CSE4/574 FALL 2022 Introduction to Machine Learning

Programming Assignment 1

# Handwritten Digits Classification

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Hype Parameter for Neural Network:

There is a lot of factors that go in choosing the different aspects of a neural network which some of them to be considered are no. of hidden layers, lambda, no. of iterations etc. After taking the data that was given to us and implementing it in the code by inserting different lambda values and obtaining the resultant validation accuracy, we get the following graph.

Lambda vs Validation Accuracy
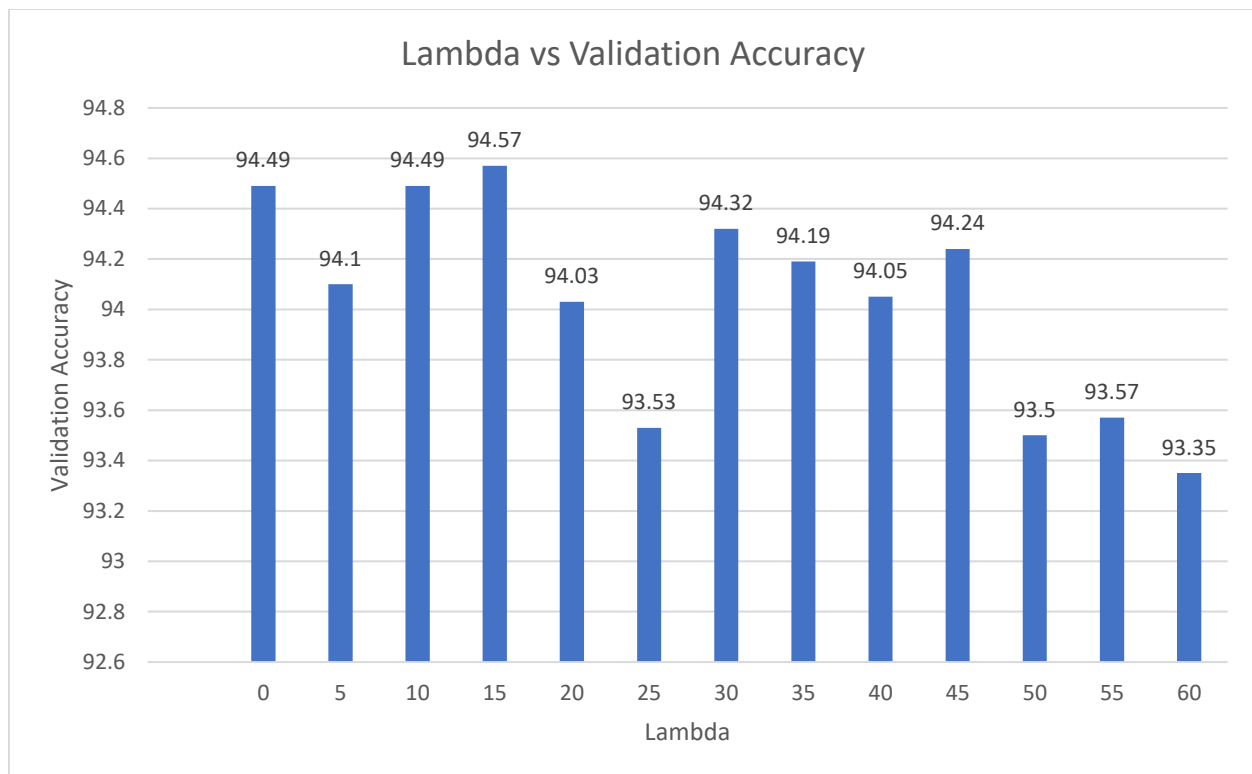
For the above graph we have kept the no. of hidden units and iterations as 50 and we have varied the lambda value from 0-60. As you can notice that the validation accuracy does increase to a point but then slowly starts decreasing until the end.

