

# **A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION SYSTEM USING ARTIFICIAL INTELLIGENCE:**

Handwritten recognition is the capability of the computer to identify and understand handwritten digits or characters automatically. MNIST data set is widely used for this recognition process. Thus, use Artificial Neural Networks to train these images and build a deep learning model. Web application is created where the user can upload an image of a handwritten digit, this image then analyzed by the model and the detected result is returned on to the user.

## **HAND WRITTEN DIGIT RECOGNITION:**

(AUTHOR:CL LIU, K NAKKASHIMA, HSAKO)

This paper presents the results of handwritten digit recognition on well-known image databases using state-of-the-art feature extraction and classification techniques. The tested databases are CENPARMI, CEDAR, and MNIST. On the test data set of each database, 80 recognition accuracies are given by combining eight classifiers with ten feature vectors. The features include chain code feature, gradient feature, profile structure feature, and peripheral direction contributively. The gradient feature is extracted from either binary image or gray-scale image. The classifiers include the  $k$ -nearest neighbor classifier, three neural classifiers, a learning vector quantization classifier, a discriminative learning quadratic discriminant function (DLQDF) classifier, and two support vector classifiers (SVCs). All the classifiers and feature vectors give high recognition accuracies. Relatively, the chain code feature and the gradient feature show advantage over other features, and the profile structure feature shows efficiency as a complementary feature. The SVC with RBF kernel (SVC-RBF) gives the highest accuracy in most cases but is extremely expensive in storage and computation. Among the non-SV classifiers, the polynomial classifier and DLQDF give the highest accuracies. The results of non-SV classifiers are competitive to the best ones previously reported on the same databases.

## **HANDWRITTEN DIGIT RECOGNITION WITH BACK-PROPAGATION NETWORK:**

(AUTHOR: LE CUN, BOSER, DENKER, HENDERSON, HOWARD, HUBBARD)

The present an application of back-propagation networks to handwritten digit recognition. Minimal preprocessing of the data was required, but architecture of the network was highly constrained and specifically designed for the task. The input of the network consists of normalized images of isolated digits. The method has 1 % error rate and about a 9% reject rate on zip code digits provided by the U.S. Postal Service. The main point of their paper is to show that large back-propagation (BP) networks can be applied to real image-recognition problems without a large, complex preprocessing stage requiring detailed engineering. Back-propagation learning was successfully applied to a large, real-world task. Our results appear to be at the state of the art in handwritten digit recognition. The network had many connections but relatively few free parameters. The network architecture and the constraints on the weights were designed to incorporate geometric knowledge about the task into the system. Because of its architecture, the network could be trained on a low-level representation of data that had minimal preprocessing (as opposed to elaborate feature extraction). Because of the redundant nature of the data and because of the constraints imposed on the network, the learning time was relatively short considering the size of the training set. Scaling properties were far better than one would expect just from extrapolating results of back-propagation on smaller, artificial problems. Preliminary results on alphanumeric characters show that the method can be directly extended to larger tasks. The final network of connections and weights obtained by back-propagation learning was readily implementable on commercial digital signal processing hard ware. Throughput rates, from camera to classified image, of more than ten digits per second were obtained.

## **HAND WRITTEN DIGIT RECOGNITION-NEURAL NET CHIPS:**

(AUTHOR: JACKEL, GRAT, HUBBARD)

A general-purpose, fully interconnected neural-net chip was used to perform computationally intensive tasks for handwritten digit recognition. The chip has nearly 3000 programmable connections, which can be set for template matching. The templates can be reprogrammed as needed during the recognition sequence. The recognition process proceeds in four major steps. First, the image is captured using a TV camera and a digital frame grab. This image is converted, using a digital computer, to either black or white pixels and scaled to fill a 16\*16-pixel frame. Next, using the neural-net chip, the image is skeletonized, i.e., the image is thinned to a backbone one pixel wide. Then, the chip is programmed, and a feature map is created by template-matching stored primitive patterns on the chip with regions on the skeletonized image. Finally, recognition, based on the feature map, is achieved using any one of a variety of statistical and heuristic techniques on a digital computer. Best scores range between 90% and 99% correct classification, depending on the quality of the original handwritten digits.

