Handwritten Character Recognition using Different Kernel based SVM Classifier and MLP Neural Network (A COMPARISON)

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ABSTRACT

Neural Networks and SVM are recently being used in various kind of pattern recognition. As humans, it is easy to recognize numbers, letters, voices, and objects, to name a few. However, making a machine solve these types of problems is a very difficult task .Character Recognition has been an active area of research in the field of image processing and pattern recognition and due to its diverse applicable environment, it continues to be a challenging research topic. It has numerous applications which include, reading aid for blind, bank cheques and conversion of any hand written document into structural text form. In this paper an attempt is made to recognized handwritten character using the multi layer feed forward back propagation neural network without feature extraction and SVM classifier. Character data is used for training the neural network and SVM. The trained network is used for classification and recognition. For the neural network, each character is resized into 70x50 pixels, which is directly subjected to training. That is, each resized character has 3500 pixels and these pixels are taken as features for training the neural network. For the SVM classifier recognition model is divided in two phases namely, training and testing phase. In the training phase 25 features are extracted from each character and these features are used to train the SVM. In the testing phase SVM classifier is used to recognize the characters. The results show that by applying the proposed system, we reached a high accuracy for the problem of handwritten character recognition.

Keywords - Handwritten character recognition, Pre-processing, Segmentation, Morphological operations, Feed forward back propagation Neural Network, Support vector machine.

1. INTRODUCTION

Handwriting recognition has been one of the most fascinating and challenging research areas in field of image processing and pattern recognition in the recent years [1] [2].Handwritten characters have infinite variety of style from one person to another person. Due to this wide range of variability, it is difficult to recognize by a machine. Several research works have been focusing on new techniques and methods that would reduce the processing time while providing higher recognition accuracy [3] [4]. Work on English handwritten character recognition can be found in [17, 18, and 19]. Most of the researchers have tried to solve the problems based on the image processing and pattern recognition techniques.

In general, handwriting recognition methods are classified into two types as off-line and on-line handwriting recognition methods. In the off-line recognition, the writing is usually captured optically by a scanner and the completed writing is available as an image. But, in the on-line system the two dimensional coordinates of successive points are represented as a function of time and the order of strokes made by the writer are also available. The on-line methods have been shown to be superior to their off-line counter parts in recognizing handwritten characters due to the temporal information available with the former [6]. However, in the off-line systems, the neural networks have been successfully used to achieve comparably high recognition accuracy levels [7] [8]. Several applications including mail sorting, bank processing, document reading and postal address recognition require offline handwriting recognition systems. In this paper a neural network without feature extraction and SVM based off-line handwritten character recognition system is proposed. For the neural network the pre-processed image is segmented into individual characters. Each character is resized into 70x50 pixels and these pixels are used to train a feed forward back propagation neural network to perform classification and recognition tasks. For the SVM the recognition model consists of two parts namely, training and testing phase. In the training phase the features are extracted from the pre-processed image and these features are used to train the SVM. In the testing phase SVM classifier is used to recognize the characters. The result shows that the proposed recognition system provides good recognition accuracy.

The rest of the paper is organized as follows. In section 2, the proposed recognition system is presented. Section 3 presents the experimental results and comparative analysis and finally, conclusion are given in section 4.

2. THE PROPOSED RECOGNITION SYSTEM

In this section, the proposed recognition system is described. A typical handwriting recognition system consists of pre-processing, segmentation, classification and post processing stages. The general schematic diagram of the recognition system is shown in Figure 1.The proposed method for the neural network which does not include feature extraction stage and include an extra cropping stage is shown in Figure 2[20]. The

proposed method for the SVM which include feature extraction stage is shown in Figure 5.

2.1 Multi layer Neural Network

2.1.1 Image acquisition

In Image acquisition, a scanned image of character data is acquired as an input image. The image can have a specific format such as JPEG, BMP etc. This image is acquired through a scanner, digital camera or any other suitable digital input device and given as an input to the pre-processing stage.

2.1.2 Pre-processing

Pre-processing stage involves all the operations that are performed on acquire image to produce a clean character image that is suitable for cropping and segmentation stage [9] [10]. The various steps performed on the image in pre-processing stage are shown in Figure 3. Binarization process converts a gray scale image into a binary image using Otsu method of thresholding. Edge operation is performed on each character to find the edge of each character. Then dilation is done to make the character larger by adding pixels around its edges.

