

Handwritten character and word recognition using their geometrical features through neural networks

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ABSTRACT

In this research we are aiming to use geometrical features and evolutionary computational algorithm to automatically recognize (read) off-line handwritten character & two letter words using Sobel edge detection technique with an increased feature extraction.

The nature of handwritten characters is difficult to identify and hence the problems that could be faced when automatically (optically) recognizing them. This Research concentrates on the feature extraction process, i.e. extraction of the main geometrical features of each of the extracted handwritten characters and then two letter words. A complete system able to recognize handwritten characters of only a single writer is proposed and discussed. A review of some of the previous trials in the field of off-line handwritten character recognition is included. The system first attempts to remove some of the variations found in the images that do not affect the identity of the handwritten word (slant correction, slope correction, and baseline estimation). Next, the system Codes the skeleton of the word so that feature information about the lines in the skeleton is extracted (segmentation and feature extraction). The features include locating endpoints, junctions, turning points, loops, generating frames (segmentation step) and detecting strokes. These features are then passed on to the recognition system for recognition. The character classification is achieved in this research using a feed-forward error back propagation neural. Similar way the two letter words from the same writer is also found and identified. In this method the data of the tow letter words is already stored in the offline dictionary for usage.

Keywords: Neural network, feed forward back propagation, feature extraction.

1. INTRODUCTION

This Character recognition is the process to classify the input character according to the predefined character class. Handwritten English Character Recognition has been a fairly challenging research topic in the field of Image Processing. Up to now, there have been lots of fruitful researches for Handwritten English Character Recognition. Character recognition is becoming more & more important in the modern world. Today use of computer increases day by day. With the increasing interest of computer applications, modern society needs that the computer should read the text. There are two types of text. One is scanned handwritten document and other is Typed text in various fonts. Also there may be a combination of both. The communication between a human and a computer become easy due to character recognition system. It helps humans ease their jobs and solve more complex problems.

For recognition of handwritten characters, classical methods are not perfect due to the following reasons

1. The same characters differ in sizes, shapes and styles from person to person and even from time to time with the same person. There are thousands styles of type in common use and a character recognition program must recognize most of these.
2. Like any image, visual characters may be distorted due to noise. Noise consists of random changes to a pattern, particularly near the edges. A character with much noise may be recognized as a completely different character by a computer program.
3. There are no hard-and-fast rules that define the appearance of a visual character. Hence it is necessary that rules are heuristically deduced from the samples.

Character recognition system has variety of commercial and practical applications. It is useful in bank Cheques/DD processing, government records, credit card imprints, postal automation, address and zip code recognition, reading commercial forms, manuscripts and their archival, license plate recognition system, smart card processing system, automatic data entry, money counting machine, writer identification etc.

A number of strategies for character recognition are available in literature. There exist several different techniques for recognizing characters. One distinguishes characters by the number of loops in a character and the other by direction of their concavities. These methods can be used one after the other to increase accuracy and speed for recognition.

2. LITERATURE SURVEY

Handwriting recognition has been one of the most fascinating and challenging research areas in field of image processing and pattern recognition in the recent years. Recognition of handwritten characters has been a popular research area for many years because of its various application potentials. Some of its potential application areas are Postal Automation, Bank Cheque processing, automatic data entry, etc. Although first research report on handwritten Devanagari characters was published in 1977 but not much research work is done after that. At present researchers have started to work on handwritten Devanagari characters and few research reports are published recently. Several research works have been focusing on new techniques and methods that would reduce the processing time while providing higher recognition accuracy.

