Homework 3 - Character Recognition Using Neural Network

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In this assignment, I have written a MATLAB code to predict the handwritten numbers provided as bitmaps in the Optical Recognition of Handwritten Digits dataset. The overall accuracy varies based on the number of hidden layers and the number of neurons in each layer. That being said, I have written a code to calculate the accuracy for different numbers of hidden layers and neurons and achieved a 96% accuracy as maximum. This report is structured as follows: first, I will explain the design of the neural network, then I will show the different results I got by changing the neural network parameters.

Neural Network Design:

The number of input and output nodes depend on the number of features and the number of labels (clusters) in the dataset respectively. So, we have 64 inputs and 10 outputs with extra node added as bias. In order to determine the number of hidden layers and the number of neurons in each layer, I did some experiments to see the change on the overall accuracy of the system.

First experiment: use one hidden layer and change the number of neurons. I measured the accuracy for the following set of neurons: [1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49]. The results are shown in Figure 1:
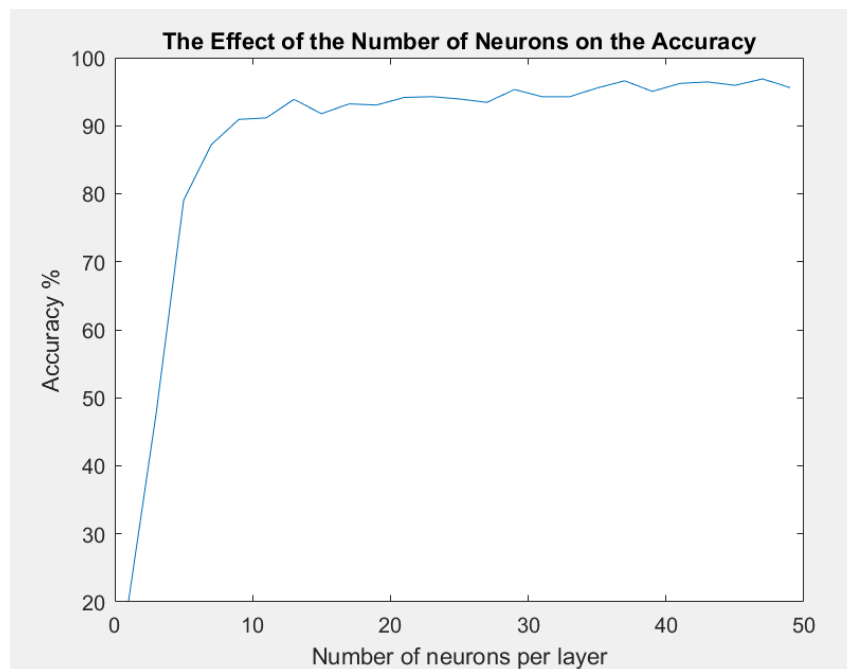
As shown in Figure 1, the accuracy of the system improves as we add more neurons in the hidden layer. This improvement keeps growing until we have ~11-13 neurons in the hidden layer. After that, the accuracy stabilizes around 92%. Based on these results, adding neurons more than ~13 neurons will not have a significant improvement on the overall accuracy.

Second Experiment: use two hidden layers and change the number of neurons. I measured the accuracy for the following set of neurons: [1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49]. The results are shown in Figure 2:
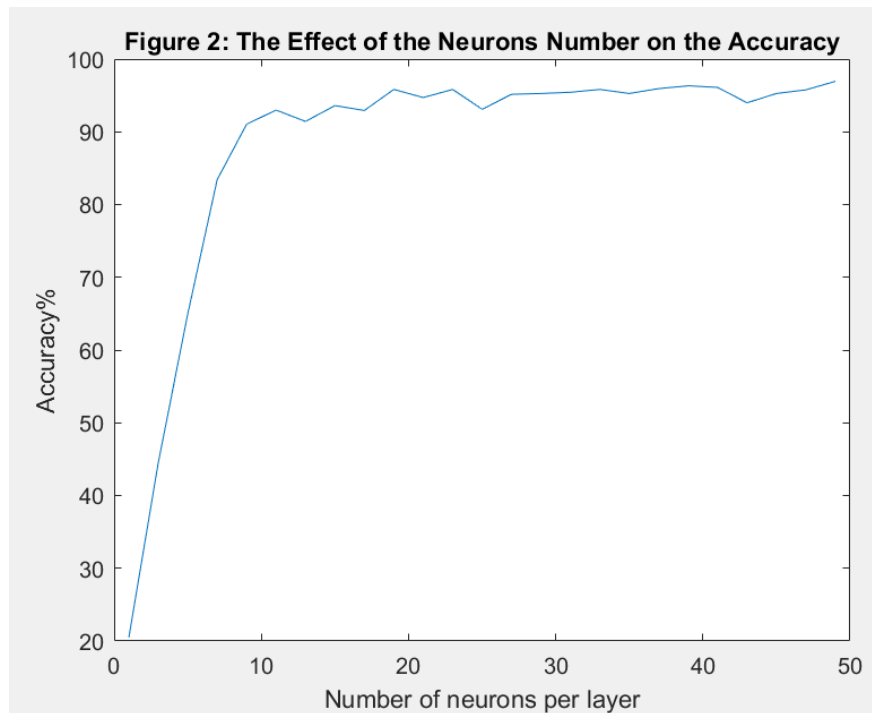

