CSE 474 Programming Assignment #1
Neural Networks

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- *Introduction*

In this assignment, we implemented a Multilayer Perceptron Neural Network and evaluate its performance in classifying handwritten digits. We also used the same network to analyze a hand-drawn images dataset and compare the performance of the neural network against a deep neural network using the TensorFlow library.

- *Explanation of how to choose the hyper-parameters regularization term λ and number of hidden units for Neural Networks*

Fixed n_hidden and plot the accuracy change along with the change of λ:

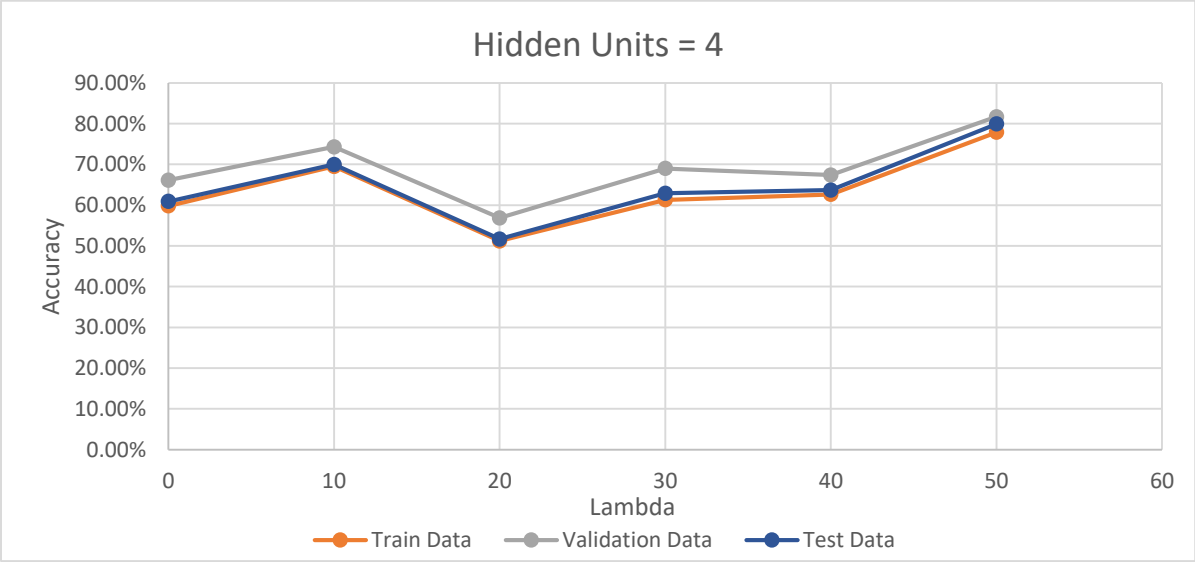


Fig. 1

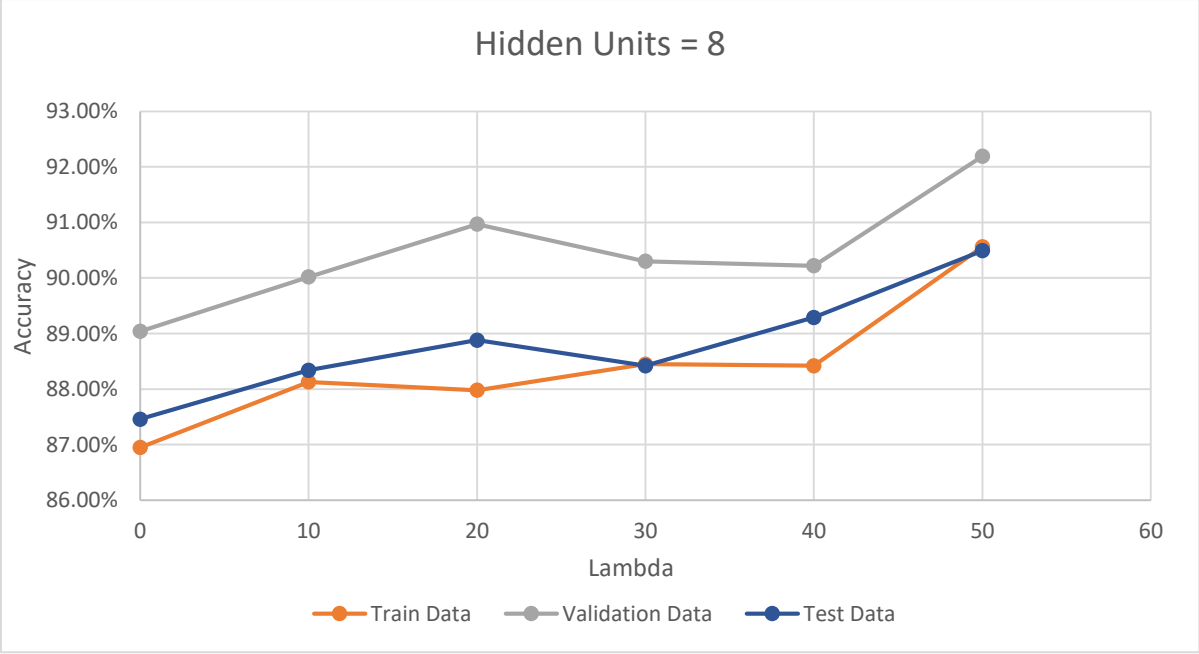


Fig. 2

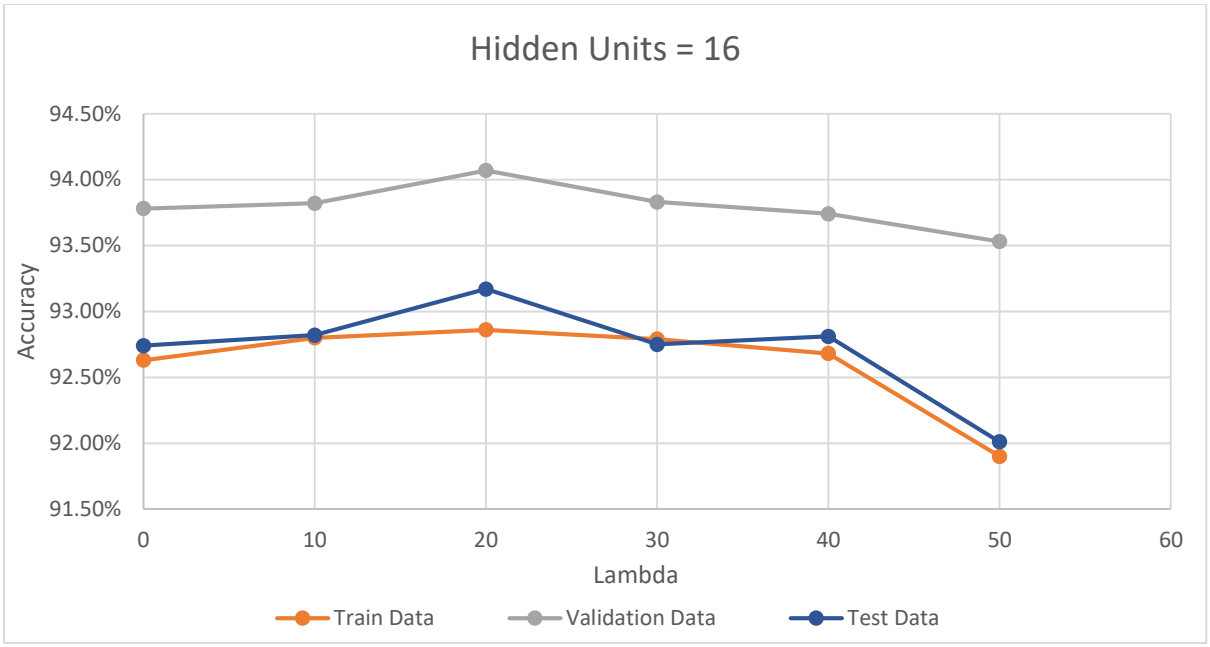

Hidden Units = 16
94.50%
94.00%
93.50%
93.00%
92.50%
92.00%
91.50%
Accuracy
0
10
20
30
40
50
60
Lambda
Train Data
Validation Data
Test Data

