# Handwritten Devanagri Number Recognition using Majority Voting Scheme

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**Abstract:This paper presents a majority voting scheme for off-line hand written Hindi numbers recognitions. The main purpose 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 performance of this technique has been tested with 5030 handwritten numerals randomly selected from CPAR datasets out of which 3000 datasets has been used for training sets and 2030 datasets has been used for test sets. The average recognition result of this approach is 94.16%.**

***Keywords: Majority voting scheme, Multiple Classifier, Multiple Feature extraction.***

## 1. INTRODUCTION

The off-line recognition of handwritten characters, particularly in numbers has been a topic of research during last few years due to huge use of bank cheques, postal code, and other office automation in various organizations. Recognition of Hindi handwritten Numbers is the one of the major problem in today's world. Hindi numbers are not recognized efficiently and accurately by computer machine. Many researchers have been done to recognize these numbers and many algorithms have been proposed to recognize numbers. Many types of software are available in the market for optical Hindi numbers recognition. No single process or single machine can perform recognition with 100% accuracy. Hindi number recognition is becoming more and more important in the modern world. It helps human ease their jobs and solve more complex problems.

The problem of recognition of hand-printed Numbers is still an active area of research. With ever increasing requirement for office automation, it is imperative to provide practical and effective solutions. It has been observed that all sorts of structural, topological and statistical information about the numbers does not lend a helping hand in the recognition process due to different writing styles and moods of persons at the time of writing. Mainly, attention is focused on recognition of hand-printed Hindi Numbers.

On the handwritten recognition researchers have been worked more than 35 years. From the last few years, the numbers of companies involved in research on handwritten recognition are gaining continually.
Recognition of handwriting is not a new technology, and now it has amplification of the public attention. The main goal of designing a handwritten recognition system with a 100% accuracy rate is difficult for researchers, because not single human beings are able to recognize every handwritten text without any confusion. It can be seen that most of the people cannot even read their own notes. Therefore there is an obligation for a writer to write clearly. The recognition is divided in two categories: machine printed and handwritten. Machine printed characters are uniform in size, shapes and pitch for any font. In contrast handwritten are non-uniform, they can be written in many different styles and sizes by different writers and also at different times even by the same writer [3].

Many algorithms or methodology for hand written number recognition [1] and each of these have their own merits and demerits. Some works has been done on Hindi, the third popular language in the world. The most important thing of a hand written recognition scheme is the selection of a good feature vector on the different styles and shapes. For the feature extraction we proposed the simple profile and contour using triangular area representation to achieve both speed and acceptable recognition accuracies in different number image.

Printed Devanagri character recognition is attempted using Kohenen neural network and other types of neural networks in 2001[11]. Sethi and Chatterjee have described Devanagri numerals recognition using the structural approach 1976[4]. The back-propagation neural network is used in [11] for the recognition of handwritten characters. In that feature extraction is done using three different approaches, namely, ring, sector and hybrid.

Figure 1: CPAR Database image samples of Devanagari Numbers

Hanmandlu and Murthy [6] proposed a fuzzy model based recognition of handwritten Hindi numerals and they obtained 92.67% accuracy. Bajaj et al [7] employed three different kinds of features namely, density features, moment features and descriptive component features for classification of Devnagari Numerals. They proposed multi-classifier connectionist architecture for increasing the recognition reliability and they obtained 89.6% accuracy. Bhattacharaya et al [8] proposed a multi-layer preceptron ,neural network based classification approach for the recognition of Devenagari handwritten numerals and obtained 91.28% recognition accuracy. C. Vasantha Laxmi, Ritu Jain, C. Patvardhan [9] proposed a method incorporates in novel way ideas regarding edge directions histogram and splines along with PCA for enabling recognition that give 94.25% accurate results.

In this work, We convert the data image in CPAR database in resolution of 48 x 48 because this form provides an invariant rendering of a number image at different resolution levels on the different physical structure of the number. This feature extraction scheme seems to be very effectual for the hand written number recognition. It has been naturalized that combining of the decisions on several classifiers usually result in better classification accuracy because different classifiers represent on different aspects of the input data and training pattern of the network we consider the back propagation and cascade feed forward neural network classifier for the classification purpose. The present technique has been tested on the CPAR data base and obtains the best recognition accuracies. In the demesne of number recognition, substantial improvement in recognition performance has been reported in a number of occasions [14,15] by considering the combination method. There are diversity of method [16,17] implementing the combination of classifiers method. For this strategy we use the majority voting scheme [27].

