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A SURVEY ON HANDWRITTEN GUJARATI CHARACTER RECOGNITION

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Abstract: Character recognition plays an important role in the modern world. In recent era character recognition systems for different languages has gain importance. Gujarati language is belongs to genre of Devnagri script. There is no more work found in the recognition of Indian language scripts. Very little work is seen in the literature on recognition of handwritten Gujarati characters. There are many techniques which can be used for recognition of handwritten characters. This paper introduces a system for handwritten text recognition based on neural network approach. The system is hybrid of image processing, segmentation and neural network. Input is image file of handwritten Gujarati characters. After that this image is digitized into binary form and then preprocessed it for the input for training neural network. Due to the nature of Gujarati script we have to segment the word for recognition of Gujarati word. Then neural network technique is use for recognition of individual Gujarati characters through training and testing.

Index Terms: Offline Handwritten Recognition, Neural Network, Gujarati Characters

I. INTRODUCTION

Character recognition, usually shortened to optical character recognition (OCR), is the mechanical or electronic translation of images of handwritten or printed text into machine-editable text. It is a field of research in pattern recognition. Character recognition is becoming more and more important in this modern world. Handwritten recognition has become a very interesting topic for researchers during last few decades. Gujarati is a regional language of state Gujarat in India. Gujarati language is belongs to the genre of Devnagri script. There is no shirolekha or headline in Gujarati character like Bangla or Hindi. There is no significant work found in the recognition of handwritten Gujarati characters. Gujarati characters are having different shapes and it's very difficult to recognize that shapes. Handwritten recognition is very difficult because it depends on various persons and their writing styles. Handwriting recognition is currently a hot topic in the research society. Generally, template matching techniques were used for machine printed character recognition and statistical classification techniques were used for handwritten text recognition [1]. Due to lack of powerful computers and data perception tools, character recognition research is limited till 1980s. In the period 1980-1990, character recognition research takes a noticeable growth along with the development in information technology [2], [3]. Research progress on the off-line and on-line character recognition during this period can be found in [4] and [5]. After 1990, pattern recognition techniques and image processing techniques were combined using artificial intelligence. Modern steering of character recognition is handled by powerful learning tools like, Artificial Neural Networks, Support Vector Machines, Hidden Markov Models, Fuzzy Set Reasoning and Natural Language Processing Tools.

II. GUJARATI SCRIPT

Gujarati is the name of script used to write the Gujarati language and spoken by the people in state Gujarat in India. Gujarati has 36 constants and 11 vowels. The shapes of many Gujarati characters are same as Devnagri script. Gujarati script has no shirolekha on top of the characters like Devnagri script. Gujarati script also does not have the distinction of Lower and Upper Cases like English script. Gujarati script has combination of constants and vowels. This is denoted by attaching a symbol of vowel to the constants. Every vowel has a unique symbol, called vowels modifiers. Table 1 gives examples of Gujarati consonants, vowels, matras, other symbols and some of the conjuncts[13].

Consonants
ક ખ ગ ઘ ઙ ચ છ જ ઝ ઞ ટ ઠ ડ ઢ ણ ત થ દ ધ ન પ ફ ભ બ મ ય ર લ વ શ ષ સ હ ળ ક્ષ જ્ઞ
Vowels
અ આ ઇ ઈ ઉ ઊ એ ઐ ઐ ઓ ઔ ઔ અં
Some Conjuncts
ક જ્ય ક્લ ચ્છ દ્ગ ત્ર સ્પ સ્ત ર્વ ક્ક ત્ય ત્ર્ય ત્ત દ્
Consonant – vowel
જા ગી જી બુ ખૂ હે કૃ કૈ પૈ પો ડૉ કૌ કં
Conjunct -vowel
જ્જા કે ક્લે ચ્છિ દ્ગી ત્રુ સ્નૂ
Vowels modifiers
ા િ ી ુ ૂ ે ૅ ો ૉ ૌ ં

Table1. Gujarati Script

III. PREPROCESSING OF IMAGE

The data is collected for recognition is scanned image of the paper document. Text digitization is done using a flat bed scanner having resolution between 100 and 600 dpi and stored in a file of picture elements, called pixels. These pixels may have values: OFF (0) or ON (1) for binary

images, 0– 255 for gray-scale images. This collected raw data must be further analyzed to get useful information. Pre-processing essentially enhances the image rendering it suitable for segmentation. Such processing includes the following:

A. RGB to Gray Scale Converter

The scanned image is stored as a JPEG image but images of other formats like BMP, TIFF etc are also used for recognition. All these images are in RGB format. In order to start working with an image it must be converted into a gray scale image. A gray scale image represents an image as a matrix where every element has a value corresponding to how bright/dark the pixel at the corresponding position should be colored. The value of a pixel lies between 0 to 1 or between 0 to 255 depending upon its class.