- a) *Quadratic classifier based Handwritten Devnagari character recognition*
- b) *Recognition of Handwritten Devnagari Characters Using MLP & Minimum Edit Distance*
- c) *Handwritten Arabic Characters recognition Using Their Geometrical Features*
- d) *Handwritten English Character Recognition*
- e) *Marathi Vowels Recognition*
- f) *Fuzzy Stroke Analysis of Devnagari Handwritten Character*
- g) *A New Method For Devnagari Character Recognition*

3. CHARACTER RECOGNITION METHODS

Generally character recognition process has four important steps – 1) Data acquisition 2) Preprocessing 3) Segmentation 4) Feature Extraction 5) Classification or recognition. The classification stage plays important role in recognition system. It is the decision making part of the recognition system. It uses the features extracted in the previous stage. The performance of a classifier depends on the quality of the features. There are many existing Classical and soft computing techniques for handwriting identification. They are given as:

1. Template matching
2. Statistical techniques
3. Structural techniques
4. Fuzzy- logic technique
5. Support Vector Machines
6. Neural networks (NNs)



4. PROPOSED SYSTEM

From literature survey, it is observed that Marathi/Devnagiri character recognition is a very challenging research task. After studying various methods for character recognition, & considering their advantages & drawbacks, I conclude that use of Neural Network (NN) is most suitable for handwritten Marathi character recognition.

A system is proposed to recognize handwritten Marathi characters. Character recognition is very vast field. Various methods are used for the same. Marathi characters are more complex than English characters. Classical methods of character recognition are not considered to be as successful for recognition of Marathi characters as Marathi characters differ in size, shape and style from person to person and from time to time with the same person. Hence this project uses the Artificial Neural Network technique using evolutionary computational algorithm for character recognition. The main advantage of using this technique is that it provides features extraction and detection that is suitable for character recognition and also improved efficiency over earlier methods. Neural network gains more success in character recognition as compared with other classical methods as it functions like neural network with evolutionary computational algorithms. Out of various ANN methods feed forward Error-back propagation algorithm is used due to its' capability of forming internal representations of features in classification.

- 1) Preprocessing
- 2) Feature extraction
- 3) Recognition.

1) Preprocessing

Initially scanned images of handwritten characters are stored as database. Then preprocessing is carried out to reduce the noise in the images. The pre-processing is a series of operations performed on the scanned input image. Pre-processing aims to produce data that are easy for the computer related systems to operate accurately. Pre-processing enhances the image features thus reducing the effect of variations in the handwritings & rendering it suitable for further processing. In this project the various operations performed during preprocessing are noise reduction, normalization, binarization, edge detection, dilation & filling. Initially load the dataset image. Then crop the required character image (i.e. character to be recognized) manually. Then cropped image is converted into gray scaled image. After this binarization is carried out. Binarization process converts a gray scale image into a binary image using global thresholding technique. After this, edge of the binary image is detected. Image dilation & filling of holes is performed after binarization. Finally object location is plotted & box is created to character image for further processing. For example character  appears like  after performing all preprocessing steps for it.

2) Feature Extraction

Feature extraction is the next step after preprocessing. After the preprocessing the feature set is extracted. Extracted features from the character images are used to train the neural network and with the help of computational evolutionary algorithm. In this stage, the features of the characters that are used for classifying them at recognition stage are extracted. The edges & end points of the image are detected & are considered as features for neural network. The binary image is segmented into individual characters and then, each character is resized into 150x150 pixels, all pixels in rows and column with the value "1" will be added and averaged. These values will be place into a 15 by 15 matrices to meet the network input requirement. Cropped binary image and resize it to 15 x 15 char representation as single vector.

3) Character Recognition

Finally character recognition is carried out using neural network. In this process a character to be recognized is assigned to the network and label is given to it. Several other patterns of the same character are taught to neural network under the computational algorithm under the same label. Hence system learns several variations in the handwritten characters and these variations gets adaptive to it.

At the time of training of the neural network weight matrix is initialized to zero. During the training process the input assigned to matrix is defined. Each character processes corresponding weight matrix. For the Bth character to be taught its weight matrix is denoted by WB. As the learning of the character progresses, the weight of the character is to be updated. In order to train the network, features of the character which are previously extracted from the character are given to neural network. To recognize these patterns, the instructions are then given to the network through software. In accordance with this, the weight matrix WB is updated. Neural networks learn through such updating of their weights. Every time, the weights are adjusted in such a way as to give an output closer to the desired output than before. In this project, feed forward back propagation neural network is used. It has 3 layers, with input layer, hidden layer & output layer. Input layer contains 40 nodes as number of characters are 40. If the features of the character are not matched with target, the error is back propagated & weights are updated. Weight updating for character is carried out in hidden layer. The process is continues till features of selected character are matched with the target. Finally output is displayed. The work is carried out in MATLAB.

