

A Survey of Modern Character Recognition Techniques

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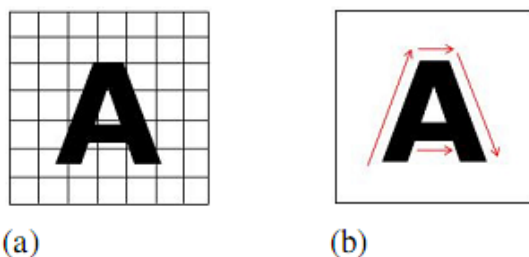
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Abstract— In this paper, we present an overview of existing handwritten character recognition techniques. All these algorithms are described more or less on their own. Handwritten character recognition is a very popular and computationally expensive task. We also explain the fundamentals of handwritten character recognition. We describe today's approaches for handwritten character recognition. From the broad variety of efficient techniques that have been developed we will compare the most important ones. We will systematize the techniques and analyze their performance based on both their run time performance and theoretical considerations. Their strengths and weaknesses are also investigated. It turns out that the behavior of the algorithms is much more similar as to be expected.

KEYWORDS: OCR, HCR, Features, Training, classification

I. INTRODUCTION

Character recognition is an art of detecting segmenting and identifying characters from image. More precisely Character recognition is process of detecting and recognizing characters from input image and converts it into ASCII or other equivalent machine editable form [1], [2], [3]. It contributes immensely to the advancement of automation process and improving the interface between man and machine in many applications [4]. Character recognition is one of the most interesting and fascinating areas of pattern recognition and artificial intelligence [5], [6]. Character recognition is getting more and more attention since last decade due to its wide range of application. Conversion of handwritten characters is important for making several important documents related to our history, such as manuscripts, into machine editable form so that it can be easily accessed and pres independent work is going on in Optical Character Recognition that is processing of printed/computer generated document and handwritten and manually created document processing i.e. handwritten character recognition. Character recognition character recognition (Fig. 1(a)) and online character recognition (Fig. 1(b)).



In offline character recognition system, document is first generated, digitized, stored in computer and then it is processed. While in case of online character recognition system, character is processed while it was under creation. External factors like pressure speed of writi have any influence in case of offline system but they have great impact on online system. Again, offline or online system can be applied on optical character (Fig 2.(a)) or handwritten characters (Fig 2.(b)). Based on that system can be classified as OCR or HCR respectively. The online methods have been superior to their counterpart i.e. offline methods due to temporal information present in character generation [4].

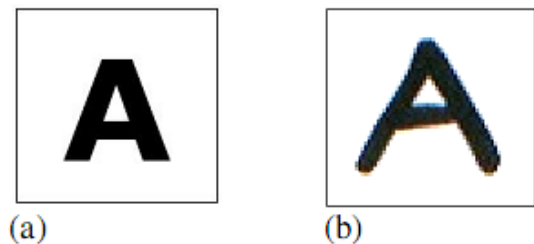


Fig 2. (a). Optical Character, (b). Handwritten Character

Accuracy of HCR is still limited to 90 percent due to presence of large variation in shape, scale, style, orientation etc. [8]. Character processing systems are domain and application specific, like there it is not possible to design generic system which can process all kind of scripts and language. Lots of work has been done on European languages and Arabic (Urdu) language. Whereas domestic languages like Hindi, Punjabi, Bangla, Tamil, Gujarati etc. are very less explored due to limited usage. In this paper, our focus is to carry out in depth literature survey on handwritten character recognition methods.

II. LITERATURE REVIEW

Image processing and pattern recognition plays significant role in handwritten character recognition. In [10], Rajbala et al have discussed various types of classification of feature extraction methods like statistical feature based methods, structural feature based methods and global transformation techniques. Statistical methods are based on planning of how data are selected. It uses the information of statistical distribution of pixels in image. It can be mainly classified in three categories: 1). Partitioning in regions, 2). Profile generation and projections 3). Distances and crossing. Structural features are extracted from structure and

geometry of character like number of horizontal and vertical lines, aspect ratio, number of cross points, number of loops, number of branch points, number of strokes, number of curves etc. Global transformation features are calculated by converting image in frequency domain like Discrete Fourier Transformation (DFT), Discrete Cosine Transformation (DCT), Discrete Wavelet Transformation (DWT), Gabor filtering, Walsh-Hadamard transformation etc.

