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Review on Handwritten Digits Recognizing System

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Abstract: Handwritten digit recognition is important area of OCR and has continued to persist as a means of communication and recording information in day-to-day life even with the introduction of new technologies. Machine recognition of handwriting has practical significance, as in reading handwritten notes in a PDA, in postal addresses on envelopes, in amounts in bank checks, in handwritten fields in forms, etc. This overview describes the nature of handwritten language, how it is transuded into electronic data, and the basic concepts behind written language recognition algorithms. And digit or characters written that are varying from person to person. Both the online case (which pertains to the availability of trajectory data during writing) and the off-line case (which pertains to scanned images) are considered. So this paper describes the different surveys that are work done in area of digit recognition with the different techniques means different feature extraction methods with various classifiers.

Keywords: OCR, Feature Extraction, MLP, k-Nearest Neighbour (k-NN), Support Vector Machine (SVM)

I. INTRODUCTION

As we all know that writing style of every person is different, so that recognition of that is sometimes difficult for human also, so if we want to use computer instead of human than think how much it is difficult for computer to recognize it. So for that we have to give best training to computer system so that we get better accuracy in recognition and for that we use good feature extraction methods and better classifier.

II. FUNDAMENTALS OF DIGIT RECOGNITION

Digit recognition is an art that perform detection, segmentation and identification of characters from image. It's improving the interface between man and machine in many applications. OCR is one of the most interesting areas of pattern recognition and AI. Lots of independent work is going on in OCR .Digit recognition process can be classified in two categories:

1) Offline digit recognition system, first generated, digitized, stored and then processed.

2) Online digit recognition system, digit is processed while it was under creation. External factors like pressure speed of writing have any influence in case of offline system but they have great impact on online system. Recognition of Digit process includes various steps to do segmentation, edge detection, feature extraction etc. Accuracy of Hand Written Digit Recognition is still limited due to large variation in shape, scale, style, orientation etc.

III. WORKING PRINCIPAL

Digit recognition processes perform the following steps:

» Image acquisition,

» Pre-processing,

» Segmentation,

» Feature extraction,

» Classification

In Step of Image acquisition image is getting by scanning documents or by capturing photograph or by directly writing using mouse. The main objective of pre-processing is to remove the noise and improve the quality of scanned digit image. This can be achieved through Noise reduction, Binarization, Normalization, Skew correction, Slant removal. The main objective of segmentation of digit image is to separate the clear digit print area from the non-digit area. In OCR feature extraction is a special form of dimensionality reduction. When the input data is become large to be processed and it is suspected to be notoriously redundant then that input data will be transformed into a reduced representation of features. Feature extraction is transforming the input data into the set of features called Features vector. This stage uses the result of previous stage to identify the digits. Classification task can be achieved by using machine learning approaches and standard classifiers: Artificial Neural Network (ANN), K-Nearest Neighbor (KNN), Hidden Markov Model (HMM), and Support Vector Machine (SVM)

So, classifier fined matching class of input with stored image.

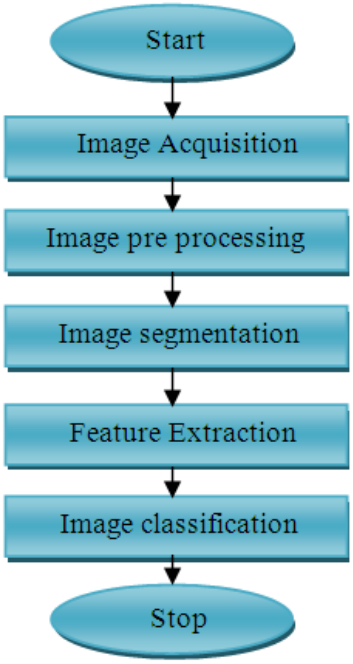

Fig. 1 Flow chart for digit recognition system [4]

IV. FEATURE EXTRATION TECHNIQUES

Feature extraction is transforming the input data into the set of features called Features vector. If the features extracted are properly chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input.

a) Water Reservoir Method [1]

This Method Work on water reservoir principle. If the water is pass round from any side top, bottom, right, left, then the cavity regions of the component where the water will be stored are considered as reservoir [1]. The reservoir area is obtained when digit is not connected. Mainly four reservoirs are formed:

» Top reservoir: Reservoir obtained only when water is gushed from top of the digit.

» Bottom reservoir: Reservoir obtained only when water is gushed from bottom of the digit.

» Left reservoir: Reservoir obtained only when water is gushed from left of the digit.

» Right reservoir: Reservoir obtained only when water is gushed from right of the digit.