## **HAND WRITTEN DIGIT RECOGNITION BASED ON CONVOLUTIONAL NEURAL NETWORK:**

(AUTHOR: DONG-YUAN GE, XI-TAN YAO, WEN-JIANG)

Tremendous strides have been made in machine learning, one of the remaining open challenges is to achieve real-time speed as well as to maintain high performance, A convolutional neural network is designed for MNIST handwritten digit recognition, where the first convolutional layer has 32 feature images, the second convolution layer has 64 feature images. Next is the full connection layer, where the first full connection layer has 2048 neurons, and the second has 784 neurons. And the output layer has 10 neurons, which is corresponding to the 10-digit labels. In the experiment TensorFlow is adopted to setup network according to the above technology. When

the training of network is completed after 500 epochs, the accuracy of the recognition is 96.1% for training set, and 95.7% for test set.

## **ARTIFICIAL NEURAL NETWORK CLASSIFICATION FOR HANDWRITTEN DIGITS RECOGNITION:**

(AUTHOR: MOHAMMED HUSSEIN NAJJ JABARDI, HARDEEN, HARLEEN KAUR)

- 1) handwritten digit recognition can be divide into two categories, offline recognition and online recognition.
- 2) Offline recognition primarily deal with the user input handwritten digit by processing and recognizing, based on patterns (the scanned images of handwritten digit transformed from the real handwritten to the digitalsystem).
- 3) On-line recognition, deals with the recognition of handwriting captured by a touch-sensitive device as mobiles and tablet, and uses the digitized trace of the pen to recognize the symbol.
- 4) The main difficulty of handwriting recognition mechanism is that there are great variability's for different writing styles

multi-stage architecture system is more suitable and do help to improve the performance of the recognition system efficiently

neural network topologies with two different models (ForwardMultilayer Neural Network FMNN and Binary Coding Neural Network BCNN)

The highest recognition reliability and minimal error rate for the recognition of handwritten digits have been achieved

. Forward Multilayer Neural Network (FWNN):

The first model is A feed-forward multilayer neural network topology with Back-propagation algorithm as training algorithm with the input vectors that represent the handwritten digit image features and single hidden neural with 10 neuron output that acts the ten digits

Binary Coding Neural Network (BCNN):

The second model is a Binary Coding Neural Network(BCNN) topology with Back-propagation algorithm as training algorithm with the input vectors that represent the handwritten digit image features and single hidden neural with 4 neuron output that acts the ten digits

The neural network is one of the active techniques that belong to artificial intelligent and accrues mythology for pattern recognition especially if we selected the correct value of parameters Number of hidden neurons and best learning rate.

Genetic Algorithm (GA) to establish a new network that can learn by itself by exploiting the power and features GA

## **A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGNITION USING NEURAL NETWORK**

Malothu Nagu, N Vijay Shankar, K Annapurna

2011

Character recognition plays an important role in the modern world. It can solve more complex problems and makes humans' job easier. An example is handwritten character recognition. This is a system widely used in the world to recognize zip code or postal code for mail sorting. There are different techniques that can be used to recognize handwritten characters. Two techniques researched in this paper are Pattern Recognition and Artificial Neural Network (ANN). Both techniques are defined and different methods for each technique is also discussed. Bayesian Decision theory, Nearest Neighbor rule, and Linear Classification or Discrimination is types of methods for Pattern Recognition. Shape recognition, Chinese Character and Handwritten Digit recognition uses Neural Network to recognize them. Neural Network is used to train and identify written digits. After training and testing, the accuracy rate reached 99%. This accuracy rate is very high

