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A Survey on Offline Handwriting Recognition Systems

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ABSTRACT

Handwriting recognition is one of the most challenging and fascinating areas in the field of image processing and machine learning. Its various practical applications include digitizing documents, reading handwritten notes and addresses on postcards, reading the amounts on checks and so on. This paper provides an overview of the different techniques used in the different phases of offline handwriting recognition.

Keywords : Pre-processing, Segmentation, Feature extraction, Classification

I. INTRODUCTION

Handwritings are personal to each individual. A handwriting recognition system aims at digitizing the handwriting by converting it into machine readable ASCII format. Several research works have been made to develop techniques which would reduce the processing time and increase the accuracy.

Handwriting recognizers are of two types: offline and online recognizers. In online recognizers, the user writes on a screen by using a stylus. Hence, the time and the order of strokes made by the writer are available. Whereas, in offline recognizers the writing is usually captured optically by a scanner and the completed writing is available as an image. Because of this, the on-line methods have been shown to be superior to their off-line counterparts in recognizing handwritten characters. But since several applications like postcard sorting, document reading and bank processing require offline handwriting recognition, it continues to be an active research area.

The organization of this document is as follows. In Section 2 (Stages of Handwriting Recognition), we will give detail of the various techniques that are used in various stages of handwriting recognition. In Section 3 (Conclusion), a conclusion is presented.

II. STAGES OF HANDWRITING RECOGNITION

Handwriting recognition is done in four phases namely preprocessing, segmentation, feature extraction and classification. Preprocessing deals with making the document ready for the later stages by removing the noise and cleaning the document. In the segmentation stage, an image of sequence of characters is decomposed into sub-images of individual characters. Feature extractions deals with extracting various parameters used for describing the character to the machine. Finally, the classifier is responsible for assigning a class to the character and generating the output.

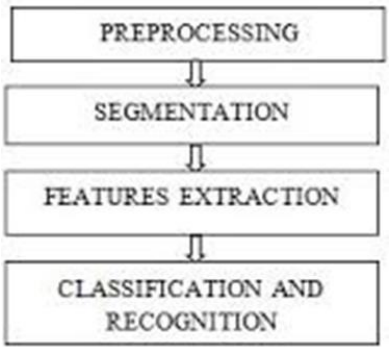

Figure 1 : Stages of Handwriting Recognition System

A. Pre-processing

The pre-processing is a series of operations performed on the scanned input image. It is done to make the image

ready for segmentation. It is done to make the image ready for segmentation. It is the first stage in the recognition process. The image provided by the user is a color image. It is first converted into a grayscale image. Various tasks performed on the image are binarization, de skewing, slant correction, skeletonization and scaling.

1. Binarization

Binarization is the process of converting the image into bi-level form. Grayscale images have pixel intensities varying from 0 to 255. Binarization converts it into 0 or 1(bi-level) by using a threshold. All the pixels in the grayscale image having intensity below the threshold are assigned 0 while all the pixels having their intensities above the threshold is assigned 1 where 0 stands for black and 1 stands for white. There are several methods used for deciding the threshold value. There are three kinds of Thresholding - Global thresholding, local thresholding and Hybrid thresholding. [1, 2, 3, 4].

In Global thresholding, a single threshold is used for the entire image. It is based on the estimation of the background intensity from the intensity histogram. The main disadvantage of this technique is that it cannot adapt well to the uneven illumination. Otsu's method is one of the most popular global thresholding techniques.

In Local or adaptive thresholding, different thresholds are used for each pixel, based on the local area information. It performs better than global thresholding for low quality images. Otsu's adaptive methods, Novel technique, Niblack method, Fuzzy C means method, Interval Type -2 Fuzzy logic are some of the local thresholding methods.

Hybrid thresholding combines the advantages of local and global thresholding to provide greater adaptability for various kinds of noise in different regions of the image. It is based on neural networks.

2. Skew detection and correction

Skew is inevitably present in the images fed as input to the system. Skew detection and correction algorithms help us in finding the skew angle and removing it. Several techniques have been proposed for this.

One of the simplest ways to detect the skew angle is by analyzing the horizontal projection profile. Each location in the projection profile stores a count of the number of black pixels in the corresponding row of the image. It has the maximum amplitude and frequency when the text in the image is skewed at zero degrees since the number of collinear black pixels is maximized in this condition [5].

Another popular method to detect the skew is by using Hough transforms. Hough transform is usually used for detection of a particular shape within an image. It is based on the fact that the highest number of co pixels are on the line co-incident with the baseline of the text [6].

3. Noise Reduction Techniques

The major objective of noise removal is to remove any unwanted bit-patterns, which do not have any significance in the output. Noise removal techniques include filtering and applying morphological operations. Filters can be used for sharpening, smoothening and removing textured background noises. Filters can be linear as well as nonlinear [7]. Various morphological operations can be designed to decompose the connected strokes, connect broken strokes, clip the unwanted points, smooth the contours, thin the characters and extract boundaries.

