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Chain code feature based recognition of handwritten Gujarati numerals

Ankit Sharma
Assistant professor
Instrumentation and Control Engineering Department
Institute of Technology, Nirma University
Ahmedabad, Gujarat, India

Dr. Dipak M. Adhyaru
Professor & Head
Instrumentation and Control Engineering Department
Institute of Technology, Nirma University
Ahmedabad, Gujarat, India

Dr. Tanish H. Zaveri
Professor
Electronics and Communication Engineering Department
Institute of Technology, Nirma University
Ahmedabad, Gujarat, India

Abstract:This paper describes chain code based method for handwritten Gujarati numeral recognition. Literature review on Indian OCR indicates that in comparison with Bangla, Hindi, Kannada, Tamil and Telugu scripts, the OCR activities related to Gujarati script is very less. Development of OCR for Gujarati script is quite challenging area for research. In this work, recognition of isolated Gujarati handwritten numerals is performed using chain code based methods. Horizontal scanning and maximum distance from centroid methods are used for deciding the starting point for calculating the chain code sequence. An overall accuracy of 96.37% and 95.62% is obtained using feed forward neural network classifier by the proposed methods respectively. One of the significant contributions of this paper is towards the generation of large and representative database for handwritten Gujarati numerals.

Keywords:Chain code, Gujarati handwritten numeral recognition, Neural network classifier.

I. INTRODUCTION

Gujarati script is part of the Brahmic family. Gujarati is the mother tongue of Gujarat state in India. All over the world more than 65 million people use Gujarati language for their communication purpose. Gujarati script is used to write the Gujarati language. Handwritten character recognition is a process of identifying characters from scanned handwritten documents. Handwritten character recognition is a challenging area for research. One significant reason for the lack of research activity in the area of Gujarati handwritten character recognition is the unavailability of benchmark database.

It is evident from Figure 1 that Gujarati numerals encompass different shapes and recognizing these shapes is a difficult task. In this work, chain code based feature extraction methodis utilized for recognition of isolated Gujarati handwritten numerals. Methods based on horizontal scanning and maximum distance from centroid are used to obtain the starting point of the chain code sequence. Chain code sequence is used as feature vector for training and testing purpose to the neural network classifier.

The rest of the paper is organized as follow. Section II gives some details regarding early attempts in optical character recognition. Section III justifies the need of pre-processing. Section IV describes feature extraction method. Section V discusses classification algorithm. Section VI describes experimentation and results, finally section VII includes the conclusion.

Figure.1 Handwritten Gujarati numerals

II. REVIEW OF RELATED WORK

In other Indian languages like Hindi, Kannada, Bangla, Tamil, Telugu there has been tremendous progress in the field of OCR as compare to Gujarati language [1]-[5].

Apurva A. Desai [7] has used profile based feature extraction method for Gujarati handwritten numerals recognition. An accuracy of 81.66% was achieved using multi layered feed forward neural network classifier.MamtaMaloo and K.V. Kale [8] used affine invariant moments based features along with Support Vector Machine classifier for recognition of handwritten Gujarati numerals. For the dataset of size 800, they achieved recognition accuracy of 91%.M.J. Baheti and K.V. Kale [9] used affine invariant moments based features with KNN and PCA based classifier and achieved recognition accuracy 90% and 84% respectively.Mukesh M. Goswami and Suman K. Mitra[10] proposed low-level stroke features for the recognition of handwritten numerals from Gujarati and Devanagari scripts. With the use of KNN and SVM classifiers they achieved average test accuracy of 98.46% and 98.65%for Gujarati and Devanagarihandwritten dataset respectively. Comparative analysis of zoning based methods for handwritten Gujarati numerals is presented by authors for handwritten Gujarati numerals [11]. Some of the attempts are also made for the recognition of printed and handwritten Gujarati characters [12]-[16].

III. PRE-PROCESSING

To recognize handwritten Gujarati numerals, important step is collection of database. In this proposed work, database was collected from people of different age groups, different

educational background and of different professions. The purpose of data collection was not disclosed to them so that they could produce samples of database with their natural handwriting styles. All writers were requested to write one single Gujarati numeral per box as shown in the Figure 2. All the filled handwritten formswere scanned with HP flatbed scanner at 300 dpi resolution and saved in JPEG format. Total 12,000 isolated numeral images (0 to 9) are generated from these forms, which includes 1200 images of each numeral from 1200 writers. These images are used for the training and testing purpose.