## **HANDWRITTEN DIGIT RECOGNITION USING DEEP LEARNING**

SHUBHAM SACHDEVA

Handwritten digit recognition is gaining a huge demand in the branch of computer vision. We are going to implement a better and accurate approach to perceive and foresee manually written digits from 0 to 9. A class of multilayer sustain forward system called Convolutional network is taken into consideration. A Convolutional network has a benefit over other Artificial Neural networks in extracting and utilizing the features data, enhancing the knowledge of 2D shapes with higher degree of accuracy and unvarying to translation, scaling and other distortions. The LeNet engineering was initially presented by LeCun et al in their paper. The creators execution of LeNet was primarily focused on digit and character recognition. LeNet engineering is clear and simple making it easy for implementation of CNN's. We are going to take the MNIST dataset for training and recognition. The primary aim of this dataset is to classify the handwritten digits 0-9. We have a total of 70,000 images for training and testing. Each digit is represented as a 28 by 28 grey scale pixel intensities for better results. The digits are passed into input layers of LeNet and then into the hidden layers which contain two sets of convolutional, activation and pooling layers. Then finally it is mapped onto the fully connected layer and given a softmax classifier to classify the digits. We are going to implement this network using keras deep learning inbuilt python library.

## **Handwritten digit string recognition using convolutional neural network**

Hongjian Zhan, Shujing Lyu, Yue Lu

2018

String recognition is one of the most important tasks in computer vision applications. Recently the combinations of convolutional neural network (CNN) and recurrent neural network (RNN) have been widely applied to deal with the issue of string recognition. However RNNs are not only hard to train but also time-consuming. In this paper, we propose a new architecture which is based on CNN only, and apply it to handwritten digit string recognition (HDSR). This network is composed of three parts from

bottom to top: feature extraction layers, feature dimension transposition layers and an output layer. Motivated by its super performance of DenseNet, we utilize dense blocks to conduct feature extraction. At the top of the network, a CTC (connectionist temporal classification) output layer is used to calculate the loss and decode the feature sequence, while some feature dimension transposition layers are applied to connect feature extraction and output layer. The experiments have demonstrated that, compared to other methods, the proposed method obtains significant improvements on ORAND-CAR-A and ORAND-CAR-B datasets with recognition rates 92.2% and 94.02%, respectively.

## **Handwriting recognition using artificial intelligence neural network and image processing**

Sara Aqab, Muhammad Usman Tariq

Due to increased usage of digital technologies in all sectors and in almost all day to day activities to store and pass information, Handwriting character recognition has become a popular subject of research. Handwriting remains relevant, but people still want to have Handwriting copies converted into electronic copies that can be communicated and stored electronically. Handwriting character recognition refers to the computer's ability to detect and interpret intelligible Handwriting input from Handwriting sources such as touch screens, photographs, paper documents, and other sources. Handwriting characters remain complex since different individuals have different handwriting styles. This paper aims to report the development of a Handwriting character recognition system that will be used to read students and lectures Handwriting notes. The development is based on an artificial neural network, which is a field of study in artificial intelligence. Different techniques and methods are used to develop a Handwriting character recognition system. However, few of them focus on neural networks. The use of neural networks for recognizing Handwriting characters is more efficient and robust compared with other computing techniques. The paper also outlines the methodology, design, and architecture of the Handwriting character recognition system and



testing and results of the system development. The aim is to demonstrate the effectiveness of neural networks for Handwriting character recognition.

## **Intelligent Handwritten Digit Recognition using Artificial Neural Network**

Saeed AL-Mansoori

2015

implement a Multilayer Perceptron (MLP) Neural Network to recognize and predict handwritten digits from 0 to 9. A dataset of 5000 samples were obtained from MNIST. The dataset was trained using gradient descent back-propagation algorithm and further tested using the feed-forward algorithm. The system performance is observed by varying the number of hidden units and the number of iterations. The performance was thereafter compared to obtain the network with the optimal parameters. The proposed system predicts the handwritten digits with an overall accuracy of 99.32%.the back propagation algorithm, this input was used to train a multilayered feed forward neural network and thereby attained a training accuracy of 99.17%.An overall accuracy of 96.6% was achieved for English handwritten digits, whereas 91.2% was obtained for Kannada digits. The FDA algorithm proved less efficient with an overall accuracy of 77.67%, whereas the backpropagation algorithm with PCA for its feature extraction gave an accuracy of 91.2%.The recognition rate was achieved at 99.7%.A neural network

architecture with hidden neurons 25 and maximum number of iterations 250 were found to provide the optimal parameters to the problem. The proposed system was proved efficient with an overall training accuracy of 99.32% and testing accuracy of 100%.