Feature extracted can be either low level or high level. Low level features include width, height, curliness, aspect ratio etc of the character. These alone cannot be used to distinguish one character from another in the character set of the language [11]. So, there are a number of other high level features which include number and position of loops, straight lines, headlines, curves etc.

Tirthraj Dash et al have discussed HCR using associative memory net (AMN) in their paper [12]. They have directly worked at pixel level. Dataset was designed in MS Paint 6.1 with normal Arial font of size 28. Dimension of image was kept 31 X 39. Once characters are extracted, their binary pixel values are directly used to train AMN.

I.K.Pathan et al have proposed offline approach for handwritten isolated Urdu characters in their work mentioned in [13]. Urdu character may contain one, two, three or four segment. In which one component is known as primary (generally represents large continuous stroke) and rest of all are known as secondary components (generally represents small stroke or dots). Authors have used moment invariants (MI) feature to recognize the characters. MI features are well known to be invariant under rotation, translation, scaling and reflection. MI features are measure of the pixel distribution around the center of gravity of character and it captures the global character shape information. If character image is single component than it is normalized in 60 X 60 pixels and horizontally divided in equal 3 parts. 7 MI are extracted from each zone and 7 MI are calculated from overall image, so total of 28 features are used to train SVM. And if image is having multi component than 28 MI are extracted from primary component (60 X 60) and 21 MI are extracted from secondary component (22 X 22). Separate SVM are trained for both and decision is taken based on rules satisfying some criteria. Proposed system claim to get highest 93.59 % accuracy.

In [4], Pradeep et al have proposed neural network based classification of handwritten character recognition system. Each individual character is resized to 30 X 20 pixels for processing. They are using binary features to train neural network. However such features are not robust. In post processing stage, recognized characters are converted to ASCII format. Input layer has 600 neurons equal to number of pixels. Output layer has 26 neurons as English has 26 alphabets. Proposed ANN uses back propagation algorithm with momentum and adaptive learning rate.

Rajib et al have proposed Hidden Markov Model based system for English HCR in their literature [8]. They have employed global as well as local feature extraction methods. Global feature involves four gradient features, six projection

features and four curvature features. And to extract local features, image is divided in to nine equal blocks and 4 gradient features are calculated from each block, so total of 36 features are extracted. So overall feature vector contains 50 features per character. $O = [G(4) P(6) C(4) L(36)]$, where G, P, C and L represents global gradient, projection, curvature and local gradient features respectively. Number in parenthesis represents number of respective features. HMM is trained using these feature and experiment is carried out. Post processing is also applied after recognition phase of HMM to highly confused group of characters like N and M, O and Q, C and O etc. For each group new feature is calculated to discriminate characters within the group.

Gradient features based method is discussed in [14] by Ashutosh et al. Experiment is carried out on Hindi, third most popular language in the world. The first research work on handwritten Devnagari characters was published in 1977. 300 Million People use the Devnagari script for documentation in central and north region of India [8]. In proposed method, Gradient Vector is calculated at each pixel and image is divided in 9 X 9 blocks. Then strength of gradient is accumulated in eight standard directions in each sub block. 9 X 9 blocks is further down sampled to 5 X 5 block using Gaussian filter. Preprocessing steps for proposed methods are as follows: Intensity values of image were adjusted and then images were converted to binary with threshold value 0.8. Connected component with pixel density less than 30 were removed from further processing. Median filter was applied to remove pepper and salt noise present in binary images. And finally, individual characters were extracted by row and column histogram processing and normalized to 90 X 90 pixel block. Gradient feature were extracted using sobel operator.