Fig 2.shows top reservoir area generated in the digits when unconnected from top.

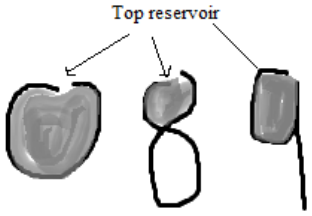

Fig 2. Top reservoir area [1]

b) Number of loop in image [1]

In structural feature number of digit image loops. So that there are number of techniques are available to find looping image. The connected component labeling algorithm is used to find number of loops. No loop =no background component - 1.For example 0, 6, 9 have 0ne loop because it has two background component.

c) Hole Feature [2]

Using the object region boundary extraction method no of holes in digit image is identify. Initially the starting pixel is located and the boundary of the region is traced until it reaches the starting co-ordinates again. So from that actual co-ordinate values of the hole boundary (inner boundary) and region boundary (outer boundary) if found. The digits 0, 4, 6, 8 and 9 contain the holes. The co-ordinates of the hole boundary was extracted. The feature vectors (FV_1) contains the number of holes (H_{cnt}), hole boundary length (H_{len}), starting coordinates of the hole boundary ($start_x$, $start_y$) and centroid (C_x, C_y). Maximum x co-ordinate value (OB_{maxx}) for the outer boundary (OB) and (IB_{maxx}) for inner boundary (IB).

$FV_1 = \{ H_{cnt}, start_x, start_y, H_{len}, C_x, C_y, OB_{maxx}, IB_{maxx} \}$	(1)

d) Fourier Descriptors[2]

For the complete shape of the image Fourier descriptors represent the boundary co-ordinates values as complex numbers derived by the Chain code algorithm. With FD The digit like 1, 2, 3, 5 and 7 were implemented. The feature vectors extracted contains centroid (C_x ,C_y), minimum coordinates (Min_x,Min_y), maximum co-ordinates (Max_x,Max_y) and x_{val} for the Max_y .

$FV_2 = \{ C_x, C_y, Min_x, Min_y, C_x, x_{val}, \}$	(2)

e) Hough transformation[3]

Hough transform method is used to detect lines, circles or other parametric curves. In this feature extraction method, first convert the input image into binary image of numerals. Divide the image into n equal zone. Calculate the value (x,y) of r for each ON pixel in each zone. The value of r is given as $r= x\cos\theta + y\sin\theta$. For each ON pixel take the standard theta values 0,30,60,90,120,150. Then calculate the largest value of ON pixel in each zone then calculate the average of largest values. For each zone which doesn't have foreground pixel, consider feature values as zero for that zone.

V. CLASSIFIERS

The classification step is main task or stage of a digits recognition system. This stage uses the result of previous stage to identify the digits.[1] This task can be achieved by using machine learning approaches and standard classifiers Artificial Neural Network (ANN), K-Nearest Neighbour (KNN), and Support Vector Machine (SVM).

a) ***Artificial Neural Network (ANN)[5][6]***

For solving the complex engineering problems Artificial Neural Networks (ANN) has been intensively used from more than last three decades. The basic element of ANN is the neuron and that the neuron is comes from the human. Neuron can be computational and communication functions in computer. As like human intelligence ANN has intelligent computing. Neurons are considered as processing element or computer. In ANN information flow is in parallel manner while knowledge is distributed between the processing units or neurons. important parameters of artificial neural network applications are:

- » Learning rate
- » Accuracy of results
- » Momentum term
- » Number of iterations used to train the neural network model.
- » Architecture of the Neural Network
- » Number of hidden neurons in the hidden layer.

