A Review on Handwritten Character Recognition

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Abstract
The paper contains a detailed review of Handwritten Character Recognition using Neural Network in Matlab. There has been sufficient research done in this field but it still remains an open research problem as handwriting styles vary of each and every individual. Achieving the character recognition accuracy rate to the best extent possible is the major challenge, which will eventually lead to the decrease in manual paper work. The paper describes the various phases of character recognition and compares the differed accuracy rate achieved using different methodologies by various researchers. The purpose is to develop Handwriting Character Recognition Software with a higher accuracy rate reducing its space and time complexities; making it optimal. A new diagonal based feature extraction method has been implemented in several papers that generates better accuracy rate compared to the traditional methods of feature extraction.

Keywords
Handwritten Character Recognition, Neural Networks, Image Processing, Feature Extraction, Optical Character Recognition, OCR

I. Introduction

Over years, organizations get on hold to numerous numbers of handwritten documents, forms and checks. Preserving such paper documents is a very tedious and a time-consuming task. Also over the years these handwritten paper documents might get distorted, and no longer be of use. In order to preserve such handwritten paper documents, if converted to a digital format it would reduce retrieval process and also make handling of such documents easier and reliable.
Optical Character Recognition (OCR) at times fails to recognize the handwritten text as the writing style varies from person to person. The main task of an OCR is to successfully identify printed text and recognize it. OCR includes the following phasesnamely, Pre-processing, Segmentation, Feature Extraction and Classification with Recognition. Output of one-phase acts as an input of the next phase in process.
OCR has been a widely important research topic in pattern recognition, machine vision and artificial learning. OCR is also known as off-line character recognition system.
Handwriting Character Recognition System (HCRS) is classified in two types namely into On-line and Off-line recognition methods.

In On-line character recognition system, the representation of two-dimensional coordinates of successive points is done; being a function of time along with the order of strokes made by the writer is made available [2].
Off-line handwriting system is basically the converting of text to an image and then further to letter codes, then used within the text processing and computer applications. The data obtained is the static representation of the handwriting. Off-line handwriting recognition is difficult than the On-line recognition, as various people have different handwriting styles [2].

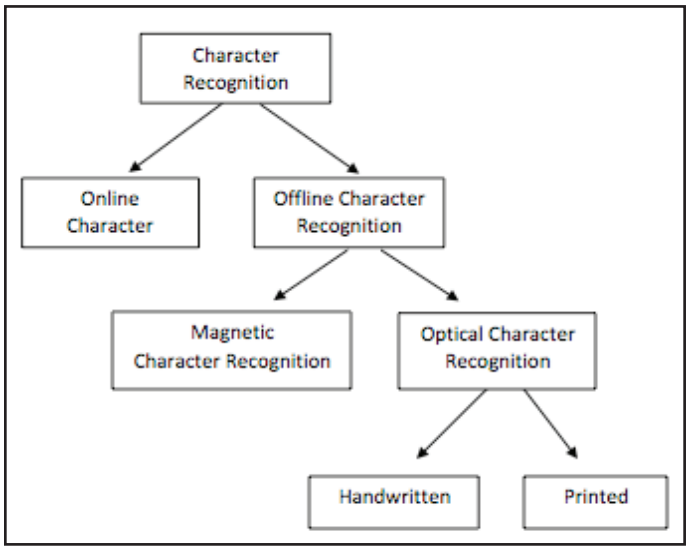

Fig. 1: Character Recognition Classification

Various novels written by authors are handwritten, these are edited first and then typed to generate a final copy and then printed to produce a book. If a suitable Handwritten Character Recognition System (HCRS) is made available, then these difficulties can be overcome. A HCRS with a high accuracy rate, which can convert any handwritten document to a digital image format, would overcome all anomalies. In some handwritten documents, a common problem faced is to successfully be able to distinguish each and every character successfully. As the writing style of very individual varies, to identity and distinguish them is difficult even for the human eye. At times the same person might not be able to identify the character written by him/her, also he/she might not always write the same character in a similar manner.
The main outcome of a HCRS would be to identify and recognize different handwriting styles. There are various number of ways to write a single character, which differs individual to individual. Hence, the aim is to achieve a high accuracy rate by classifying and recognizing characters to the extent feasible.

