A Novel Approach to Recognize the off-line Handwritten Numerals using MLP and SVM Classifiers

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Abstract— This paper presents a new approach to off-line handwritten numeral recognition. Recognition of handwritten numerals has been one of the most challenging task in pattern recognition. Recognition of handwritten numerals poses serious problems because of high variability in numeral shapes written by individuals. This paper concerns with offline handwritten numeral recognition based on MLP and SVM classifiers. The performance of character recognition system depends heavily on what kind of features extraction techniques are being used. In this work, we have collected 1200 samples of isolated numerals, contributed by 24 writers and each one has written it five times. In this paper we propose a modified Hough transformation technique and four view projection Profiles technique to extract the feature of numerals. Using the modified Hough transformation technique, we have achieved maximum accuracy of about 93.12% and 72.5% by SVM and MLP classifiers and with four view projection profiles technique; we obtained the 96.04% and 98.73% recognition accuracy by SVM and MLP classifiers.

Keywords - Feature Extraction, SVM and MLP.

I. INTRODUCTION

Optical character recognition, usually abbreviated to OCR is the mechanical or electronic translation of images of handwritten, typewritten or printed text (usually captured by a scanner) into machine-editable text or computer process-able format, such as ASCII code. Whenever a page is scanned, it is stored as a bit-mapped file. When the image is displayed on the screen, we can read it. But it is just a series of dots for the computer. The computer does not recognize any "words" on the image. OCR makes the computer read these words. It looks at each line of the image and determines which particular character is represented by dots. The recognition of handwritten characters by computer has been a topic of intensive search for many years. Handwritten numeral recognition is always the research focus in the field of image process and pattern recognition. The numeral varieties in size, shape, slant and the writing style make the research harder. The numeral character recognition is the most challenging field, because the big research and development effort that has gone into it has not solved all commercial and intellectual problems. Recognition of handwritten numeral is not a single process. It is a combination of many processes such as Digitization, Pre-processing, Feature extraction, Classification. We came across these stages during recognition of numerals. To carried out various experiments, our data set contains the 1200 data samples of numerals. 1200 samples of numerals are contributed by each of the 24 writers of different educational profiles. In this paper, the two different categories of features are used to obtain high degree of accuracy in handwritten numerals recognition. The features include Hough transformation technique and Projection Profile technique. The Hough transform is a feature extraction technique used in image analysis, computer vision, and digital image processing. The projection profile technique is also a feature extraction technique which extracts the features of an image in all directions like horizontal, vertical and diagonal. At last, we have classified the numerals using two classifiers namely SVM and MLP.

II. RELATED WORK

Related work concerns about the previous work and related techniques about numeral recognition. We have studied and analyze many different feature extraction techniques. After our detailed literature review we are able to discover the theme of our work including the techniques we have incorporated in various phases, to implement it and to evaluate our results and conclusion. Topics to be reviewed in literature survey are: Handwritten recognition systems, handwritten numerals feature extraction methods, handwritten verification

