**A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGONITIONSYSTEM USING ARTIFICIAL INTELLIGENCE:**

Handwritten recognition Is the capability of the computer toidentify and understand handwritten digits or characters automatically. MNISTdata set is widely used for this recognition process. Thus, use Artificial NeuralNetworks to train these images and build a deep learning model. Web applicationis created where the user can upload an image of a handwritten digit, this imagethen analyzed by the model and the detected result is returned on to the user.

**HAND WRITTEN DIGIT RECOGONITION:**

**(AUTHOR:CL LIU, K NAKKASHIMA, HSAKO)**

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

**HANDWRITTEN DIGIT RECOGONITION WITH BACK-PROPOGATION NETWORK:**

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

The present an application of back-propagation networks to handwritten digitrecognition. Minimal preprocessing of the data was required, but architecture of thenetwork was highly constrained and specifically designed for the task. The input ofthe 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. PostalService. 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-propagationlearning was successfully applied to a large, real-world task. Our results appear to beat the state of the art in handwritten digit recognition. The network had manyconnections but relatively few free parameters. The network architecture and theconstraints on the weights were designed to incorporate geometric knowledge aboutthe task into the system. Because of its architecture, the network could be trained ona low-level representation of data that had minimal preprocessing (as opposed toelaborate feature extraction). Because of the redundant nature of the data andbecause of the constraints imposed on the network, the learning time was relativelyshort considering the size of the training set. Scaling properties were far better thanone would expect just from extrapolating results of back-propagation on smaller,artificial problems. Preliminary results on alphanumeric characters show that themethod can be directly extended to larger tasks. The final network of connectionsand weights obtained by back-propagation learning was readily implementable oncommercial digital signal processing hard ware. Throughput rates, from camera toclassified image, of more than ten digits per second were obtained.

**HAND WRITTEN DIGIT RECOGONITION-NEURAL NET CHIPS:**

**(AUTHOR: JACKEL, GRAT, HUBBARD)**

A general-purpose, fully interconnected neural-net chip was used to performcomputationally intensive tasks for handwritten digit recognition. The chip has nearly3000 programmable connections, which can be set for template matching. Thetemplates can be reprogrammed as needed during the recognition sequence. Therecognition process proceeds in four major steps. First, the image is captured using aTV camera and a digital frame grab. This image is converted, using a digitalcomputer, 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 abackbone one pixel wide. Then, the chip is programmed, and a feature map iscreated by template-matching stored primitive patterns on the chip with regions onthe skeletonized image. Finally, recognition, based on the feature map, is achievedusing any one of a variety of statistical and heuristic techniques on a digitalcomputer. Best scores range between 90% and 99% correct classification, dependingon the quality of the original handwritten digits.

**HAND WRITTEN DIGIT RECOGONITION BASED ON CONVOLUTIONAL NEURALNETWORK:**

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

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

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

**ARTIFICIAL NEURAL NETWORK CLASSIFICATION FOR HANDWRITTEN DIGITSRECOGONITION:**

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

1)handwritten digit recognition can be divide into two categories, offlinerecognition and online recognition.

2)Offline recognition primarily deal with the user input handwritten digit byprocessing and recognizing, based on patterns (the scanned images ofhandwritten digit transformed from the real handwritten to the digitalsystem).

3)On-line recognition, deals with the recognition of handwriting captured by atouch-sensitive device as mobiles and tablet, and uses the digitized trace of thepen 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 theperformance of the recognition system efficiently

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

The highest recognition reliability and minimal error rate for the recognition ofhandwritten 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 representthe handwritten digit image features and single hidden neural with 10 neuronoutput 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 representthe handwritten digit image features and single hidden neural with 4 neuronoutput that acts the ten digits



The neural network is one of the active techniques that belong to artificialintelligent and accrues mythology for pattern recognition especially if we selectedthe correct value of parameters Number of hidden neurons and best learningrate.