B. Binarization

Binarization process converts a gray scale image into a binary image using global thresholding technique. This image format also stores an image as a matrix but can only color a pixel black or white. It assigns a 0 for black and a 1 for white. The image is then inverted to obtain image such that object pixels are represented by 1 and background pixels by 0 because it is preferred to work with 1s and leave the 0s aside. Also, smaller number 1s will mean lesser calculations.

C. Noise Reduction

The noise introduced by the optical scanning device or the writing instrument, causes disconnected line segments, bumps and gaps in lines, filled loops etc. The distortion including local variations, rounding of corners, dilation and erosion, is also a problem. Median filter is a process that replaces the value of a pixel by the median of gray levels in the neighborhood of that pixel.

D. Skew Detection and Correction

Skew Detection refers to the tilt in the bitmapped image of the scanned paper for OCR. It is usually caused if the paper is not fed straight into the scanner. Most of the algorithms are sensitive to the orientation (or skew) of the input document image, making it necessary to develop algorithms, which can detect and correct the skew automatically. Skewed lines are made horizontal by calculating skew angle and making proper correction in the raw image.

E. Thining

Thinning is a morphological operation process that is used to remove selected foreground pixels from the binary images and thin the images to single-pixel width level so that their contours are brought out more vividly. In this way, the attributes to be studied later will not be affected by the uneven thickness of edges or lines in the symbol.

F. Edge Detection, Dilation and Filling

The boundary detection of image is done to enable easier subsequent detection of pertinent features and objects of interest. Detection of edges in the binarized image is done using sobel technique. After locating the edges the image is dilated and the holes present in the image are filled. These are the operations performed in the last two stages to produce the pre-processed image suitable for segmentation.

IV. RECENT WORK

Automatic reading of numbers and characters for different scripts had been attempted in various areas. One area was reading of amounts and name on bank cheques. Then another area was the reading of postal addresses written or typed on envelopes. This application had been very popular in handwriting recognition research because of reduction done in manual work. In [8] DCT algorithm was used for feature extraction and neural network was used to train the system. This system was for recognition of online Devnagri characters. The recognition rate up to 97% was achieved. In [6] neural network technique was proposed for recognizing offline handwritten Devnagari characters. And the recognition rate up to 76% achieved on noisy characters. In [15] multilayer perceptron was used for recognition of Tamil characters. Fourier descriptor was used for feature extraction of Tamil characters. Back propagation network was used to recognition of character. Fourier Descriptors combined with back propagation network provide good recognition accuracy of 97 % for handwritten Tamil characters. The very first attempt for Gujarati script recognition was noted in [16]. In this work they used Euclidean minimum distance classifier (EMDC) and hamming distance classifier (HDC) to classify various printed Gujarati characters. Then [17] presented an algorithm to identify various zones used for Gujarati printed text. In [18] A multi layered feed forward neural network is suggested for classification of digits. The features of Gujarati digits are abstracted by four different profiles of digits. In [7] neural network technique was used to recognize handwritten Gujarati characters. Neural Network has been trained and tested on these samples for the three different sizes. The results are evaluated for different image sizes of 7x5, 14X10 and 16X16. The overall recognition rates are 87.29%, 88.52% and 88.76% for different image size. In [12] and [14] pattern matching and template matching techniques was proposed for recognizing handwritten Gujarati characters respectively. But due to some demerits of template matching technique recognition rate was not good. In [9] ANFC (Adaptive Neuro Fuzzy Classifier) was used to recognize Gujarati characters. They implemented an ANFC to handle large data set of handwritten characters of Gujrati. The recognition rates of different features are obtained. The results ensure that ANFC can be designed to handle large vocabulary problems however recognition rates are not that promising.

