Survey Paper on Hindi Digit Recognition

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Abstract
Research on OCR of Hindi script is very difficult and challenging task due to its complex structural attributes. The major difficulty with handwritten text is the variability of writing styles, both between different writers and between separate examples from the same writer overtime. Handwritten character/Numeral recognition has received large attention in academics and production fields. This paper will act as guide and update for the readers, working in the hindi Optical Character Recognition area. An overview of various statistical and structural features used for recognition based on the various research papers is presented and reviewed.

Keywords
Hindi Numeral Recognition, Off-line Handwriting Recognition, Segmentation, Feature Extraction, Image Classification.

I. Introduction

Handwritten recognition is a challenging task in the field of Numeral recognition because different writers have different writing styles. During the process of solving the problem of hand written recognition many challenges are faced like handwritten numerals may have different size, there may be a variation in their thickness, their orientation and the different kinds of noise that break the strokes in numbers or change their structure. Therefore, handwritten OCR is an area of active research.

Automatic reading of numerical fields has been introduced in various fields such as recognize zip codes on mail for postal address sorting, processing bank check amounts, numeric entries in forms filled up by hand and so on. There is a great necessity for development of the advanced techniques for recognition of numerals written in Indian scripts.

This Paper is structured as Follows: Section II reprsents the Database of Hindi numerals written by different writers and will also illustrate the variation in the writing styles of different writers and Section III describes the literature survey on various Feature Extraction techniques.

II. Database

The database is constructed by taking handwritten data from 10. Each writer was asked to write digits from 0 to 9 in Devanagari Script. The Writers for writing a data were taken from various backgrounds like school students, College students, Teachers, Shopkeepers, Housewives, engineers and many more. The writers are chosen from various backgrounds to make a database as close as possible to the real database. Data of different sizes and slants is also included in the database. Total digit images are 100 in number. Fig. 1 contains part of handwritten digits database.

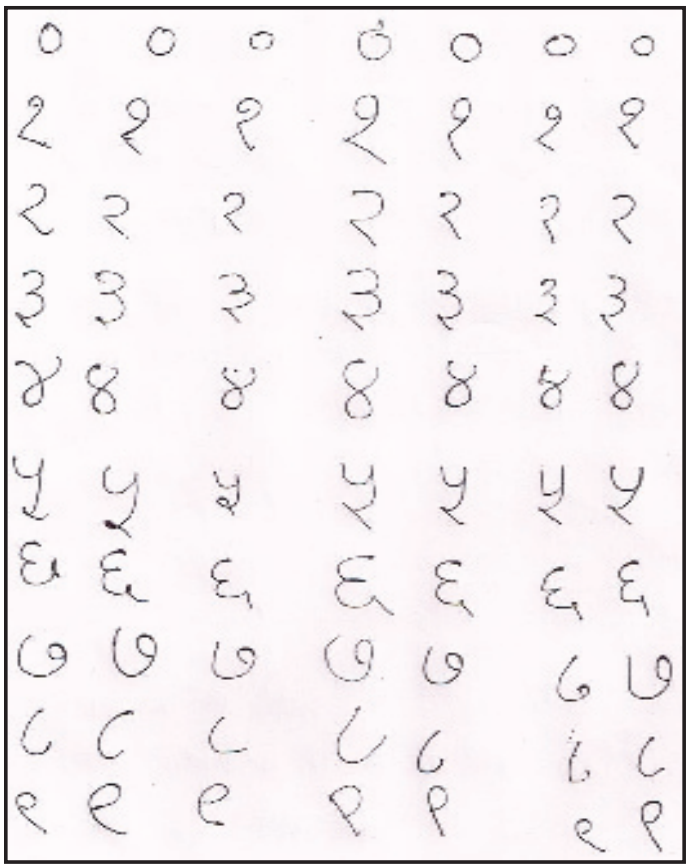

Fig. 1: Part of Database

III. Literature Survey

The work on handwritten Devanagari numeral is carried by Hanmandlu et al [1] and R. Bajaj et al [2] proposed three kinds of feature which are moment features , density features and descriptive features for classification of Devanagari Numerals and obtained 89.68% accuracy. G S Lehal and Nivedan Bhatt [3] proposed a contour extraction technique and obtained 89% accuracy. Prerna Singh and Nidhi tyagi [4] proposed a method for recognition of Handwritten Devanagari numerals using Radial basis function feed forward neural network that computes activation at the hidden neuron in a way that is different from character & numeral recognition system consist of three main components, they are pre-processing, feature extraction and classification. Satoshi Kageyu, Noboru Ohnishi, and Noboru Sugie [5] proposed system having two phases. First phase takes binary image as input and then transforms that binary image with complex-log mapping then the complex-log mapped image is passed from Fourier transform which outputs the rotation-and-scale invariant image. Then the output image is provided as input to multi-layer neural network, to get the recognition results. This technique was implemented for hand written numerals and the recognition rates of this technique are 90 to 95 %. Kurt Reiser [6] proposed vector quantization technique for recognition of hand written numerals. In this method the input image was iteratively smoothed by applying smoothning mask and the smoothed output image was fed for convolution by the four directional derivative masks which

