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OFF-LINE HANDWRITTEN DEVANAGARI SCRIPT RECOGNITION USING DIAGONAL FEATURE EXTRACTION METHOD

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ABSTRACT

Handwritten Devanagari script recognition system using neural network is presented in this paper. A new method, called, diagonal based feature extraction is used for extracting features of the handwritten Devanagari script. Fifty data sets, each containing 44 characters written by various people, are used for training neural network and 570 different handwritten Devanagari characters are used for testing. The proposed recognition system performs quite well yielding higher levels of recognition accuracy compared to systems employing the conventional horizontal and vertical methods of feature extraction.

Keywords- *Handwritten character recognition; image processing; feature extraction; feedforward neural network*

INTRODUCTION

Handwriting recognition has been one of the fascinating and challenging research areas in field of image processing and pattern recognition in the recent years [1] [2]. It contributes immensely to the advancement of an automation process and can improve the interface between human beings and machine in numerous applications. Several research works have been focusing on new techniques and methods that would reduce the processing time while providing higher recognition accuracy [3].

In general, handwriting recognition classified into two types as off-line and on-line handwriting recognition methods. In off-line recognition, the writing is usually captured optically by a scanner and complete 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 counterparts in recognizing handwritten characters due to the temporal information available with the former [4] [5]. Several applications including mail sorting, bank processing, document reading and postal address recognition require off-line handwriting recognition systems. As the result, the off-line handwriting recognition continues to be an active area for research towards exploring the newer techniques that would improve recognition accuracy [6] [7].

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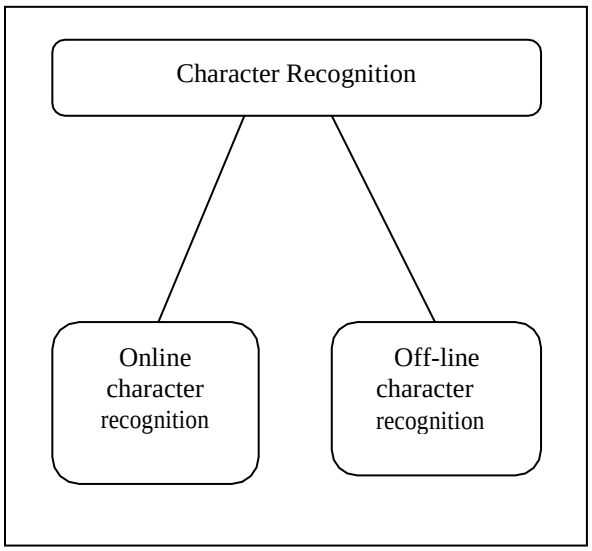

Type of Character recognition

The first important step in any handwritten recognition system is pre-processing followed by segmentation and feature extraction. Pre-processing includes the steps that are required to shape the input image into a form suitable for segmentation [8]. In the segmentation, the input image is segmented into individual characters and then, each character is resized into m x n pixels toward training neural network. The selection of appropriate feature extraction method is probably the single most important factor in achieving high performance. Several methods of feature extraction for character recognition have been reported in the literature [9]. The widely used feature extraction methods are Template matching, Deformable templates, Unitary Image transforms, Graph description, Projection Histograms, Contour profiles, Zoning, Geometric moments invariants, Zernike Moments, Spline curve approximation, Fourier descriptors, Gradients feature and Gabor features.

An artificial neural network as the backend is used for performing classification and recognition tasks. In the off-line recognition system, the neural networks have emerged as the fast and reliable tools for classification towards achieving high recognition accuracy [10]. Classification techniques have been applied to handwritten character recognition since 1990s. These methods include statistical methods based on Bayes decision rule, Artificial Neural Networks (ANNs), Kernel Methods including, Support Vector Machines (SVM) and multiple classifier combination [11][12].

Handwritten character recognition is not a simple task. Character recognition is complex task, even after writing people are not able to understand but he/she written. So to reach 100% accuracy is very difficult job. Many researchers have done lots of work in this field but, 100% accuracy in not achieved.

