

Handwritten Digit Recognition Using Convolution Neural Network

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Abstract— This survey aims to present handwritten digit recognition technique. The handwritten digit recognition technique is extremely nonlinear problem. Recognition of handwritten numerals plays an active role in day to day life now days. Office automation, e-governors and many other areas are reading printed or handwritten documents and convert them to digital media is very crucial and time consuming task. So the system should be designed in such a way that it should be capable of reading handwritten numerals and provide appropriate response as humans do. However, handwritten digits are varying from person to person because each one has their own style of writing, means the same digit or character/word written by a different writer will be different even in different languages. This paper presents a survey on handwritten digit recognition systems with recent techniques, with three well known classifiers namely MLP, SVM and can used for classification.

Keywords: This paper presents a comparative analysis that describes recent methods and helps to find future scope.

I. INTRODUCTION

Due to the variations in style of writing the digits, it is sometimes complex for the person to recognize digit. The recognition of handwritten digits by computer would be much difficult than recognition by humans, because the computer does not have that much thinking power. If we want the machine to give correct output, we need to make an perfect system. We need to provide a proper database from that machine can get trained and then recognize accurately. We need to provide a better method for feature extraction and better classifier for improving the accuracy of the system

Some practical application of OCR are as follows:-

- Reading aid from the blind.
- Automatic text entry into the computer for desktop publication, library cataloging.
- Document data compression.

1.1 Character recognition classified into following two categories :-

- Template based
- Feature based approach

1.1.1 Template based

The first approach is the machine learning approach and is the most commonly and widely used approach for the recognition process. This technique requires having a large database of test images on which the system is trained to give specific output.

1.1.2 Feature based

Feature based approach determines important properties (features) from the test patterns and employs them in a more complicated classification model.

1.2 Steps in OCR system

This section briefly explains steps involve in OCR system.

1.2.1 Pre-processing

It commonly involves low frequency background noise, normalizing the strength of the individual particle image, removing reflection and masking portions of images. Image preprocessing the technique of enhancing data images prior to computational processing. In preprocessing input image are converted into gray scale Then Gray scale image is converted into a binary image using some threshold value then removal of noise having less than 30 pixels.

1.2.2 Segmentation

Segmentation partitions an image into distinct regions containing each pixel with comparable traits. To be compelling and useful for image analysis and translation, the regions should strongly relate to depict objects or features of interest. Significant segmentation is the first step from low-level image processing, transforming a grayscale or color image into one or more other images to high-level image regarding in terms of features, objects, and scenes.

1.2.3 Feature extraction

Feature extraction a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector. This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval. In this process feature at a different level is extracted from the image.

II. BACKGROUND CONCEPTS

2.1 Artificial Neural Network

An Artificial Neural Network (ANN), also called "Neural Network" (NN), is a mathematical model or computational model that tries to simulate the structure and/or functional aspects of biological neural networks.

ANN is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems.

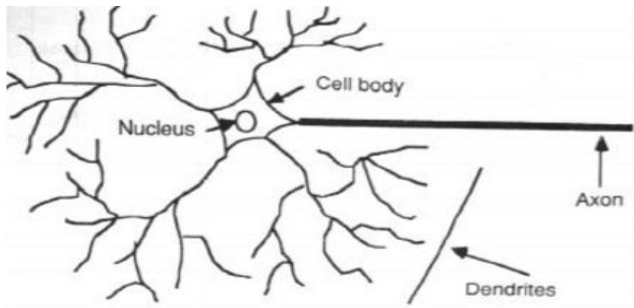


Figure 1 Biological Neural Network

Types of NNs:

- Single Layer Perceptron
- Multilayer Perceptron (MLPs)
- Radial-Basis Function Networks (RBFs)
- Hopfield Networks
- Boltzmann Machines
- Self-Organization Maps (SOMs)

- Modular Networks (Committee Machines)
- Support Vector Machines
- Bayesian Networks
- Probabilistic Graphical Models
- Hidden Markov Models

Advantages of NNs

Reason that many researchers preferred to use neural network model for solving a given the problem is related to many advantages

- Pattern recognition is a powerful technique for harnessing the information in the data and generalizing about it. Neural nets learn to recognize the patterns which exist in the data set.
 - Speed: The using of NNs is very fast, especially when it is implemented as a hardware structure, but it may be very slow when implemented on a serial computer. Smaller NNs are very fast to work which make them suitable to work with many applications like pattern recognition.
 - NNs now operate well with modest computer hardware. Although neural networks are computationally intensive, the routines have been optimized to the point that they can now run in reasonable time on personal computers. They do not require supercomputers as they did in the early days of neural network research.
 - The performance of neural networks is at least as well as classical statistical modelling, and better for most problems. The neural networks build models that are more reflective of the structure of the data in significantly less time.

