HANDWRITTEN DIGIT RECOGNITION USING NEURAL NETWORK APPROACHES AND FEATURE EXTRACTION TECHNIQUES: A SURVEY

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Abstract

In computer vision the most difficult task is to recognize the handwritten digit. Since the last decade the handwritten digit recognition is gaining more and more fame because of its potential range of applications like bank cheque analysis, recognizing postal addresses on postal cards, etc. Handwritten digit recognition plays a very vital role in day to day life, like in a form of recording of information and style of communication even with the addition of new emerging techniques. The performance of Handwritten digit recognition system is highly depend upon two things: First it depends on feature extraction techniques which is used to increase the performance of the system and improve the recognition rate and the second is the neural network approach which takes lots of training data and automatically infer the rule for matching it with the correct pattern. In this paper we have focused on different methods of handwritten digit recognition that uses both feature extraction techniques and neural network approaches and presented a comparative analysis while discussing pros and cons of each method.

Index Terms:Handwritten Digit Recognition; feature extraction; neural network.

I. INTRODUCTION

Handwritten digit recognition has become one of the most challenging tasks in the emerging field of image processing and pattern recognition. Digits which are written in various styles, shapes are easy for human to understand but it is a very complex task for the machine as the handwritten style is changing from person to person. Although handwritten digit recognition is gaining popularity because there are so many potential application areas which it's being used such as to recognize zip code or postal code, mail sorting, bank cheque processing, vehicle license plate recognition.

Digit recognition is basically a process of detecting and recognition digits from input image and convert it into appropriate machine editable forms, but constructing a system for this type of recognition faces a challenging task for the researchers due to the various types of shapes of digits that includes a large set with curves, loops, thickness, orientation size, and may depend upon writer, width, color, etc. There are many digit pairs which are similar in shape but some digits are similarity between them such as 1 and 7, 8 and 9, 5 and 6 and sometimes the digit would be written in different ways.

The performance of Handwritten digit recognition system is highly depend upon two things: First it depends on feature extraction techniques which is used to increase the performance of the system and improve the recognition rate and the second is the neural network approach which takes lots of training data and automatically infer the rule for matching it with the correct pattern. Recognition of handwritten word by computer pose serious

problems because of the high variability in the character shapes by individuals [12][13].
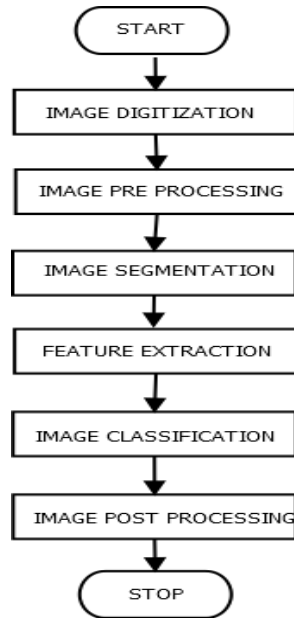

Figure 1 Steps for Handwritten Digit Recognition

A. *Image Digitization*:

In this process image might be acquired by scanning or by taking photograph of a particular document or directly writing it by using mouse. Image should be in a specific format like JPEG, JPG etc. This process is also known as acquisition process.

B. *Image Preprocessing*:

This process consists of number of procedure for enhancing the quality of the image because after scanning the quality of the image is degraded and may contain some amount of noise. It is very necessary to remove the noise as it can affect the accuracy of the system. The main reason for this step is to enhance the quality of image and making it suitable for the segmentation phase.
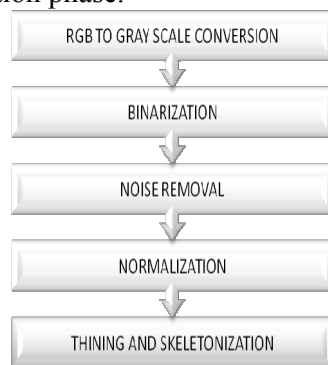

Figure 2 Steps for Pre-Processing

1. *RGB to Gray Scale Conversion*:

After scanning images are stored in different formats such as JPEG, JPG, TIFF and BMP, etc. In this step images are converted into gray scale format form RGB format and form a matrix representation.

2. *Binarization:*

In this process a gray scale image is converted into a binary image and the images are stored in matrix format where pixel should have only single color that is black or white, where 0 represent black color and 1 represent white color. Then image is altered and the output is provided into form of 0 and 1 where 0 represents background pixels and 1 represent object pixels as it is easy for machine to understand.

3. *Noise Removal*:

The document image that we have collected from the digital devices such as camera, scanner, etc, may contain some amount of unwanted noise and information, so the major objective of this step is used to remove unwanted pattern such as disconnected lines, gaps in line, bumps, etc which have no significance in the output.

4. *Normalization*:

After scanning the images may not be perfectly aligned and may not be in standard size, so in this process random size images are converted into standard size images.