II. Literature Survey

A. Neural Networks For Handwritten English Alphabet Recognition

The paper makes use of Neural Networks to recognize the English handwritten alphabets. The alphabets are represented as binary values in the form of 0 and 1. These binary images are then used as an input to the feature extraction phase, and the output of this phase is fed as an input in Neural Network system. Similar appearing alphabets were seen to be misclassified in the experiments carried out, as the data set over which the tests were carried out was small. The larger the data set used the more accurate results the system would generate.

B. Direction Based Feature Extraction

Paper presents a feature extraction method referred as the direction feature to recognize the handwritten characters. This new direction

feature extraction method proved to give better accuracy result on the segmented characters when compared to the transition feature extraction method and other methods as well. The recognition rate is above 80% proven experimentally. The characters are segmented automatically from the Cursive Digit and character Recognition (CEDAR) benchmark.

C. Diagonal Based Feature Extraction System Using Neural Network

The characters in this paper are recognized using a new technique called the diagonal feature extraction technique. There were two approaches used, firstly with 54 features and secondly with 69 features which constituted the Neural Network character recognition system. The diagonal feature extraction method was compared with the traditional horizontal and vertical feature extraction methods, by training the neural network with both the methods. Six recognition neural networks were built in process. The results experimentally revealed that 69 features gave a better accuracy rate than 54 features. The system presented in the paper seems ideal to convert handwritten text documents into structural format.

D. Handwritten English Character Recognition Using Neural Network

The paper demonstrates the use of Feed Forward Algorithm along with Back Propagation Algorithm. We paper successfully recognizes characters using a multilayer perceptron with 1 hidden layer. Higher performance can be achieved in Back Propagation once the number of hidden nodes to be used is successfully determined. The recognition of characters is proved to be better and gives an accuracy of 70% and above for English handwritten characters.

E. Digital Image Processing Techniques In Character Recognition

The paper explains the various phases of image processing being used in character recognition such as Image Restoration, Image Enhancement, Segmentation, Feature Extraction and Classification with Recognition. These techniques are used along with Neural Network due to its high tolerance to noise. This helps in removing all unwanted signals in images that are distorted over years. Successful character recognition becomes possible for such documents as well and the systems generate perfect results.

F. Character Recognition Using Neural Network

In this paper, neural network is used to recognize characters. It improves the recognition rate as the system is developed for isolated English characters – A to Z. The paper makes use of feed forward back propagation and the Neural Network is trained using Back Propagation to classify and recognize characters. The English characters are represented in the binary form as is then fed to the Neural Network for further processing. The paper fails to recognize cursive handwritings.

G. Handwritten Digit Recognition

The paper presents a comparison of the feature vectors, the feature extraction strategies are proven to perform better than their baseline counterparts. The gradient feature extraction technique works best for gray scale images giving the most accuracy rate of characters and also the Normalization-Cooperated Feature Extraction (NCFE) yields a good performance result. The gradient feature extraction technique is applied on the gray scale images and other feature extraction techniques are applied on the binary images. The combination of feature extraction along with normalization has proven to yield higher accuracy rates of character recognition.

H. Analysis Drawn

After successfully reviewing a number of papers, the following experimental results were analyzed and a comparison of the character recognition accuracy rates is given below along with the different algorithms and techniques used in each corresponding paper.

Table 1: Comparison of Accuracy Rates

S. No.	Techniques or Algorithms Used	Accuracy rate
1.	Feed forward back propagation method. [3]	85%
2.	Pre-processing and neural network based recognizing task. [4]	82.5%
3.	Segmentation and Holistic approach. [5]	98.75%
4.	Multi-layer feed forward neural network. Diagonal based feature extraction. [6]	97.8 % for 54 features and 98.5% for 69 features.
5.	Error Back Propagation Algorithm. [7]	70%
6.	Modified Hough transform method. [8]	67.3%
7.	Segmentation, Neural Network and Statistical classifier. [9]	73.25%
8.	Determining Multiple Segmentation By Contour Analysis. [10]	67.8% - Upper Case 75.7% - Lower Case 75.63% -Average accuracy