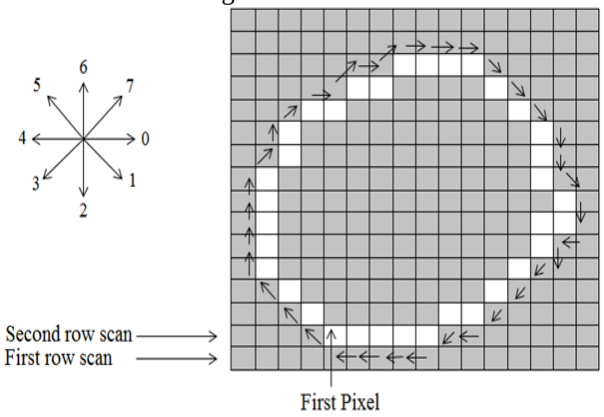
Preprocessing of the isolated handwritten numeral images is required before going for the feature extraction and classification. Size and style of handwritten numeral may vary from person to person, and for recognition purpose preprocessing steps are adapted in order to convert all the numeral images into uniform form. Preprocessing includes binarization, median filtering, resizing and thinning operations. First, these images are converted into binary images using Otsu's thresholding algorithm [17]. Median filtering is applied in order to remove any salt and pepper noise from the image and to fill holes in the object region. All the numeral images are resized to the size of 16x16 pixels with nearest neighborhood interpolation algorithm. After resizing, one pixel wide thinned image is obtained by using morphological thinning operation.

Figure.2 Special form designed for database collection

IV. FEATURE EXTRACTION

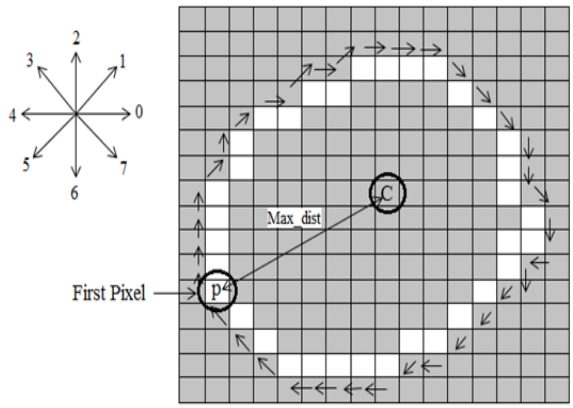
Feature extraction is a crucial step for object classification. Feature extraction is a process of identifying characteristic of the given image. These characteristics are then converted into classifier acceptable format, so that classifier can classify the given input image. The proposed feature extraction methodology is based on generating the chain code sequence using two different ways for deciding the starting point of chain code sequence. The chain code was first proposed by H. Freeman [6].In order to prove the comparative efficiency of chain based method, the same database is tested over the method based on projection profiles [4] of the numeral image.

Chain code obtained using horizontal scanning method is shown in Figure 3(a). Rows are scanned from bottom of the image to find out the first pixel which is the part of the numeral (foreground pixel). Once first pixel is obtained, chain code sequence is calculated by moving on the object contour in clockwise direction. In Figure 3(b),the second method,which is based on maximum distance from centroid is shown. Centroid of numeral image is calculated and then the numeral pixel having the maximum distance from the centroid is noted. The pixel having maximum distance from centroid is chosen as the starting pixel for the calculation of chain code sequence. The length of chain code sequence in both cases is considered as 100 since it is observed that it never crossed 100. If the length of the chain code sequence is obtained less than 100 then remaining elements are filled with value zero.



Chain Code : [5 5 5 6 6 6 6 7 6 7 0 7 0 7 0 0 0 1 1 1 2 2 1 2 4 2 3 3 3 4 3 4 4 4 4]

(a)



Chain Code: [2 2 2 2 1 2 1 0 1 0 1 0 0 0 7 7 7 6 6 7 6 4 6 5 5 5 4 5 4 4 4 4 3 3 3]

(b)

Figure.3(a) Chain code using horizontal scanning. (b) Chain code using maximum distance from centroid.

V. CLASSIFICATION

Neural network classifier with back propagation algorithm is used for recognition and classification of handwritten Gujarati numerals. Three layered feed forward neural network is used with one input layer, one hidden layer and one output layer. Number of neurons in input layer depends on the size of the feature vector which is 100. Number of neurons in the output layer is 10 depending on output class (0 to 9). For experimentation purpose, the number of epochs (ep) are varied from 1000 to 10,000 with the interval of 1000 and number of neurons in the hidden layer (n) are varied from 10 to 100 with the interval of 10. These two are considered as the design parameters for artificial neural network. In the output layer, the transfer function of each of the neurons is considered as log sigmoid while in hidden layer tan sigmoid is used as the transfer function of neurons.

VI. EXPERIMENTS AND RESULTS

Data set consists of 1200 samples of each numeral (0 - 9) is used for experimentation purpose. Experiment uses 5-fold cross validation in which dataset is divided into 4/5 training and 1/5 test samples using stratified random sampling in every fold. Hence, 9600 images are used for training purpose and 2400 images are used for testing purpose. Table 1 represents the overall performance of ANN for chain code based methods with best value of design parameters. Results are also generated for the same dataset with projection profile based feature [7] in order to provide comparative analysis of proposed approach with existing techniques. Table 2 and 3 represents result obtained for chain code method with horizontal scanning and chain code method with maximum distance from centroid method respectively. Table 4 shows the result obtained with Projection profile based feature [7] with neural network classifier.

