Handwritten digit recognition using neural network

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ABSTRACT

Handwritten digit recognition is challenging problem researchers had been research into this area for so long especially in the recent years. There are many fields concern with numbers e.g. checks in banks or recognizing numbers in car plates, the subject of digit recognition appears. The main objective is to recognize digits in different applications. E.g. different users had their own handwriting styles where the main challenge falls to let computer system understand these different styles and recognize them as standard writing. Neural network can be proving as an effective tool to solve such problem. Neural network uses various algorithms for learning and classification; such as Back Propagation Algorithm, feed forward etc.

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Introduction

Pattern recognition is an area of study that is well-established and known through years of research, especially in the field of digit recognition which is considered one of the obvious challenges and one of the significant contributors to digit recognition. Recently, a lot of works was done by depending on the computer; In order to let the processing time to be reduced and to provide more results that are accurate, for example, depending on different types of data, such as characters and digits and the numbers are used frequently in normal life operation. In order to automate systems that deal with numbers such as postal code, banking account numbers and numbers on car plates. And an automatic recognition number system is proposed in this study. 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 [1,7]. 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 application. 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.

The proposed system recognizes isolated handwritten digits as the system acquire an image consisting digits, then, the image will be processed into several phases such as image enhancement, pre-processing, and segmentation before recognizing the digit. Neural network is playing an important role in handwritten Digit recognition system A multilayer neural network will be used for the recognition phase; a feed forward back algorithm will be applied for training the network and finally change them into numeral text[2].

Framework: There are many fields concern with numbers, for example, checks in banks or recognizing numbers in car plates, the subject of digit recognition appears. A system for recognizing isolated digits may be as an approach for dealing with such application. In other words, to let the computer understand the numbers that is written manually by users and views them according to the computer process. Here, we present a way to recognize isolated digits exist in different applications. For example, different users have their own handwriting styles where here the main challenge falls to let computer system understand these different handwriting styles and recognize them as standard writing. Figure 1 shows some examples of digits. and in Fig. 2 the scenario of number recognition with Artificial Neural Network Which contains input and hiding layer and output with the number (4) for examination the Network.

Fig. 1: Examples of Handwritten digits

Fig. 2: Scenario of number recognition with artificial neural network
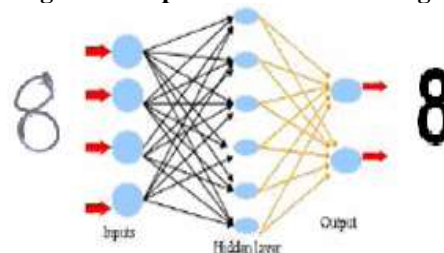
Handwritten digit Recognition System

There are four steps to build the isolated handwritten digit recognition system. These are steps are shown in figure below this is a general diagram for digit recognition system

Fig. 3: A general diagram for handwritten digit recognition

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Image acquisition: We will acquire an image as an input to handwritten digit recognition system. The image can be acquired through the scanner or digital camera or other digital input device. This image should have a specific format. E.g. bmp, jpg format etc.[8]

Pre-processing: It consist of following operation to be perform on acquired image of handwritten digit The goal of pre-processing data is to simplify pattern recognition problem without throwing away any important information. One of the primary reasons for pre-processing is to reduce noise and inconsistent data.

Noisy data can obscure the underlying signal and cause confusion. Pre-processing can often reduce noise and enhance the signal. Pre-processing is normally accomplished by some simple filtering methods.

Another reason is normalization; handwriting produces variability in size of written digits. This leads to the need of scaling the digits size within the image to standard size, as this may lead to better recognition accuracy. We tried to normalized the size of digit within the image and also translate it to a specific position

Segmentation: Since the data are isolated digits, no need to segmentation with regards to the isolated digits, to apply vertical segmentation on the image containing more than one digit will isolate each digit alone.

Feature extraction: Each handwritten digit has some features, which play an important role in pattern recognition. Handwritten digits have many particular features. Feature extraction describes the relevant shape information contained in a pattern so that the task of classifying the pattern is made easy by a formal procedure.

Among the different design issues involved in building a recognizing system, perhaps the most significant one is the selection of set of features. . In feature extraction for classification, it is desirable to extract high discriminative reduced-dimensionality features, which reduce the classification computational requirements. Feature extraction criteria for classification aim to increase class separability as possible.

Classification and Recognition: Neural Network is a network of non-linear system that may be characterized according to a particular network topology. Where, this topology is determined by the characteristics of the neurons and the learning methodology.

The most popular architecture of Neural Networks used in handwritten digits recognition takes a network with three layers. These are: Input layer, hidden layer and output layer. The number of nodes in the input layer differs according to the feature vector's dimensionality of the segment image size. In the hidden layer the number of nodes governs the variance of samples which can be accurately and correctly recognized by this Network. In our system project, the data will be divided using neural networks. In addition, we use the algorithm of back propagation [3].

Neural network Architecture

Commonly neural networks are trained, so that a particular input leads to a specific target output.