Now just to verify how the values are acting for further iterations we have increased the no. of iterations to 100 and kept the no. of hidden units at 50 and plotted the graph which can be seen below.
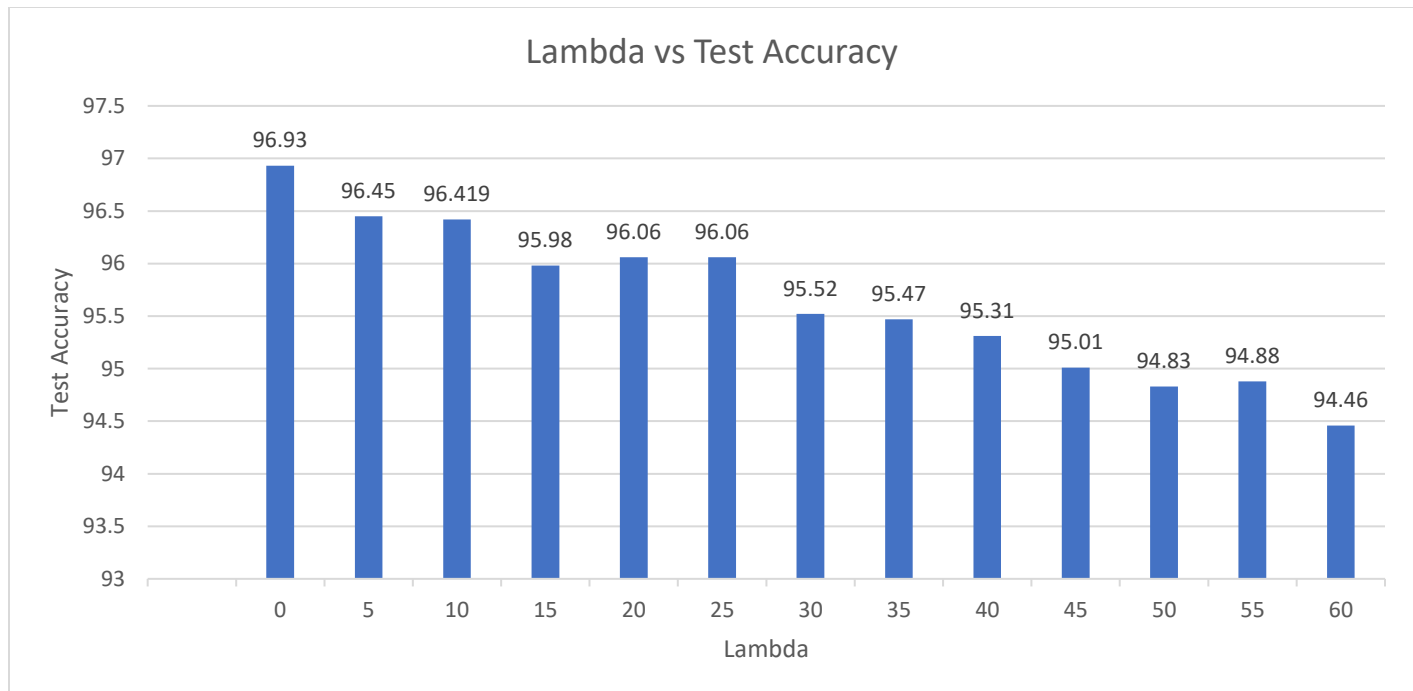
Lambda vs Validation Accuracy
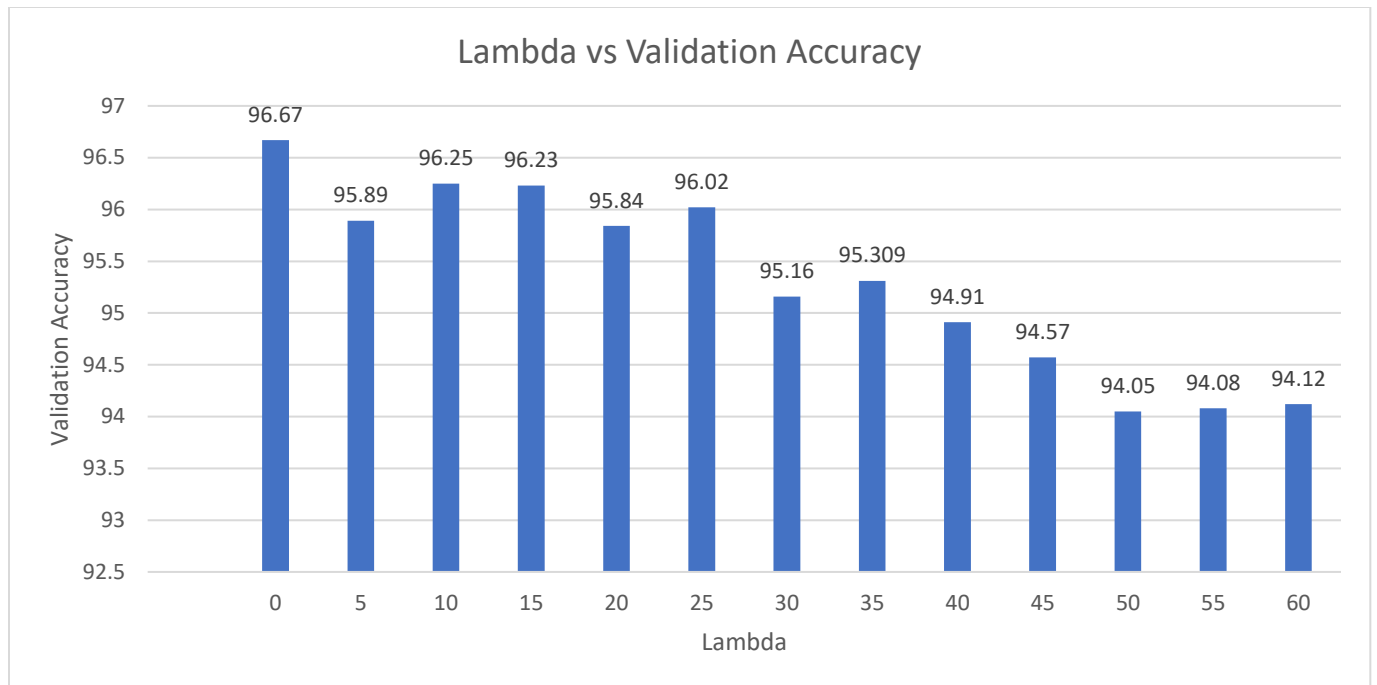
It can be seen as well the validation accuracy does keep on gradually decreasing which can be confirmed as the same pattern from the above graph.