5. EVOLUTIONARY ALGORITHM IN NEURAL NETWORK

One field that has developed from Character Recognition is Optical Character Recognition (OCR). Optical Character Recognition has advanced into a field of Handwritten Recognition. The recognition of characters is one of the earliest applications of Artificial Neural Networks. It is one of the most classical applications of the Artificial Neural Network. Neural network can be trained to deal with the noisy data. A neural network is a powerful data-modeling tool that is able to capture and represent complex input/output relationships.

Neural network gains more success in character recognition as compared with other classical methods as it functions like human brain. The goal of this network type is to create a model that maps the input to the output using historical data so that the model can then be used to produce the output when the desired output is unknown. Multi-layer feed-forward neural network, with back propagation, is most commonly used in handwritten character recognition.

In character recognition method, using neural network, various characters are taught to the network in a supervised manner. In this process a character to be recognized is assigned to the network and label is given to it. Several other patterns of the same character are taught to neural network under the same label. Hence system learns several patterns of same handwritten character and these variations gets adaptive to it.

In this project, evolutionary computation is a subfield of artificial intelligence is used that can be defined by the type of algorithms it is concerned with. The algorithms, called evolutionary algorithms, are based on adopting Darwinian principles, hence the name. Technically they belong to the family of trial and error problem solvers and can be considered global optimization methods with a metaheuristic or stochastic optimization character, distinguished by the use of a population of candidate solutions (rather than just iterating over one point in the search space). They are mostly applied for black box problems, often in the context of expensive optimization

The process of digitization is important for neural networks. In this process the input image is sampled into binary window which forms the input to the recognition system.

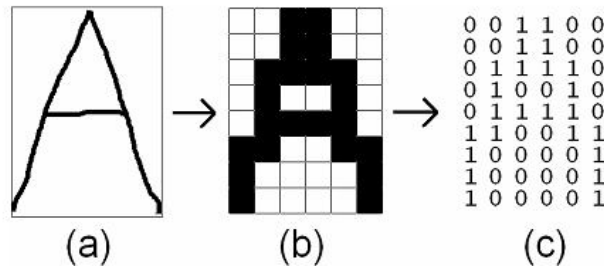


Figure 1: Digitization of character ‘A’

In the above figure, the alphabet A has been digitized into 6X8=48 digital cells, each having a single color, either black or white. This information must be understood by the computer. So this information should be encoded in a form meaningful to a computer. For this, we assign a value +1 to each black pixel and 0 to each white pixel and create the binary image matrix I. This digitization will allow the computer to check the exact details of the image.

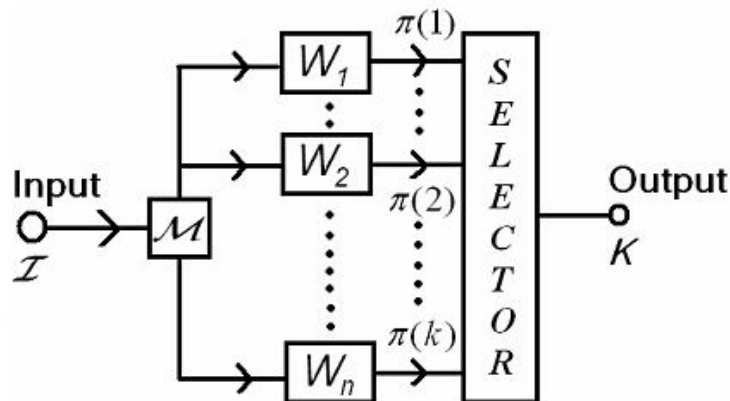


Figure 2: Neural Network Architecture

The architecture of the neural network which formed the basis for this study is as shown in the figure 2 above. Here the input to network is pattern I. This pattern is converted into matrix form M. W_1, W_2, \dots, W_n are blocks having specific weights. Input matrix M is given to these weighted blocks as shown in figure. There are total of n weighted blocks for n characters to be learned. During this training process the input assigned to matrix I defined as below:

$$\begin{aligned} & \text{If } I(i, j) = 1 \text{ Then } M(i, j) = 1 \\ & \text{Else:} \\ & \text{If } I(i, j) = 0 \text{ Then } M(i, j) = -1 \end{aligned}$$