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

**A NOVEL METHOD FOR HANDWRITTEN DIGIT RECOGONITION USING NEURALNETWORK**

Malothu Nagu, N Vijay Shankar, K Annapurna

2011

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

**HANDWRITTEN DIGIT RECOGNITION USING DEEPLEARNING**

SHUBHAM SACHDEVA

Handwritten digit recognition is gaining a huge demand in the branch ofcomputer vision. We are going to implement a better and accurateapproach to perceive and foresee manually written digits from 0 to 9. Aclass of multilayer sustain forward system called Convolutional network istaken into consideration. A Convolutional network has a benefit over otherArtificial Neural networks in extracting and utilizing the features data,enhancing the knowledge of 2D shapes with higher degree of accuracy andunvarying to translation, scaling and other distortions. The LeNet engineering was initially presented by LeCun et al in their paper. Thecreators excecution of LeNet was primarily focused on digit and characterrecognition. LeNet engineering is clear and simple making it easy forimplementation of CNN‘s. We are going to take the MNIST dataset fortraining and recognition. The primary aim of this dataset is to classify thehandwritten digits 0-9. We have a total of 70,000 images for training andtesting. Each digit is represented as a 28 by 28 grey scale pixel intensitiesfor better results. The digits are passed into input layers of LeNet and theninto the hidden layers which contain two sets of convolutional, activationand pooling layers. Then finally it is mapped onto the fully connected layerand given a softmax classifier to classify the digits. We are going toimplement this network using keras deep learning inbuilt python library.



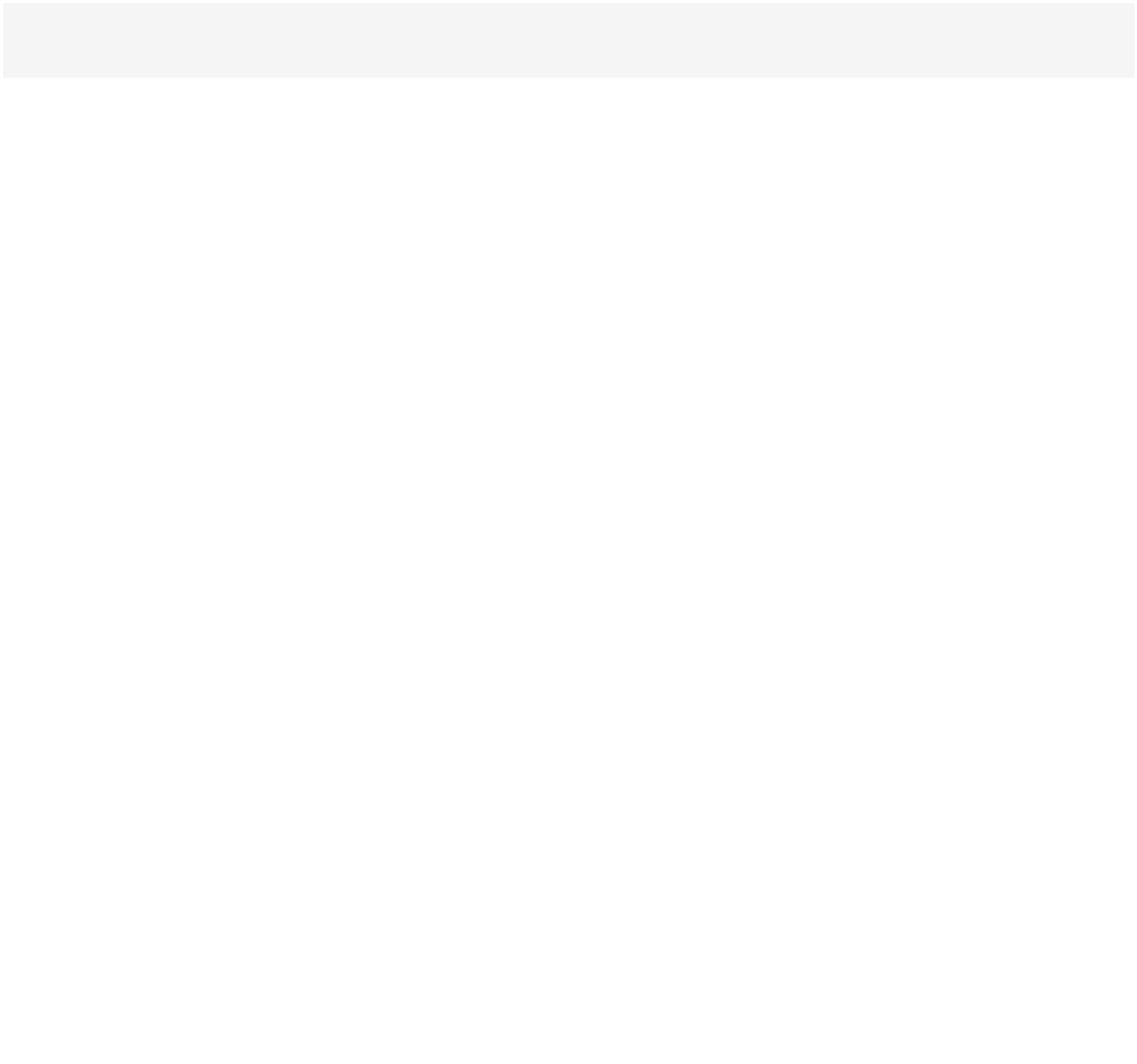
**Handwritten digit string recognition using convolutionalneural network**