III. Phases of Character Recognition

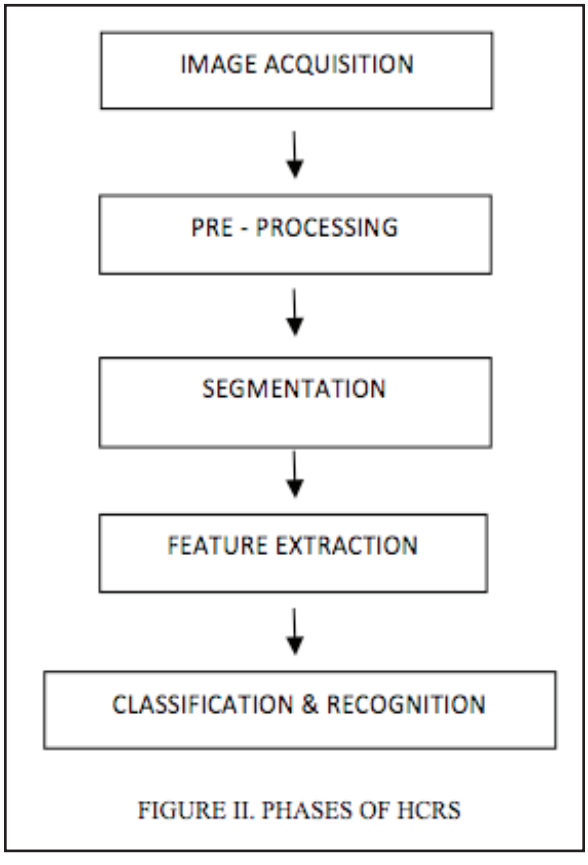

Fig. 2: Phases of HCRS

A. Image Acquisition

Image Acquisition is the first phase of handwriting character recognition. It is a method to acquire an image through a camera or a scanner. The image is of a specified file format say JPEG, PNG. The input image can be coloured, gray or in binary form. The phase of Image Acquisition consists of processing, compression, storage and display of the input image. The input image taken by the user will have some constraints that need to be adhered. The constraints may vary for different algorithms to enhance the accuracy rate of character recognition.

B. Pre Processing

The phase of preprocessing involves different stages of operations in order to enhance the image for further processing. Preprocessing involves noise reduction, binarization, edge detection and thresholding.

Usage of proper filters can be applied to remove unwanted noise signals from an image. These filters could be a mean filter, min max filter, Gaussian filter, etc. which are used to get rid of noise from an image [2].