Now we can have a look at the test data below,
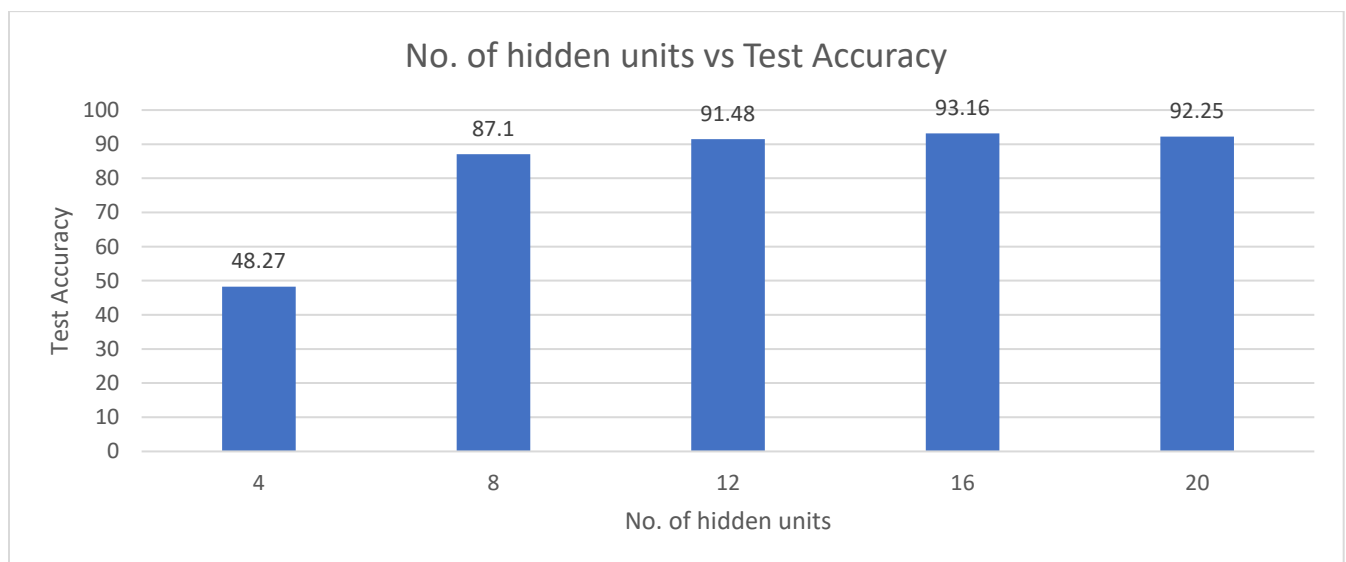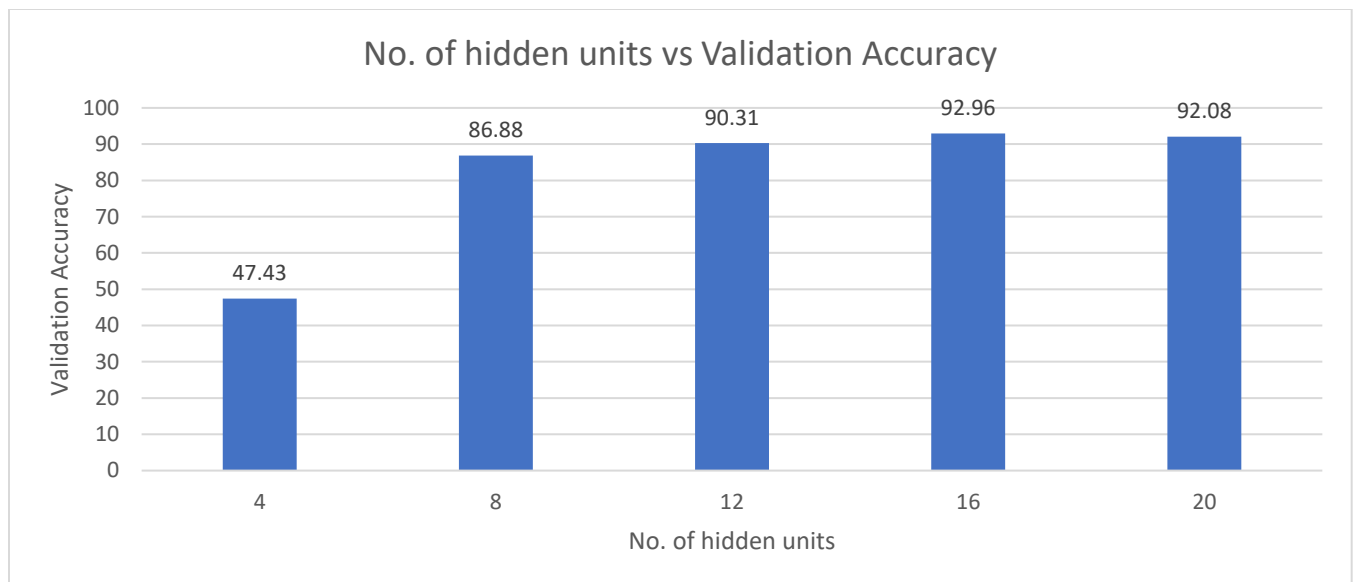
Lambda vs Test Accuracy
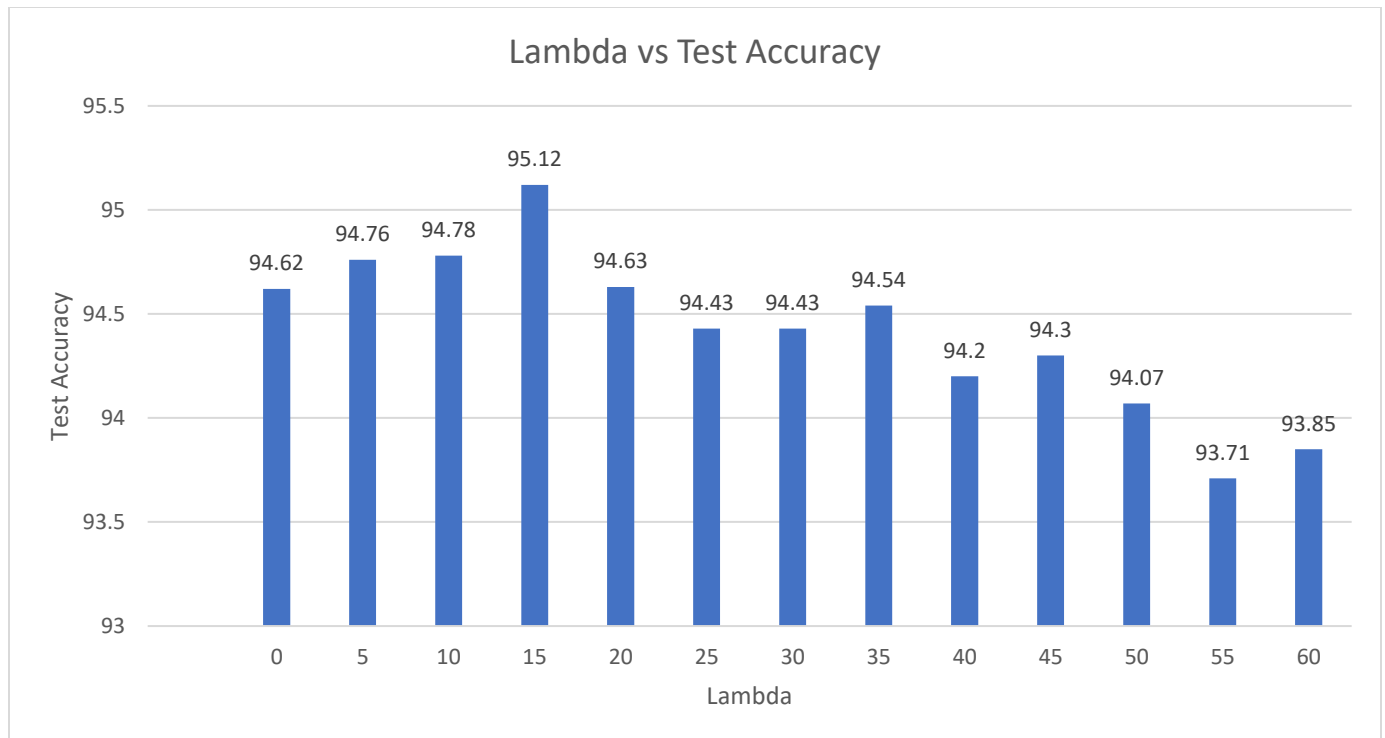
After keeping the no. of hidden units and iterations 50 we get the following graph which follows the same pattern of gradually decreasing at the end point.