V. APPROACHES FOR CLASSIFICATION OF HANDWRITTEN CHARACTER RECOGNITION

The handwriting recognition can be classified as online and off-line recognition systems. Offline handwriting recognition is performed on already written or typed documents. The type written/handwritten character is typically scanned in form of a paper document and made available in the form of

a binary or gray scale image to the recognition algorithm [7]. Offline recognition of characters is known as a challenging problem because of the complex character shapes and great variation of character symbols written in different modes. In recent years attempts have been made to develop text recognition systems in almost all languages and scripts of the world. Various types of scripts such as Chinese, Urdu, Devnagri, Sanskrit, the scope of character or text recognition systems has emerged as a very wide area of research. There is no more work found for the recognition of handwritten Gujarati characters [7]. There is a variation in handwritten scripts in all languages because different persons have different styles for writing characters. So this is the challenge that how to suppress variation and correctly identify the characters to get a good accuracy in recognition [6]. To recognize all handwritten Indic scripts segmentation is required. Separation of words from each text line is called word segmentation. Separating words into consistent characters is called character segmentation. The segmentation of characters from words, there are two types of segmentation schemes: recognition-free and recognition based segmentations. In recognition-free segmentation, a character string can be divided into segments by rules without recognition. In recognition based segmentation, segmentation points are verified with recognizer [10]. First of all, the process of how human beings recognize characters should be considered. Most people learn the alphabet letters in kindergarten or elementary schools. After a period of study and practice, humans are able to recognize large or small, upside-down or rotated, standard or special font characters.

It is important to emphasize that it is through continuous learning that humans are able to recognize a wide array of handwritten and typed characters. Numerous technique for character recognition can be classified into four general approaches of pattern recognition[11]:

- Template Matching: Direct Matching, Relaxation Matching
- Statistical Techniques: Parametric Recognition, Non Parametric Recognition, HMM, Fuzzy set reasoning
- Structural Methods: Grammatical Methods, Graphical Methods
- Support Vector Machine
- Artificial Neural Networks: Radial Basis Function, Multilayer Perceptron

Let’s see all of these techniques in details.

A. Template Matching

This is the simplest way of character recognition, based on matching the stored templates (prototypes) against the character or word to be recognized. The matching operation determines the degree of similarity between two vectors (group of pixels, shapes, curvature etc.) A gray-level or binary input character is compared to a standard set of stored prototypes. The recognition rate of this method is very sensitive to noise and image deformation. Template matching, which is also called matrix matching, is one of the most common classification methods. In template matching, individual image pixels are used as features. Classification is performed by comparing an input character image with a set of templates from each character class [14]. Each comparison results in a similarity measure between the input character and the template. One measure increases the amount of similarity when a pixel in the observed character is identical to the same pixel in the template image. If the pixels differ the measure of similarity may be decreased. After all templates have been compared with the observed character image, the character's identity is assigned as the identity of the most similar template. Template matching is a trainable process because template characters may be changed. In many commercial systems, PROMs (programmable read-only memory) store templates containing single fonts. To retrain the algorithm the current PROMs are replaced with PROMs that contain images of a new font. Thus, if a suitable PROM exists for a font then template matching can be trained to recognize that font. The similarity measure of template matching may also be modified, but commercial OCR systems typically do not allow this.

B. Statistical Techniques

Statistical decision theory is concerned with statistical decision functions and a set of optimality criteria, which maximizes the probability of the observed pattern given the model of a certain class. The major statistical methods, applied in the OCR field are Nearest Neighbor (NN), Hidden Markov Modeling (HMM), and Fuzzy Set Reasoning. Statistical classification methods are based on the Bayes decision theory which aims to minimize the loss of classification with given loss matrix and estimated probabilities. According to the class-conditional probability density estimation approach, statistical classification methods are divided into parametric and nonparametric ones[19].

C. Structural Techniques

Structural pattern recognition methods are used more often in online character recognition than in offline character recognition. Unlike statistical methods and neural networks that represent the character pattern as a feature vector of fixed dimensionality, structural methods represent a pattern as a structure (string, tree, or graph) of flexible size. In recognition, each class is represented as one or more structural templates, the structure of the input pattern is matched with the templates and is classified to the class of the template of minimum distance or maximum similarity. The structural matching procedure not only provides an overall similarity but also interprets the structure of the input pattern and indicates the similarities of the components [19].