Fig. 3

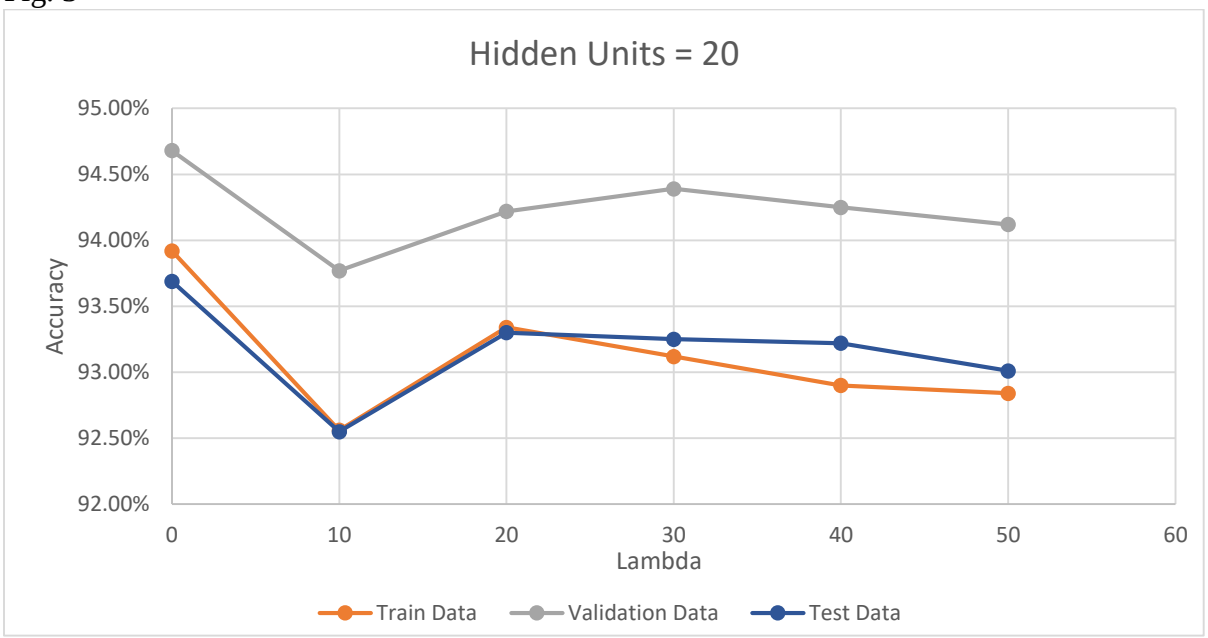

Hidden Units = 20
95.00%
94.50%
94.00%
93.50%
93.00%
92.50%
92.00%
Accuracy
0
10
20
30
40
50
60
Lambda
Train Data
Validation Data
Test Data

