A REVIEW OF DIFFERENT MACHINE LEARNING ALGORITHM FOR DIGIT CLASSIFICATION

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Abstract : Handwritten digit recognition is the ability of a computer or a machine to interpret and receive intelligible handwritten input from various sources such as cameras, tablets, photographs and other devices. Today handwritten digits are used in checks, smart calculators etc. A complete handwriting recognition system handles formatting problem, reduce classification error, and recognize the broken digits. In this review paper, some recent techniques are conferred like SVM, k-NN, ANN, SDGBBPNN, SICoNNet and Classifiers fusion for digit recognition. The purpose of using these techniques is only to enhancing system capability of recognition. This paper gives brief description of techniques used particularly for digit recognition and provides idea which technique is appropriate.

IndexTerms - **Steepest Descent Gradient back propagation Neural Network (SDGBPNN), Artificial Neural Network (ANN), Support Vector Machine (SVM), K-mean nearest neighbored algorithm (Knn), Shunting Inhibitory Convolution Neural Networks (SICoNNet).**

I. INTRODUCTION

As the use of personal computer is increasing day by day, commercial products were introduce to replace the traditional way of using mouse or keyboard for enter inputs. These systems are replaces by single pointing handwriting systems. Advancement in electronics provides the sufficient computing power for recognition systems to fit into smaller systems like tablets. Handwritten recognition systems used to provide inputs for handheld PDA's. Apple Newton was the first PDA to provide written inputs. The major problem by using these devices is the accuracy. They are not accurate system. People finds on screen keyboards more efficient than these systems. In the 1990's researchers, start working on this area of pattern recognition. The main aim of using this is to find the correct classification results both for off-line and on-line digit recognition. There is no problem in term of accuracy of using on-line digit for recognition. The major problem is the use of off-line digits as different persons have different writing styles. Neural network majorly used for classification, as it provides better classification accuracy than others used in this area like k-NN, SURF feature, Kalmar Filters etc.

II. LITERATURE SURVEY

In 1990, Y.Le cunn [1], proposed a back propagation network for recognizing handwritten digits. The pre-processing phase here includes Acquisition of the data, segmentation and finally the multi-layer network performs normalization of the digits using linear renovation method, the recognition task, the network trained with back-propagation network. With their methodology, they achieved error rate of 3.4% and the MSE reaches to 0.024.

In 1998, Daniel Cruces Alverez [2], proposed a neural network method for recognizing printed handwritten digits. The recognition performed using a multilayer and clustered back propagation algorithm. For extracting the features, Kirsch masks remain implemented and for categorizing the numerals, they used five autonomous sub networks. Thus with their method, the elimination rate is 9% and fault rate is reduced to 1%.

In 2010, Dewi Nasian [3], suggested a method for recognizing handwritten Latin characters using freeman chain code representation and feed forward neural network classifier. It usually undergoes three stages as pre-processing, feature extraction, and classification. Through the preprocessing stage, they used thinning process for obtaining the skeleton of a character, for feature extraction, they proposed a randomized algorithm and finally they used neural network as a classifier for classification of handwritten character.

In 2012, P.Pandi Selvi[4] proposed a method for recognizing handwritten numerals using multilayer ANN. The new method that they used comprises of three phases' namely preprocessing, training and recognition. Preprocessing stage accomplishes noise removal, binarization, labeling, rescaling, and segmentation operations. Training stage embraces back-propagation with feed forward technique. The proposed method instigated in Matlab. The proposed method achieves an overall accuracy of 95%.

In 2013, SuthasineeIamsa-at and Punyaphol Horata[5] offered Feature extraction methods that generally make task easy to recognize handwritten character or digits. This paper associating the recognition ability of two classifiers: Deep Learning Feed forward-Back propagation Neural Network (DFBNN) and extreme learning machine (ELM) [18]. Data set is divided into two categories non-extracted means unidentified feature and extracted feature by histograms of oriented gradient (HOG) method. The experimental result shows that using HOG (Histogram of oriented Gradient) method, the extracted features can improve recognition rates by using both of DFBNN and ELM techniques. Furthermore feed forward-back propagation neural network provides slightly higher recognition rates than those of ELM.

In 2014, Szilard Vajda and Barna Szocs[6] proposed The K-nearest neighbor method is one of the most commonly used techniques to address different classification problems. However to apply such a classification technique, a distance metric is to be considered to define a certain distance in the feature space. The main aim of this research is to learn the distance function by exploiting the specificity of the data. Training helps to estimate the distance between two patterns by adapting the weight of the network accordingly.

In 2015, Saeed AL-Mansoori [7] implements a multilayer perceptron (MLP) neural network to recognize and predict handwritten digits from 0 to 9. A dataset of 5000 samples obtained from MNIST [15]. The dataset stayed trained using gradient descent back-propagation algorithm and further tested using the feed forward neural network algorithm. The system performance characterized by varying the number of interconnected units and the number of iterations. The methodology used in this paper gives precise and reliable result.

In 2016, Emmanuel and Sherry [8] introduce linear support vector machine, naïve bays, and multilayer perceptron model to classify handwritten digits. Performance of each algorithm is analyzed in term of accuracy. Study shows that naïve bays classifier gives 40% accurate result on the other hand neural networks gives 90% accurate result. It is prove that deep learning model gives more accurate result than other existing techniques.

III. COMPARISION ANALYSIS

In this section, we generally elaborate different techniques used for recognized handwritten digits. Some techniques are useful in term of accuracy and others are useful in term of complexity. They differentiated with each other according to certain parameter. These parameter includes accuracy, complexity etc.