## 2. PROCESS OVERVIEW

The number recognition system is usually validated by running them on test on data set, on which the system have been trained. For these tests to be conclusive, the validation sets should include a fairly large number of samples to reflect the variety of writing styles that are found in real-life applications. In this work we have followed the following steps.

a) Database collection
b) Binarization
c) Noise Reduction
d) Feature Extraction
   i. Simple Profile
   ii. Contour using TAR
e) Classifying
   i. Back Propagation
   ii. Cascade Feed Forwarding
f) Majority Voting Scheme
g) Recognition

### *2.1 Database Collection*

For the purpose of validation we need a standard database. For handwritten Hindi numerals, we have the CPAR numerals database. It contain 5000 samples of numbers. The samples are collected from the different people in different writing style and also use the number of pen in different color. The database also includes some samples that cannot be recognized even by humans. The database is divided in to two disjoint sets, one for training and another for testing

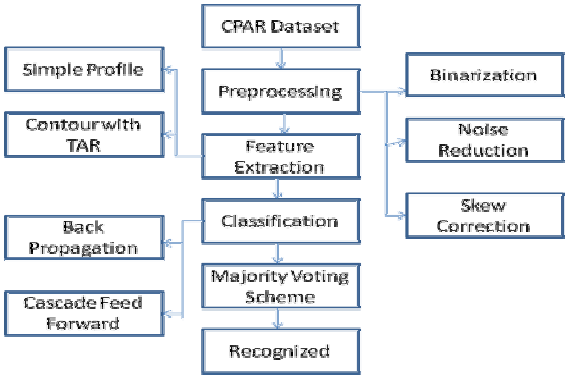


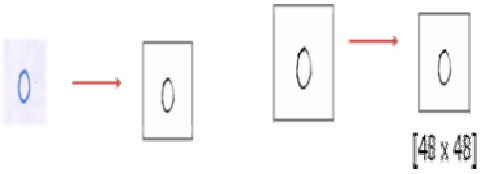

Figure 2. Block diagram of system implementation

For the training purpose we use the 3000 samples and for testing 2030 sample. If the training set contains a large number of samples with varied styles, the feature set computed from them will be able to reflect these variations in writing styles.

*2.2 Preprocessing*

2.2.1 Binarization

Firstly, that number is cropped i.e. extra pixels are removed from the number image. Then, That RGB image is converted into Gray scale image. The original scanned image is subjected to a number of processing to make it usable in further stages of the character analysis. At the time of database creation several pre-processing were used. Which includes but not limited to, the following?

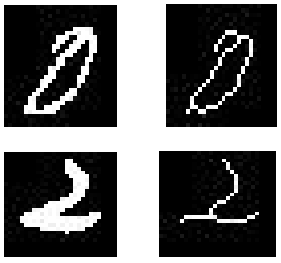



a. Binarization b. Resize of image

Figure 3. Preprocessing of the image

2.2.2 Noise Removal

The major objective of noise removal is to remove any unwanted bit-patterns, which do not have any significance in the output. Normalization helps to reduce the data size to a great extent e.g. thinning & Skelton formation extracts the shape information of the character. By the skeletonization we find out the thinness of the image.



a b

Figure 4. Noise Reduction a) Original Image b) Skelton Image

*2.3 Feature extraction*

This step is heart of the system. This step helps in classifying the numbers based on their features.The feature extraction refers to extract the features from each number image, which will become its identity and helps to increase the recognition rate. It is a difficult task to obtain these features as the nature of handwriting has high degree of variability from person to person & depending upon the Psychological condition.

For feature extraction methods we have used

- Profile- simple profile
- Contour based Triangular Area Representation (TAR)

2.3.1 Simple Profile

The profile counts the number of pixels (distance) between the bounding box of the image and the edge of the character or numeral image. Fast, less memory requirement & proved to be efficient. Profile describes the external shape of numeral and allows distinguishing between a great numbers of letters.