B. Segmentation

Segmentation is the process of decomposing an image into multiple segments. There are various methods available for segmentation. Some of them are discussed below.

1. Pixel counting is one of the simplest approaches used for segmentation. The binarized image is scanned from left to right and top to bottom. In a binarized image, 0 represents black and 1 represents white. Then, the horizontal and vertical projection profiles are created. The image can now be easily segmented into lines and words by cropping it at the minima of the horizontal and vertical profiles respectively [8].
2. Recursive segmentation is another method which is widely used for splitting connected characters. This algorithm, also based on prototype matching, systematically tests all combinations of admissible separation boundaries until it either exhausts the set of cut points, or else finds an acceptable segmentation. An acceptable segmentation is one in

which every segmented pattern matches a library prototype within a prespecified distance tolerance [9].

3. Stochastic method is another method which can be used for text based image segmentation. It is based on probabilistic algorithm, which is used to find nonlinear paths between overlapping text lines. These lines are extracted through hidden Markov modeling (HMM). This way, the image is divided into little cells. Each one them correspond to the state of the HMM. The best segmentation paths are searched from left to right. In case of touching components, the path of highest probability will cross the touching component at points with as less black pixels as possible. However, the method may fail in the case that contact point contains a lot of black pixels [10 11, 12].

C. Feature Extraction

It is the process of finding out the parameters which can be used to provide an accurate representation of the character to the machine. Some techniques used are as shown below.

1. Diagonal feature extraction scheme can be used in the feature extraction process where each individual character resized 90x60 pixels and again divided into 54 equal zones which each of size 10x10 pixels. The relevant features are extracted from the pixels of each zone by moving along the diagonals of each zone. This procedure is repeated for all the zones which lead to extraction of 54 features for each individual character. These features are then used to train a neural network [13].

2. Another method which can be used to extract the features is to scan the binary image from top to bottom and left to right. The transitions from white to black are detected. The contour is traced counterclockwise outside the pattern and expressed as an array of contour elements. Each contour element represents a pixel on the contour and contains fields for the x, y coordinates of the pixel, the slope or direction of the contour into the pixel, and auxiliary information such as curvature [14].

3. Another interesting approach to extract features is called Curvlet Transform based feature extraction. One common but important feature of the handwritten text is the orientation of the text written by the writer. Curvelet represents edges and singularities along curves more precisely with the needle shaped basis elements [15]. The elements possess super directional sensitivity and capability to capture smooth contours. In a curvlet based feature extraction system, the characters in the document are extracted using the conventional methods. . Each character sample is then cropped and resized so as to fit within a frame of standard width and height. Following this, the Curvelet transform at a single scale is applied to each of the character samples in the document to obtain Curvelet feature coefficients characterizing the character.

4. We can also use unsupervised learning algorithms for segmentation. Kohonen neural network is an unsupervised learning algorithm. It uses a self-organizing map for pattern. The Kohenen network has two layers, an input layer and a Kohonen out layer. The size of input layer is a determined by the user and matches the size of each row (pattern) in the input data file. A Kohonen feature map may be used as a layer of another neural network or by itself. There are several steps involved in this learning process. Overall the process for training a Kohonen neural network involves stepping through several epochs until the error of the Kohonen neural network is below acceptable level [16].

5. The simplest way for feature extraction is based on matching the stored patterns or prototypes against the character or word to be recognized. The matching operation determines the degree of similarity or recognition rate between two vectors (group of pixels, shapes, curvature etc.) [17].

D. Classification

It is the process of classifying the output by assigning a class to it. Some methods used are as shown below.

1. Support Vector Machines

It is extensively used for pattern recognition due to its various attractive features. SVMs are comparable to radial basis function network. The performance of SVM

classification is based on the choice of kernel function and the penalty parameter C. The RBF kernel maps nonlinear samples into a higher dimensional space, and thus can handle the case when the relation between class labels and attributes is nonlinear [18].

2. Structural Techniques

Patterns are used to describe and classify the characters in the systems. The characters are represented as the union of the structural primitives. It is assumed that the character primitives extracted from writing are quantifiable and one can find the relations among them.

3. Neural Networks

An Artificial Neural Network (ANN) is a structural design that consists of parallel interconnections of adaptive processors. Because of its parallel environment, it can perform calculation at a higher rate difference to the classical techniques. Because of its adaptive environment, it can adapt to the data and learn the characteristics of input signal. ANN contains many nodes. The inputs given by the user are received by the input layer. The results generated at the input layer are sent to the hidden layers. The output of the hidden layer is sent to the output layer. The output from one node is forward to further in the network and the final decision depends on the difficult interface of all nodes [19].

III. CONCLUSION

Research on automated recognizers dates back several ages. Today, cleanly machine printed text can be easily recognized by using any off-the-shelf OCR software. But unconstrained handwriting recognition still remains a major problem. Even though several researches have been made, we have yet to solve this problem. Neural network seems like an interesting candidate to solve this problem.

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