Hongjian Zhan, Shujing Lyu, Yue Lu

*2018*

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

bottom to top: feature extraction layers, feature dimension transpositionlayers and an output layer. Motivated by its super performance ofDenseNet, we utilize dense blocks to conduct feature extraction. At the topof the network, a CTC (connectionist temporal classification) output layer isused to calculate the loss and decode the feature sequence, while somefeature dimension transposition layers are applied to connect featureextraction and output layer. The experiments have demonstrated that,compared to other methods, the proposed method obtains significantimprovements on ORAND-CAR-A and ORAND-CAR-B datasets withrecognition rates 92.2% and 94.02%, respectively.



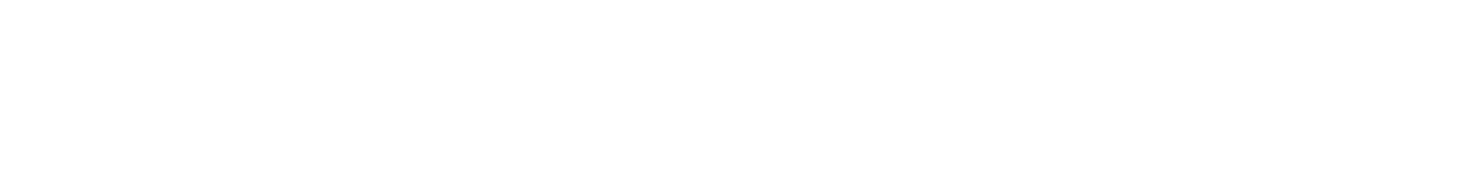
**Handwriting recognition using artificial intelligence neural**

