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Handwritten Numeral Recognition using SVM and Chain Code

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Abstract: According to recent survey, there are at least 550 million people are using Devanagari script for communication. Hindi is one of the languages, which is derived from Devanagari script. For any character recognition system, essential step is to identify individual character and find features to compare it with the template features .A system has been developed for text writing systems using Support Vector Machines (SVM) is called Handwritten Character Recognition (HCR). In this paper, we have proposed chain code and energy extracted features were passed to a Support Vector Machine The data obtained is then used for recognition using the kernel functions of SVM. The recognition accuracies are obtained on data using the kernel functions of SVM. In the proposed approach, the four-directional chain code histogram of each grid on the contour of the image is extracted

Key Words: Character recognition, handwriting character recognition, support vector machine (SVM).

1. INTRODUCTION

The aim of handwritten numeral recognition (HNR) system is to classify input numeral as one of K classes. Conventional HNR systems have two components: feature analysis and pattern classification. In Feature analysis step, Information relevant for pattern classification is extracted from the input numeral. The pattern classification step labels the numeral as one of K classes using the class models. Over the years, considerable amount of work has been carried out in the area of HNR. Various methods have been proposed in the literature for classification of handwritten numerals. These include Hough transformations, histogram methods, principal component analysis, and support vector machines, nearest neighbour techniques, neural computing and fuzzy based approaches [1].

Optical Character Recognition (OCR) is a process by which we convert printed document or scanned page to ASCII Character that a computer can recognize [2]. Main objective of OCR system is to create paperless environment and facilitates the data analysis. OCR can be considered as an application of pattern recognition, artificial intelligence and machine vision [2].

Some of the good features of text document are that characters are generally in foreground and they are monochrome with some size restrictions, generally they appear as a cluster in line or paragraph. OCR system can be classified as offline or online. In offline OCR system, raster image of character is taken as an input and then it is processed. Recognition process starts after generation of character. While in online system, (x, y) coordinate and pressure of electronic tablet is continuously measured on digital pad.

Recognition of Handwritten Devanagari Numerals or Characters [2, 3] is a complicated task due to the unconstrained shape variations, different writing style and different kinds of noise. Also, handwriting depends much on the writer and because we do not always write the same digit/Characters in exactly the same way, building a general recognition system that would recognize any digit/Characters with good reliability in every application is not possible.

The rest of the paper is organized as follows. In Section 2 a brief overview of related works is presented. Section 3 deals with the introduction of numerals and SVM section 4 describe the recognition of numerals. Section 5 gives proposed SVM method Conclusion is given in Section 6.

2. RELATED WORKS

Many systems and classification algorithms have been proposed in the past years on handwritten Character/numeral recognition in various languages like English, Arabian, Persian Chinese [5, 6].A brief review of work done in recognition of handwritten numerals written in Devanagari script is given below Hanmandlu et.al [7] presented a technique for recognition of handwritten Hindi (Devanagari script) numerals based on the modified exponential membership function fitted to the fuzzy sets. The features used are the normalized distances computed using the box approach. The exponential membership function is modified by two structural parameters that are estimated by optimizing the entropy subject to the attainment of membership function to unity.

N. Sharma, U. Pal et.al. [11] have proposed a quadratic classifier based scheme for the recognition of offline Marathi handwritten numerals and characters. The bounding box of a numeral is segmented into blocks and the chain code histogram is computed for each of the blocks.

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These chain code features are fed to the quadratic classifier for recognition.

Reena Bajaj et.al [8] has proposed a recognition scheme for handwritten Marathi numerals. Three different types of features, namely, density features, moment features and descriptive component features are used. Three different neural classifiers have been used for classification of the numerals. Finally, the outputs of the three classifiers are combined using a connectionist scheme.

A method based on invariant moments and the division of numeral image for the recognition of handwritten Devanagari numerals is proposed by Ramteke et.al. [14]. Seven central Invariant moments are used as features. The Gaussian Distribution Function has been adopted for classification. A general fuzzy hyper line segment neural network which combines supervised and unsupervised learning in a single algorithm, used for handwritten Devanagari numeral character recognition, is reported by P.M. Patil et.al. [9].