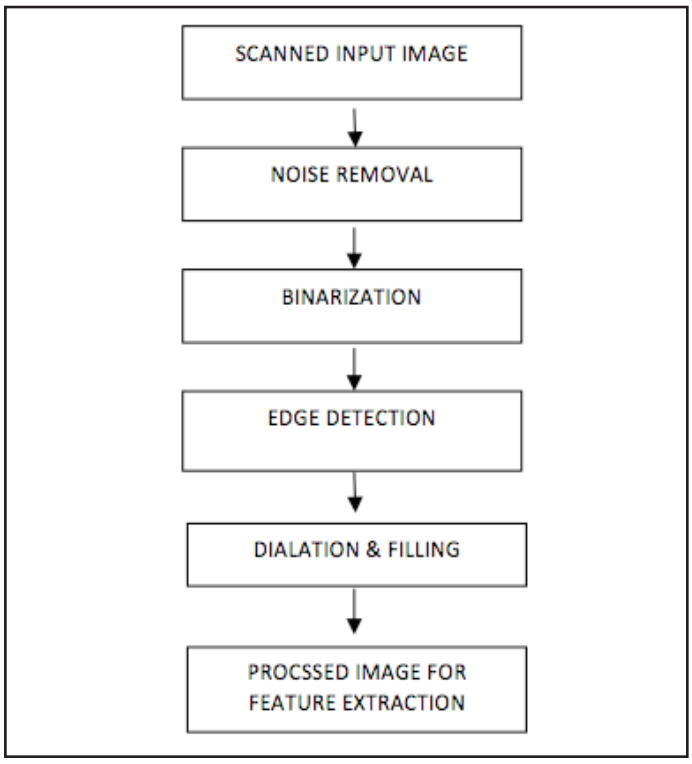

Fig. 3: Stages in Pre-Procesing

C. Noise Reduction

Noise is the haphazard variation in the brightness or the colour intensity in an image, which is not present in the original object that is imaged.The scanned input image contains noises and could even be of a lower quality that might not result in generating an appropriate desired result. The pre-processing phase includes removing unwanted noise signals and improving the quality of the image in order for the next subsequent phases of processing.

If the unwanted noise signals are not removed from the image then there might exist large gaps between line segments; to retrieve all the important information these noises ought to be removed. There might be many noises present in an image one of them namely being 'Salt and Pepper Noise' which is black and white points sprinkled in an image and is found in most images.

D. Binarization

Binarization is a process of converting the character image in binary 0,1 form. It is an important stage to be performed on gray-scale images. The phase of segmenting and pattern recognition of characters becomes easier once the process of binarization is carried out in a fruitful manner.

E. Edge Detection

Edges define the boundaries of an object; hence these object boundaries are useful in phases like identification and segmentation. Edge detection helps in filtering all anomalies and cutting unnecessary amount of data information and on the other hand preserving all the important properties in the image. There are several ways in which edge detection can be performed commonly classified into either Gradient or Laplacian. Observing the maximum and minimum in the first derivative of an image does detection of the edges in gradient method. To detect edges in an image is to search for the zero crossings in the second derivative [2].

F. Thresholding

To enhance the processing speed and decrease the storage requirements, the coloured or grey images are represented in the form of 0 or 1; that is as a binary image representing 1 for every value above a threshold selected and 0 represents everything below.

G. Segmentation

The accuracy of successful character recognition is dependent on the accuracy of segmentation done. The words are segmented into individual letters. A character is segmented from the character start to the character end. Segmentation can be further classified into External and Internal Segmentation.

External Segmentation is defined as the decomposition of the page layout into logical units. External segmentation is an important part of document analysis. Internal Segmentation is defined as the decomposition of an image into sequence of characters into sub–images [2].

H. Feature Extraction

The method of retrieving important materialistic data from raw data content. Important materialistic data is the representation of characters accurately and efficiently. The set of features being extracted from raw data in order to maximize the rate of recognition of characters with including the least amount of elements is referred to as feature extraction.

Feature extraction is not only an important phase in character recognition but also in any pattern recognition application. Techniques like Scale Invariant Feature Extraction (SIFT), Linear Discriminant Analysis (LDA), Histogram, Principle Component Analysis (PCA), Chain Code (CC), Gradient based in feature extraction are used to extract necessary and useful features from data. These features are important to train any system to perform pattern recognition tasks.

I. Zoning

In the process of zoning, the image containing character is divided into AxY zones. Features in each individual zone are extracted from the feature vector. The method to gain local characteristics leaving the global characteristics out is referred to as zoning.

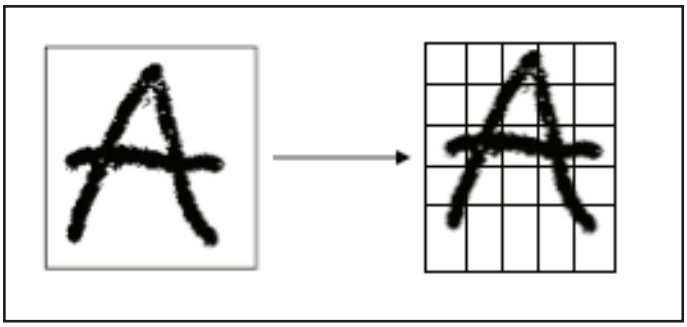

Fig. 4: Zoning in Character A

J. Diagonal Feature Extraction

Diagonal based feature extraction is a new methodology implemented for extracting the features of the handwritten alphabets. It works mainly to recognize off-line handwritten characters. For instance say, consider a character image of size 80x50 pixels that is further divided in 54 zones, each zone being 10x10 pixel size.

