A Research Survey of Devnagari Handwritten Word Recognition

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Abstract

Devnagari is the most popular script in India it is used by over 400 million people all over world. Recognition of Devnagari handwritten word has been a popular research area for many years because of its various applications. This paper describes different techniques for pre-processing, segmentation, feature extraction and classification which play an important role for recognition of word.

1. Introduction

India is multilingual/multiscript country with various languages namely Gujarati, Marathi, Konkani, Bengali, Tamil, Telugu, Punjabi, Sanskrit, Urdu. Handwritten recognition is classified into two types as offline and online. In offline recognition document is scanned and complete writing is available in image. Due to the availability of several computing devices such as Tablet PC, PDA and Smartphone in the market and affordable by common Indian online handwritten word recognition gain enough attention. In online recognition input is given by Tablet PC, PDA and Smartphone which is equipped with pen based input technology. Input data to such a online handwriting recognition consist of (x, y) coordinates along with trajectory of the pen together with a few other possible information such as pen-up, pen-down etc.

1.1. Features of Devnagari Script

Devnagari script plays an important role in the development of literature. Devnagari is used in many languages like Marathi, Hindi, Konkani and Sanskrit which is used by approximately 400 million people in northern India and it is most widely used Indic script. Devnagari is written from left to right and it does not contain any lower and upper case letters. It consists of 11 vowels and 33 consonants.

अ आ इ ई उ ऊ ऋ ए ऐ ओ औ

Figure 1. Set of vowels

क ख ग घ ङ
च छ ज झ ञ
ट ठ ड ढ ण
त थ द ध न
प फ ब भ म
य र ल व श
ष स ह

Figure 2. Set of Consonants Set of Consonants

Shirorekha or headline is the horizontal line at the upper part of the character or word. It does not contain any useful information so it should detect and then discarded. N. Joshi [14] describes a Shirorekha detection algorithm in the context of online Devnagari character recognition

2. Recognition of Devnagari Handwritten Word

The schematic block diagram consists of various stages in Devnagari handwritten word recognition as shown in figure 3.

Scan Image / Online Data

Preprocessing
Binarization, Normalization, Resampling, Noise Removal

Segmentation
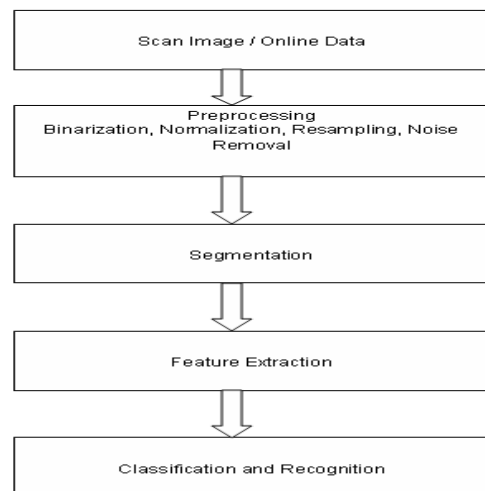
Feature Extraction

Classification and Recognition

Figure 3. Stages in Handwritten word recognition

2.1. Pre-processing

Digital images obtained from scanning may contain some amount of noise depending upon the quality of scanner. For online recognition variations of handwriting occur due to various writers. For this pre-processing is required which involves elimination of noise, binarization of images, Size normalization, skew correction, thresholding and skeletonization techniques can be used [5] [6].

2.1.1. Binarization. It is a method of transforming a gray scale image into a black and white image.

2.1.2. Size Normalization. It is required so each segmented character is normalized to fit within suitable matrix so that all characters have same data size.

2.1.3. Thresholding. Thresholding is the process of reducing a gray scale image or colour image to a binary image.

2.1.4. Noise Removal. It is necessary to eliminate imperfection like disconnected lines, gap of lines, etc. Median Filtering, Wiener Filtering method and morphological operations can be performed to remove noise.

Sobel technique is used to detect edges in binarized image [10].

2.2. Segmentation

In segmentation, pre-processed image is segmented into lines, words and characters. Segmentation process involves three steps namely line segmentation, word segmentation and character segmentation. Marathi word can be split into character by removing Shirorekha and then recognize [4].

2.3. Feature Extraction

The objective of feature extraction is to capture the essential information from data. This is an important stage as its effective functioning improves the recognition rate and reduces the misclassification. In [10] Diagonal feature extraction scheme is used for recognizing offline handwritten character. For online recognition NPen++ recognition system [1] is used for feature extraction. Some feature extraction methods are Moments, Zoning and Projection Histogram.

2.4. Classification and Recognition

The decision making stage of a recognition stage is classification stage and it use the features extracted from previous stage. A number of classification methods were proposed by different researchers some of these are template matching, SVM classifiers and artificial neural network.

2.4.1. Template Matching. This is the simplest approach of pattern recognition. Given pattern that is to be recognized is compared with stored patterns.