It is clear from the literature survey that, still there is lot of scope to design a robust system for recognition of handwritten numerals written in Devanagri script. Further, features of numerals extracted combining both energy and chain code is not found in the publications. This has motivated us to propose a method for recognition of handwritten numerals using energy and chain code and mixed code.

3. INTRODUCTION TO HINDI NUMERALS and SVM

Devanagari is the most popular amongst all Indic scripts. It is the main script for writing Hindi and various other languages. It is a two-dimensional composition of symbols attached to one or more of the four sides of a basic character, also called Conjunct character. Devanagari script is written from left to right order. It also has a native set of ten symbols for numerals (Figure 1). The present study is based on recognizing these numerals in handwriting.

Figure 1: Hindi numerals from 0-9

Machine Learning is a subfield of artificial intelligence that is concerned with the design and development of algorithms and techniques that allow computers to "learn". Machine Learning can be classified broadly into Supervised Learning, Unsupervised Learning, Semi-supervised Learning, and Reinforcement Learning. Support Vector machine is one of the supervised learning method.

Support vector machine is one of the best techniques used for linear and nonlinear classification and regression. Therefore, it is used in recognition of Handwritten Devanagari numerals. The SVM classifier was originally developed for two-class or binary classification and the demanding applications of pattern recognition led to the design of multi-class SVM classifiers using the binary SVM [2,4].

Support Vector Machine (SVM) was first heard in 1992, introduced by Baser, Guyon, and Vapnik in COLT-92. Support vector machines (SVMs) are a set of related supervised learning methods used for classification and regression. They belong to a family of generalized linear classifiers. In another terms, Support Vector Machine (SVM) is a classification and regression prediction tool that uses Machine learning theory to maximize predictive accuracy while automatically avoiding over-fit to the data.

Support vector machine classifiers fall under the category of statistical classifiers. They have gained immense popularity in recent years providing excellent recognition results in various applications. It has been used as an alternative to methods such as neural networks, hidden markov models due to its following advantages:

- SVMs exhibit good generalization.
- Few parameters are required for tuning the learning method as compared to neural network where architecture and various parameters must be found.
- It takes into account structural behavior along with the experimental data for a principled generalization capability based on SRM (structural risk minimization).

4. RECOGNITION OF NUMERALS

Experiments are conducted to find the recognition accuracies using SVM. Data collection, pre processing, feature extraction and recognition are the main phases that are followed and are described as below:

4.1Data collection: Handwritten numerals 0 to 9 is created by collecting the handwritten documents from writers. Data collection is done on a sheet specially designed for data collection. Writers from different professions were chosen including students, clerks, teachers, and vendors and were asked to write the numerals. No constraints were imposed on the use of ink or pen except that they have to write the numerals in the boxes of the sheets provided to them. Generation of database from the scanned datasheets.

Algorithm 1: Dataset Construction Phase Input: Handwritten datasheet.

Output: Isolated Character for Pre-processing.

Method: Scan the Handwritten datasheet. Image, x of Hand written numerals, i.

$d = \ldots 0$ to 9.

$n = 1 \ldots n$

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For $i \in d$ do
For $x \in n$ do
Crop character, i from datasheet.
Normalize the image, x to size of 40X40 pixels.
Store image, x of letter i.
end.
end.
Return dataset of n images for pre-processing.

o	o	o	o	o	o	o	o	o	o	o
९	੭	੭	੭	੭	੭	੭	੭	੭	੭	੭
२	੨	੨	੨	੨	੨	੨	੨	੨	੨	੨
३	३	३	३	३	३	३	३	३	३	३
४	४	४	४	४	४	४	४	४	४	४
५	५	५	५	५	५	५	५	५	५	५
६	६	६	६	६	६	६	६	६	६	६
७	७	७	७	७	७	७	७	७	७	७
८	८	८	८	८	८	८	८	८	८	८
९	९	९	९	९	९	९	९	९	९	९

Figure 2: Sample data sheet

4.2 Pre-processing: Pre-processing phase is applied to remove unwanted parts from the image. Since, data is collected in a predefined format slant correction is assumed to be performed. Binarization of image is performed using grayscale converts to binary image method. Global thresholding methods are used to automatically reduce a grey-level image to a binary image [11] The feature extraction using contour method we have also performed thinning. A minimum bounding box is then fitted to the numeral and the numeral is cropped. To bring uniformity among the numerals the cropped numeral image is size normalized to fit into a size of 40x40 pixels. Segmentation: removes the un-necessary part from the character image.