In this paper, a diagonal feature extraction scheme for the recognizing off-line handwritten characters in proposed. In the feature extraction process, resized individual character of size 90x60 pixels is further divided into 54 equal zones, each of size 10x10 pixels. The features are extracted from the pixels of each zone by moving along their diagonals. This procedure is repeated for all the zones leading to extraction of 54 features for each character. These extracted features are used to train

a feed forward back propagation neural network employed for performing classification and recognition tasks.

The paper is organized as follows, in Section II; the proposed recognition system is presented. The feature extraction procedure adopted in the system is detailed in the section III. Section IV describes the classification and recognition using feed forward back propagation neural network. Section V presents the experimental results and comparative analysis and finally, the paper is concluded in section VI.

DEVANAGARI SCRIPT RECOGNITION SYSTEM

In this section, the proposed recognition system is described. A typical handwriting recognition system consists of pre-processing, segmentation, feature extraction, classification and recognition, and post processing stages. The schematic diagram of the proposed recognition system is shown in Fig.2

A. *Image Acquisition*

In Image acquisition, the recognition system acquires a scanned image as an input image. The image should have a specific format such as .jpeg, .bmt etc. This image is acquired through a scanner, digital camera or any other suitable digital input device.

B. *Pre-processing*

The pre-processing is a series of operation performed on the scanner input image. It essentially enhances the image rendering it suitable for segmentation. The various tasks performed on the image in pre-processing stage shown in Fig. 1. Binarization process converts a gray scale image into a binary image using thresh holding technique. Detection of edges in the binarized image using sobel technique, dilation the image and filling the holes presented in it are the operations performed in the last two stages to produce the pre-processed image suitable for segmentation [13].

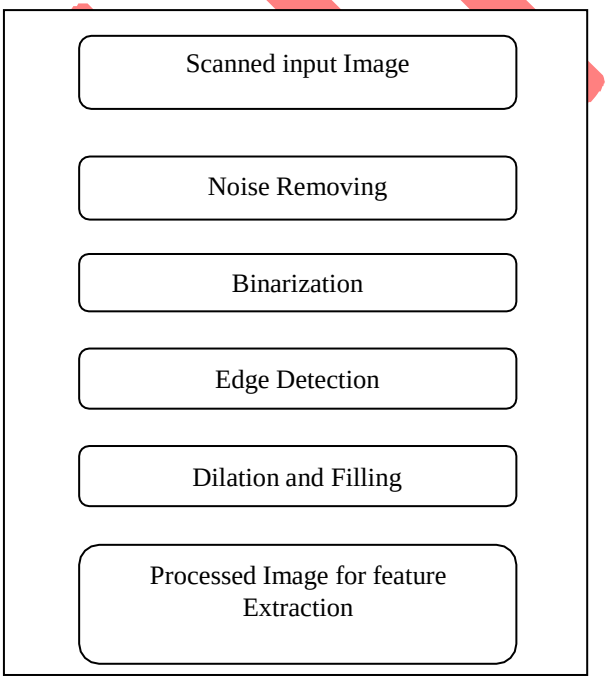

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Fig. 1 Pre-processing of handwritten character

C. *Segmentation*

In the segmentation stage, an image of sequence of characters is decomposed into sub-images of individual character. In the proposed system, the pre-processed input image is segmented into isolated 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 90x60 pixels for classification and recognition stage.

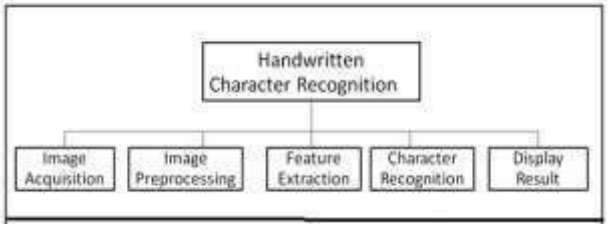

Fig. 2 Diagram of proposed recognition system.