2.4.2. SVM Classifiers. Support vector machines (SVM), when applied to text classification provide excellent precision, but poor recall. SVM have achieved excellent recognition results in various pattern recognition applications. Different types of kernel functions of SVM are: Linear kernel, Polynomial kernel, Gaussian Radial Basis Function and Sigmoid.

2.4.3. Artificial Neural Network. Neural network is a computing architecture that consists of a massively parallel interconnection of adaptive "neural" processors. Because of its parallel nature, it can perform computations at a higher rate compared to the classical techniques. Neural network architectures can be classified as, feed forward and feedback (recurrent) networks. The most common neural networks used in the OCR systems are the multilayer perceptron (MLP) of the feed forward networks and the Kohonen's Self Organizing Map (SOM) of the feedback networks.

3. Comprehensive Study

Below table shows the comprehensive study of different techniques used for handwritten character, word and script recognition.

Reference Paper	Preprocessing	Segmentation	Feature Extraction	Classification /Recognition
[1]	Preprocessing is done to normalize the position and	–	NPen++ features are used for curliness, linearity	Hidden Markov Model based lexicon driven and

	size of the sample.		and slope.	lexicon free technique used.
[2]	Image Binarization Thinning of binarized image windowing	Character recognition by neural network	Replacing the recognized characters by standard fonts.	Assembling all the separated characters in the same order as they appeared in the input image to give final output.
[3]	Thresholding method used for Binarization	Lines are segmented by noting the valleys of projection profile	Vertical Feature Bar, Horizontal Zero, Crossing, Moments	Tree Classifiers
[4]	Morphological operation are used to noise removal Thinning algorithm is used to remove the distortions Bicubic interpolation are used for standard sized image	Differential distance based technique used for identifying the Shirorekha and spine	Top, bottom, left, right or on a combination technique. A single or double vertical line called a Danda (Spine) was traditionally used to indicate the end of phrase or sentence	Preliminary classification is performed for better results.
[5]	Gaussian filter used to make input data stroke smoother and reduce noise.	–	Sequential floating search method used for Indic script	K-nearest neighbor and Support Vector Machine (SVM) used for recognition.
[6]	Edge Detection is done and thinning for slant and slope of word	–	Global word features are extracted from whole word.	Artificial neural network
[7]	Noise removal	–	Five different features from a vertical strip of uniform width, using a sliding window.	Neural network classifier known as Bidirectional Long Short Term Memory (BLSTM) used for recognition.
[8]	Smoothing, Resampling and computation the length of input stroke if it less than	Cursive stroke segmentation for line and word segmentation.	Histogram of the direction codes calculated for each sub-stroke. Obtain co-ordinates of	Modified Quadratic discriminate function (MQDF) classifier is used. It improves

	set a priori ignore it for next phases this approach is for noise removal.		centre of gravity and normalize these value by width and height of stroke	efficiency over QDF.
[9]	Preprocessing is done to normalize the position and size of the sample and to remove local noise so that the extracted features from the sample become robust.	Horizontal projection file method is used for segmentation	Images scaled into height and width using bilinear interpolation technique	feed forward algorithm
[10]	Detection of edges in the binarized image using sobel technique,	Preprocessed input image is segmented into isolated characters by assigning a number to each character using a labelling process.	Diagonal feature extraction scheme is used to extract features from each zone.	A feed forward back propagation neural network used for classification
[11]	Gabor Thresholding and Otsu Thresholding methods(global) are used for Binarization	Horizontal and vertical profile method is used for segmentation	Zone based approach is used for Feature Extraction.	Support vector machine (SVM) method is used for classification.
[12]	Detection of edges in binarized image is done by canny technique.	Preprocessed input image is segmented into isolated characters by assigning a number to each character using a labelling process.	Diagonal feature extraction scheme is used to extract features from each zone.	Chromosome function generation and Chromosome fitness function are used for classification.
[13]	Thresholding method used for Binarization. Thinning algorithm used to thin the characters	Histogram method used to convert the image to glyph	Character height, width, no. of horizontal and vertical lines.	Support Vector Machine(SVM) used for classification
[14]	Threshold technique used for preprocessing.	−	Encoding binary variation method used for extract the features. Then comparing trained	Support Vector Machine(SVM) used for classification

			text and tested image for recognize the characters.	
[15]	Global thresholding approach was used to binarized the scanned gray scale image	–	Top and bottom profile based features are used for feature extraction.	Learning Algorithm is used for classification.
[16]	Scanned document is Filtered and Binarized.	Line and Word segmentation is done through projection files	Considers some selected moment and shape as its dimensionality is reduced by principal components.	K-nearest neighbor and neural network classifiers are used for recognition

4. Conclusion

In this paper we have represented a survey of preprocessing, segmentation, feature extraction, classification and recognition techniques for handwritten Devnagari word recognition. This survey paper helps researches and developers to understand various techniques which were implemented for recognition. There is a great scope of research in the area of Devnagari Word Recognition for future research.

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