The input matrix M is now fed as input to the neural network. Each character processes corresponding weight matrix. For example, the Kth character to be taught has weight matrix denoted by W_k . As the learning of the character progresses, the weight of the character is to be updated. At the time of training of the neural network this matrix is initialized to zero. In order to train the network, input pattern of that character is given to neural network. To recognize these patterns, the instructions are then given to the network through software. In accordance with this, the weight matrix WB is updated in the following manner:

```

For all i= 1 to x
{
For all j=1 to y
{
Wk(i, j)=Wk(i,j)+C(i,j)
}
}
}
    
```

Here x and y are the dimensions of the matrix Wk(and M)

As handwriting differs from person to person (or time to time), digitized patterns of the same character are slightly differ from each other. So weight matrix has been updated number of times as per the number of digitized patterns. The matrix-elements with higher score are the ones which stand for the commonly occurring image-pixels. The elements with lesser score stand for pixels that appear less frequently in the images. Neural networks learn through such updating of their weights. Every time, the weights are adjusted in such a way as to give an output closer to the desired output than before. The method is highly adaptive; minor errors and changes in patterns are tolerable during character recognition.

6. RESULTS

The recognition system has been implemented using Matlab7.10.Described application of character recognition can be divided into three main parts. Image preprocessing to get the training data, training the neural network and at the end testing with final recognition results. Two hundred Marathi handwritten characters are used as a dataset for training & testing the neural network. Also the set of 10 small two letter words are also is used as an sample data set to for recognition of the small words.

The scanned image is taken as dataset/ input and feed forward architecture is used. The structure of neural network includes an input layer with 40 inputs, one hidden layers with 1 neurons and an output layer with 1 neurons. The gradient descent back propagation method with momentum and adaptive learning rate and log-sigmoid transfer functions is used for neural network training. Neural network has been trained using known dataset. Here the evolutionary computational algorithm play an very important role as it defines the amount of learning rate and also the efficiency. After training the network, the recognition system was tested using same dataset and the results obtained are presented in this section.

Total no. of Marathi characters (consonants & vowels) are divided into seven image templates for recognition. 3templates contain 4 sets of 10 characters each & 4 templates contain 4 sets of 4 characters each. First template contain Marathi characters क to ठ Second template contain Marathi characters ड to फ. Third template contain Marathi characters ब to स .Forth template contain Marathi characters ह to र. Fifth template contain Marathi characters ज to झ . Sixth template contain Marathi characters उ to षे. Seventh template contain Marathi characters ओ to अ .



