

# A Recognition System for Handwritten Digits Using CNN

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**Abstract:** *This paper presents a model of integrating the synergy of two superior classifiers: Convolutional Neural Network (CNN) and Random Forest Classifier (RFC), which have proven results in recognizing different types of patterns. Handwritten digit recognition is one of the practically important issues in pattern recognition applications. The applications of digit recognition include in postal mail sorting, bank check processing, form data entry, etc. The heart of the problem lies within the ability to develop an efficient algorithm that can recognize hand written digits and which is submitted by users by the way of a scanner, tablet, and other digital devices. The problem of handwritten digit recognition has long been an open problem in the field of pattern classification. Several studies have shown that Neural Network has a great performance in data classification. Ability for accurate digit recognizer modelling and prediction is critical for pattern recognition and security. A variety of classification machine learning algorithms are known to be effective for digit recognition.*

**Keywords:** CNN, Handwritten Digit recognition, Random Forest Classifier, Feature extraction

## 1. Introduction

In this section an overview of handwritten digits' recognition is provided. The importance of handwritten digits, efficient digits' recognition and their role in digits' recognition is discussed. Role of IT in handwritten digits' recognition is also provided.

This is an overview of the most recent published approaches to solving the handwriting recognition problem. This paper aimed at clarifying the role of handwriting recognition in accordance with today's maturing technologies. It tries to list and clarify the components that build handwriting recognition and related technologies such as OCR (Optical Character Recognition) and Signature Verification. This paper could also be regarded as a survey of handwriting recognition and related topics with a rich list of references for the interested reader. Levels of practicality of use of this technology for different languages and cultures is also discussed. It is well known that the handwritten digit's recognition is a challenging problem. In recent years, there are many algorithms proposed for handwritten digits' recognition. The results have shown that the proposed method can lead to an improvement of the recognition rate compared with other SOM - based algorithms.

In the machine learning context, it is commonly known that each standard learning algorithm usually shows different performance on different datasets. In other words, the use of an algorithm may lead to the production of strong classifiers on some datasets but the classifiers trained on other datasets using the same algorithm may be much weaker. In the case of handwritten digits' recognition, a standard learning algorithm may be capable of learning some but not all specific characteristics of handwritten digits. Also, the same classifier may show different performance on different datasets, due to the different data distribution. In addition, instances of handwritten digits usually show very diverse

characteristics due to different handwriting styles of different people, even if the instances belong to the same class.

Handwriting digits' recognition refers to the process of transforming the ordered trajectory generated by writing on handwriting equipment into the internal code of digits. It is actually a mapping process from the coordinate sequence of handwritten trajectory to the internal code of digits. It is one of the most natural and convenient means of human-computer interaction. With the popularity of mobile information tools such as smartphones and handheld computers, handwritten digits' recognition technology has entered the era of large - scale application. Handwritten digits recognition enables users to input text in the most natural and convenient way. It is easy to learn and use, and can replace keyboards or mouse. There are many kinds of devices for handwriting inputs, such as electromagnetic induction handwriting boards, pressure - sensitive hand - writing boards, touch screens, touch panels, ultrasonic pens, etc. Handwriting digits' recognition belongs to the category of digits' recognition and pattern recognition. In terms of the recognition process, digits recognition can be divided into two categories: off - line recognition and on - line recognition. In terms of recognition objects, it can also be divided into two categories: handwriting digits' recognition and print digits' recognition.

In this paper, we propose a Recognition System model of integrating the synergy of two superior classifiers: Convolutional Neural Network (CNN) and Random Forest Classifier (RFC), which have proven results in recognizing different types of patterns. Handwritten digit recognition is one of the practically important issues in pattern recognition applications. The applications of digit recognition include in postal mail sorting, bank check processing, form data entry, etc. The heart of the problem lies within the ability to develop an efficient algorithm that can recognize hand

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written digits and which is submitted by users by the way of a scanner, tablet, and other digital devices. The problem of handwritten digit recognition has long been an open problem in the field of pattern classification. Several studies have shown that Neural Network has a great performance in data classification

This paper is organized as follows. Section II, includes some related work in Hand recognition system using CNN. Section III, provides a detailed description about the System and its components. In Section IV, Results and Discussions. Section V concludes the paper and outlines future work.

## 2. Literature Survey

Handwritten digit recognition has recently been of very interest among the researchers because of the evolution of various Machine Learning, Deep Learning and Computer Vision algorithms. In this paper [1], the results of some of the most widely used Machine Learning Algorithms like SVM, KNN & RFC and with Deep Learning algorithm like multilayer CNN using Keras with Theano and Tensor flow are compared [1].

