Improving Various Off-line Techniques used for Handwritten Character Recognition: a Review

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ABSTRACT
Handwritten character recognition is always an advanced area of research in the field of image processing and pattern recognition and there is a large demand for OCR on offline hand written documents. Even though, sufficient studies have performed from history to this era, paper describes the techniques for converting textual content from a paper document into machine readable form. The computer actually recognizes the characters in the document through a revolutionizing technique called Optical Character Recognition (OCR). There are many paper deals with issues such as hand-printed character and cursive handwritten word recognition which describes recent achievements, difficulties, successes and challenges in all aspects of handwriting recognition. Their many papers present a new approach which improves current handwriting recognition systems. Some experimental results are included. Selection of a relevant feature extraction method is probably the single most important factor in achieving high recognition performance with much better accuracy in character recognition systemsn this paper, we describe the formatting guidelines for IJCA Journal Submission.

Keywords
Feature Extraction, Image Acquisition, Off-Line & Online Handwriting Character Recognition, Segmentation and Training.

1. INTRODUCTION
We Character recognition is a form of pattern recognition process & Image processing. In reality, it is very difficult to achieve 100% accuracy. Even humans also will make mistakes when come to pattern recognition. Pattern distortion, shrinking of paper, presence of unwanted objects or disoriented patterns will affect the percentage accuracy& performance. In this overview, Character Recognition (CR) is used as an umbrella or group term, which covers all types of machine recognition of characters in various application domains.

Off-line character recognition is known as Optical Character Recognition (OCR), because the image of writing is converted into bit pattern or called digitization by an optically digitizing device such as optical scanner or camera. The recognition is done on this bit pattern data for machine-printed or hand-written text. The research and development is well progressed for the recognition of the machine-printed documents. In recent Years, the focus of attention is shifted towards the recognition of hand-written script too.

The main advantage of the off-line recognizers is to allow the previously written and printed texts to be processed and recognized. The drawbacks of the off-line recognizers, over on-line recognizers are summarized as follows:

1. Off-line conversion usually requires costly and imperfect pre-processing techniques prior to feature extraction and recognition stages.
2. The lack of dynamic information results in lower recognition rates compared to on-line recognition.

Some applications of the off-line recognition are large-scale data processing such as postal address reading; check sorting, office automation for text entry, automatic inspection and identification. Recently, content based image or video database systems make use of off-line character recognition for indexing and retrieval, extracting the writings in complex images.

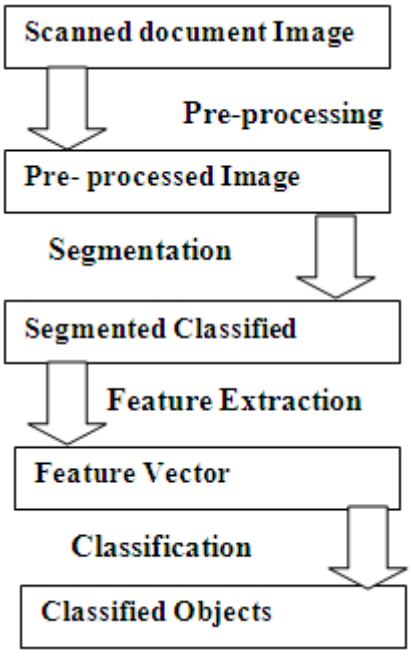

Figure 1System Block Diagram: Off-line Handwritten character Recognition

2. ARCHITECTURE OF A GENERAL CHARACTER RECOGNITION SYSTEM

There are five major stages in the CR problem:-

2.1 Image Acquisition

In this phase the input image taken through camera or some scanner. The input captured may be in gray, colour or binary from scanner or digital camera.

2.2 Image Preprocessing

The output of the image acquisition is fed as input to the preprocessing step. In this step, firstly the output is converted into the binary form by assigning '1' to black and '0' to white portion of the scanned image. This may contain some blurred or noises. Which may affect the accuracy of the system performance?

2.2.1 Noise removal

It contain various techniques of cleaning, smoothing, enhancing etc are used to remove noise. Noise is defined as any degradation in the image due to external disturbances. Quality of handwritten documents depends on various factors including quality of paper, aging of documents, quality of pen, color of ink etc. Some examples of noise are salt and pepper noise, Gaussian noise. These noises can be removed to certain extent using filtering technique. Technical details of filtering can be found in [1]. 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. Prior to the character recognition, it is necessary to eliminate these imperfections. Hundreds of available noise reduction techniques can be categorized in two major groups [2] as filtering, morphological operations.