resulted in four images, each corresponding to convolution with each of the derivative masks. For the training of local features a perceptron learning rule was use and obtained the accuracy of 96.7%. Chuen-Tsai Sun, Tsuey-Yuh Shuai and Guang-Liang Dai [7] proposed three versions of the fuzzy filters which were one-dimensional fuzzy filters, two-dimensional fuzzy filters, and genetic-algorithm-based fuzzy filters as feature detectors and noise filters. The recognition rate obtained for one-dimensional filters was 90%, for two dimensional filters was 92% and for genetic-algorithm-based fuzzy filters was 95.7%. Its main benefit is that it learns by itself from the training data and selects the most suitable positional features without any high-level guidance from humans. A. Elnagar, F. Al-Kharousi, and S. Harous [8] proposed a method for the recognition of handwritten Hindi numerals which is based on structural descriptors of the shapes of numerals. In this method first of all, hand written numeral is scanned, normalized and thinned after this pre-processing stage the pre-processed image is passed through the algorithm which segments the scanned image into strokes to extract features and results the syntactic representation of numeral image and then recognition is performed based on all structural descriptors obtained above and resulted the recognition rate 90 to 94%.Anilkumar N. Holambe, Dr.Ravinder.C.Thool and Dr.S.M.Jagade [9] have extracted the features of handwritten and printed characters and numerals of Devanagari script. They extracted the Gradient features of the Devanagari script by using two operators i.e. Sobel and Robert operator respectively. They computed gradient feature in 8,12,16,32 directions and got different feature vectors respectively. By using 8-directional Sobel operator 94% accuracy was obtained for handwritten Characters, 94.2% was obtained for handwritten numerals, 98% accuracy was obtained for Printed Characters and 97% was obtained for Printed numerals , By using 12-directional Sobel operator accuracy 94.76% was obtained for handwritten Characters, 94.44% was obtained for handwritten numerals, 98% accuracy was obtained for Printed Characters and 97% was obtained for Printed numerals, By using 16-directional Sobel operator accuracy 96% was obtained for handwritten Characters, 95% was obtained for handwritten numerals, 98.45% accuracy was obtained for Printed Characters and 98.05% was obtained for Printed numerals and By using 32-directional Sobel operator accuracy 97% was obtained for handwritten Characters, 96% was obtained for handwritten numerals, 98.78% accuracy was obtained for Printed Characters and 98.0% was obtained for Printed numerals. By using 8-directional Robert operator 94.45% accuracy was obtained for handwritten Characters, 94% was obtained for handwritten numerals, 97% accuracy was obtained for Printed Characters and 96% was obtained for Printed numerals , By using 12-directional Robert operator accuracy 95.06% was obtained for handwritten Characters, 96% was obtained for handwritten numerals, 98% accuracy was obtained for Printed Characters and 95% was obtained for Printed numerals, By using 16-directional Robert operator accuracy 95.67% was obtained for handwritten Characters, 95% was obtained for handwritten numerals, 98.02% accuracy was obtained for Printed Characters and 96.05% was obtained for Printed numerals and By using 32-directional Robert operator accuracy 96.09% was obtained for handwritten Characters, 97% was obtained for handwritten numerals, 98.0% accuracy was obtained for Printed Characters and 97.0% was obtained for Printed numerals. Here the accuracy obtained by Sobel operator is high as compared to Robert operator. Banashree N. P., and R. Vasanta[10] proposed a recognition scheme for handwritten Hindi (devnagiri) numerals by using global based feature extraction approach using end-points information, which is extracted from images of isolated numerals. These feature vectors are fed to neuromemetic model that has been trained to recognize a Hindi numeral. In proposed scheme data sets are fed to neuromemetic algorithm, which identifies the rule with highest fitness value of nearly 100 % & template associates with this rule is nothing but identified numerals. Therecognition rate by using this approach is 92-97 %.