methods *etc*. In [1] authors have used sliding window based on the Hough transform as feature extraction technique. In order to build the directional feature vector sequence, image is divided into two windows and determines the dominant direction that based on the Hough transform. In order to recognize the Tifinagh character, they build a different model for each character that is called discriminating hidden Markov model. Finally the class of the input character is determined by the Viterbi classifier and the experiment results indicate the promising prospect of this approach. In [2] authors have used some morphological operations like erosion and dilation are used to remove the noise and then segmented the image into isolated manner. Some statistical features like zone density, projection histogram, 8 directional zone density features with some geometric features like area, perimeter, and eccentricity for extracting the features from handwritten character. In geometric features firstly Area of character image defined number of non pixels in the image. Perimeter defined the length of the smoothest boundary in pixels. The eccentricity is the ratio of distance between foci of the ellipse and its major axis length. The value lies at 0 and 1. For classification feed forward Multi layer preceptron neural network used for classification and recognition. In [3] author has presented four different profiles pattern as feature extraction technique. In pre-processing phase thinning and skew correction are also done of handwritten numerals. For classification neural network is used and she obtained 82% of success rate for Gujarati handwritten digit identification. In [4] author have used three profiles namely, Vertical profile, Horizontal profile and diagonal directions are used for feature extracting 54 features from each character. They have proposed diagonal feature extraction scheme for the recognition of offline handwritten characters. A feed forward back propagation neural network with two hidden layer classifier used to perform the classification. In [5] authors have proposed zone based feature extraction method for recognition of the numerals. Densities of object pixels in each zone were calculated by using zone based feature extraction system. In this method whole image is divided into 4 × 4 zones. For obtaining more accuracy these zones are further divided into 6 × 6 zones. The division of zones is carried up to 8 × 8 zones and 116 features are extracted in all. For classification and recognition purpose, nearest neighbor classifier is used. In [6] authors have presented three sets of features to recognize Gurumukhi numerals, namely, Distance Profile Features having 128 features, Projection histograms having 190 features and background Directional Distribution (BDD) having 144 features. For distance computation they have used Distance profile features. For count the number of foreground pixels in vertical, Horizontal, Left and right diagonal profile they have used projection histogram features and in background directional distribution they calculated the directional distribution value of background pixels for each foreground pixel by using masks for each direction. For classification, an SVM classifier with RBF (Radial Basis function) kernel used.. In [7] authors have have used the Principal Component analysis technique for extracting the features from each numeral image. PCA technique is used for dimensionality reduction and extracting important information such as machine learning, neural network, signal processing. RBF (Radial basis function) is used as a classifier for classification and recognition the data. In [8] authors have used the SVM classifier for recognition of handwritten Gurumukhi character recognition. For extracting the features of character, diagonal features extraction technique has used. In the diagonal feature method, firstly, the character image is divided into different zones and secondly features are calculated in each zone of the character. Each zone has 19 diagonals and these 19 sub features are averaged to form a single pixel and placed in the corresponding zone as a feature, if the diagonal do not have foreground pixel the feature value is taken as zero. In [9] authors have proposed zone based feature extraction algorithm. The character image is (50 × 50) is further divided into 25 equal zones (10 × 10). With reference to the image centroid, the average pixel distance in each zone column computed. For each zone 10 features are extracted and this procedure is sequentially repeated. This procedure is sequentially repeated for each zone row and for each zone 10 features are extracted. Finally 500 such features are extracted for classification and recognition. The nearest neighbor feed forward back propagation neural network and support vector machine classifiers are used for classification and they obtained a better recognition rate than others.

III. DATA COLLECTION

Data collection for the experiment has been done for the different individuals. Currently we are developing datasets for English numerals. We have collected 1200 handwritten numeral samples from 24 different writers. Writers were provided with the plain A4 sheet and each writer has asked to write the numerals from 0 to 9 for five times. The database is totally unconstrained and has been created for validating the recognition system. The collected documents are scanned using HP-scan jet 5400c at 300dpi which is usually a low noise and good quality image. The digitized images are stored as binary images in BMP format. The samples of handwritten numeral are shown in figure 1.

Fig 1. Samples of offline handwritten numerals

IV. ARCHITECTURE OF OFFLINE NUMERAL RECOGNITION SYSTEM

The process of optical character/numeral recognition of any script can be broadly divided into basic four stages. Recognition of handwritten numeral is not a single process. It is a combination of many processes such as Digitization, Pre-processing, Feature extraction, Classification. We came across these stages during recognition of numerals [Kumar et al., 2011]. The architecture of numeral system is shown in figure 2.