FEATURE EXTRACTION METHOD

In this stage, the features of characters that are crucial for classifying them at recognition stage are extracted. This is an important stage as its effective functioning improves the recognition rate and reduces the misclassification [14]. First of all try to understand Devanagari script, Devanagari script written left to right along a horizontal line. Its basic set of symbols consists of 34 consonants („vyanjan") and 11 vowels („svar"). Characters are joined by a horizontal bar that creates an imaginary line when Devanagari text is suspended and no spaces are used between words. A single or double vertical line called „Puran Viram" was traditionally used to indicate the end of phrase or sentence. In part, Devanagari owns its complexity to its rich set of conjuncts. The language is partly phonetic in that a word written in Devanagari can only be pronounced in one way, but not all possible pronunciations can be written perfectly. Diagonal feature extraction scheme for recognizing off-line handwritten characters in proposed in this work. Every image of size 90x60 pixels is divided into 54 equal zones, each of size 10x10 pixels (Fig.3(c)). The features are extracted from each zone pixels by moving along diagonals of its respective 10x10 pixels. Each zone has 19 sub-features values are averaged to form a single feature value and placed in the corresponding zone (Fig. 3(b)). This procedure is sequentially repeated for the all the zones. There could be some zones whose diagonals are empty of foreground pixels. The feature values corresponding to these zones are zero. Finally, 54 features are extracted for each character. In addition, 9 and 6 features are obtained by averaging the values placed in zones row-wise and column-wise, respectively. As result, every character is represented by 69, that is, 54+15=69 features.

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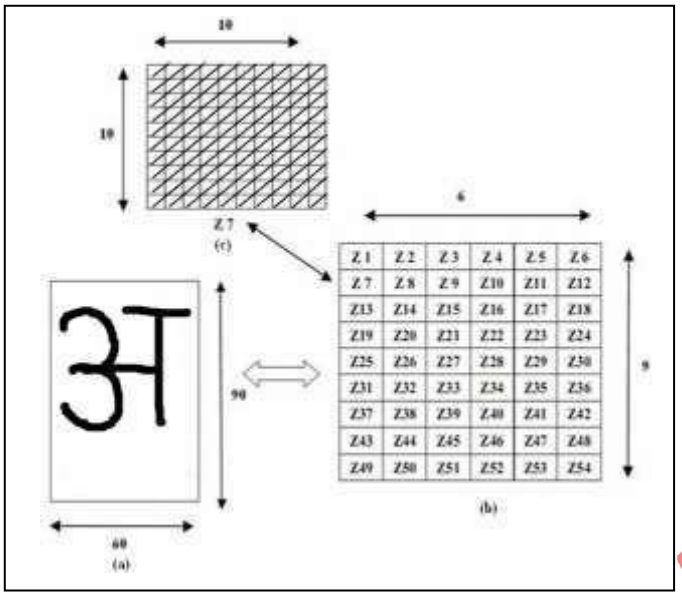

Fig. 3 Procedure for extracting feature from the characters

CLASSIFICATION AND RECOGNITION

The classification stage is the decision making part of a recognition system and it use the features extracted in the previous stage. It is very important stage, success of any neural network depend upon the classification, in this stage input is classified that in which class particular input is belong. Artificial neural networks are one of the popular techniques used for classification due to their learning and generalization abilities. They have been traditionally used for character recognition application. Out of various architectures, multilayer perceptron (MLP) is widely used. The MLP is a fully connected network, where every neuron in a layer is connected to each and every neuron in the next layer by a weighted link through which the state of the neuron is transmitted. It consists of an input layer, a hidden layer and an output layer. The feature vector is applied as the input signal to the neurons in the hidden layer from the input layer. A bias is similar to weight. It acts exactly as a weight on a connection from a unit whose activation as always one. Each neuron in the hidden layer includes a nonlinear activation function. In proposed work, a feed forward back propagation neural network having two hidden layers with architecture of 54-100-100-44 is used to perform the classification. The hidden layers use log sigmoid activation function, and the output layer is a competitive layer, as one of the characters is to be identified. The feature vector is denoted as X where X= (f1, f2,…fd) where f denotes features and d is the number of zones into which each character is divided. The number of input neurons is determined by length of the feature vector d. The total numbers of characters n determines the number of neurons in the output layer. The number of neurons in the hidden layers is obtained by trial and error. The most compact network is chosen and presented.

Once the network weights and biases are initialized, the network is ready for training or learning. The hidden neurons enable the network to learn complex tasks by extracting progressively more meaningful features from the input vectors. A learning rule is a procedure for modifying weights and

biases of a network. The purpose of the learning rule is to train the network to perform a pattern recognition task.