U. Pal, A. Belaid and B. B. Chaudhuri[11] proposed the scheme which is based on the features obtained from the concept of water overflow from the reservoir as well as topological and structural features of the numerals. The proposed scheme is tested on data collected from different individuals of various background and obtained an overall recognition accuracy of about 92.8% from12000 data. Rawan I. Zaghloul, Dojanah M.K. Bader Enas and F. AlRawashdeh[12] proposed an algorithm which was implemented in MATLAB and tested with a large sample of handwritten numeral datasets for different writers in different ages. Pattern recognition techniques are used to identify Hindi (Arabic) handwritten numerals. In this scheme they used various feature extraction techniques like Detection of loops, detection of centroid, horizontal projection and segmentation of numeral image to find useful information. After testing, high accuracy was achieved, it ranges from 95% for some numerals and up to 99% for others. BAHETI M. J., KALE K.V. and JADHAV M.E[13] proposed a comparison of the offline handwritten character recognition system for the isolated Gujarati numerals. They used affine invariant moments based model for the feature extraction. They used KNN classifier and PCA to reduce dimensions of feature space and used Euclidean similarity measure to classify the numerals. KNN classifier obtained 90 % as recognition rate whereas PCA obtained recognition rate of 84%. After the comparison it is observed that KNN classifier has shown better results as compared to PCA classifier. Akhilesh Pandey, Amresh Kumar, Rajiv Kumar and Amod Tiwari[14] proposed a majority voting scheme for off-line hand written Hindi numbers recognitions. The main objective of this research is to find out best recognition result using multiple classifiers. The proposed technique uses simple profile and contour base triangular area representation technique for finding feature extraction and majority voting scheme on back propagation and cascade feed forward neural network for classification. The average recognition result of this approach is 94.16%.

IV. Components of OCR

A. Pre-processing
B. Feature extraction
C. Classifications

1. Pre-processing

Pre-processing is the starting phase of document analysis. The main motive of pre-processing stage is to improve the quality of the image being processed. Numeral & character data presented on the paper is captured by scanning the paper and store it in to an image format and this image undergoes successive operations which are helpful in reducing distortion and noise which is added during scanning process. It also helps in removing slantness, skewness and performs the thinning of an image by reducing redundant data and makes it efficient for the processing in further stages of recognition. Effectiveness of the recognition directly depends upon the effectiveness of the pre-processing operations. The pre-processing stage includes the following operations:

1. Binarization
In Binarization a grayscale input image is converted into to a Binary image by using an optimal threshold.

2. Noise Removal
The noise introduced during scanning process by scanning device results in the presence of bumps and gaps in lines, disconnected line segments, filled loops etc. The distortion including local variations, rounding of corners etc. before the recognition stage, it is necessary to eliminate these distortions [15-16]. These distortions can be removed by various noise removal techniques which can be categorized as filtering, morphological operations and noise modeling.

3. Skew Detection and Correction
Due to variations in different writing styles or during the scanning process the skewness may introduce in document and the writing may be slightly tilted in the image. This will degrade the performance of segmentation and recognition stage and decrease the accuracy of the system therefore it should be traced and eliminated. After skew detection, Skewed lines are made horizontal by calculating skew angle and making proper correction in the image [17-18].

4. Image Size Normalization
Size normalization process involves the adjustment of character or numeral to a predefined standard Size. Every segmented character or numeral is required to fit within suitable matrix so that all characters or numerals have same data size [16].

5. Thinning and Skeletonization
Thinning plays an important role in Recognition, and since recognition is dependent on the effectiveness of the thinning and skeletonization algorithm. It is a process for reducing foreground regions in a binary image and retains the significant aspects of the pattern under process. It cleans the image so that only reduced amount of data needs to be processed in the next image processing stages

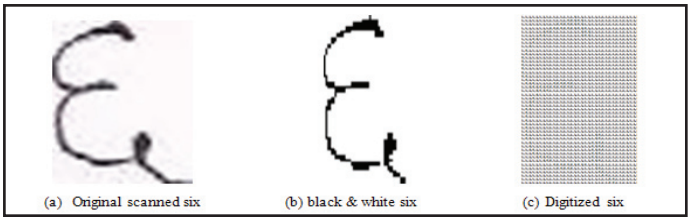

Fig. 2:

B. Feature Extraction
Feature extraction may be defined as the process of finding important attributes from a large amount of data so that the problem of pattern recognition can be solved easily. In this process, a set of features are extracted for each class which will help to differentiate it from other classes. The extracted features should be able to identify each character or numeral set uniquely.

1. Statistical Features
Statistical features of an object/image are extracted using simple image processing techniques. In general statistical features are derived from the statistical distribution of points like zoning, moments, n-tuples, characteristic. Mainly statistical features are more significant in pattern recognition area. The statistical methods are classified as:

2. Zoning
The Character or Numeral image is divided in to N*M Zones. In this feature number of foreground pixels are considered in each zone of an image and the darker zones represent higher density of zone pixels, Contour direction features, It measure the direction of the contour of the character or Numeral [19] which are generated by dividing the image matrix into rectangular and diagonal zones and computing histograms of chain codes in these zones.

3. Crossings
This feature is used to count the number of transitions from background to foreground pixels along vertical and horizontal lines through the character or Numeral image. Simply we can say number of crossing of a contour by a line segment in a specified direction.