II. LITERATURE SURVEY

- This paper author presents an approach to digit recognition using single layer neural network classifier with Principal Component Analysis (PCA). The handwritten digit recognition is an important area of research as there are so many applications which are using handwriting recognition and it can also be applied to new applications. There are many algorithms applied to this computer vision problem and many more algorithms are continuously developed on this to make the handwriting recognition classify digits more accurately with less computation involved. [1].
- In this paper author proposes the use of hybrid Hidden Markov Model (HMM) /Artificial Neural Network (ANN) models for recognizing

unconstrained offline handwritten texts. This paper's author also present new techniques to remove slope and slant from handwritten text and to normalize the size of text images with supervised learning methods. [2]

- In this paper the author describes after many years of stagnation, the MNIST handwriting recognition benchmark record dropped from 0.40% error rate to 0.35%. Here they report 0.27% for a committee of seven deep CNNs trained on graphics cards, narrowing the gap in human performance.[3]
- In this paper author described the neural network (NN) has emerged over the years and has made remarkable contribution to the advancement of various fields of endeavor. The purpose of this work is to examine neural network and their emerging applications in the field of engineering, focusing more on the controls. In this work they have examined the various architectures of NN and the learning process.[4]
- In this paper author describe automatic recognition of text on scanned images has enabled many applications such as searching for words in large volumes of document, automatic sorting of postal mail, and convenient editing of previously printed documents. This paper provides a comprehensive review of these methods.[5]
- In this paper author reviewed the importance of the pattern classification and its application. They list the characteristics of Arabic language writing style, furthermore focused on the preprocessing step of the recognition system. They described and tested algorithm to create skeleton which will be the base representation of Arabic words which they will use for feature extraction phase.. [6].
- In this paper the author describes a classification method for on-line handwritten digit based on off-line image representations. The goal is to use image-based features to improve classifier accuracy for on-line handwritten input. In this paper they describe an initial framework that can be used to achieve the goal. [7].
- A generic system is projected for the popularity of on-line written Arabic lettering. Usual mining of options from online knowledge victimization self-organizing maps (SOMs) avoid heuristic mining of options. The presentation of a perceptron classifier is aggressive with MLP (multilayer perceptron) and genetic coding-based approach and may be a higher acceptable handheld computing device [8].
- In this paper neural networks are known to be capable of providing good recognition rate at the present of noise where other methods normally fail. Neural network with various architectures and training algorithms have successfully been applied for a letter or character recognition.[9].
- In this paper the author investigates techniques to combine multiple representation of a handwritten digit to increase classification accuracy without significantly increasing system complexity or recognition time. In pen-based recognition, the input is the dynamic movement of the pen tip over the pressure sensitive tablet. [10].
- In this paper the author investigates the application of deformable templates for recognition of handprinted digits. Two characters are matched by deforming the contour of one to fit the edge strengths of the other, and a dissimilarity measure is derived from the amount of deformation needed, the goodness of fit of the edges, and the interior overlaps between the deformed shapes.[11]
- In this paper, a system automatically locates and organize ZIP Code in handwritten address is described. Given a grayscale image of a handwritten address is blocked, the system preprocesses the image by thresholding, border removal and underline removal[12].
- In this paper a system for recognizing totally unconstrained handwritten numerals is described. It comprises a feature extractor and two classification algorithms. The system was trained and tested on real-life handwritten ZIP codes.[13].
- In this paper the author describes the result of their investigation into the development of a recognition algorithm for identifying numerals that may be isolated or connected, broken or continuous. Using a structural classification scheme. The recognition algorithm is derived as a tree classifier. [14].
- In this paper a new set of topological features (primitives) for use with syntactic classifier for high-accuracy recognition of handwritten numerals is proposed. The tree grammar used in this study enables the realization of high-recognition speed with minimal preprocessing of the test pattern.. [15].

