Design of Optimal MLPNN for handwritten digit recognition application

Seema B Kawale, Mrs. Naveeta Kant

Abstract— This paper describes the implementation of a Multilayer Perceptron Neural Network for handwritten digit recognition. The paper provides the knowledge about previously implemented techniques for same application and also provides their merits and demerits. In this paper Optimal Multilayer Perceptron.Neural network has been designed to reduce complexity of the circuit. Results are also stated to verify the concept presented in this paper

Index Terms— Activation function,Ambiguos digits, Feature extraction,Handwritten digit recognition, Multilayer Perceptron Neural network(MLPNN), Neural Network (NN), Optimal Neural Network.

1 INTRODUCTION

Pattern recognition is the application used in many fields which required data to be matched with database present in the system. Different types of Neural network which are trained by features of input data are used worldwide for this application. To achieve results Optimal Multilayer Perceptron neural network [1], which will give output by considering less number of neurons in hidden layer and Input layer, is designed. Many researchers have designed different types of neural network for above application with some merits and demerits. This paper suggests a method to improve the performance by implementing Optimal MLPNN. This paper uses basic theory of Neural network and its pattern recognition application. According to this theory, a detailed discussion that states the method of implementing the Neural Networks for handwritten digit recognition is presented. While designing the Neural network circuit complexity is increased. Solutions have been proposed in this paper to reduce the complexity of the network without altering the output.

This paper provides a detailed design of the MLPNN for handwritten digit recognition. Results have been provided to prove the effectiveness of this design. We predicted we would face one problem that is the similarity between the digits like 1 and 7, 5 and 6, 3 and 8, 9 and 8 [2]. Also many people write same digits in different form, so that would affect the output. If we consider ambiguous digits then accuracy of the network reduces. We have also tested ambiguous digits which will not detect properly. This paper comprises of Section I which gives a basic idea of block diagram followed by Section II, section III and section IV which will explain block diagram. In section V, we have explained neural network. Final section present the results achieved by this project.

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2 SYSTEM OVERVIEW

To achieve the expected result, we have to design a circuit by using different techniques and with the help of certain algorithms.For this application we have designed a circuit which have following three stages:

1. Preprocessing
2. Feature Extraction.
3. Design of Neural network.

Diagram shown below is block diagram of our system:

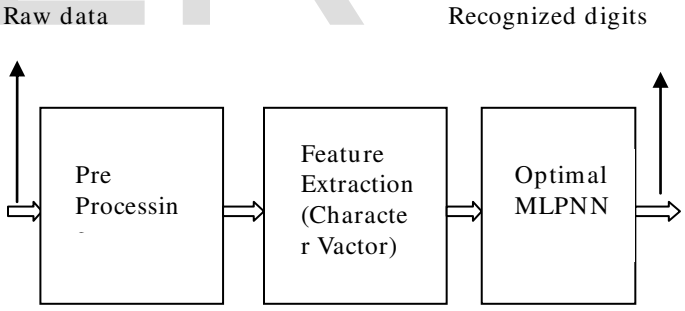

Fig. 1. Block diagram of proposed system[2]

Figure 1 shows three blocks which are basic steps for design of pattern classifier. First block is a Preprocessing block which preprocess the raw data. Feature extraction step will extract features of preprocessed data. For our application we have used character vector feature. This extracted features are given to Neural Network which is designed to compare the training and testing data set. After comparison output is generated.

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3 PREPROCESSING

Preprocessing is a technique applied on raw data to get proper input with reduced noise. Following steps need to be followed while using preprocessing:

A. Image Acquisition

Image acquisition involves collection of data from user. This data can be obtained from scanning the digits or we can use a standard database. In this paper we are using scanned digits for training and testing.

B. Gray Scaling:

For proper processing of digits ,those digits should be converted from color images to gray images[4]. This step convert color digits into gray images. The formula is stated below:

$$Y = 0.299*R + 0.587*G + 0.114B \quad (1)$$

C. Binarization:

The grayscale image is having value between 0-255 and it will increase complexity while processing digits[1].For proper process of analysis and recognition digits are converted .After conversion digits have value between 0 and 1 which will decrease the complexity.

D. Normalization:

Every digits written by different person is different in size i.e. in height and in breadth. This may create problem while training neural network. Also the size of these digits are huge and this created problem in designing recognition system. So all digits chosen as 28X28.Normalization will scale all digits in exactly the same size so that only by pixel value these digits are distinct not in size. This will help to distinguish between digits based only on feature not on size.

4 FEATURE EXTRACTION USING CHARACTER VECTOR

Character vector is widely used feature extraction technique which will provide us pixel value of that digit in particular area. After Binarization step the pixel value of digit is in the range of 0 and 1. This step will give us a value of each pixel present in digit with help of different pixel value in particular area. Following figure shows the Pixel value of the digit with the help of which we can find character vector of each digit. This character vector is different for each digit hence can be used for recognition.