2.1.3 Cropping

The cropping operation is performed on the pre- processed image so that the each character in an image can be tightly fit in a square box that is equal in size to the width and height of the characters.

2.1.4 Segmentation

In the segmentation stage, an image of sequence of character is decomposed into sub-images of individual character [11]. In this system, the pre-processed input image is segmented into individual characters by assigning a number to each character using a labeling process. This labeling provides information about number of characters in the image. Each individual character is uniformly resized into 70X50 pixels and used as the input to the neural network. the output layer is 26 as the proposed system is designed to recognize characters. [13]

2.1.6 Post- processing

Post-processing stage is the final stage of the recognition system. It prints the corresponding recognized characters in the

2.1.5 Classification and Recognition

The classification stage is the decision making part of the recognition system [12]. A feed forward back propagation neural network is used for classifying and recognizing the handwritten characters. The 3500 pixels derived from the resized character in the segmentation stage form the input to the classifier. The neural classifier consists of two hidden layers besides an input layer and an output layer. The hidden layer uses log sigmoid activation functions and output layer is a competitive layer as one of the characters is required to be identified at any point in time. The total number of neurons in structured text form by calculating equivalent ASCII value using recognition index of the test samples.

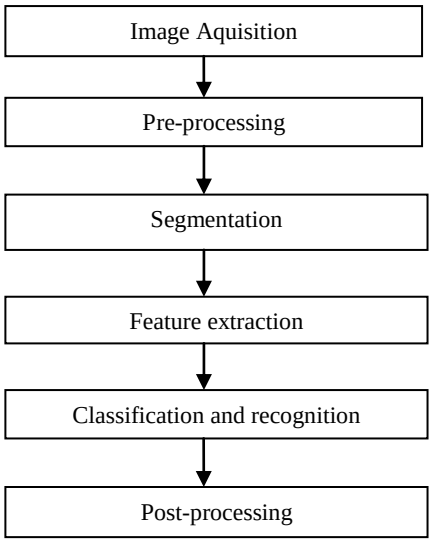

Figure1. General Off line Character Recognition System

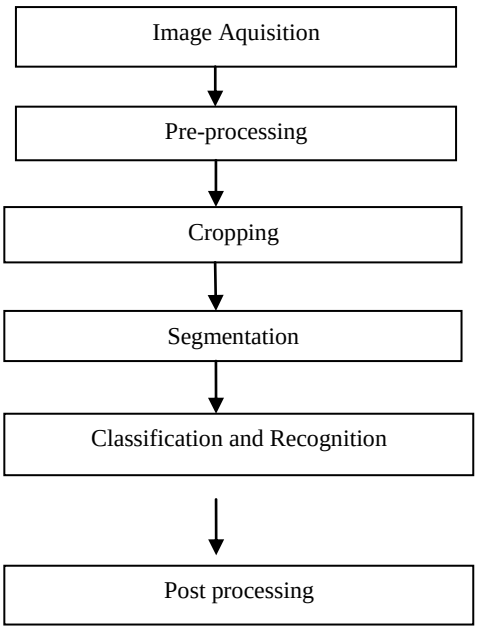

Figure2. Schematic Diagram of Proposed Recognition System using Neural Network

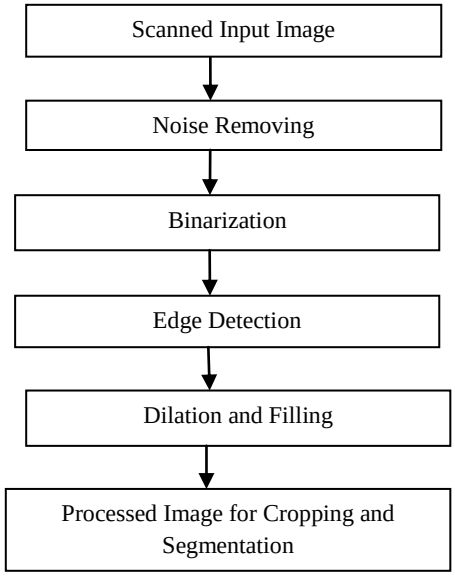

Figure 3. Pre-processing of Handwritten characters Image

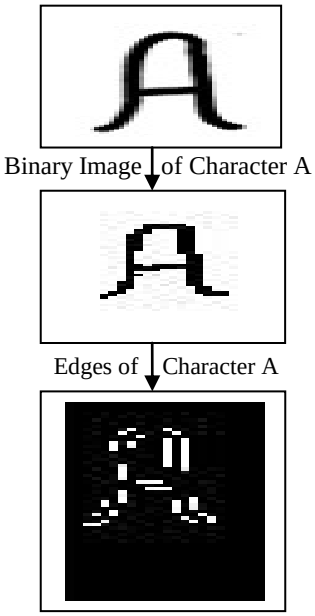

Figure 4. Images of Pre-processing steps

2.2 Support Vector Machine