We ran the code even at 100 iterations and 50 hidden units to see the pattern and it can be seen in the below graph.
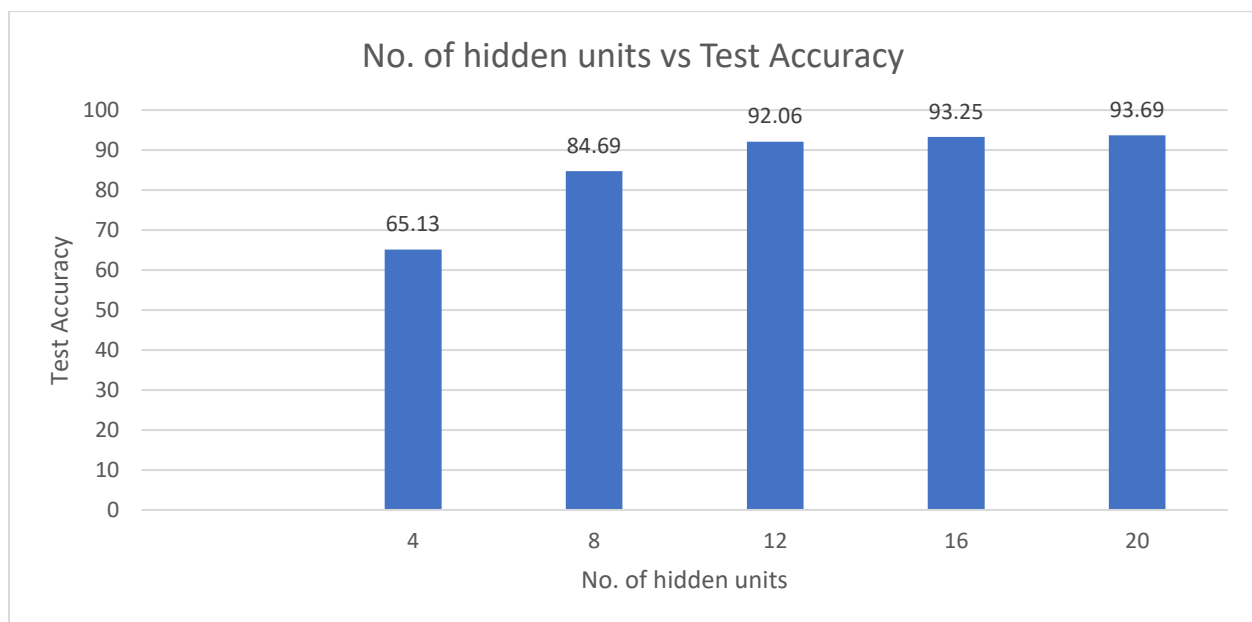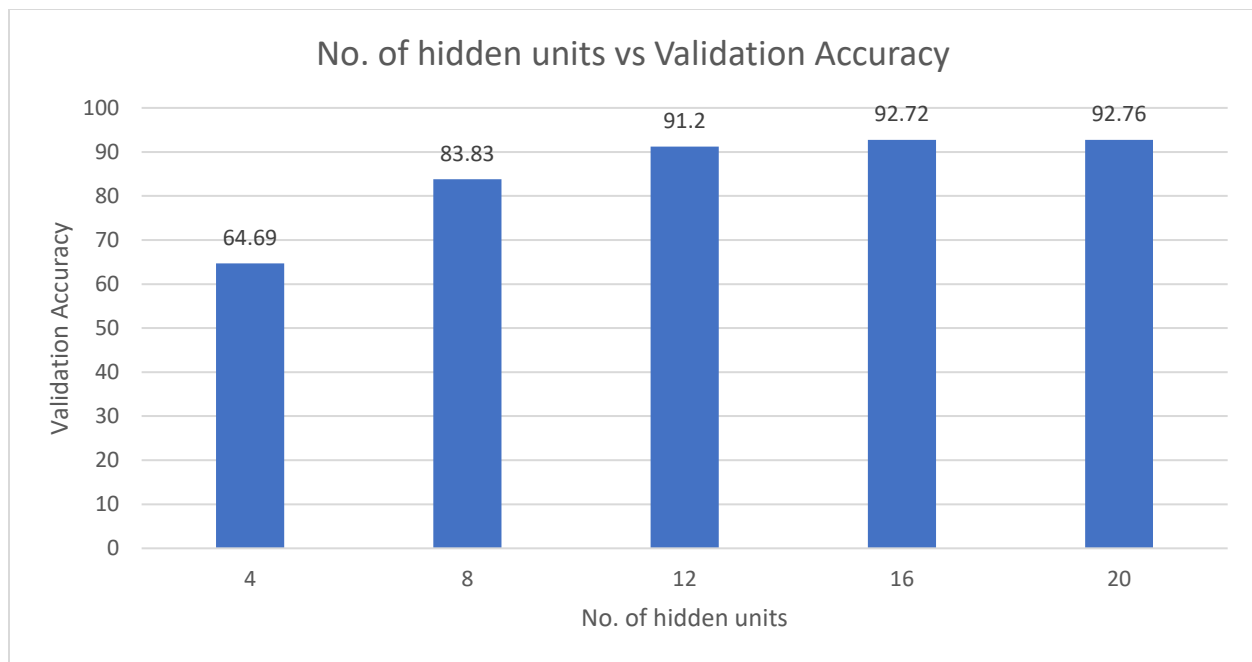
Lambda vs Test Accuracy

