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Recognition of Devanagari Handwritten Numerals using Two Different Approaches

S.L. Mhetre* *Sinhgad Academy of Engg, E&TC Dept, Pune university, India.*

M.M.Patil *Sinhgad Academy of Engg, E&TC Dept, Pune university, India*

Abstract— This paper proposes two methods for automatic recognition of Handwritten Devanagari Numerals. In first method, Grid features i.e. structural features are extracted and minimum distance is calculated using these features for classification. In second method, ICZ (Image Centroid Zone) & ZCZ (Zone Centroid Zone) features based on distance information are extracted and given to an already trained Neural Network for classification. The accuracies obtained using two approaches are evaluated.

Keywords— Artificial Neural Network, classification, feature extraction, Handwritten Numeral Recognition, pre-processing.

I. INTRODUCTION

Handwritten numeral recognition is a type of machine intelligence also called as artificial intelligence or computational intelligence. It is a challenging task as compared to printed character recognition because of large degree of variations in writing styles by different users. Such type of machines has ability to learn, adapt, make decision and display results that are not explicitly programmed into their original capabilities and they also learns and manages processes by their own. Now many organizations like banks, postal services come across huge number of handwritten documents, so for easy retrieval of data this handwritten data is converted into digital form [1]. Conversion of data manually is tiresome and time consuming job; therefore a perfect text recognizer should be developed so that it will have ability to see, interpret and read text by its own. OCR system that recognizes printed text fails to recognize handwritten text. Hence special OCR system for recognition of handwritten numerals should be developed.

Hindi is the national language of India and one of the most popular languages in the world which is the form of Devanagari script. Hence in this paper Devanagari numerals are chosen for recognition. The system provides us an opportunity for automatic processing of bank checks, processing of numerical entries on different forms or storing and searching the document automatically in very less time. For developing an efficient and more accurate technique efforts are taken by many researchers in India [2], [3]. Bajaj used median filtering for noise removal and extracted three types of features i.e. density features, moment features and descriptive component features [4], whereas box approach is proposed by Hanmandlu for feature extraction [5]. R. Jain and C. Patvardhan used edge direction histogram features along with PCA for enhancing recognition accuracies of handwritten devanagari numerals [6].

II. DATA COLLECTION

As standard dataset is not available for devanagari, hence data is collected from persons of different age, gender, background and qualification by providing them a sheet of paper. In this way two sets are created, one containing template images and another containing images that are to be recognized. The sample is as shown in Fig.1. below:

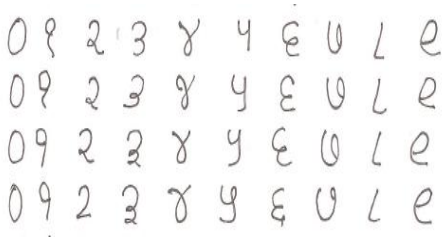


Fig. 1 Samples for Handwritten Devanagari Numerals

III. PROPOSED SYSTEM

There are three main steps for handwritten numeral recognition: Pre-processing, Feature extraction and Classification. The basic flow of the system is shown in Fig.2. The remaining paper is laid out as follows section III describes different pre-processing steps, section IV describes feature extraction, section V describes classification methods, section VI describes test results using both algorithms.

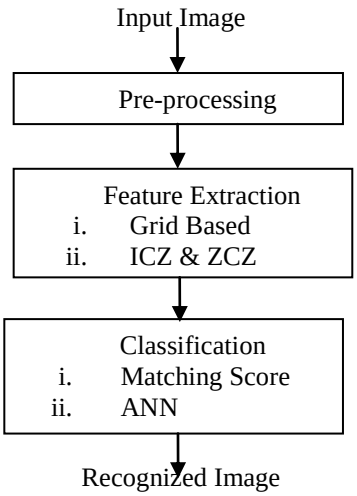


Fig. 2 Recognition Flow for Devanagari Numerals

A. Pre-processing

Different image processing steps like enhancing, cleaning, thresholding, extracting region of interest comes under same family named as pre-processing. Different steps used in this paper are :

- Color to gray conversion: Hue and saturation are removed from the input image except luminance. In this way color image is first converted into gray scale image.
- Noise Removal: Noise which may be introduced due to either hardware or software limitation must be removed before feature extraction. Removal of noise reduces the amount of information to be processed at the same time increasing the accuracy rate.
- Thresholding: This step simply converts a gray scale image into binary image. It is a non-linear operation.
- Thinning: It can be also called as skeletonization. This is done since numeral width does not provide us any useful or extra information hence extra edge points are removed reducing numeral from many pixel wide to single pixel.
- Size Normalization: For proper classification the input images are normalized to standard value.