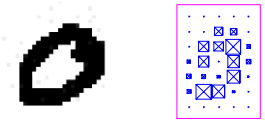

Fig. 2. Pixel Value of Zero

5 MULTILAYER PERCEPTRON NEURAL NETWORK

"A Neural network is a massively parallel distributed processor that has a natural propensity for storing experimental knowledge and making it available for use". [6]

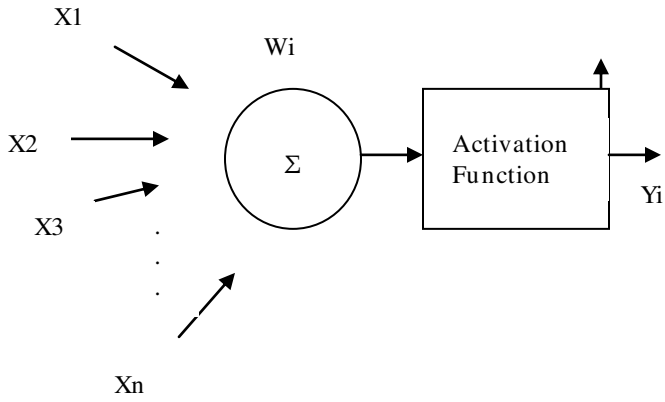

Fig. 3. Simplified Neuron Model [5]

The neuron consist of inputs X1,X2 etc. these inputs are given to hidden layer which process this input by using weights and pass this processed input to output layer. The purpose of weights in the neuron model is to adjust the relative importance of connections to other neurons[7].

The total input I received by the soma of the artificial neuron is [9].

$$I = w_1x_1 + +w_2x_2 + \cdots + w_nx_n \quad (2)$$

$$= \sum_{i=1}^{n} w_ix_i \quad (3)$$

To generate the final output y, the sum is passed on to a non linear filter called Activation Function Or Transfer Function or Squash function which releases the output.

This network as its name indicates is made up of multiple layers. Thus architectures of this class besides processing an input and an output layer also have one or more intermediary layers called hidden layers. The computational units of hidden layer are known as hidden neurons or hidden units. The hidden layer aids in performing useful intermediary computations before directing the input to the output layer.[9]

The input layer neurons are linked to the hidden layer neurons and the weights on these links are referred to as input hidden layer weights. Again the hidden layer neurons are linked to the output layer neurons and the corresponding weights are called as hidden output layer weights. A multilayer feedforward with l inputs neurons m_1 neurons in the first hidden layer, m_2 neurons in the second hidden layer and n output neurons in the output layer is written as l-m_1-m_2-n[9].

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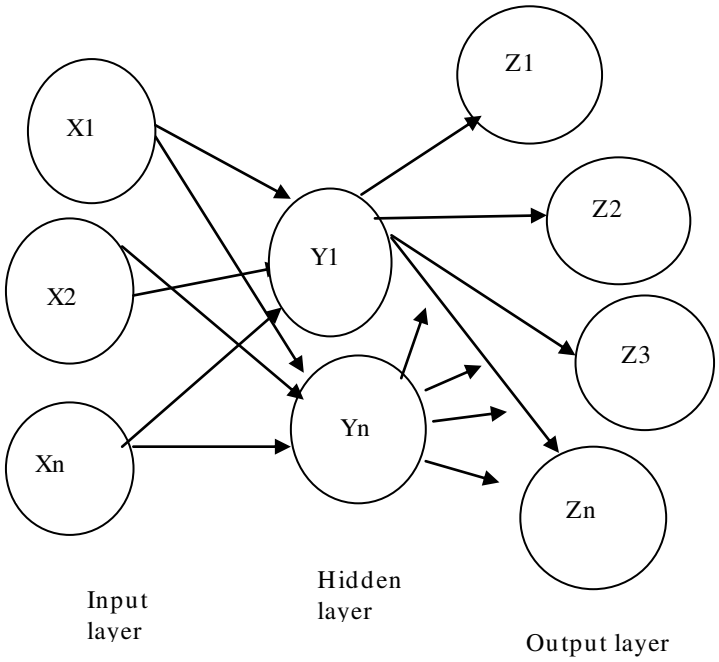

Fig. 4 Multiple perceptron neural network

In this paper we have designed Neural network by using following specifications. As this is optimal Neural network we have tried many combinations of hidden layer and input layer neurons to achieve the output using less number of neurons.

TABLE 1
DESIGNED NEURAL NETWORK

Type of NN	MLPNN
No of input layer Neuron	36
No of hidden layer neuron	37
Activation function	TANSIGMOIDAL
Training samples	100
Testing Sample	10

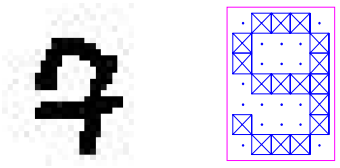

Fig. 5 Recognition of Ambigous digit 7

In Figure 5, Seven is ambiguous digit and it is recognized as nine. Such ambiguous digits will not give proper output.

Fig. 6 Recognition of Ambigous digit 1

In Figure 6, Original digit is one but it is recognized as two. We have taken 100 such samples and tested NN for these digits.
The Experimental results are summarized in following table:

TABLE 2
EXPERIMENTAL RESULTS SUMMARY

Class	samples	Ambiguous digits		Normal digits	
		True detection	False detection	True detection	False detection
0	100	69	31	94	6
1	100	58	42	94	6
2	100	72	28	93	7
3	100	72	28	89	11
4	100	78	22	95	5
5	100	70	30	90	10
6	100	67	33	93	7
7	100	42	58	92	8
8	100	48	52	90	10
9	100	49	51	95	5

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6 RESULT

After design and analysis of neural network two types of digits i.e. normal and ambiguous ones were tested. Ambiguous digits are those digits which are not written properly and hence they are not recognized properly. According to table 2 the average false detection for ambiguous digits is 37.5% whereas it is 7.5% for the normal digits.

7 CONCLUSION

Increased number of neurons do not yield the best results rather it complicates the circuit. The time required for training is more as we increase the number of hidden layer neurons leading to delayed output. To overcome these disadvantages a method of optimal MLPNN has been proposed. This paper introduces a scheme to improve the results by using lesser number of neurons in the hidden layer.

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