# **Simplified Neural Network Design for Hand Written Digit Recognition**

Muhammad Zubair Asghar, Hussain Ahmad, Shakeel Ahmad, Sheikh Muhammad Saqib, Bashir Ahmad, Muhammad Junaid Asghar

2011

Neural Network is abstraction of the central nervous system and works as parallel processing system. Optimization, image processing, Diagnosis and many other applications are made very simple through neural networks, which are difficult and time consuming when conventional methods are used for their implementation. Neural Network is the simplified version of human brain. Like human brain, neural networks also exhibit efficient performance on perceptive tasks like recognition of visual images of objects and handwritten characters etc: Recognition of handwritten digits is one of the oldest applications of ANN. The recognition of digits written in different handwritings and also from scanned text has remained a trouble thus it has received much attention of researchers in the field of artificial neural networks. We can distinguish among handwriting of different persons due to the fact that human brain is capable to even slight variations of visual images. In this research work a very simple and flexible neural network scheme is proposed and implemented for handwritten digit recognition, which will assist beginners and AI students who want to understand perceptive capability of neural network. In the proposed system, a very simple design of artificial neural networks is implemented. First of all learning mechanism of the neural network is described and then its architecture is discussed. Proposed network is trained in supervised manner using various (approx: 250) patterns/fonts of handwritten digits. Unique token is allocated to digit when it is made input to the system. Network becomes adaptive when different patterns of the same digit are taught to the network for one particular token.

## **Handwritten Character Recognition using Neural Network**

Author : Chirag I Patel

Ripal Patel

Palak Patel

Optical character recognition, usually abbreviated to OCR, involves computer software designed to translate images of typewritten text (usually captured by a scanner) into machine-editable text, or to translate pictures of characters into a standard encoding scheme representing them in (ASCII or Unicode). OCR began as a field of research in artificial intelligence and machine vision. Though academic research in the field continues, the focus on OCR has shifted to implementation of proven techniques. The backpropagation neural network discussed and implemented in this paper can also be used for almost any general image recognition applications such as face detection and fingerprint detection.

## **Handwritten digit recognition using neural network**

Author : Berend-jan Van Der zwaag.

Artificial neural networks have been developed since the 1940s, but only the past fifteen years have they been widely applied in a large variety of disciplines. Originating from the artificial neuron, which is a simple mathematical model of a biological neuron, many varieties of neural networks exist nowadays. Artificial neural nets have successfully been applied to handwritten digit recognition numerous times, with very small error margins. The work described in this paper does not have the intention to compete with existing systems, but merely served to illustrate to the general public how an artificial neural network can be used to recognize handwritten digits. It was part of NeuroFuzzyRoute in the Euregio, an exposition in the framework of the world exposition EXPO2000 in Hannover.

## **Handwritten character recognition**

Author : saniya firdous

Handwriting has continued as a means of communication in our day-to-day life. As each person's handwriting is unique, it is sometimes hard to interpret the information they try to convey. Handwriting Recognition is an ability of a computer to receive and interpret intelligible handwritten input from sources such as paper documents, photographs, touch-screens and other devices. Though it is a difficult problem due to the great variations of writing styles, different size and orientation angle of the characters, it is still found useful for the applications in some way. In this project, the challenge is classifying the image of any handwritten word, which might be of the form of cursive or block writing. Along with this, Text-to-Speech is used to help people who have trouble reading on-screen text.

## **Digital recognition using neural network**

Author : sadik altaweel

Digit recognition has been extremely found and studied. Various approaches in image processing and pattern recognition have been developed by scientists and engineers to solve this problem. That is because it has an importance in several fields and it may probably be used in checks in banks or for recognizing numbers in cars plates, or many other applications. In this study, system for recognized of digits is built, which may benefit various fields, the system concerning on isolated digits, the input is considered to be an image of specific size and format, the image is processed and then recognized to result of an edited digits.

