

# Classification and Recognition of Gujarati Numeral using Nearest Neighbour Approach

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## ABSTRACT

This paper focuses on optical Gujarati digit recognition. To recognize Gujarati digit certain set of operations like pre-processing is carried out. As a result of feature extraction vector of 9 elements is derived representing no. of connected neighbor pixels and last element presenting total of 8 elements. Classification repository is derived by applying pre-processing and feature extraction steps for each digit to create classification repository matrix of 10 X 9 size, where row represents Gujarati digit 0 to 9. To test this model image containing isolated Gujarati digit is given as input and the result of feature extraction vector is compared with last element of each row of classification repository matrix. If total matches then digit is recognized on the basis of index of the row. In case of similar total for two digits each element of vector is compared with row of classification repository matrix. Methodology, implementation of it and results obtained are presented in this paper.

**Keywords:** Gujarati numeral recognition, pattern recognition, artificial intelligence, pre-processing, nearest neighbor.

## I. INTRODUCTION

Offline document recognition is a process of finding sentences, words, characters, digits etc. from the image and converting it into editable format. To preserve old records and documents they are generally scanned and preserved as an image whereas to search anything from that it makes it difficult as the image is in non-searchable format. To make it searchable it requires recognition and conversion into editable format. Due to this and many other applications character recognition both handwritten and printed is widely researched area for various language scripts and to achieve higher accuracy rate.

The Gujarati script was adapted from the ancient Nagari script for writing in Gujarati language. The earliest known document in the Gujarati script is a manuscript dating from 1592, and the script first appeared in print form in a 1797 advertisement.[1] In India, Gujarati is native language to the state of Gujarat. It is an Indo-Aryan language. Following table shows numerals of Gujarati. [2][3].

Gujarati Digits				
૦	૧	૨	૩	૪
Zero (sunya)	One (ek)	Two (be)	Three (tran)	Four (char)
૫	૬	૭	૮	૯
Five (panch)	Six (cha)	Seven (sat)	Eight(aath)	Nine(nav)

**Figure 1.** Numerals of Gujarati Script

This paper is one such attempt to offline Gujarati numeral recognition. The paper first presents previous work in the area followed by methodology used to recognize the Gujarati numeral.

## Previous Work

To recognize Gujarati Numeral Mamta Maloo and K. V. Kale [4] have proposed Support Vector Machine. The work is carried out on four sets with pre-processing steps, segmentation. For feature extraction affine invariant moments is used. Features extracted are given as input to support vector machine. Using this model

they are able to achieve approximately 91% of recognition rate.

Avani R. Vasant [5] et. al. have presented system for recognizing offline handwritten Gujarati digits using Neural Network. Over 3900 samples of handwritten Gujarati digits the experiment was performed and result obtained on three different image size group i.e. 7X5, 14X10, 16X16 and the recognition rate obtained was 87.29%, 88.52%, 88.76%.

Mamta Baheti[6] have proposed invariant moment for feature extraction and Gaussian distribution function for classification to recognize Gujarati numerals.

Mukesh M. Goswami and Suman K. Mitra[7] have presented in their paper to recognize Gujarati handwritten numeral using low level stroke features like end points, curve segments, line segments, junction points. K-nearest neighbour classifier, support vector machine and radial basis functions were used for experiment over 14000 samples. Average accuracy on Gujarati dataset was concluded as 98.46%.

To recognize handwritten Gujarati numeral zoning based feature extraction method is presented in a paper by Ankit K. Sharma [8] et.al. For classification Naïve Bayes classifier and multilayer feed forward neural network is performed where results were more promising with the later one.

Ravi Nagar and Suman K. Mitra [9] have presented their work on recognizing Gujarati handwritten numeral by using orientation of strokes as feature extraction method to prepare feature set. For classification linear support vector machine is used.

Archana N. Vyas and Mukesh M. Goswami [10] in their work of classification of Gujarati numerals have presented three methods feature extraction where one is focusing on global direction and uses freeman chain code, whereas in second and third Fourier descriptor and discrete cosine transform coefficient are computed. For classification three methods were proposed i.e. K-nearest neighbour, Support vector machine and back propagation neural network. The highest recognition rate can be traced for DFT.

## II. METHODS AND MATERIAL

Proposed Method is considering isolated digit for recognition hence segmentation is omitted here.

### A. Pre-processing

Pre-processing of reference image is required to make it ready for feature extraction which involves some of the operations to be performed as below:

**RGB to Grey Scale:** Image whose every pixel containing RGB value will be converted to grayscale. Obtained image's every pixel will have value in the range of 0-255.

**Thresholding and Binarization:** Global threshold using otsu's method is calculated which is given as a base to convert grayscale image to binary image whose every element will have value 0/1.

**Extracting Region of Interest:** To obtain desire region of interest it requires detection of edges. Top-Left corner to Bottom-Right corner of image is scanned row wise to find only the image having region of interested their by cropping the remaining region.

**Thinning:** All lines are reduced to single pixel thickness. Thinning operation is performed infinite time shrinking so as to obtain minimal structure.