There, the network is adjusted, based on a comparison of the output and the target, until the network output matches the target. In both networks we applied feed forward back propagation neural network algorithm.
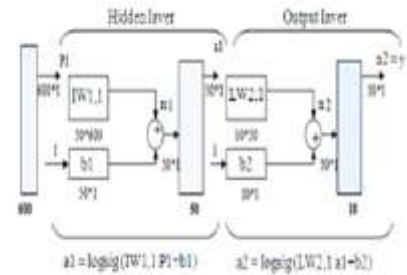
Fig. 4: Two layers network, one hidden and one output, with 50, 10 neurons respective

The first network (two layers) shown in Fig. 4 is consisted of an input layer P1 of a vector of 600 inputs and an input weights IW1,1 of 50×600 and b1 a vector bias with 50 biases connecting the input vector with the hidden layer which consist of 50 neurons. n1 = IW1,1 P1+ b1 represents the input for the 50 neurons of the hidden layer. a1 is the output of 50 neurons of the hidden layer resulted of applying an activation function on n1, a1 is now is the input vector of the next layer which is here the output layer. LW2,1 of 10×50 represents layer weights and b2 a vector bias with 10 biases which connects the hidden layer with the output layer which consist of 10 neurons. n2 = IW2,1 a1+ b2 the input for the 10 neurons of the output layer. a2 is the output of 10 neurons of the output layer resulted of applying an activation function on n2. The output layer of the first network consist of 10 neurons since we need to classify 10 digits [0,1,…,9], each of which correspond to one of the possible digits that might be considered.
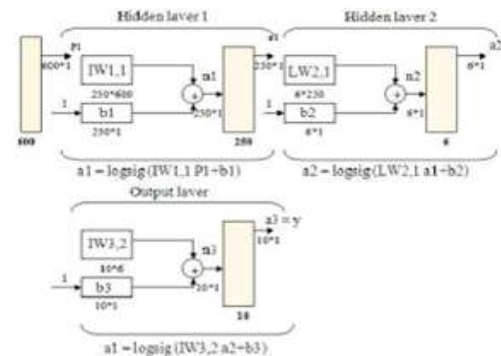
Fig. 5: Three layers network, two hidden and one output, with 250,6,10 neurons respectively for each layer

The architecture of the second network (three layers) as illustrated in Fig. 5 also is the same as the architecture of the first network except that there are an additional hidden layer rather than one hidden layer. The input vector also consists of 600 inputs. There are two hidden layers, the first consists of 250 neurons and the second consists of 6 neurons. The output layer also consists of 10 neurons. Also the same as in the first network, each neuron is used to correspond to one of the possible digits that might be considered.

Both networks are fully connected feed forward network, which means activation travels in a direction from the input layer to the output layer and the units in one layer are connected to every other unit in the next layer up [4].

The back propagation algorithm consists of three stages. The first is the forward phase, spread inputs from the input layer to the output layer through hidden layer to provide outputs. The second is the backward stage, calculate and propagate back of the associated error from the output layer to the input layer

through hidden layer. And the third stage is the adjustment of the weights [5].

The backward stage is similar to the forward stage except that error values are propagated back through the network to determine how the weights are to be changed during training. During training each input pattern will have an associated target pattern. After training, application of the net involves only the computations of the feed forward stage. Hereafter, we will describe the algorithm used to train the network in details [6].

Training algorithm:

1. Initialize weights by zero
2. While E >= 0.000001 iterate steps 3-9

{Feed forward stage}

3. For input layer, assign as net input to each unit (Xi, i = 1…n) its corresponding element in the input vector. The output for each unit is its net input. We have (600×10) input vector
4. For the first hidden layer units calculate the net input and output:

$$net_j = b_j + \sum_{i=1}^{n} x_i w_{ij}, \; o_j = f(net_j)$$

And repeat step 4 for all subsequent hidden layers

5. For the output layer units calculate the net input and output:

$$net_j = b_j + \sum_{i=1}^{n} x_i w_{ij}, \; o_j = f(net_j)$$

{Back propagation stage}

6. For each output unit calculate its error:

$$\delta = (t - o).f'(net)$$

7. For last hidden layer calculate error for each unit:

$$\delta_k = f'(net_j).\sum_k \delta_k w_{kj}$$

And repeat step 7 for all subsequent hidden layers:

{Update weights and biases}

8. For all layers update weight for each unit:

$$\Delta w_{ij}(n+1) = \alpha \delta_j o_i + \Delta w_{ij}(n)$$
$$\Delta b_j(n+1) = \alpha \delta_j + \Delta b_j(n)$$

9. Test stopping condition in step-2

By applying the three stages, feed forward, back propagation of error and adjustment of weights and biases represents one epoch. In our research, the first network used needed 36 epochs to reach the goal and the other network needed 33 epochs to reach the goal. The goal in the first network was until E <= 0.00001, while in the second network was until E <= 0.000001.

Result and Discussion

We have experimented two networks, one with two layers and another with three layers. Both networks have been trained on the same training data set using feed forward back propagation algorithm. We used different ordering for the data set in the training process. The same test data set has been used for testing both networks. In Table 1, we show the results and a comparison between the two networks constructed. We observe that the net2 converged more rapidly than net1 as the number of epochs is greater in net1, in spite of that error rate in net1 is greater than in net2. The accuracy of recognition is 83% in net1 and 88% in net2.

Fig 6: Recognition of Digit

Conclusion

We can conclude that we reached the computer to the human's brain by the importance use of isolated digits recognition for different applications. This recognition starts with acquiring the image to be pre-processed throw a number of steps. As an important point, classification and recognition have to be done to gain a numeral text. In a final conclusion, neural network seems to be better than other techniques used for recognition.

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Table 1: Comparison between the networks constructed

Network	Net 1	Net 2
Number of layers	2	3
Input vector	600.00000	600.00000
Num of neurons in hidden1	50.00000	250.00000
Num of neurons in hidden 2	-	6.00000
Neurons in output layer	10.00000	10.00000
Learning rate	0.10000	0.10000
Error rate	0.00001	0.000001
Num of epochs	40.00000	36.00000
Accuracy	83%	88%