The results shown in Figure 1 are very similar to the results shown in Figure 2 with insignificant improvement. Table 1 shows a comparison between using one hidden layer and two hidden layers with different number of neurons per layer.

Table 1: A comparison between the results of experiment 1 and 2

Number of Hidden Layers	Maximum Accuracy	Average Accuracy After 11 neurons
One hidden Layer	96.88% with 47 neurons	93%
Two Hidden Layers	96.94% for 49 neurons	94.88%

Third Experiment: based on the results achieved in experiment 1 and 2, the improvement of the accuracy is insignificant after a certain number of neurons. Therefore, I experimented how the accuracy changes as we increase the number of hidden layers and keeping the number of neurons fixed (I picked 15 as the number of neurons). Figure 3 shows the accuracy achieved by using different number of hidden layers. As shown in Figure 3, the increase of layers' number has not improved the accuracy significantly and the average accuracy was found to be 93.8%.

The Effect of Hidden Layers Numbers on the Accuracy
(Number of neurons =15)
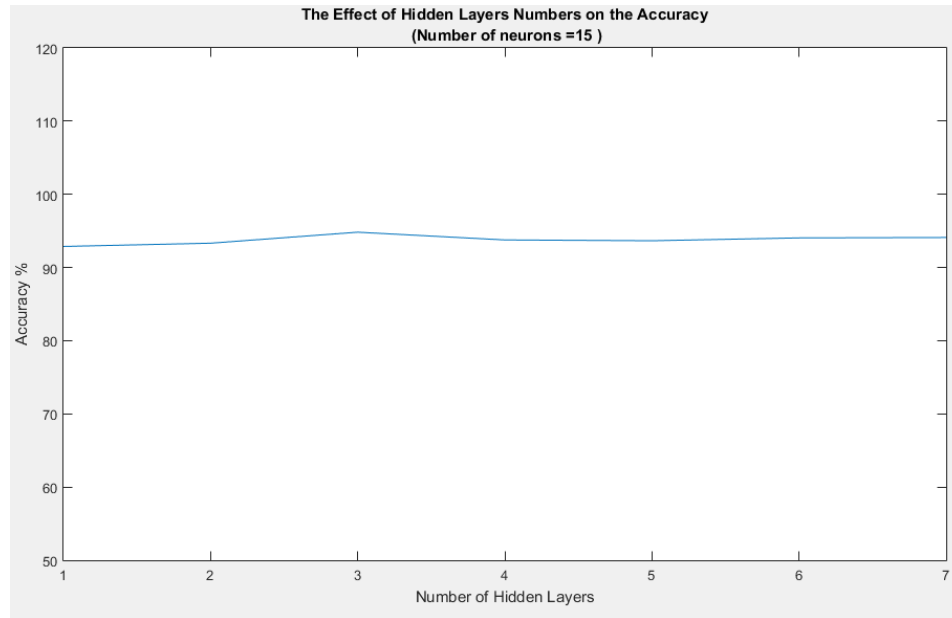
Given the results found in the experiments discussed earlier in this report, it would be feasible to use only one hidden layer and more than ~13 neurons in each layer. Figure 4 shows the design of the neural network:
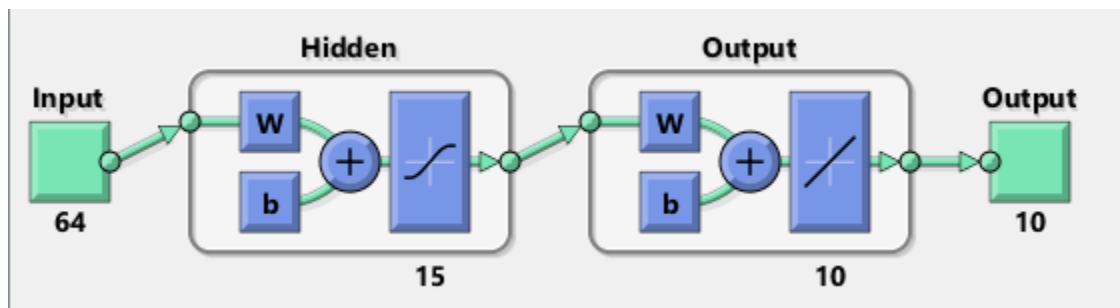