2.2.2 Filtering

It aims to remove noise and diminish spurious points, usually introduced by uneven writing surface and/or poor sampling rate of the data acquisition device. Various spatial and frequency domain filters can be designed for this purpose. The basic idea is to convolute a pre-defined mask with the image to assign a value to a pixel as a function of the gray values of its neighboring pixels. Filters can be designed for smoothing, sharpening, thresholding, removing slightly textured or colored background and contrast adjustment purposes [3].

2.2.3 Morphological Operations

The basic idea behind the morphological operations is to filter the document image replacing the convolution operation by the logical operations. Various morphological operations can be designed to connect the broken strokes decompose the connected strokes, smooth the contours, thin the characters and extract the boundaries [3]. Therefore, morphological operations can be successfully used to remove the noise on the document images due to low quality of paper and ink, as well as erratic hand movement.

2.2.4 Thresholding

It is to extract the foreground (ink) from the background (paper) [4]. Given a threshold, T between 0 and 255, replace all the pixels with gray level lower than or equal to T with black (0), the rest with white (1). If the threshold is too low, it may reduce the number of objects and some objects may not be visible. If it is too high, we may include unwanted background information. The appropriate threshold value chosen can be applied globally or locally.

Global thresholding picks one threshold value for the entire document image, often based on an estimation of the background level from the intensity histogram of the image. Local (adaptive) thresholding use different values for each pixel according to the local area information [5]. In [6], a comparison of common global and local thresholding techniques is given by using an evaluation criterion that is goal-directed in the sense that the accuracies of a character recognition system using different techniques were compared.

On those tested, it is shown that locally adaptive method produces the best result. Additionally, the recent study [7] develops an adaptive logical method by analyzing the clustering and connection characteristics of the characters in degraded document images.

2.2.5 Skeletonization

It purpose an image preprocessing operation performed to make the image crisper by reducing the binary-valued image regions to lines that approximate the skeletons of the region. A comprehensive survey of thinning methodologies is discussed in [8].

2.2.6 Normalization

It is the process of converting the random sized image into standard sized image. This size normalization avoids inter class variation among characters as shown in fig 1. Bilinear, Bicubic interpolation techniques are a few methods for size normalization [9].

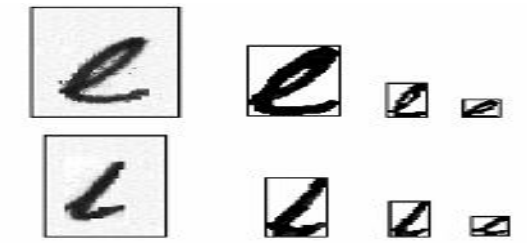

Figure 2Normalization of characters "e" and "l" [26]

2.2.6.1 Skew Normalization and Baseline Extraction

Due to inaccuracies in the scanning process and writing style, the writing may be slightly tilted or curved within the image. This can hurt the effectiveness of later algorithms and therefore should be detected and corrected. Additionally, some characters are distinguished regarding to the relative

position In [10], attractive repulsive Neural Network is used for extracting the baseline of complicated handwriting in heavy noise .After skew detection, the character or word is translated to the origin, rotated or stretched until the baseline is horizontal and re-translated back into the display screen space.

2.2.6.2 Slant Normalization

One of the measurable factors of different handwriting styles is the slant angle between longest strokes in a word and the vertical direction. The most commonly used method for slant estimation is the calculation of the average angle of near-vertical elements. In [11], vertical line elements from contours are extracted by tracing chain code components using a pair of one-dimensional filters. Coordinates of the start and end points of each line element provide the slant angle. In slant detection is performed by dividing the image into vertical windows. These windows are then further divided horizontally by removing window portions that contain no writing. The slant is estimated based on the center of gravity of the upper and lower half of each window averaged over all the windows. Lastly, in a variant of Hough transform is used by scanning left to right across the image and calculating projections in the direction of 21 different slants. The top three projections for any slant are added and the slant with the largest count is taken as the slant Value.

Figure 3Slant angle estimation (a) near vertical element, (b) average slant angle

2.2.6.3 Size normalization

It is used to adjust the character size to a certain standard. Methods of character recognition may apply both horizontal and vertical size normalizations. In the character is divided into number of zones and each of these zones is separately scaled. Size normalization can also be performed as a part of the training stage and the size Parameters are estimated separately for each particular training data [12].