5. *Thinning*:

It is a process in which regions in binary valued images should be reduced to lines and produces the object skeleton of one pixel.

C. *Image Segmentation*:

An image is divided into sub-images so that it becomes easy to analyze it and more meaningful. The main objective of digit segmentation is to separate the clear digit print area from the non-digit area []. It is the most complicated step in handwritten digit recognition due to variation in writing styles.

D. *Feature Extraction*:

It is the most important stage of recognition system. It is a process of obtaining the appropriate information by transforming the input data into set of features. It is basically related to dimensionality reduction, when there is a large amount of input data to be processed and it contains some redundancy, at that point of time input data will be transformed into a reduced representation of features. The main objective of feature extraction is to improve the recognition rate.

E. *Classification*:

This stage is the decision making stage for the digit recognition. After obtaining the extracted set of features, this stage uses the features to decide which classifier is use for identifying the class of digits. Classifiers now compare the input feature with the stored pattern and then we find out the suitable and best matching class for input.

F. *Post-processing*:

Post processing is last step in the digit recognition system. This step is not the compulsory step in digit recognition but sometimes this step helps to improve the accuracy of the system

II. NEURAL NETWORK

A neural network is an information processing unit which is highly motivated by biological nervous system such as brain. It consists of a huge number of highly inter-connected processing elements called as neurons working in coordination to solve specific problems. The main objective of neural network is to process information and solve problem in the same way as the human brain does. It is used in various potential application areas like data classification areas, pattern recognition, identifying learning rate and recognition rate [11].
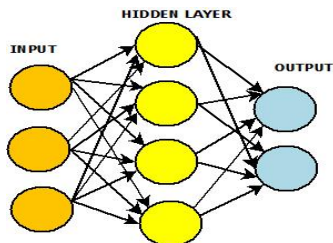

Figure 3 Neural Network

FEATURE EXTRACTION

Feature extraction is one of the most essential phases in handwritten digit recognition. For increasing the performance of recognition rate feature extraction plays an important role. It can be used to extract relevant information from a set of features because the output of the recognition system highly depends upon the features.

It can be used to extract relevant information from a set of features because the output of the recognition system highly depends upon the features. The main goal of feature extraction is to collect the most appropriate information by transforming the input data into set of features.

Feature extraction is the most critical step in any pattern classification task. The key idea of feature extraction is to find an effective, discriminatory representation of the patterns under study (digits in our case) that minimizes the intra-class variability and which maximizes inter-class variability [14][15][16].

Though there are a large variations and ambiguity in the handwritten digits so it becomes a major task to handle for this a good feature extraction technique is used to improve the recognition rate as well as increase performance of the system. Feature extraction techniques are combined in three classes which are as follows-:

- Statistical features

- Structural features

 - Hybrid features

Table 1 Literature Survey on Handwritten Digit Recognition

Sr.No	Name of Author	Year	Neural Network	Feature Extraction	Pros	Cons
[1]	A.Gattal and C.Djeddi	[2016]	SVM classifier	OBIFs and concavity feature	High recognition rate	Certain digit causes issue in recognition
[2]	L.M.Seijas and R. F. Carneiro	[2015]	SVM classifier	BFSS,ABACO,BPSO	BFSS achieved the best accuracy rate than other methods	Result may vary using other classifier.
[3]	R.Babu and C.Babu	[2015]	NNC	Novel based on distance	Process time is quick.	Other classifier may vary the result.
[4]	Bourche .EL Qucinny and A. Hammouch	[2014]	SVM classifier	Discrete cousin transform	Higher recognition rate and can be used for Arabic.	Performance decreases.
[5]	R.Babu and A.Kumar	[2014]	KNN	Fill hole density	Deals with only neighborhood pixels	Overhead increases.
[6]	Mamta garg	[2013]	MLP and SVM	Hough transform	Robust detection takes place between noise and partial occlusion	Accuracy not good
[7]	Akhtar and Qureshi	[2013]	K-NN and SVM	Wavelet technique	High recognition is achived	Performance and result may increase.
[8]	J.Pradeep and E.Srinivasan	[2011]	MLP	Diagonal based	Provides accurate information.	Not suitable for digits with straight lines.
[9]	RMO.Cruz and T.Ingren	[2010]	Classifier ensemble	Multi-zoning and modified edge maps	Improved recognition performance	Strategy needed for rejecting the ambiguous data
[10]	K.labusch and E.barth	[2008]	SVM	Sparse coding	Better performance is achieved	Doesn't use prior knowledge for handwritten

IV. Conclusion

In this paper several distinct approaches of neural network and feature extraction technique have been presented for the recognition of handwritten digits. The main objectives of handwritten digit recognition system is to achieve accuracy and high recognition rate, so for achieving this a number of steps are involved in this system like digitization, preprocessing, feature extraction and classification, etc each step have their own significance in the system. This paper describes a review of recent method which are used in the field of handwritten digit

recognition and also shows the advantage and disadvantage related to the particular technique.

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