D. Support Vector Machine

It is primarily a two-class classifier. An SVM is a binary classifier with discriminant func- tion being the weighted combination of kernel functions over all training samples. After learning by quadratic programming (QP), the samples of non-zero weights are called support vectors (SVs). Due to the high complexity of training and execution, SVM

classifiers have been mostly applied to small category set problems. The support vectors replace the prototypes with the main difference between SVM and traditional template matching techniques is that they characterize the classes by a decision boundary. Moreover, this decision boundary is not just defined by the minimum distance function, but by a more general possibly nonlinear, combination of these distances [23].

E. Artificial Neural Networks

The purpose of classification is to assign each point in the space with a class label. Hence, once a pattern is represented, the problem becomes one of the classical classification to which a variety of classification methods can be applied. The classification methods that have shown success or are potentially effective to character recognition are Multilayer Perceptron and Radial basis function. These are the classification methods which are potentially effective for character recognition. A neural network is a computing architecture that consists of 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. Because of its adaptive nature, it can adapt to changes in the data and learn the characteristics of input signal. Output from one node is fed to another one in the network and the final decision depends on the complex interaction of all nodes. In MLP networks, a linear combination of input entries is computed using a function that returns the inner (scalar) product between the input entries and the synaptic weights conversely to RBFNNs where the combination functions are based on the Euclidean distance between the input entries [22]. As shown in [21] that RBF based recognition system better then MLP based recognition system but RBF based system takes little more time while training.

VI. COMPARISON OF CLASSIFICATION METHODS

The template matching has high speed, but is not very effective when there are font discrepancy, font slant, font defilement, stroke connection and stroke breaking due to the environment or the instrument itself. Template matching techniques results into less accuracy and inability to learn from experience [14]. Structural recognition, statistical methods and neural networks are more often adopted for the ease of feature extraction and learning from samples. Structural methods face two major difficulties: extracting structural primitives (strokes or line segments) from input patterns, and learning templates from samples. Primitive extraction from online character patterns (sequences of pen-down points) is much easier than from offline character images. In practice, the templates are often selected from samples, constructed artificially or interactively. This is why structural methods have not been widely used in practical recognition systems [19]. Statistical pattern recognition is based on the Bayes decision theory and is instantiated by classifiers based on parametric and nonparametric density estimation. Its principles are also important for better understanding and implementing neural networks, support vector machines (SVMs), and multiple classifier systems. Unlike statistical methods that are based on class wise density estimation, neural networks, SVMs, and boosting are based on discriminative learning, that is, their parameters are estimated with the aim of optimizing a classification objective. Discriminative classifiers can yield higher generalization accuracies when trained with a large number of samples. To train the parameters of SVM classifiers are complex compare to neural classifiers because SVMs are trained by quadratic programming. Neural classifiers consume less storage and computation compare to SVM because learning of SVM is done by QP which often results large number of SVs, which should be stored and computed in classification. The neural network has relatively great space to enhance this recognition effect, which can accomplish higher recognizing ratio with more training. Character recognition technique has to cope with the high variability of the handwritten cursive letters and their intrinsic ambiguity (letters like “u” and “n” can have the same shape). Also it should be able to adapt to changes in the input data. Template matching, statistical techniques and structural techniques can be used when the input data is uniform over time whereas neural network (NN) classifier can learn changes in the input data. Also NN has parallel structure because of which it can perform computation at a higher rate than classical techniques.

Table II
Details of handwritten Gujarati Character Recognition Systems

Method	Classifier	Data Set Size	Accuracy
Vasant et al.[7]	Neural Networks	3900	88.76%
Prasad et al.[9]	ANFC	Not Specified	68%
Prasad et al.[12]	Pattern Matching	Not Specified	71.66%
Apurva et al.[18]	Neural Networks	265	82%

VII. CONCLUSION

From the survey it is noted that for any handwritten character recognition system the system is good if accuracy of recognition rate is high. In character recognition system there are many classifiers are used for classification of characters. Each of them has advantages and disadvantages. But Neural Network is mostly used for classification of handwritten character recognition because it has good accuracy.

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