A lot of classification techniques using Machine Learning have been developed and used for this like K - Nearest Neighbors, SVM Classifier, Random Forest Classifier etc. but these methods although having the accuracy of 97% are not enough for the real world applications. The Artificial Neural Networks can almost mimic the human brain and are a key ingredient in image processing field. For example, Convolutional Neural Networks with Back Propagation for Image Processing, Deep Mind by Google for creating Art by learning from existing artist styles etc.

The process. Artificial Neural Network (ANN) carried out the classification, and the overall classification accuracy is 99.60%. The performance of the ANN is more effectively better while corresponded to the classification using Support Vector machine (SVM) [2].

ANN will be initialized to construct a classification model. The percentages of training, validation and testing data is distributed to avoid the network overfitting problem. Training Data is provided to ANN train the model to recognize the digits. Testing will be done by giving testing data to test the performance of the model [2]

CNN is able to the learning full architecture CNN (for example, LeNet5) to provide remarkable recognition accuracy in the MNIST handwritten digit recognition. LeNet5 - simple convolutional neural network its recognizing simple digit images. n. For all experimental images, the pixel's values also have been normalized to a range. Where the black pixels are pixels with negative value, the white pixels are pixel with positive value, and the grey pixels are pixels with zero [3]

CNN (convolution neural network is a sequence of layers. They used three main layers: Convolution layers: - this layer gets the pre - processed image as an input. Pooling layers: - this layer gets input from the previous layer after this pooling operation, author gets feature map and its output is

same as previous layer. Fully connected layers: - this is the last layer of the network it will compute the class scores among MNIST dataset. Rectified Linear Unit (ReLU), Pooling, and Softmax function. These four mathematical functions are the fundamental building blocks for all CNNs (to the best of authors knowledge). Therefore, understanding these four mathematical functions is very helpful for learning the latest CNN [3].

Future efforts can study the optimization of deep learning, and apply it to more complex image recognition problems. It is interesting is to look at building a real - time classifier and a related application (mobile and/or desktop) that will take in user input and immediately do recognition and convert that to a digit (1, 7), (3, 5), (3, 8), (8, 5) and (6, 9). r, is different from the reported related works in the context that we compare three algorithms depending on four factors including accuracy, performance and execution time. While, to the best of our knowledge, most of the related works focused on the accuracy [4].

## 3. Proposed Method

Digit recognition problem is a promising problem in handwriting recognition problem. It is also one of the challenging problems in computer vision and machine learning. It is so called challenging task as developing an accurate automated recognition of handwritten digits is difficult. The applications of digit recognition includes bank check processing and online form data submitted by users by using digital devices. The variation in handwriting among people makes it difficult to train the computers to recognize handwritten digits. This work employs machine learning techniques to address the digit recognition problem. To analyse various classification techniques and finding the best technique for digit recognition, the work focuses on utilizing a tool that would embrace multiple types of classification models with diverse performance metrics.

Figure 1 explains the essential flow of A recognition system for Handwritten Digits Using CNN. The proposed model contains the four stages in order to classify and detect the digits:

- A. Pre - processing
- B. Segmentation
- C. Feature Extraction
- D. Classification and Recognition



Figure 1: System Architecture

Deep Learning has emerged as a central tool for self - perception problems like understanding images, a voice from humans, robots exploring the world. We aim to implement the concept of Convolutional Neural Network for

digit recognition. Understanding CNN and applying it to the handwritten digit recognition system is the target of the proposed model. Convolutional Neural Network extracts the features maps from the 2D images. Then it can classify the images using the features maps. The convolutional neural network considers the mapping of image pixels with the neighbourhood space rather than having a fully connected layer of neurons. The convolutional neural network is a powerful tool in signal and image processing .

Convolutional Neural Networks Convolutional neural networks are deep artificial neural networks. We can use it to classify images cluster them by similarity (photo search) and perform object recognition within scenes. It can be used to identify faces, individuals, street signs, platypuses and many other aspects of visual data. The convolutional layer is the core building block of a CNN. The layer's parameters consist of a set of learnable filters (or kernels) which have a small receptive field but extend through the full depth of the input volume. During the forward pass, each filter is convolved across the width and height of the input volume, computing the dot product, and producing a 2 - dimensional activation map of that filter. As a result, the network learns when they see some specific type of feature at some spatial position in the input. Then the activation maps are fed into a down sampling layer, and like convolutions, this method is applied one patch at a time. CNN has also fully connected layer that classifies output with one label per node. And how it works.