Fig. 4

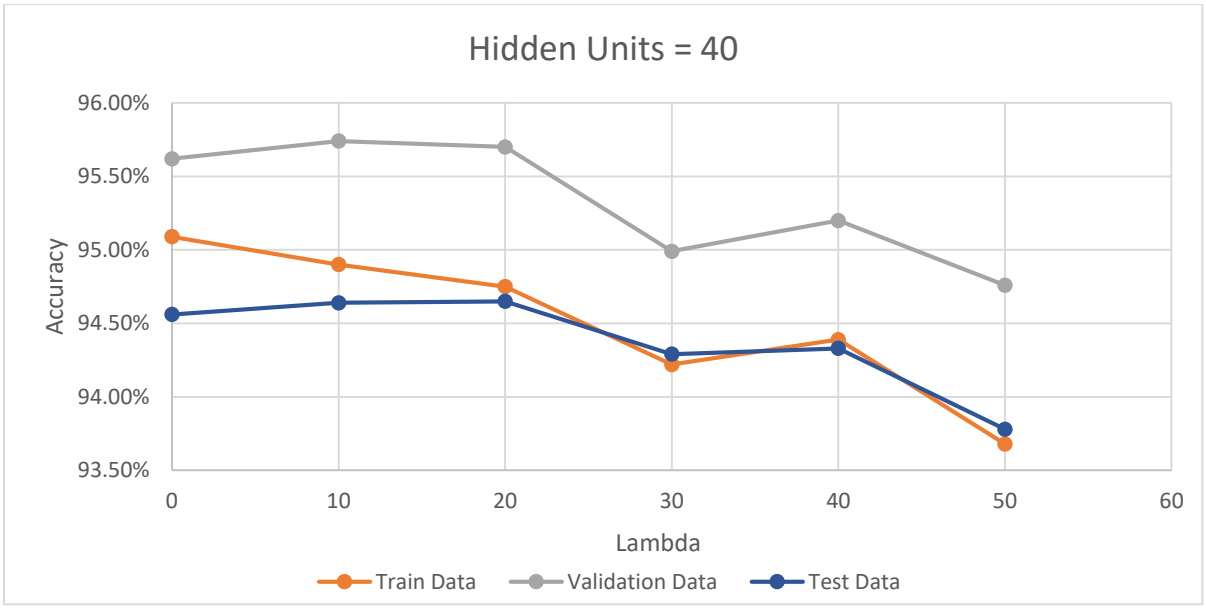


Fig. 5

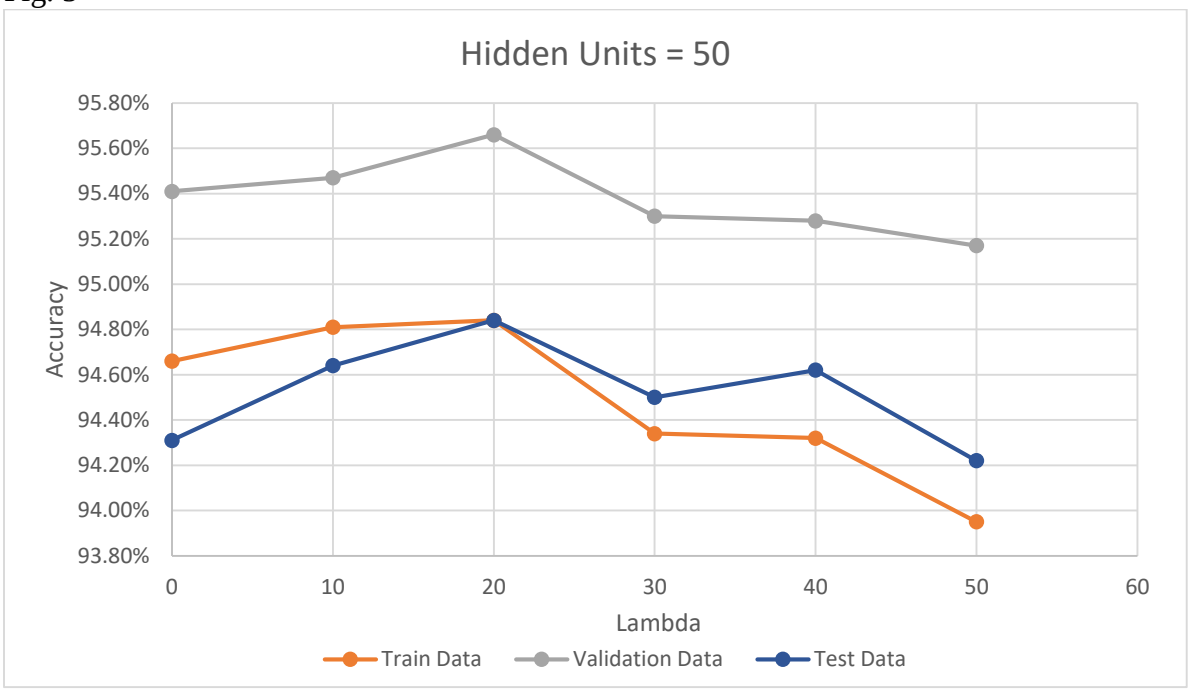


Fig. 6

Fixed λ and plot the accuracy change along with the change of n_hidden:

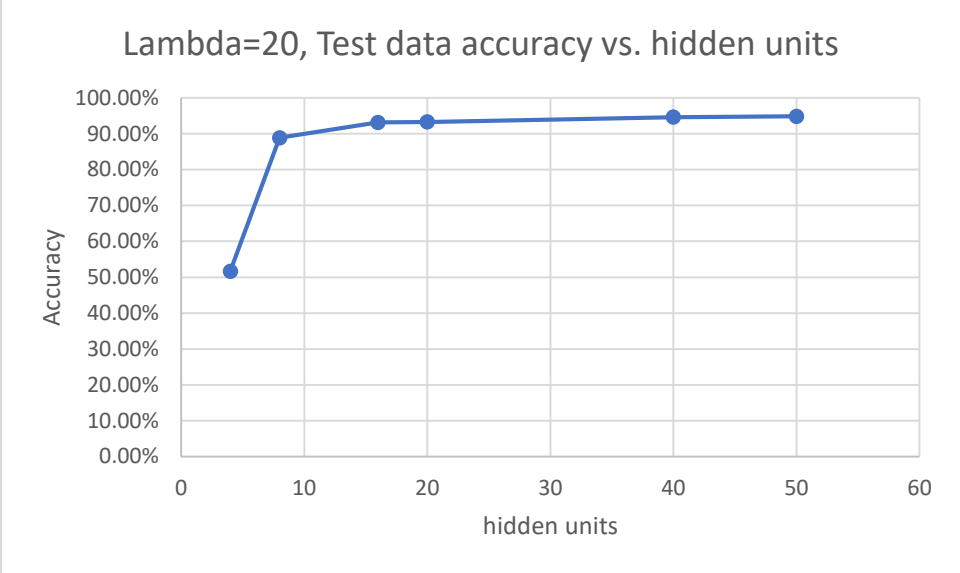


Fig. 7

Analysis:

We tested six λ values: 0, 10, 20, 30, 40, 50, and six hidden node values: 4, 8, 16, 20, 40, 50. Then we plot the graphs (as above).

From Fig. 7, we can observe that when λ is fixed, the accuracy increases along with number hidden units increase. Thus, when number of hidden units are 50, we can get the highest accuracy.

From Fig.1 to Fig. 6, we can observe that when the number of hidden nodes increase, the overall accuracy increases.

From Fig. 1 to Fig. 6, we can observe:

1. When there are 4 hidden nodes, the highest test accuracy occurs when $\lambda = 50$. The highest accuracy is 79.92%.
2. When there are 8 hidden nodes, the highest test accuracy occurs when $\lambda = 50$. The highest accuracy is 90.49%.
3. When there are 16 hidden nodes, the highest test accuracy occurs when $\lambda = 20$. The highest accuracy is 93.17%.
4. When there are 20 hidden nodes, the highest test accuracy occurs when $\lambda = 0$. The highest accuracy is 93.69%.
5. When there are 40 hidden nodes, the highest test accuracy occurs when $\lambda = 20$. The highest accuracy is 94.65%.
6. When there are 50 hidden nodes, the highest test accuracy occurs when $\lambda = 20$. The highest accuracy is 94.84%.