2.3 Segmentation

The pre-processing stage yields a "clean" document in the sense that sufficient amount of shape information, high compression and low noise on normalized image is obtained. The next stage is segmenting the document into its sub components Segmentation step contains line segmentation, word segmentation and character segmentation. Methods for character segmentations [13] are based on i) white space and pitch ii) projection analysis and iii) connected component labeling . Segmentation is an important stage, because the extent one can reach in separation of words, lines or characters directly affects the recognition rate of the script.

2.3.1 Explicit Segmentation

In this strategy, the segments are identified based on "character like" properties. The process of Cutting up the image into meaningful components is given a special name, "dissection". Dissection is a process that analyzes an image without using specific class of shape information. The criterion for good segmentation is the agreement of general properties of the segments with these expected for valid characters. Available methods based on the

Dissection of an image use white space and pitch, vertical projection analysis, connected component analysis [14] and landmarks. Moreover, explicit segmentation can be subjected to evaluation using linguistic context.

2.3.2 Implicit Segmentation

This segmentation strategy is based on recognition. It searches the image for components that match predefined classes. Segmentation is performed by the use of recognition confidence, including syntactic or semantic correctness of the overall result. In this approach, two classes of methods can be employed; methods that make some search process and methods that segment a feature representation of the image [15].The second class of methods segments the image implicitly by classification of subsets of spatial features collected from the image as a whole.

2.4 Feature Extraction

This is also called as data extraction & gives data from perspective areas. Features are a set of numbers that capture the salient characteristics of the segmented image. There is different feature extraction methods proposed for character recognition in the following, hundreds of document image

2.4.1 The Future Research Directions

In this paper [16], a diagonal feature extraction scheme for the recognizing off-line handwritten characters is proposed. In the feature extraction process, 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 their diagonals of each zone. This procedure is repeated for all the zones which lead to extraction of 54 features for each individual character. These extracted relevant features are used to train a feed forward back propagation neural network for performing classification and recognition tasks. Extensive simulation studies show that the recognition system using diagonal features provides good recognition accuracy & less time for training.

In this work [17], an attempt is made to extract minimum number of features to represent the pattern forward inputs for Feed Forward Back Propagation Neural Network (FFBPNN). The binary image like a pattern stored in the frame is partitioned into square regions. A feature from each region is calculated by the co-ordinate distance of 1s.pixels and density. The neural network is trained with the extracted features and (RMSE) Root Mean Square Error which obtained

in the training process is used as performance indicator to stop the FFBPNN learning. Tested the proposed feature extraction and classification algorithms on the handwritten numeral database and found very good classification recognition rate with minimum training time.

In this paper [18], an algorithm to Optical Character Recognition (OCR) for Kannada numerals is discussed. The freshness exists in segmentation of the numeral into four equal parts and in spite of all using one of these parts i.e., left bottom Segment to extract recognition features. The algorithm also proposes a single conflict resolution technique to resolve conflicts while conflicting features are encountered. A minimum number of features are extracted by the algorithm so as to improve the response time by reducing training time .

An interesting approach [19] in this paper, work has been performed to recognize Handwritten English Character using a multilayer perceptron with only one hidden layer. Boundary tracing along with Fourier Descriptor is the feature extracted technique from the handwritten character. Identified each relevant Character by analyzing its shape and features which are compared and distinguishes each character. To achieve high performance an analysis was carried out to determine the number of hidden layer nodes of back propagation network in the recognition of handwritten characters. The system was trained using 500 data samples of handwritings given by both male and female participants of different age groups. Test result was performed on 500 samples other than samples for training that indicates that Fourier Description combined with back propagation network provide good recognition accuracy of 94% for handwritten English characters with less training time.

Another method [20], for recognition character .Firstly multiscale neural training with modifications in the input training vectors is accepted in this paper to acquire its advantage in training higher resolution character images. Secondly, selective thresholding, where minimum distance technique was proposed to be used to increase the level of accuracy of character recognition? The captured images were then used to generate input vectors for the back propagation neural network for training. In this case, multiscale technique with selective thresholding is proposed and the results using this method will be compared with other techniques. The results show that such methods with moderate level of training epochs can produce accuracies of at least 85% and with less training time more for and written upper case English characters and numerals.

In this paper [21], we use Kohonen neural network & it's a self organization map for pattern classification which use unsupervised learning algorithm. 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. The training process for the Kohonen neural network is competitive. For each training set one neuron will "win". This winning neuron will have its weight adjusted so that it will react even more strongly to the input the next time. As different neurons win for different patterns, their ability to recognize that particular pattern will be increased. The results are quite encouraging in terms of percentage of characters being successfully recognized with good classification recognition rate & minimum training time.