**a) Pre - Processing:**

The role of the pre - processing step is it performs various tasks on the input image. It basically upgrades the image by making it reasonable for segmentation. The fundamental motivation behind pre - processing is to take off a fascinating example from the background. For the most part, noise filtering, smoothing and standardization are to be done in this stage. The pre - processing additionally characterizes a smaller portrayal of the example. Binarization changes over a gray scale image into a binary image. The initial approach to the training set images that are to be processed in order to reduce the data, by thresholding them into a binary image. The first step in data preprocessing is data normalization. This is done to apply distance calculations on it. This involves transforming the data to fall within a smaller or common range, such as [0, 1]. The raw image data is based on the standard 8 - bit unsigned integer which has a high value range of [0, 255] at each pixel (attribute). Expressing an attribute in smaller units will lead to a larger range for that attribute, thus tend to give such attributes greater effect or “weight.”

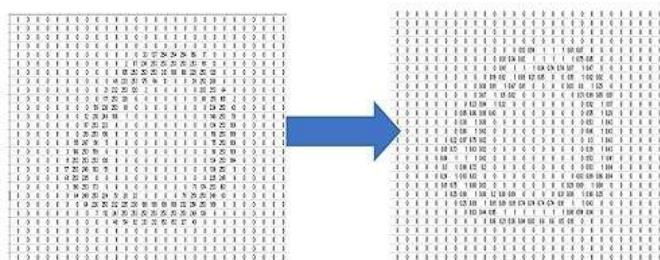


Figure 2: Raw Image and normalized image

After Normalization, we used the median filter to remove noise this is a nonlinear digital filtering technique to improve the image by removing especially Gaussian noise. We used Median Filter because it preserves the edge while removing the noise as edge is an important aspect of an image. Figure 3 shows the processed image of the median filter. An unwanted horizontal line connected to number “Zero” is removed after Median Filter

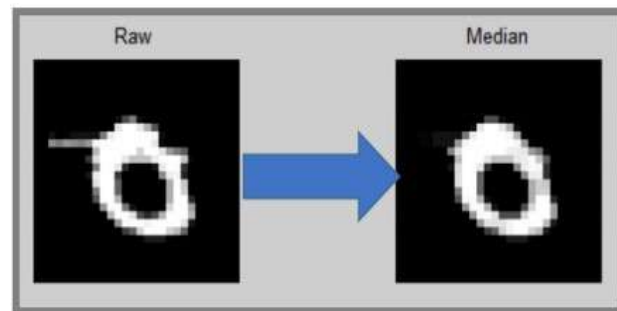


Figure 3: Raw Image and image after Median Filter

The next step in preprocessing is the image sharpening technique which uses a blurred, or "unsharp", negative image to create a mask of the original image. The unshaped mask is then combined with the positive (original) image, creating an image that is sharper than the original. Sharpening uses a filter that amplifies the high - frequency components of a signal. It's a necessary step taken after Median Filter as Median Filter not only remove noise, but also weaken the entire image in general. Sharpening can restore or enhance some of the useful information weakened by Median Filter. Figure 4 shows the image sharpening after processing Median Filter.

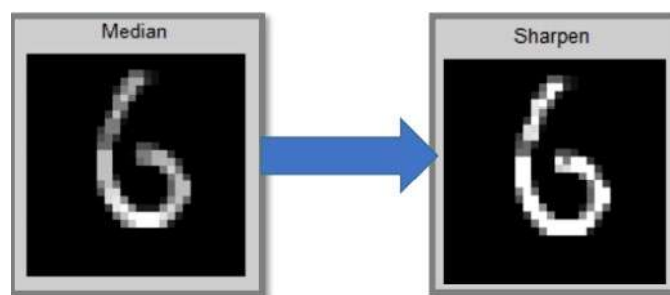


Figure 4: Median Filter and sharpened image

Attribute reduction techniques is done to obtain a reduced representation of the data set that is much smaller in volume, yet closely maintains the integrity of the original data. That is, mining on the reduced data set should be more efficient yet produce the same (or almost the same) analytical results. Each original image has a total of 784 attributes. It would be beneficial to reduce the total attributes to a relatively small amount so that it's more data efficient and easier to be processed.

**b) Segmentation**

Once the pre - processing of the input images is completed, sub - images of individual digits are formed from the sequence of images. Pre - processed digit images are segmented into a sub - image of individual digits, which are assigned a number to each digit. Each individual digit is resized into pixels. In this step an edge detection technique is being used for segmentation of dataset images. an image of sequence of digit is decomposed into sub images of individual digit. Preprocessed input image is segmented into isolated digit by assigning a number to each digit using a labeling process.

**c) Feature Extraction**

After the completion of pre - processing stage and segmentation stage, the pre - processed images are represented in the form of a matrix which contains pixels of the images that are of very large size. In this way it will be valuable to represent the digits in the images which contain the necessary information. This activity is called feature extraction. In the feature extraction stage redundancy from the data is removed.