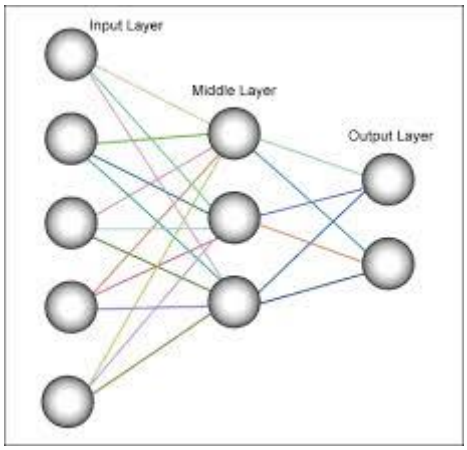

Fig 3.Neural Network

The ANN models could be Feed backward or Feed forward. In real time applications the Feed forward model provides good results in real time application. Feed forward ANN could be of type linear or nonlinear. The non-linear ANN could be supervised or unsupervised. To be the intelligent The ANN model needs training and For training, different algorithms of the ANN are used. Learning actually the procedure of changing parameters used in ANN model. So The most important Task in the ANN models is the adjustment of the weights and for that adjustment ANN algorithm is use. Weights are regularly adjusted For better performance of the ANN models.

```
Assign all network input and output
Initialize all weights with small random numbers, typically between -1 and 1
repeat
for every pattern in the training set
    Present the pattern to the network
    //    Propagated the input forward through the network:
    for each layer in the network
        for every node in the layer
            1. Calculate the weight sum of the inputs to the node
            2. Add the threshold to the sum
            3. Calculate the activation for the node
        end
    end
```



```
    //      Propagate the errors backward through the network
      for every node in the output layer
            calculate the error signal
      end
      for all hidden layers
        for every node in the layer
          1. Calculate the node's signal error
          2. Update each node's weight in the network
        end
  end
 //     Calculate Global Error
       Calculate the Error Function
 end
while ((maximum  number of iterations < than specified) AND
      (Error Function is > than specified))
```

b) Support Vector Machine (SVM),[6][7]

In machine learning, support vector machines learning models with associated learning algorithms that analyze data and recognize patterns which are used for classification and regression analysis. The basic SVM takes a set of input data and predicts, for each given input, which of two possible classes forms the output, making it a non-probabilistic binary linear classifier. Given a set of training examples, each belong to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on. In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces.

Algorithm: Simple SVM [6]

Candidate SV = {closest pair from opposite classes}

While there are violating points do

Find a violator

Candidate SV = candidate SV U violator

If any _p < 0 due to addition of c to S then

Candidate SV = candidate SV \ p

Repeat till all such points are pruned

end if

end while

c) K-Nearest Neighbor (KNN),[6][7]

The k-nearest neighbor algorithm is used for classifying the characters based on neighborhood in the feature space. The k-nearest neighbor technique using Euclidean distance method is to be used in this paper. The performance of KNN classifier is observed for different values of k ranges from 1 to 3. The Euclidean distances are computed between the test vectors to all the stored vectors. The computed distances are ranked in ascending order. The k nearest neighbors is then chosen. The majority rule with the nearest point tiebreak is used for classification.

K-NN Algorithm [6]:

Input: (actual input), S(data set)

Output: class of x

for (x′, l′) ∈S do

{

1. Compute the distance d (x′, x).

2. Sort the |S| distances by increasing order.

3. Count the number of occurrences of each class lj among the k nearest neighbors.

4. Assign to x the most frequent class.

Table 1

Feature Extraction Methods With Recognition Rate And Classifier

Feature Extraction method	Classifier	Accuracy	Year
-Object region boundary analysis -Fourier Descriptors -Chain code based algorithms[2]	-Hole -Fourier Descriptor -MLP-BP	98.15%	IEEE 2014
Zoning[9]	MLP	91%	American Journal 2013
-Number of loop in image -Water reservoir feature -Maximum Profile Distance -Fill profile density[1]	K-nearest neighbor	96.94%	IEEE 2014
Zoning[10]	Sparse Representation Classifier	94%	IEEE 2014
NM[11]	MLP-BP	95.70%	IEEE 2013
Absent[12]	-CNN -PCA -SVM -Multiclassifier system	98.5%	IEEE 2013

Table 2

Feature Extraction Methods With Training Time, Number Of Training & Test Samples

Feature Extraction method	Dataset Name		Training Time
	Test sample	Training sample	
-Object region boundary analysis -Fourier Descriptors -Chain code based algorithm[2]	-		NM
	210	100	
Zoning[9]	OWN		0:00:08-0:00:10 sec.
	300	800	
-Number of loop in image -Water reservoir feature -Maximum Profile Distance -Fill profile density[1]	MNIST		NM
	5000	5000	
Zoning[10]	CMATERdb 3.1.1.1		NM
	1000	5000	
NM[11]	HODA		NM
	2000	6000	
Absent[12]	MNIST		NM
	10000	60000	

VI. Conclusion

This survey paper represents different feature extraction method along with different classifier in recent year and also do the comparison of different feature extraction method along with different classifier .This survey show that Hole, Fourier Descriptor, MLP With Feature extraction methods Object region boundary Fourier Descriptors, Chain code based algorithms give highest result .Different method with K-nearest neighbor also give good result. From this survey some issue are found. Dataset are not available for language like Hindi or also for other country language etc. In Most of the Paper training time is not considered. So by using most recent techniques or methods we can increase the performance of recognizing system.

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