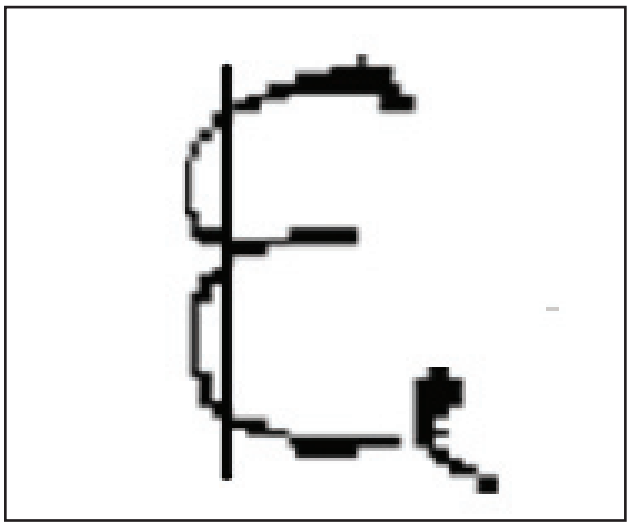

Fig. 3: Crossings in Hindi Numeral six

4. Distance
Distance may be horizontal or vertical. Vertical Distance calculates the distances of the first image pixel detected from the upper and lower boundaries, of the image, along vertical lines. Horizontal Distance calculates the distances of the first image pixel detected from the Left and right boundaries, of the image, along horizontal lines.

5. Projections
Hand written character or Numeral images can be illustrated by projecting the pixel values onto lines in horizontal and vertical directions. This representation creates one-dimensional signal from a two dimensional image, which can be used to represent the image. In this projection feature we count the number of black pixels row wise or column wise. [20].

6. Structural Features
Various global and local properties of characters can be represented by geometrical and topological features with high tolerance to distortions and style variations. In this category, lines, curves, spines, extreme points, maxima and minima, cups above and below a threshold, openings to the right, left, up and down, cross (X) points, branch (T) points, line ends (J), loops (O), direction of a stroke from a special point, inflection between two points, isolated dots, a bend between two points, horizontal curves at top or bottom, straight strokes between two points, ascending, descending and middle strokes and relations among the stroke that make up a character are considered as features.

7. Loops & Concave Arcs

These features are extracted from the representation of the character/Numeral by its polygonized contours. Both the external boundaries and the internal boundaries of the character/numeral in order to describe the it by an ordered list of vertices. The retained variables correspond to: (1) number, perimeter and location of concave arcs and (2) number and location of loops or holes. Concave arcs are only extracted from the ordered list of vertices corresponding to the external boundaries, and are obtained by calculating the interior angle between two successive segments. If this angle is lower than 1, then these two successive segments form a concave vertex and the process goes on until an angle superior to 1 is found. A concave arc is thus defined as an uninterrupted sequence of concave vertices. The perimeter of a concave arc is obtained by adding the length of the segments and its position is found by calculating the barycenter of the vertices. Holes are directly defined by the ordered lists of vertices corresponding to the internal boundaries.

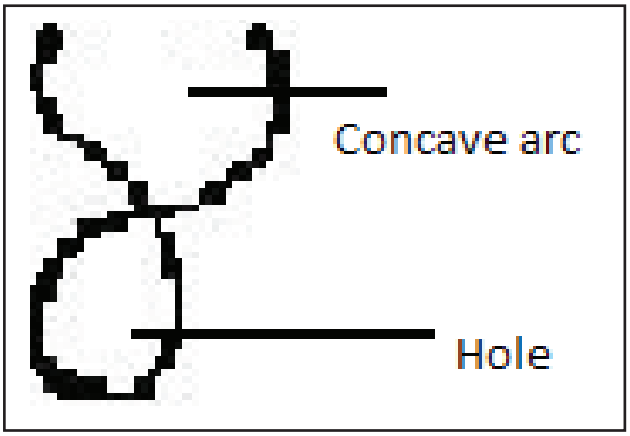

Fig. 4:

8. End Points and Junctions

These pure structural features end points, Y and X-junctions are extracted on the skeletonized representation of the character/ numeral. The variables retained are the number and the X–Y position of these features. A black pixel is considered to be an end point if there is only one black pixel in its 3*3 neighborhoods.

9. Classification

The classification is the process of identifying each Numeral and assigning to it the correct character class. This stage uses the features extracted in the feature extraction stage to identify the text segment according to preset rules. Classification is usually accomplished by comparing the feature vectors corresponding to the input character with the representative(s) of each character class, using a distance metric. Traditionally nearest neighbor classifier and binary classifier trees have been the two most commonly used classifiers. Support Vector Machines (SVM) is also widely used for classification in pattern recognition.

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