**network and image processing**

Sara Aqab, Muhammad Usman Tariq

Due to increased usage of digital technologies in all sectors and in almostall day to day activities to store and pass information, Handwritingcharacter recognition has become a popular subject of research.Handwriting remains relevant, but people still want to have Handwritingcopies converted into electronic copies that can be communicated andstored electronically. Handwriting character recognition refers to thecomputer's ability to detect and interpret intelligible Handwriting input fromHandwriting sources such as touch screens, photographs, paperdocuments, and other sources. Handwriting characters remain complexsince different individuals have different handwriting styles. This paper aimsto report the development of a Handwriting character recognition systemthat will be used to read students and lectures Handwriting notes. Thedevelopment is based on an artificial neural network, which is a field ofstudy in artificial intelligence. Different techniques and methods are used todevelop a Handwriting character recognition system. However, few of themfocus on neural networks. The use of neural networks for recognizingHandwriting characters is more efficient and robust compared with othercomputing 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 demonstratethe 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 andpredict handwritten digits from 0 to 9. A dataset of 5000 samples were obtainedfrom MNIST. The dataset was trained using gradient descent back-propagationalgorithm and further tested using the feed-forward algorithm. The systemperformance is observed by varying the number of hidden units and the numberof iterations. The performance was thereafter compared to obtain the networkwith the optimal parameters. The proposed system predicts the handwrittendigits with an overall accuracy of 99.32%.the back propagation algorithm, thisinput was used to train a multilayered feed forward neural network and therebyattained a training accuracy of 99.17%.An overall accuracy of 96.6% was achievedfor 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 gavean accuracy of 91.2%.The recognition rate was achieved at 99.7%.A neuralnetwork

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 DigitRecognition**



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

2011

Neural Network is abstraction of the central nervous system and works asparallel processing system. Optimization, image processing, Diagnosis andmany other applications are made very simple through neural networks,which are difficult and time consuming when conventional methods areused for their implementation. Neural Network is the simplified version ofhuman brain. Like human brain, neural networks also exhibit efficientperformance on perceptive tasks like recognition of visual images ofobjects and handwritten characters etc: Recognition of handwritten digits isone of the oldest applications of ANN. The recognition of digits written indifferent handwritings and also from scanned text has remained a troublethus it has received much attention of researchers in the field of artificialneural networks. We can distinguish among handwriting of differentpersons due to the fact that human brain is capable to even slightvariations of visual images. In this research work a very simple and flexibleneural network scheme is proposed and implemented for handwritten digitrecognition, which will assist beginners and AI students who want tounderstand perceptive capability of neural network. In the proposedsystem, a very simple design of artificial neural networks is implemented.First of all learning mechanism of the neural network is described and thenits architecture is discussed. Proposed network is trained in supervisedmanner 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 aretaught 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, involvescomputer software designed to translate images of typewritten text (usuallycaptured by a scan-ner) into machine-editable text, or to translate pictures ofcharacters into a standard encoding scheme representing them in (ASCII orUnicode). OCR began as a field of research in artificial intelligence andmachine vision. Though academic research in the field continues, the focus onOCR has shifted to implementation of proven techniques.The backpropagationneural network discussed and implemented in this paper can also be used foralmost any general image recognition applications such as face detection andfingerprint detection.

**Handwritten digit recognition using neural network**

**Author : Berend-jan Van Der zwaag.**

Artificial neural networks have been developed since the 1940s, butonly the past fifteen years have they been widely applied in a large variety ofdisciplines.Originating from the artificial neuron, which is a simplemathematical model of a biological neuron, many varieties of neural networksexist nowadays.Artificial neural nets have successfully been applied tohandwritten digit recognition numerous times, with very small error marginsThe work described in this paper does not have the intention to compete withexisting systems, but merely served to illustrate to the general public how anartificial neural network can be used to recognize handwritten digits.It waspart of NeuroFuzzyRoute in the Euregio, an exposition in the framework ofthe world exposition EXPO2000 in Hannover.

**Handwritten character recognition**

**Author : saniya firdous**

Handwriting has continued as a means of communication in ourday-to-day life. As each person's handwriting is unique, it is sometimes hardto interpret the information they try to convey.Handwriting Recognition is anability of a computer to receive and interpret intelligible handwritten inputfrom sources such as paper documents, photographs, touch-screens and otherdevices.Though it is a difficult problem due to the great variations of writingstyles, different size and orientation angle of the characters, it is still founduseful for the applications in some way.In this project, the challenge isclassifying the image of any handwritten word, which might be of the form ofcursive or block writing. Along with this, Text-to-Speech is used to help peoplewho have trouble reading on-screen text.