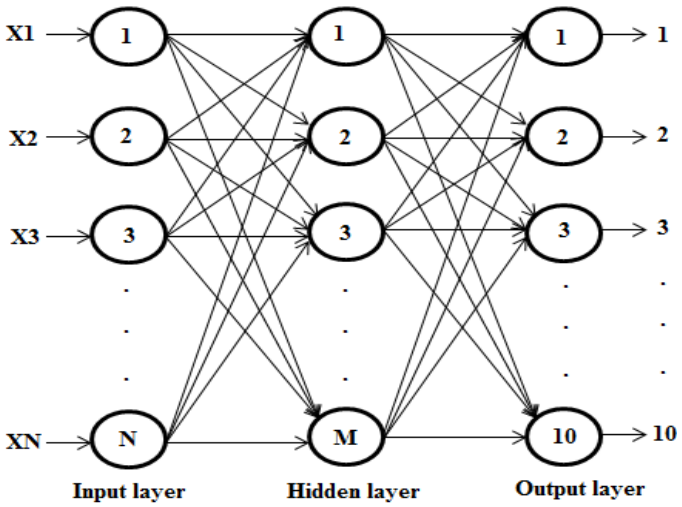


Figure.4 Architecture of Neural network

Method	Best Value of Design Parameters (ep, n)	Accuracy (%)
Chain code method with horizontal scanning	(8000, 20)	96.37 %
Chain code method with maximum distance from centroid	(10000, 30)	95.62 %
Projection profile based method [7]	(3000, 100)	93.20 %

Table (1) Performance of ANN for chain code based methods and Projection profile based method

Digit	૦	૧	૨	૩	૪	૫	૬	૭	૮	૯
૦	238	2	0	0	0	0	0	0	0	0
૧	0	229	3	0	0	0	1	1	0	6
૨	0	2	234	4	0	0	0	0	0	0
૩	0	0	8	219	0	0	11	2	0	0
૪	0	0	0	0	237	3	0	0	0	0
૫	1	0	0	0	4	233	2	0	0	0
૬	0	0	0	4	1	6	221	5	3	0
૭	0	1	1	2	0	0	5	228	1	2
૮	0	0	0	0	0	0	0	0	240	0
૯	0	0	0	0	0	0	3	4	3	230

Table (2) Chain code method with horizontal scanning using neural network classifier, the accuracy achieved 96.37 %.

Digit	૦	૧	૨	૩	૪	૫	૬	૭	૮	૯
૦	229	2	1	0	0	1	1	0	5	229
૧	0	233	7	0	0	0	0	0	0	0
૨	0	6	228	0	1	1	4	0	0	0
૩	0	0	0	237	2	1	0	0	0	0
૪	0	0	1	9	224	4	0	0	0	0
૫	1	1	2	0	1	218	9	3	5	1
૬	1	0	0	0	0	10	219	3	7	1
૭	0	0	0	0	0	0	0	240	0	0
૮	0	0	0	0	1	6	0	1	232	0
૯	229	2	1	0	0	1	1	0	5	229

Table (3) Chain code method with maximum distance from centroid using neural network classifier, the accuracy achieved 95.62 %.

Digit	૦	૧	૨	૩	૪	૫	૬	૭	૮	૯
૦	234	0	2	0	0	0	1	2	0	1
૧	0	221	3	0	3	1	5	1	3	3
૨	0	6	219	2	1	4	2	0	6	0
૩	0	1	3	216	2	4	9	5	0	0
૪	0	0	1	3	228	2	3	0	3	0
૫	1	4	2	1	5	221	2	2	1	1
૬	0	2	1	5	3	1	216	9	0	3
૭	3	4	1	0	0	0	5	223	1	3
૮	0	0	1	0	2	0	0	0	236	1
૯	1	1	5	0	1	2	2	0	5	223

Table (4) Projection profile basedmethod using neural network classifier, the accuracy achieved 93.20 %.

VII. CONCLUSION

In this proposed work, Chain code based methods are applied for recognition of Gujarati handwritten numerals. Database consist of 12,000 isolated numeral images (0 to 9) is generated for experimentation purpose. Two different ways are proposed for deciding the starting point for the calculation of chain code sequence. Chain code method with horizontal scanning and chain code method with maximum distance from centroid method are used for feature extraction from preprocessed numeral images. Feed forward back propagation neural network is used for classification purpose. Chain code method with horizontal scanning provides the accuracy of 96.37% while chain code method with maximum distance from centroid method provides the accuracy of 95.62%. In order to prove the comparative efficiency of chain code based methods, generated database is tested with existing method for Gujarati numerals based on projection profile [7]. Experimental results

show significant improvement over existing methods for Gujarati handwritten numeral recognition and validate our proposal.

VIII. ACKNOWLEDGMENT

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