From six observations above, we can find that when there are 50 hidden nodes, and $\lambda = 20$, we can have the highest test accuracy among all of these experiments. The highest frequency is 94.84%. Thus, when there are 50 hidden nodes and $\lambda = 20$, we can have our best accuracy: 94.84%.

- *Training time analysis*

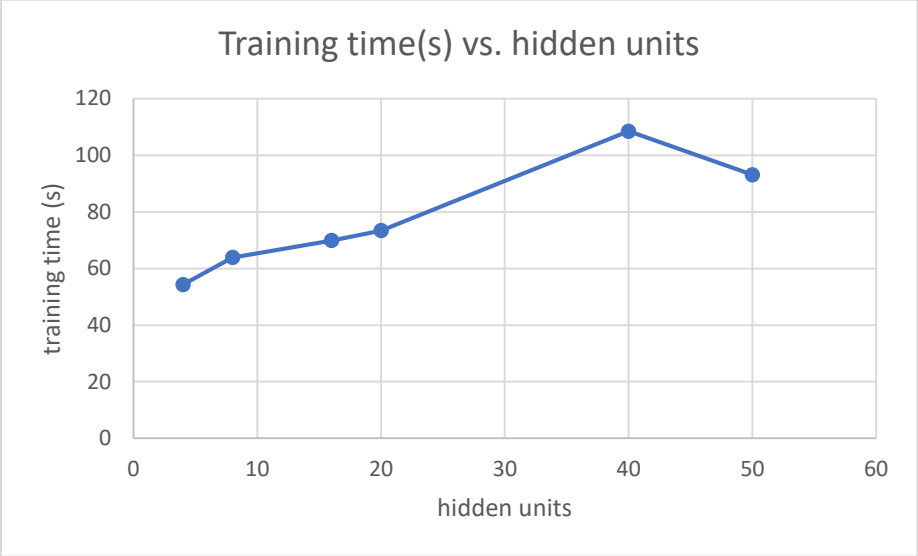


Fig. 8

The plot above is the data when $\lambda = 30$. Then we tried different number of hidden nodes: 4, 8, 16, 20, 40, 50, and got the training time respectively. From the plot, we can observe: when λ is fixed, the training time will increase with hidden units increase overall. However, there is a peak training time when number of hidden units are 40.

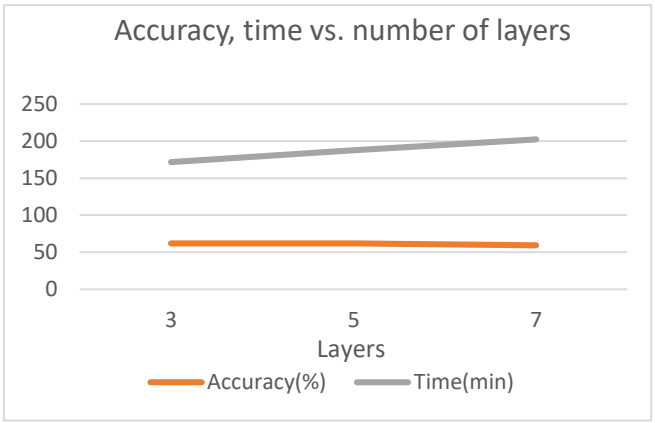
- *The accuracy on AI_quick_draw dataset using your code*

```
Training set Accuracy:55.19444444444444%

Validation set Accuracy:55.489999999999995%

Test set Accuracy:55.17999999999999%
```

From the data, we can find that the training set accuracy, validation set accuracy, and test set accuracy are close.

- *Add more layers to the deep neural network to create networks and compare both the accuracy and training time among those deep neural networks*

Layers	Accuracy	Time
3	62.004%	171.75min
5	61.776%	187.5min
7	59.3%	202.15min



. Fig.9

The accuracy decreases with the number of layers increase. However, the time increases with the number of layers increase. The data shows that the accuracy will not be better if we add more layers, and the running time

increases with the layers increase. Thus, the best performance occurs when there are three layers: the accuracy is 62.004%, and time is 171.75mins.