A Novel approach to Recognize Handwritten Gujarati Digits

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Abstract— Handwritten Character Recognition (HCR) is one of the applications of pattern recognition which can be online or offline. HCR systems convert handwriting into letter codes. Because of its large differences in writing style, context-independency and high recognition accuracy requirement, handwritten digits identification is still a very difficult problem. Analyzing the characteristic of handwritten digits, this paper proposes a new handwritten digit identification method based on combining structural features. Given a handwritten digit, a variety of structural features of the digit including bounded region, number and position of end points are identified using structural identification algorithms. Recognition of digits is done using decision tree.

Key words: Handwritten Character Recognition (HCR), Recognize Handwritten Gujarati Digits

I. INTRODUCTION

Recognition of handwritten characters is one of the most popular and interesting research areas in pattern recognition. The development of this type of system leads to better human-machine interface. HCR is a process of classifying handwritten characters and numerals into appropriate classes based on the features extracted from each character and numerals. HCR system can be of two types: online or offline.

A HCR system consists of main three steps. First step is Preprocessing where raw image is taken as an input and few processes are applied. Usually these processes are noise removal, Binarization, segmentation, skew detection, thinning etc. Feature extraction is done in the second step from pre-processed image. The methods of feature extraction are: structural and statistical methods, zone based feature extraction, LLS, DFT, DCT, DWT, freeman chain code etc. The third step is classification of image using different features. PCA, k-NN, SVM, ANN, decision tree etc. are some common methods for classification of digits.

It is founded that recognition of handwritten numerals include the following features: (1) Handwritten numerals are free in writing, very different in writing style and varying in shape. Therefore, no simple and single scheme exists with very high recognition rate in handwritten numerals (2) Handwritten numerals require very high accuracy. In actual use, handwritten numerals are usually concerned with accounting, financing and other fields, so the required accuracy to recognize handwritten digit is very high. (3) Variety in handwriting leads difficulty to propose a generalize algorithm. [9]

In this paper, recognition of Gujarati digits using structure based feature extraction is described. There is no standard database is available of Gujarati digits. The samples for this work are collected from different aged and gender person. Structural features like bounded region, number and position of end points are useful for digit classification. For classification of digits, a decision tree is constructed.

Rest of the paper is organized in following sections. In section 2 related work done is discussed. Proposed work is elaborated in section 3. In section 4, various challenges are discussed. Section 5 is about conclusion.

II. RELATED WORK

Horizontal, vertical projection & two diagonal features used by Apurva A. Desai [4] who proposed for Gujarati handwritten numeral identification. She used multi layered feed forward neural network for classification. The features of Gujarati numerals are extracted by four different profiles of numerals. Thinning and skew-correction are also done for pre-processing of handwritten numerals before their classification. She achieved approximately 82% of accuracy for Gujarati handwritten numeral identification.

Archana N. Vyas and Mukesh M. Goswami [3] have focused on the problem of identifying handwritten Gujarati numerals. Feature extraction methods are Freeman chain code which is part of spatial domain, DFT and DCT which are part of transform domain. The result of feature extraction method is given to three different classifiers which are K-NN, SVM and back propagation neural network. It is concluded that chain code gives same accuracies irrespective of classifier. In K-NN as values of K increases result gets better. SVM performs well with transform methods of feature extraction.

Chhaya C. Gohell and et. Al. [6] have developed online handwritten Gujarati text recognition system. An online writing pad for Android is used for writing character set. For capturing the features of low level strokes, the hierarchical histograms of 12 strokes and 8 directional features are generated. Recognition of characters is done using k-NN classifier. Digits are classified using a joint occurred in writing of that digit and from that joint strokes are identified. It is shown that as value of k increases, result gets better.

Archana Vyas and Swital Macwan [2] proposed with classification of Gujarati characters. Many techniques like DWT, DCT and DFT (transform domain), Edge detection (Spatial Domain), Freeman chain code (Structural method), Zernike Moments (Statistical method) are used to extract features. For classification of characters SVM is used for each techniques of feature extraction.

Mahendra M. Mendapara and Mukesh M. Goswami [5] have focused on the strokes of pens while writing the digits. Strokes of each character are identified and differentiate from each other. Advantages of this system are: reusability, reduction in number of strokes, ordering of strokes. For feature extraction technique with 16 direction code is used for stroke identification. These direction codes are as follows: two horizontal, two vertical, four diagonal, and eight other direction codes. After stroke identification k-NN is used for classification of digits. Each different stroke is identified separately.

LI Ziyi, MA Liyao, KE Xiaolu, WANG Yong [10] have proposed a belief decision tree for classification of digits. For feature extraction, image is divided into 9 parts with 2 horizontal and 2 vertical lines. Also, pixels on these lines are considered as feature. Using these ten features, a decision tree is constructed. The result of this method is 73%.

Dadong Zhao, Jeong-Young Song, Mousavinezhad, S. Hossein [9] have elaborated structure of digits. Due to different style of writing, accuracy of recognition might decrease. In this model, authors have focused on structural features like endpoints, three-cross point, four-crossed point, horizontal line and position of endpoints and four-crossed points are considered. Combinations of these features are used to construct decision tree.

III. PROPOSED WORK

A. Preprocessing

The steps involved in pre-processing are: Data collection and Scanning, Noise Removal, Binarization, Segmentation, Skew correction and Thinning.