**Digital recognition using neural network**

**Author : sadik altaweel**

Digit recognition has been extremely found and studied. Variousapproaches in image processing and pattern recognition have been developedby scientists and engineers to solve this problem. That is because it has animportance in several fields and it may probably be used in checks in banks orfor recognizing numbers in cars plates, or many other applications. In thisstudy, system for recognized of digits is built, which may benefit variousfields, the system concerning on isolated digits, the input is considered to bean image of specific size and format, the image is processed and thenrecognized 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 themodern world due to its practical applications in our daily life. In recent years,numerous recognition systems have been introduced within manyapplications where high classification efficiency is required. It helps us tosolve more complex problems and makes ease our tasks. An early stagehandwritten digit recognition was presented for zip code recognitionAutomatic processing of bank checks, the postal address is widely usedapplications of handwritten digit recognition. A human being has beenproffered a common bias to distinguish numerous objects with variationssuch as digits letters, faces, voice However, executing a computerized systemto do certain kinds of duties is a very complex and challenging matter. Inaddition, pattern identification is the fundamental ingredient of a computervision and artificial intelligence based system.

**Neural Network Based Handwritten Digits Recognition-AnExperiment and Analysis**

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

*2009*

Handwritten digit recognition has become very useful in endeavors ofhuman/computer interaction. Reliable, fast, and flexible recognitionmethodologies have elevated the utility. This paper presents an experimentand analysis of the Neural Network classifier to recognize handwrittendigits based on a standard database. The experimental setup implementedin Matlab determines the ability of a Multi-Layer Neural Network to identifyhandwritten digit samples 5-9. This network is the representative forrecognition of remaining digits 0-4. We consider not only accuraterecognition rate, but also training time, recognition time as well as thecomplexity of the networks. The Multi-Layer Perceptron Network (MLPN)was trained by back propagation algorithm. Network structures vary withthe hidden units, learning rates, the number of iterations that seemnecessary for the network to converge. Different network structures andtheir corresponding recognition rates are compared in this paper to find theoptimal parameters of the Neural Network for this application. Using the

optimal parameters, the network performs with an overall recognition rate94%.

**Offline handwritten digit recognition using neural network (AUTHORL:Sumedha B Hallale, Geeta D Salunke)**

Optical character recognition is a typical field of application of automaticclassification methods. In this paper, we have introduced a whole new ideaof recognition of isolated handwritten digits which is known to be a difficulttask and still lacks a satisfactory technical solution. The present paperproposes a novel approach for recognition of handwritten digits ie neuralnetwork classification. Back propagation neural network is one of thesimplest methods for training multilayer neural networks. In this paper, wedesigned a back propagated neural network and trained it with a set ofhandwritten 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 thebrain performs a particular task. Character recognition techniques help inrecognizing the characters written on paper documents and converting it indigital form. Character recognition is gaining interest and importance in themodern world due to its application in various fields. Handwritten characterrecognition is a very difficult problem due to great variation of writing style,different size and shape of the character. Accuracy and efficiency are themajor parameters in the field of handwritten character recognition. Neuralnetwork is a technique used to improve the accuracy and efficiency of thehandwritten character recognition system. This paper throws light on theimproved neural network technique to recognize the offline handwrittencharacters.

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**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 theireyes and brains. Computer vision works on enabling computers to see andprocess images in the same way that human vision does. Severalalgorithms 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 identifyand determine the handwritten digit from its image with better accuracy. Weaim to complete this by using the concepts of Convolutional NeuralNetwork and MNIST dataset. We will also show how MatConvNet can beused to implement our model with CPU training as well as less trainingtime. 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 thiswork, we aim to learn and practically apply the concepts of ConvolutionalNeural Networks.

By

M. Pradeep Raj

K. Praveen Kumar

R. Sheshayee

K. Sameerul Anwar