In this paper [22] a handwritten Kannada and English Character recognition system based on spatial features is presented. Directional spatial features via stroke length, stroke density and the number of stokes are employed as potential & relevant features to characterize the handwritten Kannada numerals/vowels and English uppercase alphabets. KNN classifier is used to classify the characters based on these features with four fold cross validation. The proposed system achieves the recognition accuracy as 96.2%, 90.1% and 91.04% for handwritten Kannada numerals, vowels and English uppercase alphabets respectively.

In this paper [23] this is the simplest way of character recognition, 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.) A binary input or gray-level character is compared to a standard set of stored prototypes. According to a similarity measure (e.g.: Euclidean, Jaccard or Mahalanobis, Yule similarity measures etc). A template matcher can combine multiple information sources, including match strength and k-nearest neighbor measurements from different metrics. The recognition rate of this method is very sensitive to image deformation and noise. For improved classification Deformable Templates and Elastic Matching are used for recognition task

In this paper [24], we have applied a new feature extraction technique to calculate only twelve directional feature inputs depending upon the gradients. Significant Features extracted from handwritten characters are directions of pixels with respect to their neighboring pixels. These inputs are given to a back propagation neural network with one hidden layer and one output layer. An analysis has been also carried out to compare the recognition accuracy, training time and classification time of newly developed feature extraction technique with some of the existing techniques. Experimental result shows that the new approach provides better results as compared to other techniques in terms of training time, recognition accuracy and classification time. The work carried out in this paper is able to recognize all type of handwritten characters even special characters in any language.

2.5 Classification

The feature vector obtained from previous phase is assigned a class label and recognized using supervised and unsupervised method. The data set is divided into training set and test set for each character. Character classifier can be Baye's classifier, Nearest neighbor classifier, Radial basis function, Support vector machine, Linear Discriminant functions and Neural networks with or without back propagation .

2.5.1 Methodology

CR systems extensively use the methodologies of pattern recognition, which assigns an unknown sample into a pre-defined class. Numerous techniques for CR can be investigated in four general approaches of Pattern Recognition, as suggested in [25]: Template Matching; Statistical Techniques; Structural Techniques; Neural Networks.

2.5.1.1 Template Matching

CR techniques differ broadly according to the feature set selected from the long list of features, illustrate in the previous segment for image representation. Features can be as simple as the gray-level image frames with individual words or characters or as complicated as graph representation of character primitives. The simplest way of character recognition is based on matching the stored prototypes against the character or word stored in database for reorganization [26]. Generally matching operation decides the degree of similarity between two vectors (group of pixels, shapes, curvature etc.) in the feature space. Matching techniques can be further studied in three classes:

2.5.1.2 Direct Matching

A gray-level or binary input character is openly compared to a patterns stored in database or standard set of stored prototypes. According to a similarity measure (e.g.: Yule similarity measures, Mahalanobis, Jaccard or Euclidean etc.), a prototype matching is done for recognition. The matching techniques can be as complex as decision tree analysis or as simple as one-to-one comparison in which only selected pixels are tested. A template matcher can combine multiple Information sources, including k-nearest neighbor measurements and match strength from different metrics [26]. Although direct matching method is instinctive and has a solid mathematical background, the recognition rate of this method is very receptive to noise.

2.5.1.3 Deformable Templates and Elastic Matching

An alternative method is the use of deformable templates, where an image deformation is used to match an unknown image against a database of known images. Two characters are matched by deforming the shape of one, to fit the edge power of the other [27]. A dissimilarity measure is derived from the amount of bend needed, the decency of fit of the edges and the interior overlap between the distorted shapes (see figure 4).

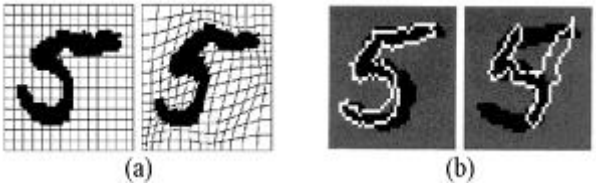

Figure 4 (a) Deformations of a sample digit, (b) Deformed template superimposed on target image, with dissimilarity measures [25].

2.5.2 Statistical Techniques

Statistical decision theory is concerned with a set of optimality criteria, and statistical decision functions which maximizes the probability of the experimental pattern given the model of a certain class [28]. Statistical techniques are, mostly, based on three major assumptions:

1. Distribution of the feature set is Gaussian or in the worst case uniform,

2. There are sufficient statistics available for each class,

3. Given ensemble of images {I}, one is able to extract a set of features {fi} ∈ F, i ∈ {1... n}, which represents each distinct class of patterns.