Figure 4: the design of the neural network

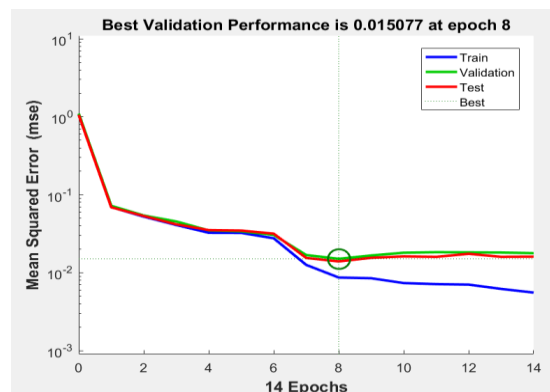Figure 5 shows the performance of the network using one hidden layer and 15 neurons:

Figure 5: performance of the neural network
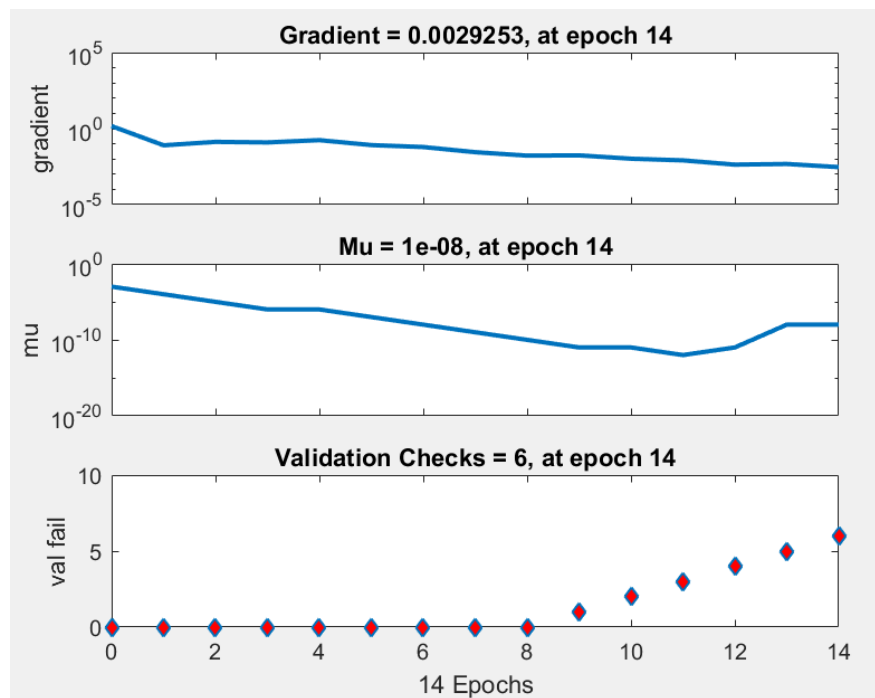
Figure 6 shows the training statistics:

Figure 6: training statistics

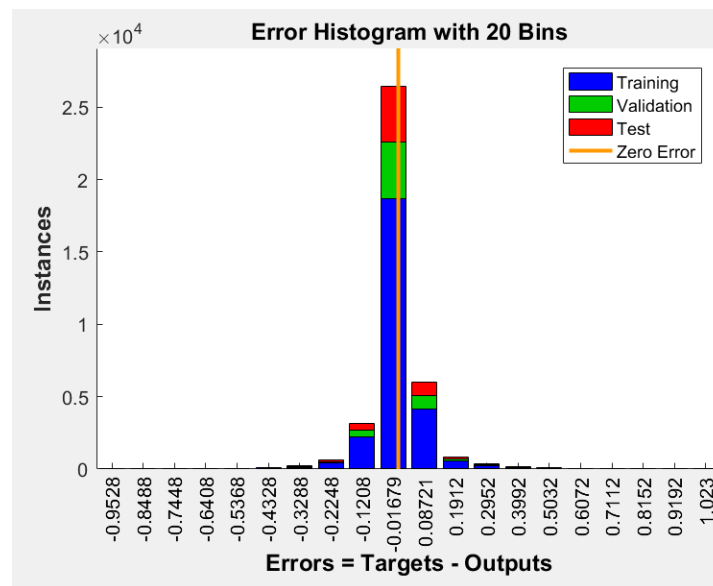Figure 7 shows the error histogram of the training model:

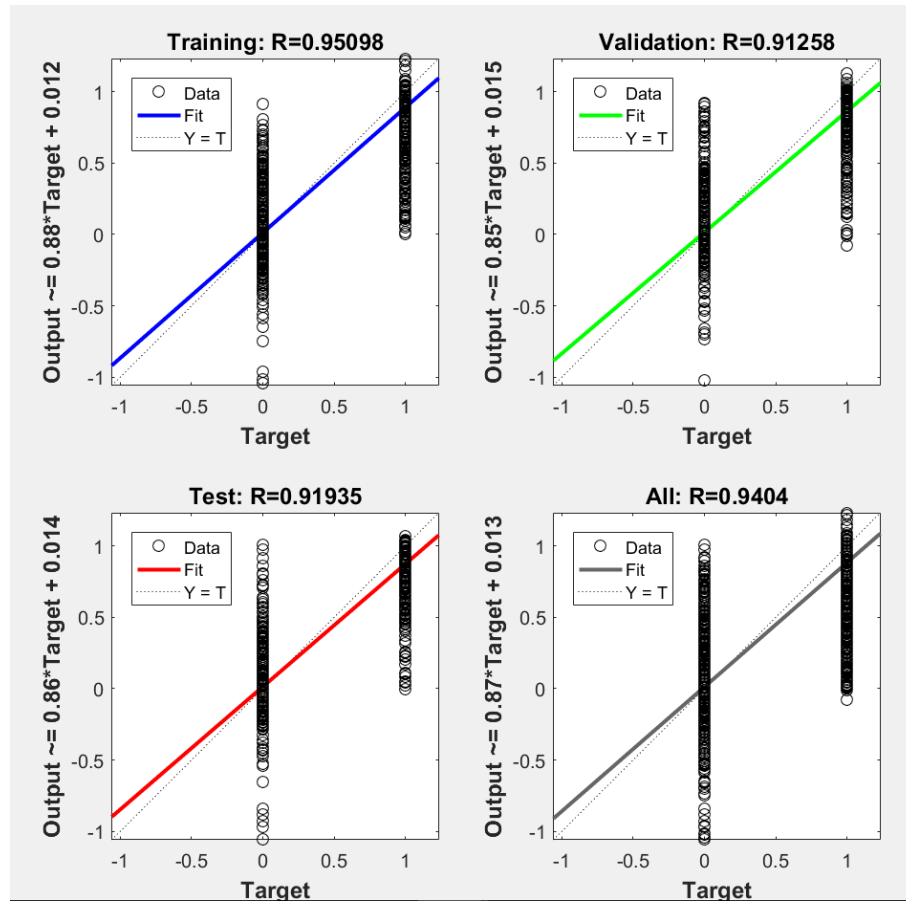Figure 7: error histogram

Figure 8 shows the regression:

Figure 8: Regression

Conclusion:

In this assignment I have designed and implemented a neural network to detect the handwritten numbers in the given dataset. Based on the results experiments I have done, I decided to use only one hidden layer with a number of neurons more than ~13. The experiments show that the number of neurons affects the accuracy of the system up to certain level. The accuracy achieved is more than 93% in average.