1) Data collection and Scanning

Collection of data is done on A4 size of paper which is divided into equal size of grids. After that this paper is scanned using scanner. [2]

2) Noise Removal

Different noises like salt and pepper noise, blurring, etc. occur in image. For increasing the efficiency of feature extraction methods, such noise should be removed from the acquired images. In this scenario salt and pepper noise can be occurred. Here, median filter and bilateral filter are used. [2]

3) Binarization

Binarization process refers to the converting a gray scale image to binary image. In this type of image intensity of pixels are either 0 or 1.This step is useful when thinning algorithms are used. Otsu's binarization method is suitable for this step. [3]

4) Segmentation

The acquired image is consist of many digits, from that the concerned digit needed to segment for recognition purpose.

5) Skew Detection

When people writes they usually keeps paper cross to their body. This situation leads skew occurrence in digits. For efficient recognition of handwritten digits skew detection is necessary.

6) Thinning

The thinning process usually carried out to remove the unwanted pixels. In this step, Zhang and Suen thinning algorithm is used. [3]

B. Feature Extraction

All digits have specific structure which can be identify using structural method of feature extraction. Digits have features like bounded region, end points, joint point, sharp curves etc. In this model, bounded region, number of end points and location of end points are taken as features. According to the availability of bounded region, digits are categorized as shown in figure given below:

Digit	Bounded Region	Conditions
	Same	$X_1 = X_2$ and/or $Y_1 = Y_2$, $W_1 = W_2$ and/or $H_1 = H_2$
	Upper Left	$X_1 = X_2$ and/or $Y_1 = Y_2$, $W_1 > W_2$ and/or $H_1 > H_2$
	Lower Middle	$(Y_1 + H_1) = (Y_2 + H_2)$
	Upper Middle	$(Y_2 - H_2) = H_1$

Fig. 1 Digits with bounded region

Where,

X1, Y1, W1, H1 are x- axis co-ordinate, y- axis co-ordinate, width and height of outer region

X2, Y2, W2, H2 are x- axis co-ordinate, y- axis co-ordinate, width and height of inner region

Bounded region may not be available. So, number of end points and location of end points are considered. According to number of endpoints digits available in digit, classification of digits is shown in figure 2, 3 and 4.

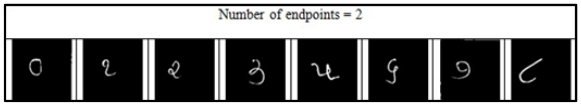

Fig. 2: Digits with 2 endpoints

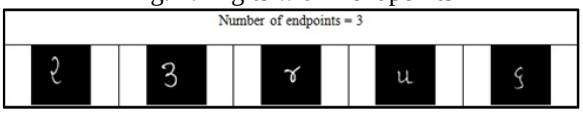

Fig. 3: Digits with 3 endpoints

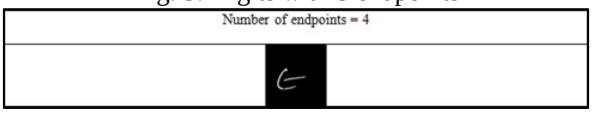

Fig. 4: Digits with 4 endpoints

C. Classification

Classification of Gujarati digits can be shown as figure given below:

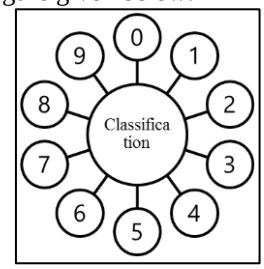

Fig. 5: Classification of digit

There are many classifiers for digit recognition. For Example decision tree, k-NN, SVM, ANN etc. Decision tree is simple to construct of categorical data. Decision tree is used as a hierarchical approach for classifying digits. Features of digits will be placed as branching condition in node while taking decision. Here, there are 10 different classes for 10 different digits. According to bounded region classification of digits are shown below:

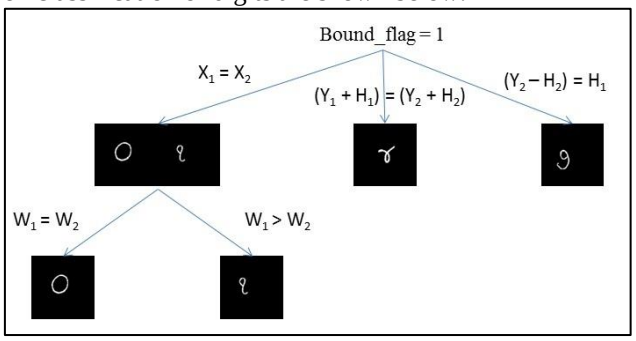

Fig. 6: Digit Classification using bounded region

Where,

X_1, Y_1, W_1, H_1 are x- axis co-ordinate, y- axis co-ordinate, width and height of outer region

X_2, Y_2, W_2, H_2 are x- axis co-ordinate, y- axis co-ordinate, width and height of inner region.

Every digit does not contain bounded region. These digits can be identified using number of end points and position of end points. X and Y co-ordinates of each end point are considered for classification of digits. Gujarati Digit ૯ can easily classify as it has 4 end points. Other digits have 2 and 3 end points and sometime bounded region is also need to combine with position of end points.

IV. CHALLENGES

As we know that, there is large difference in writing style of people, the difficulties for this kind of system increase. Also some digits create confusion in recognition. For example ૨ and ૩ are not significantly different, which effects on accuracy of system.

Sometime, digits are overwritten, which is common human habit. Possibly, it may not be recognize as digit. Overlapping of digit is also a challenge.

V. CONCLUSION

Every digit have specific structural features which are bounded region, end points, cross points, line segment etc. These digits can be classified using these features or combination of these features. Instead of identifying strokes or other feature vector,

structural based feature extraction is very simple and useful technique. These features can be used in hierarchical approach. This approach motivates to create a decision tree as classifier

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