The network training parameters are:

- Input Nodes : 54/69
- Hidden Nodes :100 each
- Output nodes : 44 (33 consonants, 11 vowels)

RESULTS AND DISCUSSION

The recognition system has been implemented using Matlab 7.1. The scanned image is taken as dataset/input and feed forward architecture is used. The structure of neural network includes an input layer with 54/69 inputs, two hidden layer with 100 neurons and an output layer with 44 neurons. The gradient descent back propagation method with momentum and adaptive learning rate and log-sigmoid transfer functions is used for neural network training. Neural has been trained using known dataset. A recognition system using two different feature lengths is built. The number of input nodes is chosen based on the number of features. After training the network, the recognition system was tested using several unknown dataset and the results obtained are presented in the section.

Two approaches with three different ways of feature extraction are used for character recognition in the proposed system. The three different ways of feature extraction are horizontal direction, vertical direction and diagonal direction.

In the first approach, the feature vector size is chosen as 54, i.e. without row-wise and column-wise features. The results obtained using three different types of feature extraction are: (i) the speed of convergence, i.e. number of epochs required to achieve the training goal and (ii) training stability. However, the most important parameter of interest is the accuracy of the recognition system. The results presented in Table 1 show that the diagonal feature extraction yields good recognition accuracy compared to the others types of feature extraction. Fig. 5 shows the Error (MES) vs. Training Epochs performance function of the network with 54 features obtained though diagonal extraction. The desired performance goal has been achieved in 923 epochs.

In the second approach, the feature vector size is chosen as 69 including the row-wise and column-wise features. The results obtained for the second approach is also presented in Table II and it shows that the diagonal feature extraction provides higher recognition accuracy, compared to the others types of feature extraction. Fig. 6 shows the Error (MSE) vs. Training Epochs performance of the network with 69 features obtained though diagonal extraction. It can be noted that it requires 854 epochs to reduce the mean square error to the desired level.

TABLE I. COMPARSION OF RECOGNITION RATE RESULTS OBTAINED USING DIFFERENT ORIENTATION WITH 54 FEATURES

COMPARSION OF RECOGNTION RATE			
NETWORKS	1	2	3
FEATURES EXTRACTION TYPE	VERTICAL	HORIZONTAL	DIAGONAL
NUMBER OF NODES IN INPUTLAYER	54	54	54
NUMBER OF NODES IN FIRST HIDDEN LAYER	100	100	100
NUMBER OF NODES IN SECOND HODDEN LAYER	100	100	100
NUMBER OF NODES IN OUTPUT LAYER	44	44	44
RECOGNTIONRATE PERCENTAGE	92.69	93.68	97.80

TABLE II. COMPARSION OF RECOGNITION RATE RESULTS OBTAINED USING DIFFERENT ORIENTATION WITH 69 FEATURES

COMPARSION OF RECOGNTION RATE			
NETWORKS	1	2	3
FEATURES EXTRACTION TYPE	VERTICAL	HORIZONTAL	DIAGONAL
NUMBER OF NODES IN INPUTLAYER	69	69	69
NUMBER OF NODES IN FIRST HIDDEN LAYER	100	100	100
NUMBER OF NODES INSECOND HODDEN LAYER	100	100	100
NUMBER OF NODES IN OUTPUT LAYER	44	44	44
RECOGNTION RATE PERCENTAGE	92.43	94.73	98.19

CONCLUSION

A simple off-line handwritten devanagari script recognition system using a new type of feature extraction, namely, diagonal feature extraction is proposed. Two approaches using 54 features and 69 features are chosen to build the neural network recognition system. To compare the recognition efficiency of the proposed diagonal method of feature extraction, the neural network recognition system is trained using the horizontal and vertical feature extraction methods. Six different recognition networks are built. Experimental results show that 69 features gives better recognition accuracy than 54 features for all the types of feature extraction. From the test results it is identified that the diagonal method of feature extraction yields the highest recognition accuracy of 97% for 54 features and 98% for 69 features. The diagonal method of feature extraction is verified using a number of test images. The proposed off-line handwritten character recognition system with better quality recognition rates will be eminently suitable for several applications including postal/parcel address recognition, bank processing, document reading and conversion of any handwritten documentinto structural text form.

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