There are various techniques used for classify handwritten dataset. They can designate as follow:
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3.1 Artificial Neural Network

This class majorly contains neural network algorithms like Artificial Neural Network (ANN), Convolution Neural Network (CNN), Restricted Boltzmann Machine (RBM), long short-term memory (LSTM) neural networks and Shunting Inhibitory Convolution neural networks (SICoNNet). RBM and Hopfield neural network algorithms are conventionally used network for digit recognition system. ANN and CNN give desired result in term of accuracy. These algorithm generally used back-propagation algorithm for training handwritten dataset.

SDGBPNN is majorly used back-propagation algorithm. This algorithm performs two tasks one is propagation of values and weight update [8]. The advantages of this algorithm are:

- In term of accuracy, this algorithm provides better result than other does but they are not guarantee to provide global minimum, which is very necessary for error function. Instead of providing global minimum, they provide local minimum.

Shortcoming arises due to this algorithm includes:

- This method does not require normalization of input values, as we know normalization helps to improve network performance.

Long short-term memory (LSTM) and SICoNNet is a new class of convolution neural networks [7]. Shunting inhibitory neurons remain used as information dispensation elements. These networks are flexible in term of input size, fields' size, number of layers, and number of feature maps. The concealed layer contains inhibitory neurons and output layer contains sigmoid neurons. The advantages of using this scheme are:

- These networks reduce the number of connection within the layers, which leads to increase the network generalization ability.
- Ability to extract higher order feature by taking inputs from set of feature map.

Although these networks provide tremendous advantages but they exhibit certain disadvantages also,

- SICoNNet are good in complexity wise but they are not suitable in term of accuracy.

3.2 Support Vector Machine

Support vector machine (SVM) is one of the machine learning algorithms used in this area. A supervised learning algorithm analyzes data and recognize pattern [9]. SVM classifier enables real time environment for classification because it does not requires any offline training as ANN requires [10]. This is one of the biggest advantages of this algorithm. This technique provides other benefits too [11]:

- SVM require regularization parameter, which avoiding over-fitting problem.
- This technique does not provide local minima because as defined by convex optimization problem.

Disadvantage of using this technique:

- Determination of exact parameter for regularization is very difficult.

3.3 K-Nearest Neighbor Algorithm

K-Nearest neighbor algorithm (K-NN) is majorly used machine learning algorithm [11] based on distance matrix. It provides lot of advantages like:

- Robust to noisy dataset used for training.
- This algorithm effectively used when training dataset is large.

In spite of these advantages, they exhibit certain disadvantage that makes this algorithm insufficient for certain application.

- Computational cost is very high because of calculation of distance matrix for every instant of samples.
- Distance based learning is not always useful because there is no clear cut which type of distance is used for certain attributes.

3.4 Classifier Fusion

Classifier fusion is a technique in which two or more classifier attributes are combined to form new method.

- In this technique, the disadvantage of one technique is overcome by another used technique. In this way we can increase accuracy of the proposed system but the major disadvantage of this is computational calculations requires are more. Table I. describe various statistical scheme used to recognize handwritten digit and shows corresponding recognition accuracy [10].

Table I. various statistical schemes and recognition accuracy

Sr.No.	SCHEME	ACCURACY	REJECTION
1	Product	97.70%	3.88%
2	Average	97,71%	4.17%
3	Max-Max	97.07%	5.65%
4	Naïve Bayes	96.92%	5-36%
5	Borda Count	96.80%	6.01%
6	Fuzzy Integral	97.07%	5.48%

IV. CONCLUSION AND FUTURE SCOPE

In this paper, we have illustrated some techniques used for offline recognition of handwritten isolated digits. Although these techniques exhibit certain kind advantages, we cannot say that only one technique gives accurate result. Through this review paper, it is clear that all techniques have certain advantages and disadvantages. This work can extended to increase the results by using or adding some more relevant features. Many efforts have been made to get higher accuracy and there is tremendous scope of improving recognition accuracy by developing new feature extraction techniques or modifying the existing feature extraction techniques. Table II gives brief explanation of area of application where these techniques used majorly.

Table II. Distribution of Classification techniques corresponding to accuracy and area of applications

Classifier	Techniques	Accuracy	Application	Pros & Cons
Naive Bayes [12]	L2-Norm	40	Automatic Document Classification00	Easy to compute, Less Accurate
ANN [8]	MLP,CNN	90	Iris data classification, Handwritten data classification	Efficient & Reliable, Architecture wise complex
SVM [10]	Structural Feature	94.2	Gender Identification, Face Recognition, Digit classification	Avoid over-fitting problem, Difficult to determine exact parameter
k-NN[11]	Binary pattern variance	89.81	Age estimation, Digit Recognition, Kidney disease classification	Suitable for large training data, Computation cost is high
Classifier Fusion [12]	Decision Template Approach, PCA	97.28	Digit classification, ECG extraction	High accuracy Require more computational ability

Table II. Gives better idea of choosing best classifier. All these classifier mentioned above are used for pattern recognition i.e. Handwritten digit recognition. From this, we got an idea about classifier in term of accuracy. Accuracy wise classifier fusion method gives desired result but if our application demand less complexity, then Naïve Bayes classifier majorly used although it give less accurate result but for simpler application user use this classifier . Classifier fusion method achieve high accuracy with the help of various scheme described in table I. Because of its high computational cost this algorithm used for convinced application which requires high accuracy. If we move toward ANN, it provides efficient and suitable result. With the help of feature extraction techniques, this classifier gives more accurate result than other does.

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