**Steps: For Applying the Simple Profile Algorithm**

- Load the data Image from the CPAR database.
- Resize the all image in 48 x 48 pixels
- Find out the left, right, top, bottom profile of the image.
- Then merge all the profile to form the feature vector.
- Then train neural network using 3000 samples.

After training apply the classify test on the 2030 data set sample. Here we use two classifier back propagation and cascade feed forward.

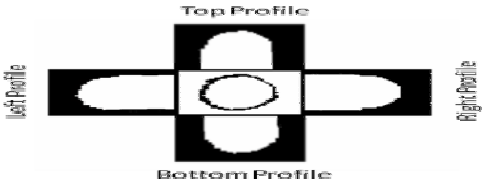



Figure 5. All Profile of number 0

2.3.2 Contour Based using TAR

Algorithm:

Step 1. Find contour points from an image. Suppose there are N contour points like C0(x0,y0), C1(x0,y0)…….Cn-1(xn-1,yn-1).

Step 2. Divide the contour points in three equal segments by using their floor value. E.g. S1=S2=S3=Floor(N/3).

Step 3. Form a triangle using the first points in all the segments.

Step 4. Repeat step 3 till last point in each segment.

*2.4 Classification*

In the decision making tasks of the human activity classification is very important. A classification problem comes out when an object needs to be assigned into a predefined group or class based on a number of observed attributes related to that object. The recognition of the numbers we train the neural network on the training data set samples 3000.

The network trains its weight array to minimize the selected performance measure, i.e., using back propagation algorithm and cascade feed forward algorithm.

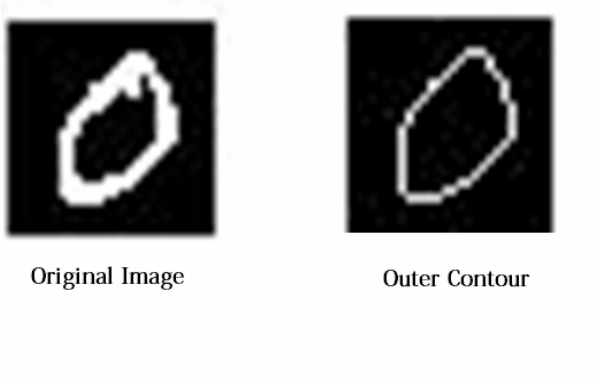



Figure 6. Contour of Number 0

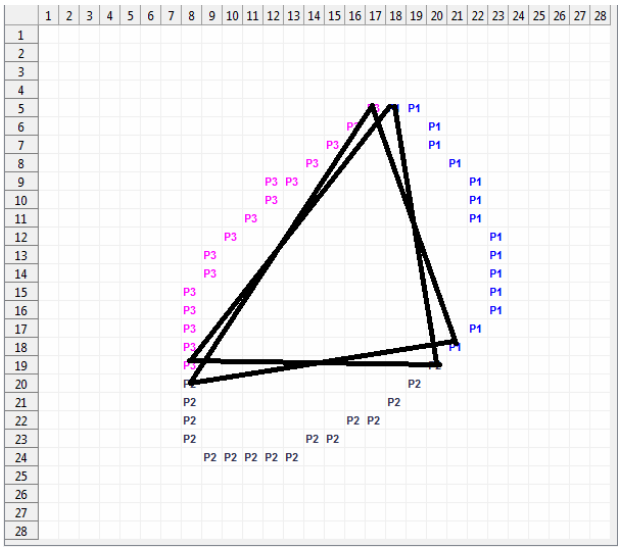


Figure 7. TAR formation

The following are taken as inputs:

a) The input pattern
b) No. of neurons in each hidden layer
c) Value learning rate
d) Value of momentum constant
e) Error value for convergence

An effective strategy of judging training adequacy is the use of a validation set. With increased training, the recognition error on validation set decrease monotonically to a minimum value but then it starts to increase, even if the training error continues to decrease. For better network performance, training is terminated when the validation error reaches its minimum.

