	97.77	0.79
3	97.66	91.66	98.33	85.93	99.06	0.88
4	97.66	85	99.07	91.07	98.34	0.8793
5	98.00	88.33	99.07	91.38	98.70	0.898
6	95.16	68.33	98.15	80.39	96.54	0.739
7	95.66	85	96.85	75.00	98.30	0.797
8	93.5	71.67	95.93	66.15	96.82	0.688
9	95.166	83.3	96.48	72.46	98.11	0.775
10	92.66	60	92.69	64.28	95.58	0.62

Figure 7: Figure 5 :

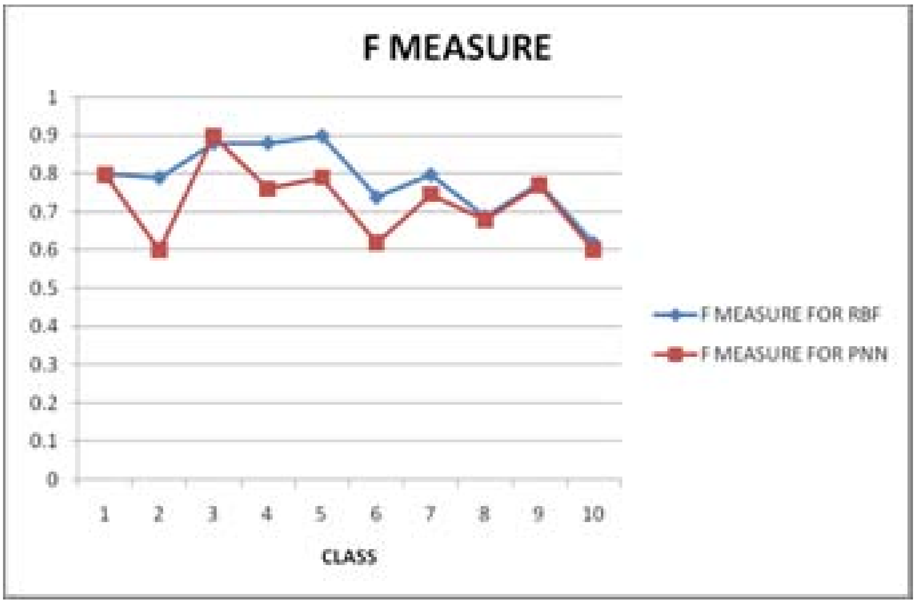


Figure 8:

Class	Accuracy	Sensitivity	Specificity	Precision	NPV	F Measure
1	95.80	81.67	97.40	77.78	97.75	0.796
2	92.10	58.33	96.11	62.50	95.4	0.6
3	98.00	88.33	99.01	91.37	98.70	0.898
4	96.00	61.66	99.80	97.36	95.90	0.76
5	96.00	73.30	98.50	84.62	97.08	0.79
6	93.16	56.67	97.22	69.38	95.28	0.62
7	94.66	78.30	96.48	71.2	95.77	0.746
8	93.33	70.00	95.92	65.62	96.66	0.68
9	94.66	88.33	95.37	67.94	98.65	0.77
10	91.00	68.30	93.52	53.94	96.37	0.6

Figure 9:

2

Figure 10: Table 2 :

3

?	% Characters Correctly Classified
.6	72.5
1.2	78.2
1.8	77.8
2.4	78.8
3.0	78.2

Figure 11: Table 3 :

4

?	% Characters Correctly Classified
.9	70.7
1	71.3
1.1	71.7
1.2	72.0
1.3	72.3
1.4	72.5
1.5	72.2
1.6	71.7

Figure 12: Table 4 :

5

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Figure 13: Table 5 :

6

[Note: 1. The Performance metric accuracy which is a function of specificity and sensitivity is a measure for comparing two classifiers. The accuracy of RBF network for all the classes except classes with labels 8 and 10 is above 95% where as with PNN the accuracy for four classes with labels 1, 3, 4, 5 are above 95% and for the remaining is less than 95%. The comparison of accuracy measure is shown in figure5. 2.]

Figure 14: Table 6 :

[Romero and Touretzky] , R Romero , . D Touretzky .