IV. FEATURE EXTRACTION

Feature extraction is the process that helps to extract characteristics or important parts of input image that is a basic need of classification task. Our job is to select or extract such features that will help to build an efficient and powerful classification tool. Here two feature extraction techniques are used. The algorithms are explained as below:

A. Grid based feature extraction

Size of image after normalization is 128×96 (pixels). This dimension is not fixed we can take any dimensions for operational feasibility. The normalized input image is then divided into small and equal rectangular areas of size m×n. Here the value of m×n is 16×12. In this way the input image is divided into 192 cells. Each cell is called as Grid area. Now a zero matrix of size m×n (here 16×12) is defined. Relation between zero matrix and grid area is such that each grid area belongs to corresponding pixel in zero matrix.

a) First grid cell is selected and number of numeral pixels for the selected grid is calculated.
b) If the number is greater than 3 then corresponding pixel in zero matrix is replaced by 1 else by 0.

In this way step a) and b) is repeated for each grid area of input image.

B. ICZ (Image Centroid Zone) & ZCZ(Zone Centroid Zone)

For both ICZ and ZCZ feature extraction methods input image of size 150×75(pixels) (normalized size) is provided. The input image is then divided into equal rectangular zones of dimension m×n. Here the value of m×n is 10×5. Hence the image is divided into 50 equal zones.

1)Algorithm for ICZ

a) Centroid of image is calculated.
b) For first zone distance between image centroid and each numeral pixel is calculated.
c) Average distance is calculated for first zone.
Step b) and c) is repeated for each zone.
In this way 50 ICZ features are extracted for given input image.

2)Algorithm for ZCZ

a) Calculated centroid for each zone.
b) For first zone distance between zone centroid and each numeral pixel is calculated.

c) Average distance is calculated for first zone.
Step b) and c) is repeated for each zone.
In this way 50 ZCZ features are extracted for given input image.

V. CLASSIFICATION

This is the last stage for numeral recognition and goal of this stage is to assign the input pattern to a class out of already defined or trained class sets. Here we have used two different classification methods.

A. Matching Score

Matching score simply calculates the similarity between the input image and template images in the database. For this it uses the features extracted using grid based technique. But before recognition the input image which is to be recognized is also passed through same pre-processing steps. And its size is normalized to 16×12 (pixels). Hence for recognition matching score is calculated between input image and each image in the database. The input image will be recognized with the image in database for which we will get minimum score.

B. Artificial Neural Network

Artificial Neural Network is a computational model which is an extremely simplified model of brain [7]. It is also called as mathematical model. Brain contains interconnected neurons, similarly ANN uses the approach of interconnected group of neuron that processes information using connectionist approach. It contains one input layer, one hidden layer and one output layer connected sequentially in such a way that output of input layer given as input to hidden layer and output of hidden layer given as input to output layer. For input layer we are providing the feature set of database images and output layer neurons are targeted to our expected results. The system changes structure on the basis of external and internal information that flows through it during learning phase, hence it is also called as an adaptive system. It recognizes pattern in the inputs and produces noiseless output. The multilayer ANN is as shown in Fig.3 below:

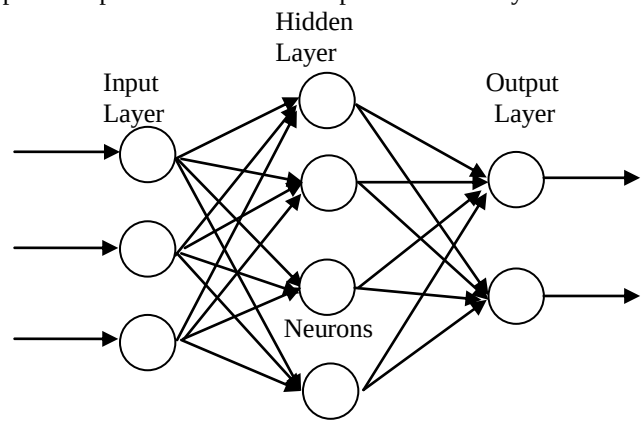


Fig. 3 Model of Artificial Neural Network

VI. RESULT

"Fig. 4" shows the image given as input for recognition using both Matching Score and ANN.