Figure 3: Recognition for template Letter

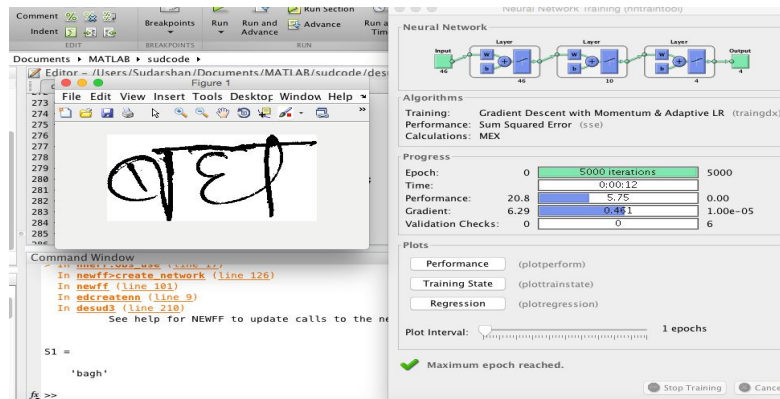


Figure 4: Recognition for template word

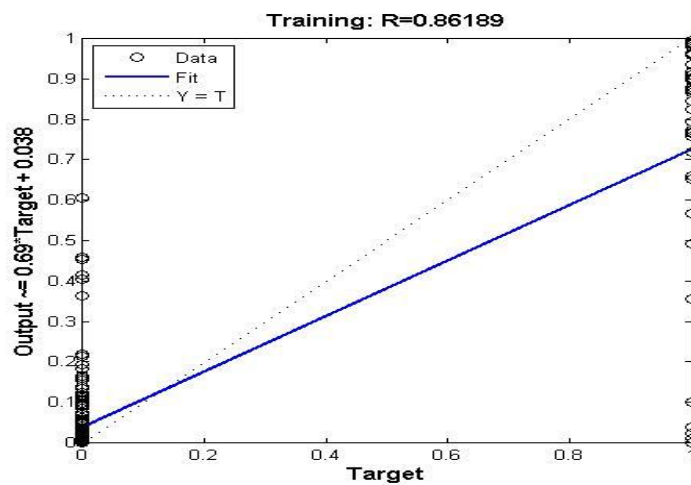


Figure 5: Regression Plot

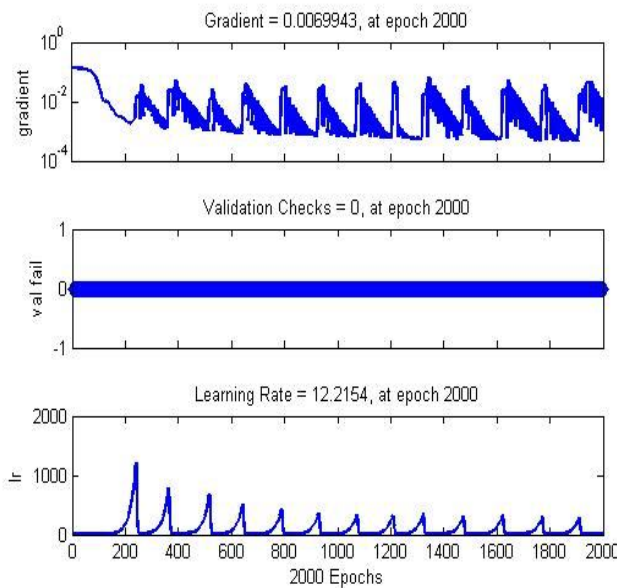


Figure 6: Training Plot

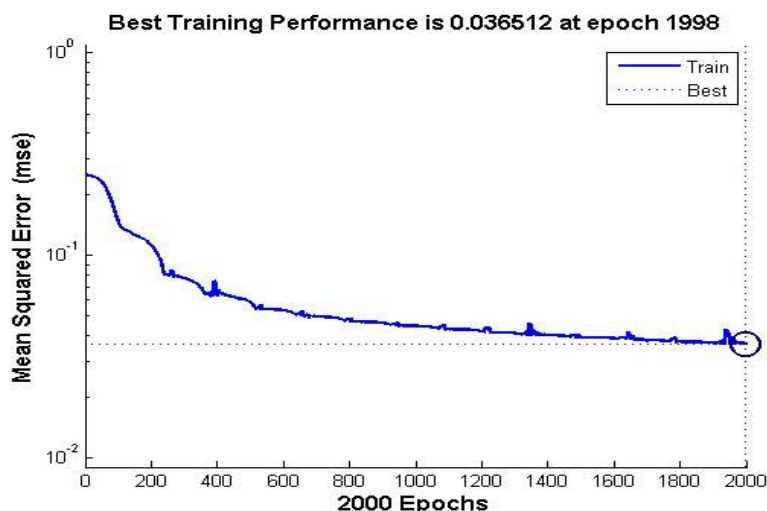


Figure 7: Performance Plot

7. LIMITATIONS

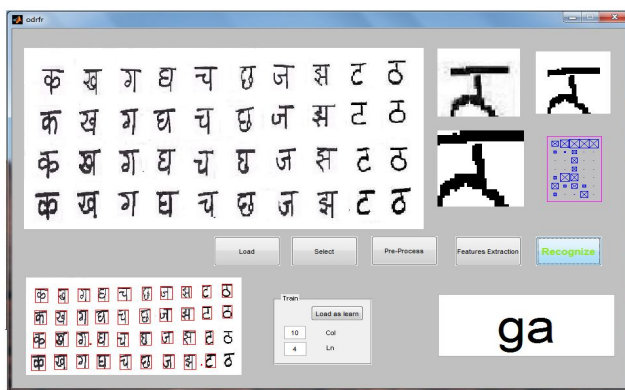


Figure 8: Wrong recognition due to wrong cropping

The limitation of this work is that if the character is not selected properly & if improper cropping of the character is done, neural network will not recognize the character correctly. This process of incorrect recognition for character ग is shown in figure 4. The character ग is incorrectly recognized as Devnagari script contains core characters in the middle strip & optional modifiers above and/or below core characters. Most of the characters in Devnagari script is formed by curves, holes, and also strokes. The alphabet itself contains more than one number of symbols.

In Devnagari script vowels occur either in isolation or in combination with consonants. When consonants are combine with modifiers, modified characters of consonants are formed Figure 5 shows vowels, modifiers & modified characters of consonant क. System is unable to recognize modified & compound Marathi characters.

Also Devnagariscrip has compound characters. These compound characters are formed by combining two or more basic characters as shown in Figure 5. The shape of compound character is usually more complex than the constituent basic characters.

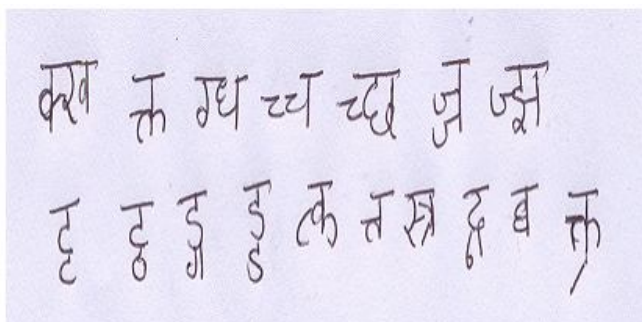


Figure 9 Compound Devanagari Characters

Handwriting recognition has been one of the challenging research areas in the field of image processing and pattern recognition. Though it is a complicated task, it has numerous applications such as, reading aid for blind, bank Cheques, conversion of any hand written document into structural text form, office automation for text entry, automatic inspection and identification, paper checking of students. It can be used in bill processing system, in job application form sorting