The concept of (SVM) Support Vector Machine was introduced by Vapnik [14]. The objective of any machine that is capable of learning is to achieve good generalization performance, given a finite amount of training data, by striking a balance between the goodness of fit attained on a given training dataset and the ability of the machine to achieve error-free recognition on other datasets. With this concept as the basis, support vector machines have proved to achieve good generalization performance with no prior knowledge of the data. [15] The principle of an SVM is to map the input data onto a higher dimensional feature space nonlinearly related to the input space and determine a separating hyper plane with maximum margin between the two classes in the feature space. A support vector machine is a maximal margin hyper plane in feature space built by using a kernel function. This results in a nonlinear boundary in the input space. The optimal separating hyper plane can be determined without any computations in the higher dimensional feature space by using kernel functions in the input space [16]. Commonly used kernels include:-

a) Linear Kernel

$$K(x, y) = x, y$$

b) Polynomial Kernel

$$K(x, y) = (x. y+1)^d$$

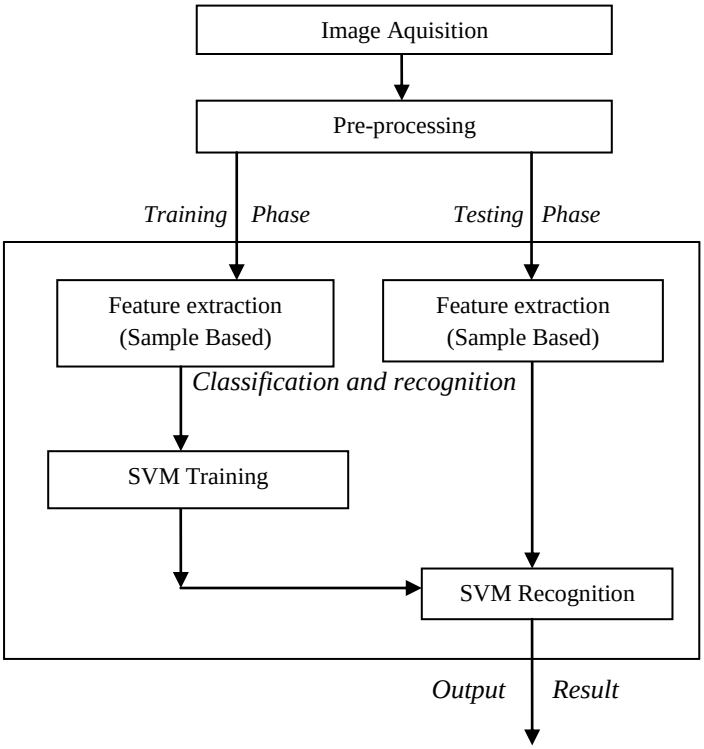

Figure 5.Schematic diagram of proposed recognition system using SVM.

2.2.1 Image acquisition

In Image acquisition, a scanned image of character data is acquired as an input image. The image can have a specific format such as JPEG, BMP etc. This image is acquired through a scanner, digital camera or any other suitable digital input device and given as an input to the pre-processing stage.

2.2.2 Pre-processing

Pre-processing stage involves all the operations that are performed on acquire image to produce a clean character image that is suitable for feature extraction stage.

2.2.3 Feature Extraction

In feature extraction stage, first the width and height of a character is found out by finding the minimum and maximum column, minimum and maximum row. After that each character is divided into 25 blocks by taking samples at a distance of five pixel from each other and one feature is find out corresponding to each block. Therefore, 25 features are found out corresponding to each character and these features are then used to train the SVM classifier

Table 1.