Gujarati Digit	Original Input Image	Binary Image	Extracting Region of Interest	Thinning
Five		157 X 181		37 X 41

**Figure 2 :** Pre-processing operations on Gujarati numeral 'Five'

### B. Feature Extraction

In Binary image each pixel will have either 1 or 0 value. A pixels with value 1 is examined for their eight neighbours. Total no. of neighbours with whom current pixel is connected that indicates neighbouring pixels having value 1 are counted and stored in a matrix element at p(i,j) index. This process is repeated for every

pixel of image. The pixel in the corner will have three neighbour pixels and pixels in the extreme rows and columns will have 5 neighbour pixels.

$p(i-1,j-1)$	$p(i-1,j)$	$p(i-1,j+1)$
$p(i,j-1)$	$p(i,j)$	$p(i,j+1)$
$p(i+1,j-1)$	$p(i+1,j)$	$p(i+1,j+1)$

**Figure 3 :** Pixel and its eight neighbour pixels

1	1	1	1	1	0
0	1	1	0	1	0
0	1	0	1	0	1
1	1	1	1	1	1
0	0	1	0	0	1
0	1	1	1	1	0

**Figure 4 :** Sample Binary Image Containing 1 and 0

From the binary image as displayed in Figure 4 as example matrix of same size as binary image is derived (shown in Figure 5).

2	4	4	4	2	2
4	5	6	6	4	3
4	5	7	5	6	3
2	4	5	4	5	3
3	6	6	7	6	3
1	2	3	3	2	2

**Figure 5.** Matrix representing count of neighbour pixels

From the resultant matrix vector of nine elements is derived. The first element of this vector contains count of no. of elements in above obtained matrix having value 1, second element contains count of no. of elements having value 2 and so on up to eight neighbours. 9th element represents the total of all eight elements of vector.

Pixel value	1	2	3	4	5	6	7	8	Total
Count	1	7	7	8	3	6	2	0	34

**Figure 6 :** Vector representing total count

### C. Classification Repository

To classify the given input digit image for each digit pre- processing and feature extraction steps are repeated for Gujarati digit ‘0’ to ‘૯’. The analysis so obtained is as below. Classification repository represents matrix of size 10 X 9. Where each row represents the digit and each column represents the analysis count obtained in previous step.

All the digits except ઝ and ઞ have unique total hence easily classified. If total obtained is 79 then there are two possibilities between ઝ and ઞ in that case each vector elements will be compared and on the basis of which it can be classified.

**TABLE I**

DERIVED MATRIX FOR GUJARATI DIGITS ‘ZERO’ TO ‘NINE’

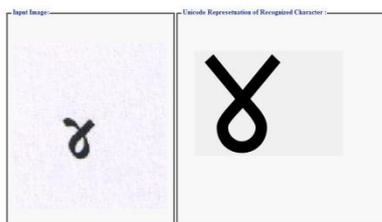
Gujarati Digit	Count of pixels with value								Total
	1	2	3	4	5	6	7	8	
૦	0	77	0	0	0	0	0	0	77
૧	1	52	3	0	0	0	0	0	56
૨	3	52	5	1	0	0	0	0	61
૩	4	60	6	0	0	0	0	0	70
૪	3	67	7	2	0	0	0	0	79
૫	3	77	1	0	0	0	0	0	81
૬	4	60	6	0	0	0	0	0	70
૭	1	77	1	0	0	0	0	0	79
૮	2	47	0	0	0	0	0	0	49
૯	5	47	3	0	0	0	0	0	55

## D. Classification and Recognition

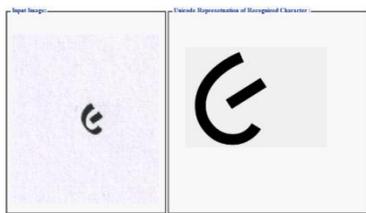
Based on given input image for recognition pre-processing and feature extraction steps is performed, the result of feature extraction i.e. vector of 9th element is compared with last element of each row of classification repository matrix turn by turn. If it matches with 1st row then the digit is classified and recognized as '0'.

## III. RESULTS AND DISCUSSION

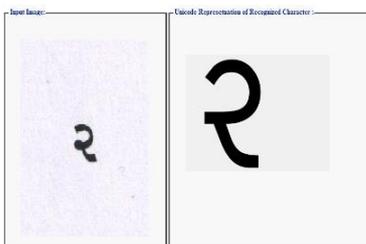
Sample input and output of recognition is shown in figure. Where HTML hex entity is used to display output of recognized digit.



(a)



(b)



(c)

**Figure 7.** Result of recognizing of Gujarati numeral (a) 'Four' (b) 'Nine' (c) 'Two'

## IV. CONCLUSION

Exploring eight neighbours and making feature extraction vector and recognizing digit on the basis of total is promising method for classification of digits. On the other hand, feature extraction and deriving classification vector is time consuming as every pixel of binary thinned image needs to be traversed. Overall

results obtained are satisfactory. This method is applied on over 100 samples and the accuracy obtained to recognize printed Gujarati digit is high up to 95%, the discrepancy in recognizing digit is due to some noise involved in the image while scanning.

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