4.3Feature extraction: Feature extraction algorithm makes the classification process more effective and efficient. Two well defined methods of feature extraction used in our method are energy, chain codes and mixed form. Energy is defined as the total energy present in each segment. We have done no. of segments of each character and energy is obtained by counting the total number of 1s in each segment (i.e. Total White Pixels).Thus, we have a feature vector for energy method as final database. This final database is fed to the support vector machine to perform the desired function i.e. training or classification [14].

Let (v1, v2, v3…v_n) is the intensity value of image corresponding the index value [(x1y1), (x2y2)… $(x_n y_n)$].

The energy of the segment
$E = 1/n2 \ |Vij|^2$
$Vij = 1$ or 0

so that
$|Vij| = 1$ or 0
$= Vij$
$|Vij| \ 2 = 1$ or 0
$= Vij$ So that $E = 1/n2 \ Vij$
For the recognition as feature vector is
F= [E1……Em]

Chain codes are used to represent a boundary by a connected sequence of straight-line segments of specified length and direction chain codes[1] are generated by locating a boundary pixel, also called as starting pixel, and then moving along the boundary either clockwise or anticlockwise, finding next boundary pixel and assign this new pixel a code depending upon its location from the previous pixel. The process of finding the next pixel is terminated when starting pixel is encountered. The codes may be 4-directional or 8-directional depending upon 4-connectivity or 8-connectivity of a pixel to its neighboring contour pixel. A 4-directional chain code
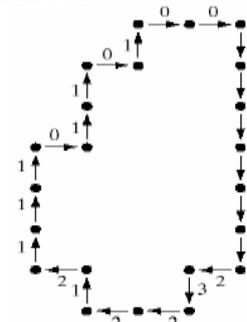
Figure 3: Connectivity chain code

It is observed that the chain code for different numerals has different length code and length of each chain code depends on the size of the handwritten numeral. More ever length of chain code is very high in case of certain handwritten numerals.
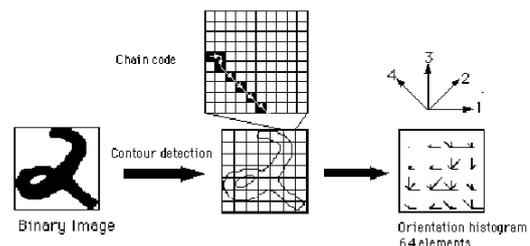
In Mixed form both the energy and the chain code are combined to produce the result.

5. PROPOSED SVM CLASSIFIER

The objective of recognition is to interpret a sequence of characters taken from the test set. The SVM (binary classifier) [14] is applied to multiclass Character Recognition problem by using one-versus-rest type method. The SVM is trained with the training samples using different kernel.

- Classifier performs its function in two phases; Training and Testing. After pre-processing Feature Extraction process, Training is

performed by considering the Feature vector which is stored in the form of matrices. Result of training is used for testing the numerals.

- Energy and chain codes and mixed form are computed for all the images in the training set by performing method. The result of the training step consists of the (Model) set of support vectors determined by the SVM based method.
- During the recognition step, the energy and chain codes are computed in the same way, and the model determined during the training step is used to perform the SVM decision.

The proposed method is implemented using Mat lab software and Statistical Pattern Recognition Tool Box for Mat lab.

6. RESULTS

In this research work, we have collected handwritten character from different peoples different kernel function of SVM i.e. Linear or dot product, Quadratic, RBF (Radial Basis Function) and Polynomial. We have compared the recognized performance of using a SVM kernel function. Complete Recognition rate are performed in Table1.

Features	SVM (kernel function)	Recognition Rate %
Energy	Linear	84%
	RBF	90.1%
	Polynomial	86.4%
Chain Code	Linear	84%
	RBF	86%
	Polynomial	86%
Mixed	Linear	84%
	RBF	90.%
	Polynomial	86%

7. CONCLUSION

In this paper we have presented an efficient method for recognition of Hindi handwritten numerals using energy and chain codes. SVM is used for classification. The average recognition of 90.1 % is achieved using four segment methods. The proposed method can be extended to recognition of numerals of other Indic both for online and offline.

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