Detail of the four Neural Based Character Recognition Systems

Networks	1	2	3	4
No. of Layers	2	2	3	3
No. of neuron in input layer	3500	3500	3500	3500
No. of neurons in 1st hidden layer	100	200	100	200
No. of neurons in 2nd hidden layer	0	0	100	100
No. of neuron in output layer	26	26	26	26
Learning rate	0.01	0.01	0.01	0.01
Error rate	1.00E-08			

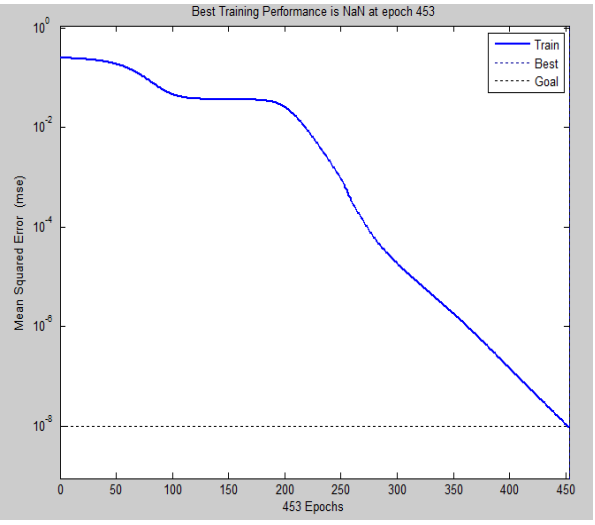

Figure 6.The variation of MSE with training epochs.

3. RESULTS AND PERFORMANCE EVALUATION

The proposed recognition system for the neural network has been implemented using Matlab7.6. Four different neural networks architectures were chosen and each was trained with data sets for a target MSE of 1e-4 and learning rate with 0.01 as shown in Table. 1

Table 2.

The Performance Comparison of the four Neural Based Character Recognition System

Networks	**Recognition accuracy in %**			
	1	**2**	**3**	**4**
A	75	75	95	100
B	70	65	65	75
C	75	85	90	90
D	70	80	75	75
E	70	85	80	85
F	75	85	85	85
G	60	60	60	75
H	65	65	75	70
I	75	70	70	75
J	70	75	80	80
K	70	65	75	80
L	75	75	80	80
M	70	65	75	80
N	65	75	80	80
O	75	80	75	85
P	80	80	85	90
Q	65	60	70	70
R	65	75	75	80
S	70	80	80	85
T	75	85	80	90
U	75	80	80	85
V	75	70	75	80
W	70	70	80	80
X	60	65	75	75
Y	65	75	80	75
Z	60	80	75	80
Total %	71.9	74.03	77.69	80.96

Table 3.

The Performance Comparison of the three Kernel Based SVM Classifier Character Recognition Systems

Kernel Used	Recognition accuracy in %		
	Linear	Polynomial	Quadratic
A	100	95	95
B	100	95	100
C	95	100	95
D	100	90	100
E	100	100	100
F	100	100	100
G	95	95	100
H	100	95	100
I	100	90	100
J	80	85	80
K	90	85	95
L	100	100	100
M	100	100	100
N	100	95	100
O	95	100	95
P	100	100	100
Q	60	60	60
R	95	100	75
S	90	95	100
T	95	95	90
U	85	85	85
V	90	90	85
W	100	100	100
X	100	100	100
Y	95	90	95
Z	100	100	100
Total %	94.80	94.00	94.23

3.1 Performance Evaluation

We tested the performance on Handwritten Character Recognition. For our dataset out of 1340 data samples we considered 780 data samples as training data and 560 as testing data. Some samples of handwritten character are shown in figure.6.The results show that SVM gives more superior results than Neural Network.

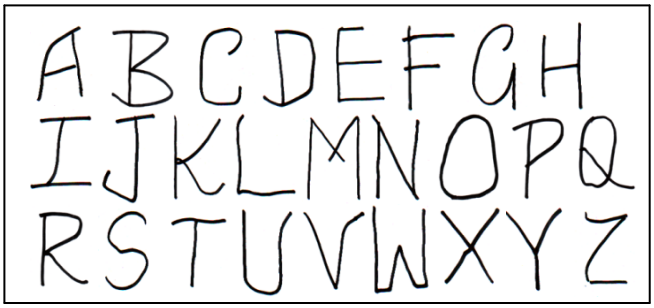

Figure 7.Handwritten Character Data Samples.