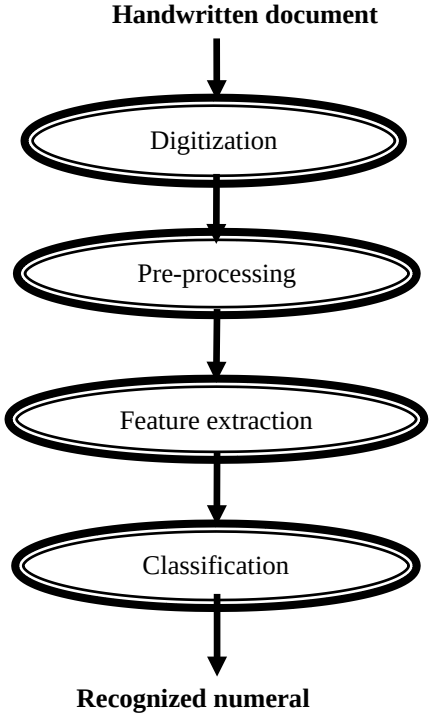

Fig 2.Architecture of numeral recognition system

- **Digitization**

This is the first phase of handwritten numeral recognition system. In this phase handwritten document is converted into digital form by using a scanner or other electronic machine and it's stored in gray format which is fed into pre-processing phase It is called digitization.

- **Pre-processing**

In pre-processing phase, the various operations are performed on the numeral images such as binarization is done by using Ostu's algorithm [Majumdar and Chaudhuri, 2006], normalization the image 100 × 100 size and thinning is performed by using Zhang algorithm.

- **Feature extraction**

This is the most important phase of handwritten numeral recognition system. The main objective of feature extraction is to extract all the essential characteristics of the numeral image. Each numeral image has some set of features which are extracted. The selection of the appropriate feature extraction method is probably the single most important factor in achieving high recognition performance. So, the extracted features should be able to classify each numeral uniquely [Dhandra et al., 2010]. This stage is the main stage of HNR (Handwritten Numeral Recognition) because the output highly depends upon the extracted features. The widely used feature extraction techniques are Zoning, Projection profiles, Hough transform, Chain code, Fourier descriptor etc. In

this phase, we can extract structural features or statistical features or both. The feature extraction techniques extract the features for classification and recognition of numeral. There are two types of feature extraction techniques. The feature extraction technique can be grouped into three classes namely.

- Structural features
- Statistical features
- Hybrid features

The structural technique uses the qualitative measurements for recognizing the numeral image statistical technique uses the quantitative measurements and Hybrid technique is the combination of structural and statistical features used for recognition [Hallur et al., 2012]. We have proposed two feature extraction techniques namely, modified Hough transformation technique and four view projection profiles.

Algorithm of modified Hough transformation: Recognition of offline handwritten numerals

Input: Pre-processed offline handwritten numeral images

Output: Recognized numerals.

Begin:

1. Convert the grayscale image into a binary image of numeral and normalized into 100 ×100 sizes.
2. Divide the bitmap image of n (=25) number of zones.
3. Calculate the values *(x, y)* of *r* as following for each *ON* pixel in each zone.

$$\boldsymbol{r = xcos\theta + ysin\theta}$$

4. Take the standard theta values 0, 30, 60, 90, 120, 150 for each *ON* pixels.
5. Calculate the largest values of *ON* pixels in each zone and then calculate the average of largest values of each pixel from each zone and store this value as a feature element in the corresponding zone.
6. For the zones, that do not have foreground pixel, then consider the feature value as zero.
7. These steps will give a feature vector of *n* elements.Four view projection profiles technique

The four view projection profiles technique is used to count the off pixels vertically, horizontally (L to R) and (R to L) and diagonally till the on pixel or boundary of the numeral image is not found. First of all numeral image is divided into no. of 25 zones, in each zone features are extracted to form feature vector.

Algorithm of four view projection profiles: Recognition of offline handwritten numerals

Input: Pre-processed offline handwritten numeral image

Output: Recognized numerals.

Begin:

1. Convert the gray scale image into a binary image of numeral and normalized into 100 ×100 sizes.
2. Divide the image into *n* numbers of zones.
3. Find the Horizontally (L to R) and (R to L), vertically and Right diagonal projection profiles in each zone.
4. Store the average of peak values of horizontal (L to R) and (R to L), vertical and right diagonal projection profile.
5. Store these values as feature elements into feature vector.
6. These steps will give a feature set with *n* elements.

V. CLASSIFICATION

Classification phase is the decision making phase of the handwritten numeral recognition system. The main objective of this phase is to identify the numeral and assign it to correct numeral class. This phase uses the features, which have been extracted in the previous stage for making the class membership of numerals. There are various types of classifiers are used like Support vector machine, Multilayer preceptron.