Various languages use specific script to write. One of them is Devanagari which is most widely used for many major languages such as Marathi, Hindi, Sanskrit, etc. Hindi & Marathi are most commonly used languages by several thousand people. The project describes recognition of offline handwritten Marathi characters and small two letter words using neural network. Described application of character recognition can be divided into three main parts. Image preprocessing to get the training data, training the neural network and learning through the evolutionary computational algorithm at the end testing with final recognition results. Dataset is prepared by 200 handwritten samples by different people. Image preprocessing is carried out to get the training data for the neural network. Features extracted from characters are used for training the neural network. Total 35 features are extracted from each character. Feed forward back propagation neural network is used for classification & recognition purpose. Multilayered neural network with one hidden layer is used. The network uses 1 output nodes and 40 input nodes. All the neurons use log-sigmoid transfer functions Recognition accuracy for individual templates is above 90%. Average accuracy of all templates is 94 % which is better as compared to other character recognition techniques. But the system is unable to recognize modified & compound Marathi characters. There are several possible changes that could improve the performance. The neural network approach with evolutionary computational algorithm explained here shows the learning ability and adaptability of neural networks. Though ANN (Artificial Neural Network) has complexity in computations, it offers several advantages in pattern recognition and classification in the similar manner close to human intelligence to a small extent.

8. FUTURE SCOPE

This project present recognition system for offline handwritten Marathi vowels & consonants and small two letter words. Further research can be developed to recognize modified as well as compound Characters and bigger words. Also research work can be extended to online character recognition system. So that application potential will increase. The Implementation of this system along with the voice system will allow the user to learn a new language and also to speak. Various historical data symbols and logos can be described by the image taken of the character.

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