## **Handwritten digit recognition using neural network**

(Author : Kh tohidul islam

Dr.Ram gopal raj

Ghulam mujtaba

Henry friday nweke)

Handwritten digits recognition becomes increasingly important in the modern world due to its practical applications in our daily life. In recent years, numerous recognition systems have been introduced within many applications where high classification efficiency is required. It helps us to solve more complex problems and makes ease our tasks. An early stage handwritten digit recognition was presented for zip code recognition Automatic processing of bank checks, the postal address is widely used applications of handwritten digit recognition. A human being has been proffered a common bias to distinguish numerous objects with variations such as digits letters, faces, voice However, executing a computerized system to do certain kinds of duties is a very complex and challenging matter. In addition, pattern identification is the fundamental ingredient of a computer vision and artificial intelligence based system.

## **Neural Network Based Handwritten Digits Recognition-An Experiment and Analysis**

(MJ Islam, QMJ Wu, M Ahmadi, MA Sid-Ahmed)

*2009*

Handwritten digit recognition has become very useful in endeavors of human/computer interaction. Reliable, fast, and flexible recognition methodologies have elevated the utility. This paper presents an experiment and analysis of the Neural Network classifier to recognize handwritten digits based on a standard database. The experimental setup implemented in Matlab determines the ability of a Multi-Layer Neural Network to identify handwritten digit samples 5-9. This network is the representative for recognition of remaining digits 0-4. We consider not only accurate recognition rate, but also training time, recognition time as well as the complexity of the networks. The Multi-Layer Perceptron Network (MLPN) was trained by back propagation algorithm. Network structures vary with the hidden units, learning rates, the number of iterations that seem necessary for the network to converge. Different network structures and their corresponding recognition rates are compared in this paper to find the optimal parameters of the Neural Network for this application. Using the

optimal parameters, the network performs with an overall recognition rate 94%.

## **Offline handwritten digit recognition using neural network**

(AUTHOR: Sumedha B Hallale, Geeta D Salunke)

Optical character recognition is a typical field of application of automatic classification methods. In this paper, we have introduced a whole new idea of recognition of isolated handwritten digits which is known to be a difficult task and still lacks a satisfactory technical solution. The present paper proposes a novel approach for recognition of handwritten digits ie neural network classification. Back propagation neural network is one of the simplest methods for training multilayer neural networks. In this paper, we designed a back propagated neural network and trained it with a set of handwritten digits. The average success rates of recognition of all digits are 91.2%.

## **Offline handwritten character recognition using improved back-propagation algorithm**

(AUTHOR: Ashok Kumar, Pradeep Kumar Bhatia)

2013

A neural network is a machine designed to model the way in which the brain performs a particular task. Character recognition techniques help in recognizing the characters written on paper documents and converting it in digital form. Character recognition is gaining interest and importance in the modern world due to its application in various fields. Handwritten character recognition is a very difficult problem due to great variation of writing style, different size and shape of the character. Accuracy and efficiency are the major parameters in the field of handwritten character recognition. Neural network is a technique used to improve the accuracy and efficiency of the handwritten character recognition system. This paper throws light on the improved neural network technique to recognize the offline handwritten characters.

# Recognition of handwritten digit using convolutional neural network (CNN)

(AUTHOR: Md Anwar Hossain, Md Mohon Ali)

2019

Humans can see and visually sense the world around them by using their eyes and brains. Computer vision works on enabling computers to see and process images in the same way that human vision does. Several algorithms developed in the area of computer vision to recognize images. The goal of our work will be to create a model that will be able to identify and determine the handwritten digit from its image with better accuracy. We aim to complete this by using the concepts of Convolutional Neural Network and MNIST dataset. We will also show how MatConvNet can be used to implement our model with CPU training as well as less training time. Though the goal is to create a model which can recognize the digits, we can extend it for letters and then a person's handwriting. Through this work, we aim to learn and practically apply the concepts of Convolutional Neural Networks.

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