Velappa et al have proposed multiscale neural network based approach in [15]. Neural networks like Feed forward back propagation neural network requires long training time to memorize and generalize all input feature vectors [10]. And still there are good chances of misclassification. Generalization problem can be overcome by using multi scale neural network [11]. Proposed system first convert camera captured RGB image to binary image. Width to Height Ratio (WH), Relative Height (RH) ratio, Relative Width ratio (RW) is calculated to remove unnecessary connected components from image. For multi scale neural network, detected character is resized to 20 X 28 pixels, 10 X 14 pixels and 5 X 7 pixels. Binary features of these different resolution images are given to three layer feed forward back propagation algorithm.

In literature [16], T.Som et al have discussed fuzzy membership function based approach for HCR. Character images are normalized to 20 X 10 pixels. Average image (fused image) is formed from 10 images of each character. Bounding box around character is determined by using vertical and horizontal projection of character. After cropping image to bounding box, it is resized to 10 X 10 pixels size. After that, thing is performed and thinned image is placed in one by one row of 100 X 100 canvas. Similarity score of test image is matched with fusion image and characters are classified.

Paper	Offline	Model /Features	Dataset Size	Accuracy Claimed
[8]	√	HMM Gradient (4), Projection (6), Curvature (6), Local Grad (4)	100 Writers X 5 sample of each = 13000 Samples (26 Alphabet) Training Set : 2600	98.26 %
			Char Testing Set: 10,400	
[11]		FFBPNN Freeman Code		
[14]		Gradient SVM	20 Writer X 10 Samples = 7200 Samples (36 Alphabets) Normalized Size: 90 X 90	94.00 %
[15]		Multi scale Neural Network	10 sample X 26 Alphabets = 260 10 X 10 numeric = 100	85.00 %
[16]		Fuzzy Membership based function	10 sample X 26 char = 260	
[17]		Single Layer NN. Binary features	26 Characters only	80.00 %
[18]		Modified Cascaded ANN 5 features from each block of character	Total 100 Characters from 10 persons	67.00 %
[20]		Zone based hybrid feature extraction model		

In literature [17], Rakesh kumar et al has proposed single layer neural network based approach for HCR to reduce training time. Characters are written on A4 size paper in uniform box. Segmented characters are scaled to 80 X 80 pixels. Each 0 is replaced by -1 for better training. Diagonal based feature extraction work is mentioned in [19], which is improved by Sharma et al, discussed in [20]. They have proposed zone based hybrid feature extraction method. Euler number concept is used to improve speed and accuracy. Thresholding, filtering and thinning operations are performed as a part of preprocessing. Segmentation can be classified into three broad categories: Top down, Bottom up and Hybrid techniques. In proposed method segmented character is resized to 90 X 60. After calculating Euler number from this image, character is divided in to 10 X 10 pixel 54 zones. Each zone value is replaced by average intensity value and is used as feature value. 9 and 6 features are extracted by averaging values row wise and column wise, so it forms total 69 features. A FFBPNN with configuration 69-100-100-26 is used for classification.

III. CONCLUSIONS

Comparison between all discussed literatures is shown in table I with all possible dimensions. Literature review shows that neural network is the prime choice among researchers for training purpose. However various kind of changes have been proposed in feature extraction methods. Work can be extended from single character or set of characters to document processing. Many applications are awaiting the enhancement in character recognition to be adopted it fully. Hybrid model can be proposed which counts on more than one feature extraction methods to discriminate characters properly. Post processing is also crucial to discriminate similar structured characters like Q and O, M and N like pairs in English language. It is not possible to design fully automated system which can handle all kind of variability. HCR system must be domain specific as well as bounded to limited versatility in writing style for robustness. Handwritten character recognition is still a burning research area of pattern recognition. Each and every step contributes directly to the accuracy of system, like preprocessing, segmentation, feature extraction, training methods etc all. So all these area are open for independent research. A lot can be improved in each of step.

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