As seen in the above cases where we kept the same no. of hidden units, here we are changing the no. of hidden units to 4,8,12,16,20 and keeping the lambda constant at 0 having iteration 50 we are plotting the graph for both validation and test accuracy which can be seen below.

No. of hidden units vs Validation Accuracy

No. of hidden units	Validation Accuracy
4	47.43
8	86.88
12	90.31
16	92.96
20	92.08

No. of hidden units vs Test Accuracy

No. of hidden units	Test Accuracy
4	48.27
8	87.1
12	91.48
16	93.16
20	92.25

Looking at the above 2 graphs we can we see the accuracy starts off low but then jumps at the 2nd hidden unit and keeps increasing until the end.

Now to see if there is a similar pattern, we will increase the lambda value to 20 and keep the same no. of hidden units and same iteration which is 50 and the following graphs will show us.

No. of hidden units vs Validation Accuracy

No. of hidden units	4	8	12	16	20
Validation Accuracy	64.69	83.83	91.2	92.72	92.76

No. of hidden units vs Test Accuracy

No. of hidden units	4	8	12	16	20
Test Accuracy	65.13	84.69	92.06	93.25	93.69

As you can see from the above figures the starting accuracy at hidden unit 4 is higher but as before when lambda is 0 follows the same pattern where it keeps increasing till the end which lets us know that whenever we increase the no. of hidden units, we can get a higher accuracy value.

Now if we were to look at training time and how much time it takes with those particular hidden units while keeping lambda 0 and iteration at 50, we get the following plot.
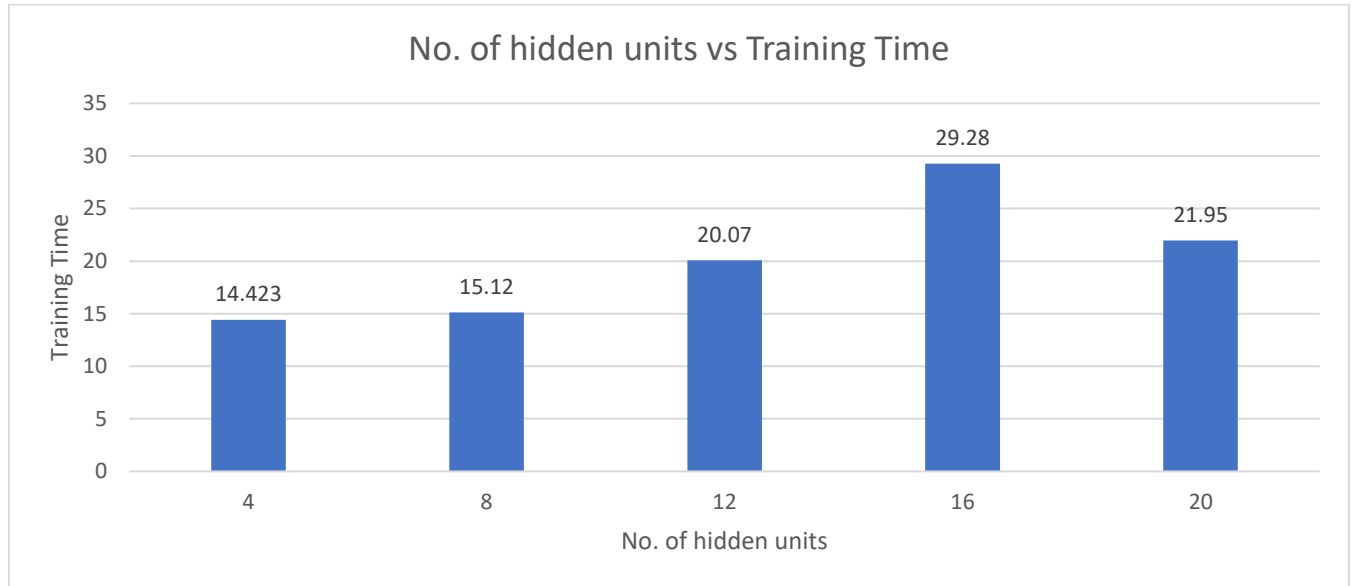
From the above figure we can see that the training time does increase when no. of hidden units increases but up to only a certain point and then it decreases.
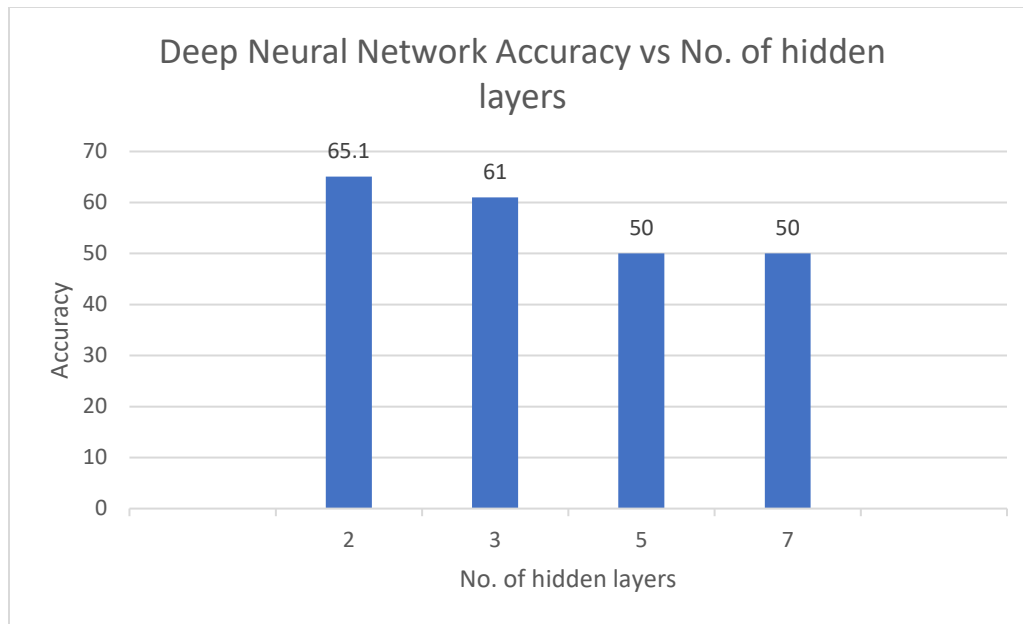
Accuracy method on the CelebA data set:

For the CelebA data set, we ran the facenn script python script and we achieved an accuracy as shown in the below graph
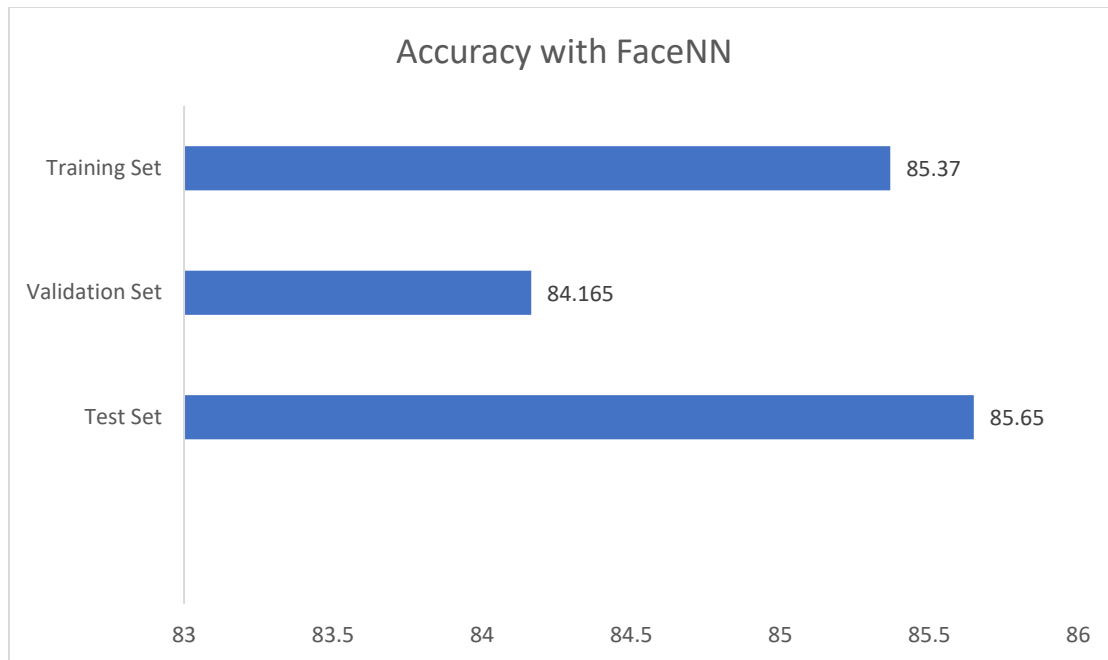
Comparasion of CelebA results with Deep Neural Network Accuracy:

When we run the code with the following hidden layers, we get the figure below

Deep Neural Network Accuracy vs No. of hidden layers

In this case we can notice that increasing no. of hidden layers doesn't specifically increase the accuracy but it does the opposite and it does decrease at hidden layer 7.