Fig. 4 Input Image

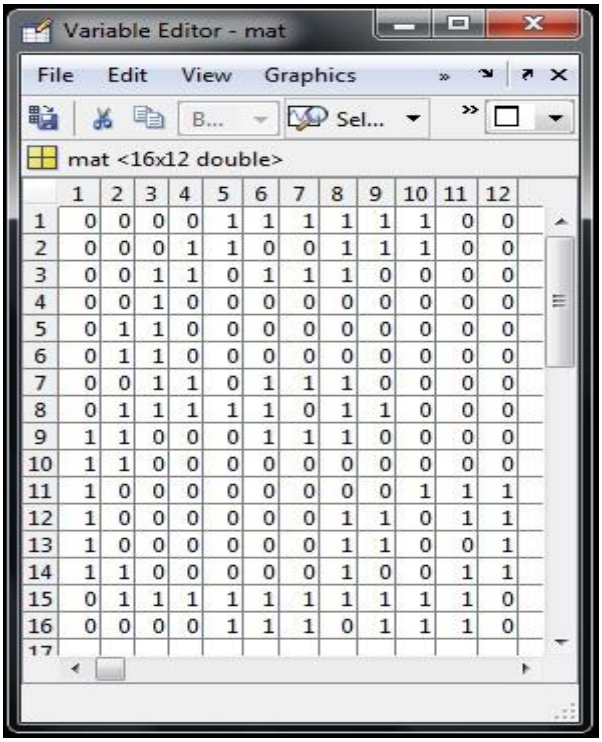
Image after pre-processing appears as:

Fig. 5 Pre-processed Image

A. Recognition using Matching Score

For matching score grid features of input image are extracted as shown in Fig. 6. The distance is calculated for input image with each image in database (here database consists of 500 images) using these features. Thus we will get a 'dist' matrix of size 1×500.

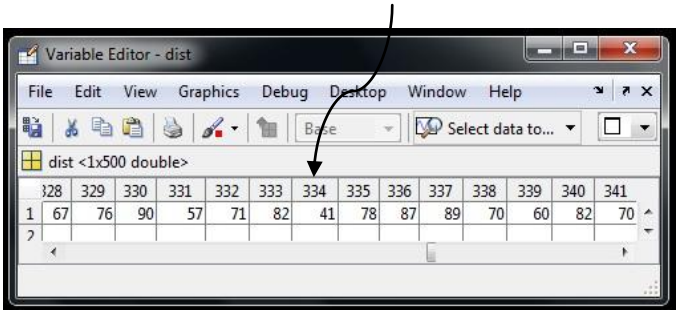
As shown in Fig. 7 the minimum distance is 41. Hence the input image is recognized with 334th image in database as shown in Fig. 8.



	1	2	3	4	5	6	7	8	9	10	11	12
1	0	0	0	0	1	1	1	1	1	1	0	0
2	0	0	0	1	1	0	0	1	1	1	0	0
3	0	0	1	1	0	1	1	1	0	0	0	0
4	0	0	1	0	0	0	0	0	0	0	0	0
5	0	1	1	0	0	0	0	0	0	0	0	0
6	0	1	1	0	0	0	0	0	0	0	0	0
7	0	0	1	1	0	1	1	1	0	0	0	0
8	0	1	1	1	1	1	0	1	1	0	0	0
9	1	1	0	0	0	1	1	1	0	0	0	0
10	1	1	0	0	0	0	0	0	0	0	0	0
11	1	0	0	0	0	0	0	0	0	1	1	1
12	1	0	0	0	0	0	0	1	1	0	1	1
13	1	0	0	0	0	0	0	1	1	0	0	1
14	1	1	0	0	0	0	0	1	0	0	1	1
15	0	1	1	1	1	1	1	1	1	1	1	0
16	0	0	0	0	1	1	1	0	1	1	1	0

Fig. 6 Grid features of Input Image

Minimum distance (Matching Score)



328	329	330	331	332	333	334	335	336	337	338	339	340	341
1 67	76	90	57	71	82	41	78	87	89	70	60	82	70

Fig. 7 Distance matrix

Fig. 8 Database Image

The output window generated showing result for Matching Score is shown below:

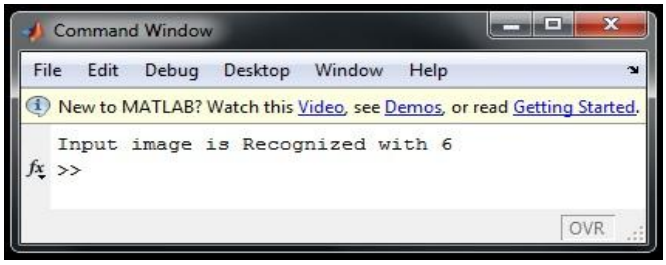
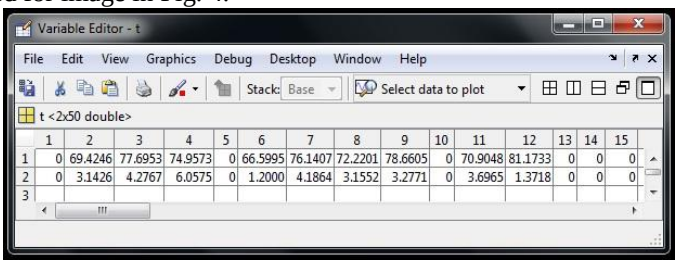


Fig. 9 Output Window for Matching Score

B. Recognition using Artificial Neural Network

ICZ & ZCZ features are extracted for classification of handwritten Devanagari numerals using ANN. Fig. 10 shows ICZ and ZCZ features extracted for image in Fig. 4.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0	69.4246	77.6953	74.9573	0	66.5995	76.1407	72.2201	78.6605	0	70.9048	81.1733	0	0	0
2	0	3.1426	4.2767	6.0575	0	1.2000	4.1864	3.1552	3.2771	0	3.6965	1.3718	0	0	0
3															

Fig. 10 ICZ & ZCZ features

These extracted features are applied to an already trained neural network that generates output as shown below:

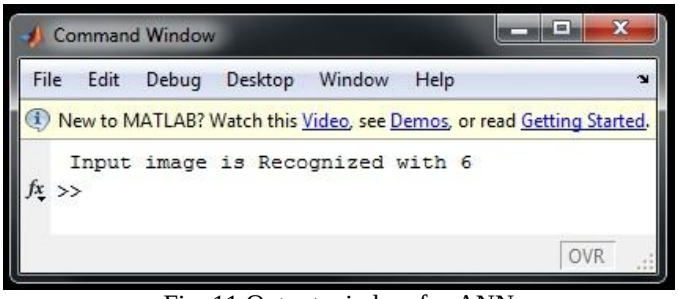


Fig. 11 Output window for ANN

Accuracy for both methods i.e. matching score and ANN is calculated using same database consisting of 500 training samples (50 handwritten samples for each numeral) and 500 testing samples. In this way, the output for both algorithms is as shown below:

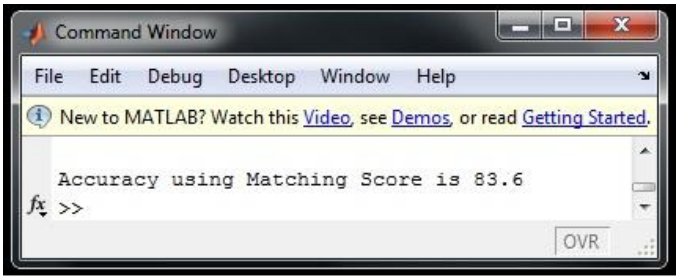


Fig. 12 Accuracy for Matching Score

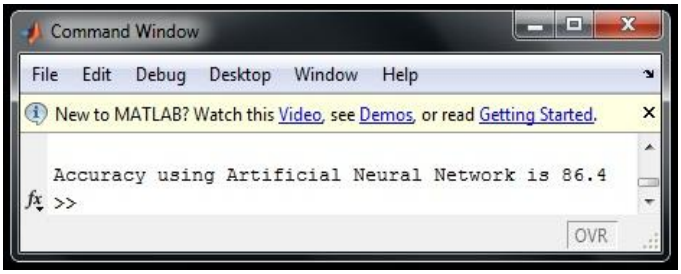


Fig. 13 Accuracy for ANN

Comparative results for both methods are summarized in Table I below:

TABLE I
COMPARATIVE RESULTS

Sr. No.	Method	Template Image	Test Image	Recognized Image	Accuracy
1	Artificial Neural Network	500	500	432	86.40%
2	Matching Score	500	500	418	83.60%

VII. CONCLUSION

Matching score is a simple method but its results are easily hampered by noise, skewness in images etc. which results in reduction in accuracy, whereas ANN has good resistance against noisy images. Though neural network architecture is complex but accuracy of ANN can be further increased by increasing the number of samples for training the network.

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