The measurements taken from n-features of each word unit can be idea to represent an n-dimensional vector space and the vector, whose coordinates correspond to the dimensions taken, symbolize the original word unit. The major statistical approaches, applied in the CR field are the followings:

2.5.2.1 Non-parametric Recognition

The finest known method of non-parametric categorization is the Nearest Neighbor (NN) and is widely used in CR. An incoming pattern is classified using the cluster, whose center is the minimum distance from the pattern over all the clusters. It does not involve a priori information about the data.

2.5.2.2 Parametric Recognition

Since a priori data or information is available about the characters in the training data, it is possible to obtain a parametric model for each character. Once the consideration of the model, which is based on some probabilities, is obtained, the characters are classify according to some decision rules such as Baye's method or maximum Likelihood.

2.5.3 Structural Techniques

These patterns are used to describe and classify the characters in the CR 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. The following structural methods are applied to the CR problems:

2.5.3.1 Grammatical Methods

These methods may combine any type of statistical features and topological under some syntactic and semantic rules [29]. Proper tools, like language theory, allow us to explain the acceptable constructions and to take out the relative information about the writing by using various varieties of grammars, such as graph grammars, string grammars, stochastic grammars and picture description language. In grammatical methods, training is done by relating each character by a grammar Gi. In the recognition phase, the string, tree or graph of any unit (character, word or sentence) is analyzed in order to make a decision to which pattern grammar it belongs. Top-down or bottom-up parsing, both do syntax analysis. Given a sentence, a derivation of the sentence is constructed and the corresponding derivation tree is uncovered. The grammatical technique in the CR area is applied in character word and sentence levels [30].

2.5.4 Neural Networks (NN)

Artificial Neural Network (ANN) is defined as an estimate structural design that consists of especially parallel interconnection 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 adjust in the data and learn the characteristics of input signal. ANN contains many nodes. The output from one node is forward to further in the network and the final decision depends on the difficult interface of all nodes. In spite of the different underlying principles, it can be shown that most of the neural network architectures are equivalent to statistical pattern recognition methods. Several approaches exist for training of artificial neural networks. These include the error correction, competitive learning and Boltzmann. They cover up continuous and binary valued input, in addition to unsupervised and supervised learning. On the other hand, neural network architectures can be classified into two major sets specifically; feed-forward and feedback (recurrent) networks and the majority common ANN used in the CR systems are the multilayer perceptron of the feed forward networks and the Kohonen's Self Organizing Map (SOM) of the feedback networks, use multi-network systems in hand-printed character recognition by bending point features and join outline direction which is provide to various neural networks. The feed forward neural network approaches to machine-printed character recognition problem is demonstrate to be successful, where the ANN is trained with a stored pattern or database of 94 characters and tested with 300000 characters produced by post script laser printer, with 12 common fonts in size [31]. Errors were not detected. In this paper, propose a 2-layer ANN, trained by centroid dithering process. The modular neural network (MNN) architecture is used for unrestricted handwritten numeral recognition in the whole classifier is collected of associate networks. A subordinate network, which contains 3 layers, is responsible for a class among 10 classes. The finest OCR packages in the market use collective techniques based on neural networks for machine- printed characters. Even when input is clean, they need complicated pre-processing techniques for noise removal and normalization. External segmentation is the main job for page layout decomposition where the Projection profile is adequate for character segmentation.

3. CONCLUSION

In this paper, character recognition systems for handwritten Malayalam, Tamil, English, Telgu and Kannada script are discussed in detail. Different segmentation techniques and various Classifiers with different features are also discussed. We believe that our survey will be helpful for researchers in this field There are many factors that affect the performance of OCR system .The recognition rate of OCR system with the candidate image of different styles of writing is quite high. An encouraging 98% results are achieved. However, other kinds of preprocessing and feature extraction model may be tested for a better recognition rate in the future research in OCR System.

4. FUTURE SCOPE

The work can be extended to increase the results by using or adding some more relevant features. We can use some features specific to the mostly confusing characters, to increase the recognition rate. We can divide the entire character set to apply specific and relevant features differently. More advanced classifiers can be used and multiple classifiers can be combined to get better results.

Our work is constrained to isolated characters. The situation becomes more critical, when the characters are joined, overlapped, and distorted. To recognize strings in the form of words or sentences segmentation phase play a major role for segmentation at character level and modifier level. Hence there is major scope to extend the work to recognize such category of complex strings that will require advanced and complex techniques mostly for Segmentation phase.

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