IV. SURVEY REPORT

AUTHOR	PAPER TITLE	YEAR	TECHNIQUE	RESULT
Vineet Singh, sunil pranit Lal [1].	Digit Recognition Using Single Layer Neural Network with Principal Component Analysis.	2014	To minimize the features for ease of computation and to achieve maximum accuracy on digit recognition, PCA algorithms was proposed.	NN without PCA=98.29% Accuracy NN+PCA=98.39% Accuracy
Salvador espana-Boquera, Maria jose Castro-Bleda, Jorge Gorbe-Moya, Francisco Zamora-Martinez[2]	Improving offline handwritten text recognition with Hybrid HMM/ANN models.	2011	Used hybrid hidden Markov model (HHM) /Artificial Neural Network (ANN)	WER CER HMMs 38.8% 18.6% HMMs, MLP WER=22.4, CER=9.8
Dan Claudiu Ciresan, Ueli Meier, Luca Maria Gambardella and Jurgen Schmidhuber[3]	Convolution Neural Network Committees for handwritten Character Classification.	2011	Used Convolution Neural Network (CNN) and NIST database.	Over All Accuracy=100%
Oludele Awodele and Olawale Jegede[4]	Neural Network and Its Application IN Engineering.	2009	Used Neural Network (NN) and Artificial Neural Network (ANN).	Programs could be developed which require feedback from the user in order to be effective but simple and "passive" sensors, could provide effective feedback into a neural control system.
Liana M. Lorigo, Venu Govindaraju[5]	Offline Arabic Handwriting Recognition .	2006	Used in optical character recognition.	Highest Rate Achieve 70-Lexicon Words=97%
Hasan Al-Rashaideh[6].	Preprocessing phase for Arabic Word Handwritten Recognition.	2006	Used IFN/ENIT database for Arabic handwritten.	The present review about pattern recognition and its importance, and its application also we list the characteristics of writing in Arabic language.
A.Teredesai ,E.Razlaft ,J.Subrahmonia,V.Govindaraju[7].	On-Line Didit Recognition using Off-Line Features.	2002	This framework for handwritten digit classification is based on Genetic Programm (G.P.), the result is reported on the UNIPEN digit dataset.	Single Class=94% Accuracy for 3Digit Lowest Accuracy=82% for 5 digit
Tim klassen [8]	Towards Neural Network Recognition of Handwritten Arabic Letters.	2001	To recognize the Arabic handwriting they proposed NNHALR system toward a Neural network approach to solve it robustly.	Template/Dynamic=96% Accuracy Evolution Neuro Fuzzy =89% Accuracy NNHALR=78 % Accuracy
Mohd Yusoff Mashore and Siti Noraini Sulaiman[9].	Recognition of Noisy Numerals Using Neural Network .	2001	Used MLP network trained using Levenberg-Marquardt algorithms.	Normal Numerals=100% Blended Numerals=95% Partially Deleted=81%
Fevzi Alimoglu, Ethem Alpaydin [10].	Combining Multiple Representation for Pen-based Hanwritten Digit Recognition.	2001	Used two multi-layer perceptron (MLP)	Over all=70% Accuracy
Anil K. Jain and Douglas Zongker[11]	Represent and Recognition of Handwritten Digits using Deformable Templates.	1997	Used deformation template and NIST special Database.	NIST Data Asymmetric=97.55% Symmetric=98.55% IBM Data Asymmetric=89.35% Symmetric=93.64%
Sargur N. srihari, Edward cohen, Johathan J, Hull,and leonard kuan [12]	A System to Locate and Recognize Zip Codes In Handwritten Addresses.	1989	Template matching using stored prototype. A mixed approach that uses statical and structure analysis of digit boundary.	Correctly Recognition=72.2% Accuracy Error rate=2.4% Accuracy
Louisa lam and Ching Y. Suen [13].	Structural Classification and Relaxation Matching of Totally Unconstrained Handwritten ZIP-code Numbers.	1988	Used feature extractor and to classification algorithms	Recognition Rate=93.15% Accuracy Reliability=97.64% Accuracy Substraction Rate=2.25%
M. Shridhar and A. Badreldin [14].	Recognition of Isolated and Simply Connected Handwritten Numerals.	1986	Using a structural classification scheme and recognition algorithms is derived as a tree classifier.	Recognition Accuracy=98% Accuracy
M. Shridhar and A. Badreldin M. Shridhar and A. Badreldin [15].	A High-Accuracy Syntactic Recognition Algorithm for Hanwritten Numerals.	1985	Used syntactic classifier.	Over All Accuracy Worked out=99% Accuracy

V. CONCLUSION

This survey report comprises of various sections and includes a survey study which comprises of several research papers related to the topic. In this research, it has been clearly observed that the evaluation of handwritten digit recognition is worth enough due to its several features like variety of numbers. Though handwritten digit recognition have delivered same scalable performance. It is necessary to provide a comparative study for handwritten digit recognition for the future scope.

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