In the present work, we considered multi resolution features based on a profile and contour using TAR and a voting scheme on the responses of a set of Back Propagation and cascade feed forward networks for the classification purpose. The present technique has been tested on Hand written devnagri hindi numbers and obtained both speed and recognition accuracies
comparable to the state-of-the-art techniques. The reason for obtaining high speed recognition rate in the proposed approach is that a profile and contour feature-extraction tool fits naturally with digital computer with its basis functions defined by just multiplication and addition operators – there are no derivatives or integrals.

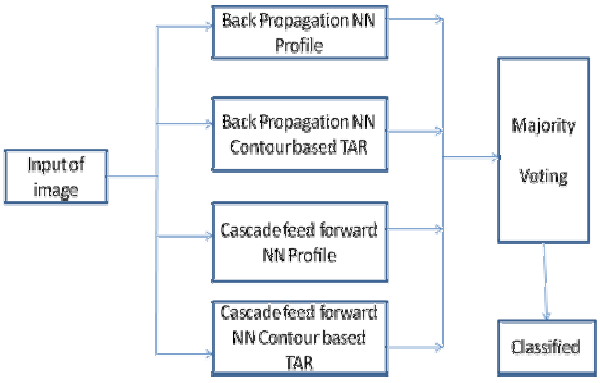



Figure 8. Block Diagram of Classification and majority voting

In the present work, we considered multi resolution features based on a simple profile and contour using TAR and a voting scheme on the responses of a set of Back Propagation and cascade feed forward networks for the classification purpose. The present technique has been tested on Hand written devnagri hindi numbers and obtained both speed and recognition accuracies comparable to the state-of-the-art techniques. The reason for obtaining high speed recognition rate in the proposed approach is that a profile and contour feature-extraction tool fits naturally with digital computer with its basis functions defined by just multiplication and addition operators – there are no derivatives or integrals.

**Steps for the Majority Voting Algorithm**

Step 1. Trained the neural network using back propagation and cascade feed forward neural network and test the 2030 sample to find out the best result.
Step 2. Collect the result and apply the majority voting algorithm.
Step 3. If the result set having all T the image is classified but if two set have the value T and two have F value the image is unclassified.
Step 4. If the result set having three T and one F value the given image is unclassified.

## 3 RESULTS

CPAR database consists of 5030 isolated handwritten Hindi numerals equally distributed over all classes. This database includes possible variation with respect to age, sex and education, place and also mental status of the person who write on the paper. So there are number of variation in the writing style of a single person at a different time. Handwritten Devanagari Number sets are taken. These steps are followed to obtain best accuracy of input handwritten Hindi number image from the CPAR database. First of all, training of system is done by using different data set or sample. And then system is tested for few of the given sample, and accuracy is measured. The data set was divided into two parts. The first part is used for the training the system and the second was for testing purpose. For each number, feature were computed and stored for the training the network. The tables given below display the results obtained from the program. The variance is very small but it is there.

Three network layer one input layer, twenty hidden layer and one output layer are taken. If number of neurons in the hidden layer is increased, then a problem of allocation of required memory is occurred. Also, if the value of error tolerance is high, desired results are not obtained, so changing the value of error tolerance i.e. say, high accuracy rate is obtained. Also the network takes more number of cycles to learn when the error tolerance value is less rather than in the case of high value of error tolerance in which network learns in less number of cycles and so the learning is not very fine.

## 4 CONCLUSION

Offline handwritten Hindi number recognition is a difficult problem, not only because of the great amount of variations in human handwriting, but also, because of the overlapped and joined numbers**.** Recognition approaches heavily depend on the nature of the data to be recognized.