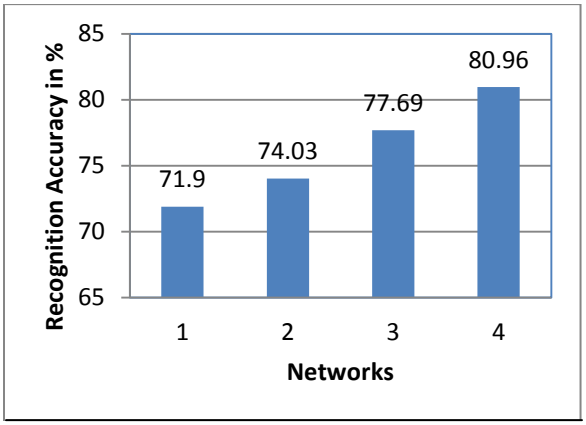

Figure 8. Comparison of the recognition accuracy for individual networks

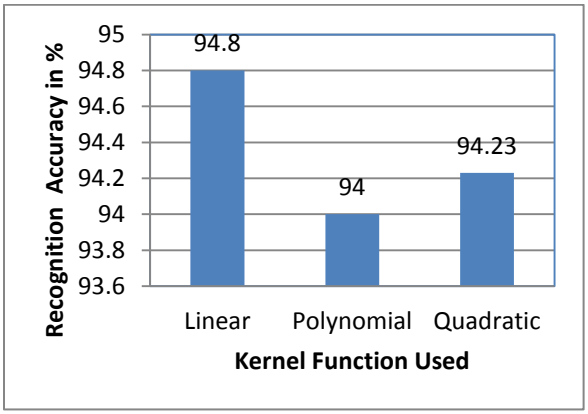

Figure 9. Comparison of the recognition accuracy for Kernel Function Used

Neural Network classifier and SVM classifier show different properties in the following respects [21].

3.1.1Training Complexity

The training time of neural network is linear with the number of input vector since the parameters of neural network are adjusted by negative gradient descent. But the training time of SVM is proportional to the square of number of samples since the SVM are trained by quadratic programming (QP) and least square

programming (LS). So training of SVM is more complex than neural network.

3.1.2 Selection of model

The generalization performance of SVM is less influential than neural network in term of model selection. The convergence of neural network training suffers from local minima, but SVM training guarantees finding global minima. Also the performance of neural network is sensitive to the size of character, but the performance of SVM is insensitive to the size of character due to the use of Kernel function.

3.1.3 Classification accuracy:

SVM gives more classification accuracies than the neural network in the recognition of handwritten character and proved in many experiment. But the main limitation of SVM classifier is that it gives inaccurate result for the character belonging to different class.

3.1.4 Storage and execution complexity:

Neural Network has much less parameter and these parameters are easy to control. During training SVM generally results in a large number of support vectors which must be stored and computed during the recognition of characters. So Neural network classifier requires less storage and computation than SVM.

Table 4.

Comparison of SVM and MLP Neural Network on our Dataset

Classifier		Test Data	Training Data
SVM	Linear	94.80	100
Multi layer feed forward Back propagation Neural Network	Two Hidden Layer (One with 200 and other with 100 neuron)	80.96	100

4. CONCLUSION

The result obtained for recognition of handwritten characters show that reliable classification is possible using SVMs. Of the several neural networks architectures used for classifying the characters, the one with two hidden layers, having 200 neurons in first hidden layer and 100 neurons in second hidden layer has been found to yield the highest recognition accuracy of 80.96%. Of the several Kernel function used in SVM for classifying the characters, the linear kernel function yields the highest recognition accuracy of 94.8 and this accuracy is more than the neural network model. The handwritten recognition system described in this paper will find potential applications in handwritten name recognition, document reading, conversion of any handwritten document into structural text form and postal address recognition. The SVM-based method described here for offline Handwritten Character can be easily extended to other Indian scripts and Handwritten numerals also.

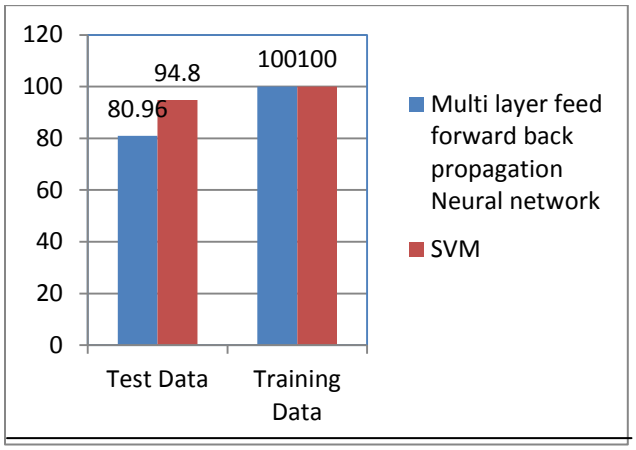

Figure10. Comparison of the recognition accuracy for FFBP Neural Network and SVM

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