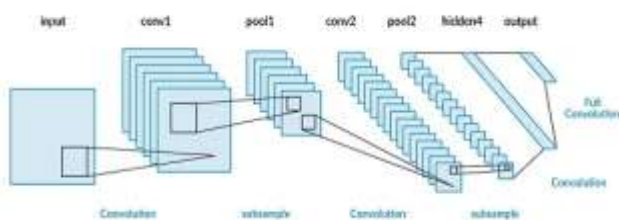


**Figure 5:** Feature Extraction

The architecture proposed in this paper contains three components, feature extraction, feature dimension transposition and output layer. By taking advantage of Dense Net, author utilize dense blocks to conduct the feature extraction These dense blocks extract a feature sequence automatically from each input image output layer is adopted to calculate the loss at the training procedure and output the prediction results in testing phase.

**Classification and Recognition:**

In the classification and recognition step the extracted feature vectors are taken as an individual input to each of the following classifiers. In order to showcase the working system model extracted features are combined and defined using following three classifiers: K - Nearest Neighbor Random Forest Classifier Support Vector Machine.



**Figure 6:** A simple structure of CNN

After the Feature Extraction step, each of the proposed algorithms Convolutional Neural Network (CNN), Deep Belief Network (DBN), Deep Neural Network (DNN) is trained separately with the training images. Classification &

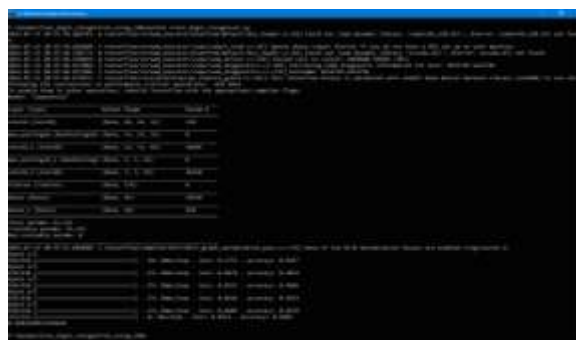
Recognition: After the training step, “the classification & Recognition stage is the decision making part of a recognition system and it uses the features extracted in the previous stage. A feed forward back propagation neural network having two hidden layers with architecture of 54 - 100 - 100 - 38 is used to perform the classification. The hidden layers use log sigmoid activation function, and the output layer is a competitive layer, as one of the digits is to be identified

**4. Results and Discussions**

In this section we present results and discussions for A recognition system for Handwritten Digits Using CNN. In addition, we provide a working example illustrating how A recognition system for Handwritten Digits Using CNN works.

**Creating and training the model**

We provide in this subsection example of the flow of how A recognition system for Handwritten Digits Using CNN works:

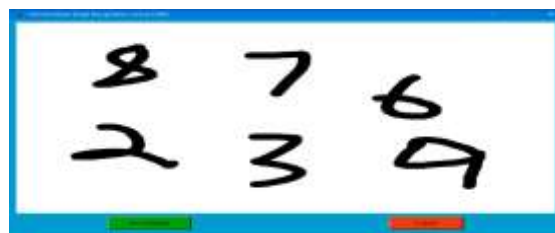


**Figure 7:** Creating and training the model

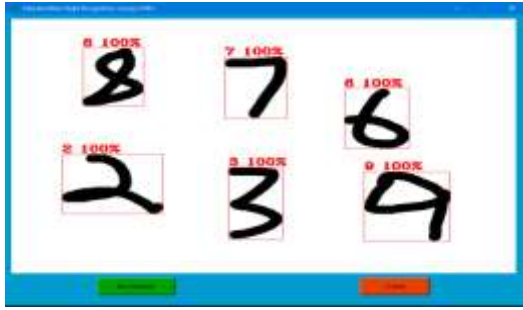


**Figure 8:** Creating GUI to draw the digits

This step will create the GUI to draw the digits.



**Figure 9:** drawing the digits on GUI



**Figure 10:** Recognizing the digits on GUI.

By observing the figure 10 we can notice that all the digits are recognized with 100 % accuracy.

## 5. Conclusion and Future Work

A recognition system for handwritten digit has attracted some interests in the research community by introduction of large dataset. In this paper, the well - known random forest (RF) and convolutional neural network (CNN) algorithms are investigated for handwritten digit recognition on the dataset. Using the dataset as a standard testbed, we have performed some experiments with different preprocessing steps, feature types, and baselines. It is then shown that RFs and CNNs perform competitively with the state - of - the - art methods on this dataset, while CNNs being the fastest if appropriate hardware is available. This paper demonstrates that there exist various ways to create adaptive digits' recognition system. This paper can also be implemented for further on - line handwriting digit recognition system. The data set will be split into two parts, one part for training and other part for testing. By training the models well, the accuracy of the output can be increased. The proposed paper helps to recognize the handwritten digits. This work can be further extended to recognize handwritten characters

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