**Confusion Matrix**

| Output Class \ Target Class | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 186 9.2% | 3 0.1% | 4 0.2% | 0 0.0% | 6 0.3% | 3 0.1% | 2 0.1% | 7 0.3% | 2 0.1% | 2 0.1% | 86.5% 13.5% |
| 2 | 2 0.1% | 160 7.9% | 5 0.2% | 7 0.3% | 5 0.2% | 3 0.1% | 1 0.0% | 1 0.0% | 4 0.2% | 32 1.6% | 72.7% 27.3% |
| 3 | 1 0.0% | 3 0.1% | 144 7.1% | 26 1.3% | 2 0.1% | 7 0.3% | 1 0.0% | 3 0.1% | 2 0.1% | 2 0.1% | 75.4% 24.6% |
| 4 | 0 0.0% | 8 0.4% | 11 0.5% | 140 6.9% | 1 0.0% | 7 0.3% | 1 0.0% | 0 0.0% | 0 0.0% | 0 0.0% | 83.3% 16.7% |
| 5 | 4 0.2% | 8 0.4% | 3 0.1% | 2 0.1% | 157 7.7% | 29 1.4% | 1 0.0% | 1 0.0% | 0 0.0% | 4 0.2% | 75.1% 24.9% |
| 6 | 1 0.0% | 4 0.2% | 14 0.7% | 9 0.4% | 16 0.8% | 139 6.8% | 2 0.1% | 1 0.0% | 0 0.0% | 3 0.1% | 73.5% 26.5% |
| 7 | 3 0.1% | 1 0.0% | 8 0.4% | 11 0.5% | 5 0.2% | 10 0.5% | 181 8.9% | 11 0.5% | 5 0.2% | 5 0.2% | 75.4% 24.6% |
| 8 | 4 0.2% | 1 0.0% | 4 0.2% | 1 0.0% | 6 0.3% | 1 0.0% | 5 0.2% | 178 8.8% | 1 0.0% | 0 0.0% | 88.6% 11.4% |
| 9 | 2 0.1% | 1 0.0% | 6 0.3% | 4 0.2% | 4 0.2% | 2 0.1% | 3 0.1% | 1 0.0% | 181 8.9% | 3 0.1% | 87.4% 12.6% |
| 10 | 0 0.0% | 14 0.7% | 4 0.2% | 3 0.1% | 1 0.0% | 2 0.1% | 6 0.3% | 0 0.0% | 8 0.4% | 152 7.5% | 80.0% 20.0% |
| | 91.6% 8.4% | 78.8% 21.2% | 70.9% 29.1% | 69.0% 31.0% | 77.3% 22.7% | 68.5% 31.5% | 89.2% 10.8% | 87.7% 12.3% | 89.2% 10.8% | 74.9% 25.1% | 79.7% 20.3% |

Table 1: Final Confusion Matrix by Back propagation Classifier

In this paper we considered a majority voting scheme on simple profile and contour using TAR based recognition of hand written numerals. In this approach we consider the back propagation and cascade feed forward as a classifier on the 48 x 48 resolution levels. This strategy of used multiple classifier of similar type to improve recognition accuracy without significant increase in computation of features.

| Script | Back Propagation | | Cascade Feed Forward | | Percentage | Result |
|---|---|---|---|---|---|---|
| | Profile | Contour | Profile | Contour | | |
| Hand Written Hindi (CPAR) database | T | T | T | T | 94.61 | Classified |
| | F | T | T | T | 70.59 | Unclassified |
| | F | F | T | T | 60.98 | Unclassified |
| | T | T | F | T | 79.7 | Classified |
| | T | T | F | F | 62.4 | Unclassified |

Table 2: Result of majority voting scheme where T denote the recognized and F denote the unrecognized

% Average = Success Count * 100 / (Success Count + Failure Count)

By that we achieved the 94.61% accurate result.

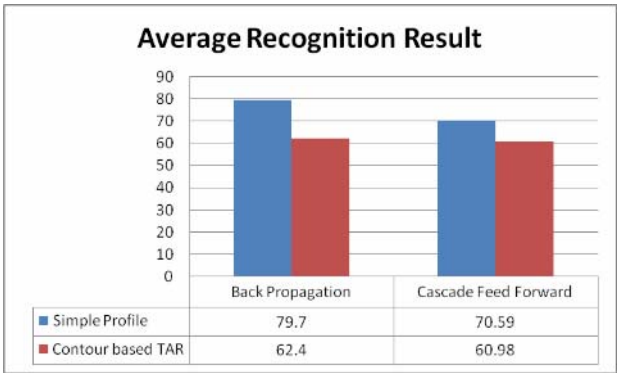



Figure 9. Avarage Recognition Result

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