[Kunte.R.S and Samuel.R.D.S ()] 'A simple and efficient optical character recognition system for basic symbols in printed Kannada text'. *SADHANA* Kunte.R.S and Samuel.R.D.S (ed.) 2007. 32 (5) p. .

[Heutte et al. ()] 'A structural /stastical feature based vector for handwritten character recognition'. Heutte , T Paquet , . J Moreau , Oliver . *Proceedings of Int. Joint Conf. on Neural Networks*, P K Patra, M Nayak, . S Nayak, GobbakN (ed.) (Int. Joint Conf. on Neural Networks) 1998. 2002. p. . (Probabilistic Neural Network for Pattern Classification)

[Nawaz et al. ()] 'An Approach to offline Arabic character recognition using neural networks'. . S N Nawaz , Zidouri M Sarfraz , G Al-Khatib . *Proceedings of the 11th IEEE Int. Conf. on Electronics, Circuits and Systems*, (the 11th IEEE Int. Conf. on Electronics, Circuits and Systems) 2004.

[Negi and Bhagavati ()] 'An OCR system for Telugu'. Krishna A B Negi , Bhagavati . *Proceedings of Int. conf. on Document Analysis and Research*, (Int. conf. on Document Analysis and Research) 2001. p. .

[Chinese characters by using neural network Proceedings of the Int. Multitopic conf. INMIC ()] 'Chinese characters by using neural network'. *Proceedings of the Int. Multitopic conf. INMIC*, (the Int. Multitopic conf. INMIC) 2006. p. .

[Jeatrakul and Wong ()] 'Comparing the Performance of Different Neural Networks for Binary Classification Problems'. Jeatrakul , K Wong . *Proceedings of the Eighth Int. Sym. on Natural Language Processing*, (the Eighth Int. Sym. on Natural Language Processing) 2009.

[Koche (2010)] 'Comparison of Neural Network and Template Matching Technique for Identification of Characters in License Plate'. Koche . *Proceedings of the Int. Conf. on Information Science and Applications ICISA 2010*, (the Int. Conf. on Information Science and Applications ICISA 2010Chennai, India) 2010. 6 February 2010. 2010.

[Han and Kamber ()] Han , Kamber . *Data Mining concepts and Techniques*, 2009. Elsevier publishers. (nd ed.)

[Birijesh ()] 'Handwritten Hindi Character Recognition Using Multilayer Perceptron and: Radial Basis Function Neural Networks'. K V Birijesh . *Int. Jour. of Computer Science & Communication* 2010. 1 (2) p. .

[Tan et al. ()] *Introduction to Data Mining, Pearson Education*, . P N Tan , Steinback , Kumar . 2007.

[Khawaja et al. ()] A Khawaja , S Tinghi , . N M Menon , Rajpur . *Recognition of printed ©2011 Global Journals Inc. (US)*, 2006.

[Optical Chinese Character Recognition Using Probabilistic Neural Networks Pattern Recognition ()] 'Optical Chinese Character Recognition Using Probabilistic Neural Networks'. *Pattern Recognition* 1997. 30 p. . (Thibadeau.R)

[Khatatneh et al. ()] 'Probabilistic Artificial Neural Network For Recognizing the Arabic Hand Written Characters'. K Khatatneh , M Ibrahiem , Basem El Emary , Al-Rifai . *Jour. of Computer Science* 2006. 2 (12) p. .

[Vijay ()] 'Radial Basis Function and Subspace Approach For Printed Kannada Text Recognition'. . K Vijay . *Proceedings of the IEEE Int. Conf. on Acoustics, Speech and Signal Processing*, (the IEEE Int. Conf. on Acoustics, Speech and Signal Processing) 2004.

[Vatkin and Selinger (2001)] 'The system of Handwritten Characters Recognition on the Basis of Legendre Moments and Neural Network'. M Vatkin , Selinger . *The Intr. Wor. on Discrete-Event System Design, DESDes'01*, 2001. June 27-29.

[Ashok and Rajan ()] 'Writer Identification and Recognition Using Radial Basis Function'. J Ashok , . E Rajan . *Int. Jour. of Computer Science and Information Technologies* 2010. 1 (2) p. .