The features in each zone are extracted by moving across the diagonal of the zone. Every zone has N number of diagonal lines and the foreground pixels on the diagonal are summed to extract a single feature. Thus extracting N number of sub features from each zone [6].

K. Classifications and Recognition

When an input image is feed into the character recognition system, all-important features are retrieved and inputted to a trained classifier like an artificial neural network. A comparison of the input features with stored patterns is done to find the appropriate match class for the input image. This is done with the help of classifiers. Correct labelled training data is required to classify test samples.

L. Template Matching

Template matching is referred as a system prototype. This prototype is used to successfully recognize alphabets, numbers and characters by comparing two or more images. To locate a sub image in a particular image is known as a template of that image. This process is called template matching. After finding a number of templates, their centers help in determining the registration parameters. The process of template matching is to determine the similarities in a template (sub-image) and window of the same size image.

M. Parametric Recognition

As the prior information is already available regarding characters in the data set, it becomes possible to gain a parametric model for every individual character. Based on probabilities obtained, the classification of the characters is done on the basis of decision rules.

N. Neural Network

An Artificial Neural Network (ANN) is used to perform recognition tasks and classification. In offline systems, of character recognition, the ANN has become one of the best tools for classification and high recognition of characters. Neural Networks is divided into two models mainly being feed-forward and feed-backward networks. Feed-forward network have one or more hidden layers depending on the algorithm being used. Multiple layers of neurons with transfer functions enable the network to learn and identify different linear and non-linear relationships between I/O vectors.

The NN architecture is used here to achieve pattern recognition of handwritten characters. The classifier comprises of various smaller sub-networks, a sub-network containing 3 layers.

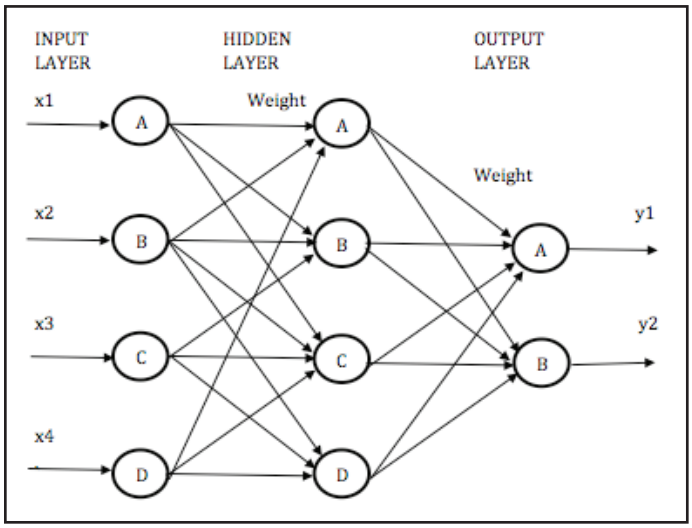

Fig. 5: Neural Network

IV. Conclusion

After reviewing the papers, it was observed that some techniques like direction feature extraction and diagonal feature extraction techniques were proved to be better in generating higher accuracy results compared to the traditional horizontal and vertical methods. Also neural networks provide a plus feature of having higher tolerance to noise.

Feed forward model of the Neural Network is trained using Back Propagation in order to classify and recognize characters. The combination of feature extraction with normalization has proven to yield higher accuracy rates of character recognition.

It was also observed that bigger the training data set, helps in achieving a higher accuracy rate when features are extracted from similar looking characters. This is highly beneficial; as handwritten characters appear similar, so good feature extraction techniques need to be used to avoid such anomalies.

V. Future Work

The HCRS currently being implemented in Neural Networks could be replaced with deep learning in order to enhance the accuracy results of characters. The use different feature extraction techniques help in improving the accuracy rate. It should also be noted that larger the data set taken helps in enhancing the results giving desired accuracy. A HCRS can be used to recognize cursive handwritings and can further be extended to also recognize the characters of other languages as well.

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