- **Support vector machine**

SVM is group of learning algorithm which is used for classification and regression. The Support Vector Machine (SVM) was first proposed by Vapnik and has since attracted a high degree of interest in the machine learning research community [Srivastava and Bhambhu, 2009]. Support vector machines build the hyper plane or set of planes which are used for classifying the data into two classes. SVM uses the supervised learning approach which means the training data is controlled by an external agent (experts) and it classifies unseen data based on a set of labelled training data set. SVM maps the input data into higher dimensional space where a maximally separated hyper plane is constructed. For multiclass classification, we decompose multiclass problem into multi binary class problems, so we build a combined multiple binary SVM classifiers. We obtained such multiclass SVM classifier tool LIBSVM and practical guide for SVM and implementation [Jindal et al., 2012, Chang et al., 2001, Hsu et al., 2003].

- **Multi layer Preceptron classifier**

MLP's are feed-forward networks of simple processing units (neurons) with at least one "hidden" layer. The MLP classifier is used for the classification. The MLP network consists of three layers namely, input layer, hidden layer and output layer. A neuron has more than one input, the individual inputs C_1, C_2, C_3…..…. C_R is weighted by corresponding elements $W_{1,1}$, $W_{1,2}$…..… $W_{1,R}$. The sum of the $W_i C_{i R}$ products gives the net activation of the neuron This activation value is subjected to a transfer function to produce the neuron's output. Every neuron has bias *b* which is summed with weighted inputs to form the net input N [Nazzal et al., 2008].The architecture of Multilayer Preceptron is shown in figure 1.3.

$$N=W_{1,1}+C_1+W_{1,2}+C_2+W_{1,3}+C_3\ldots\ldots\ldots\ldots\ldots W_{1,R}+C_R+B$$

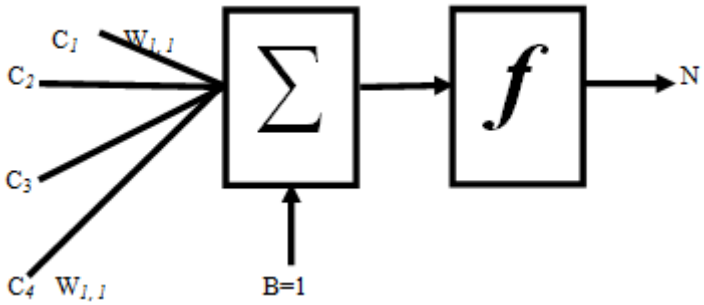

Fig. 3 Architecture of Multilayer preceptron [Nazzal et al., 2008]

VI. EXPERIMENTAL RESULTS AND DISCUSSION

In this work, firstly we took the samples of numeral on white paper in an isolated manner, then converts into digital form by using a scanner or other electronic device. Our dataset contains 1200 images of offline handwritten numerals. 1200 samples of offline handwritten numerals are contributed by each of the 24 writers of different educational profiles and each writer wrote five times numerals. Out of 1200 images, 60% data is used to train the system and 40% is used for testing purposes. Using the modified Hough transformation technique, we have achieved maximum accuracy of about 93.12% and 72.5% by SVM and MLP classifiers and with four view projection profiles technique; we obtained the 96.04% and 98.73% recognition accuracy by SVM and MLP classifiers. This proposed work provides better numeral recognition rate than the existing work. The results show that four view projection profiles technique performs well in recognizing the offline handwritten numerals than modified Hough transformation technique. As a whole, it offers a satisfactory rate but it is subject to further improvement.

VII. FUTURE SCOPE

The handwritten numeral recognition has been extensively researched in the past few decades and has always been the challenging task. In this research work a lot of efforts have been made for increasing the accuracy of offline handwritten numeral recognition.

Our ultimate goal is to design a numeral recognition system having maximum accuracy and propose new feature extraction techniques which provide good results. The accuracy can be increased by considering the large dataset and this work can also be extended for handwritten character recognition of Indian scripts..

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