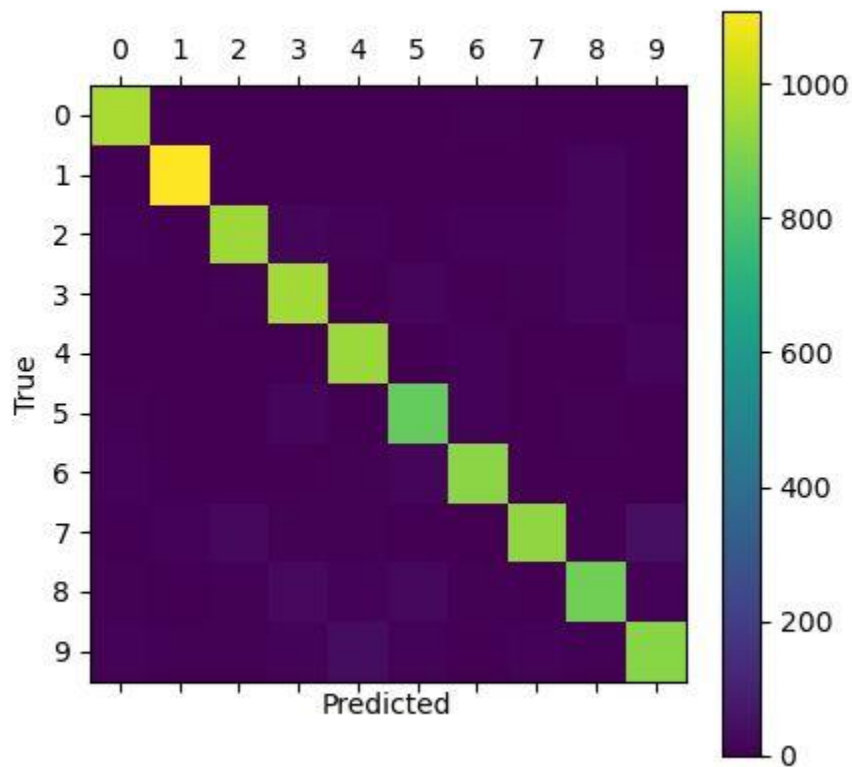**Comparison of performance of the deep neural network vs convolution neural network:**

Using the cnnscript, after running the code we were able to obtain the Test error which contained the accuracy and avg loss and also the confusion matrix was shown which can be all seen in the following figures.
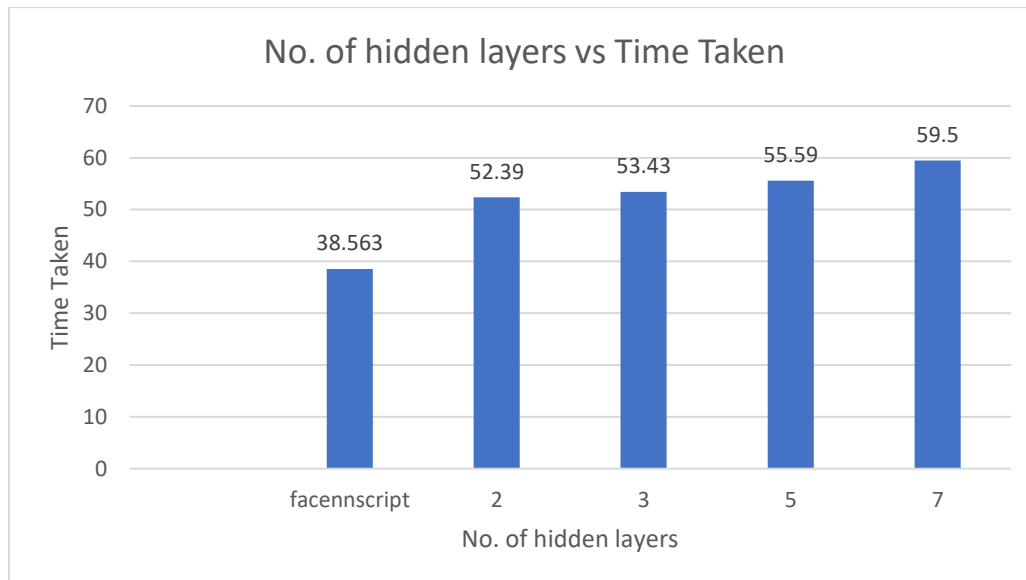
```
Test Error:
 Accuracy: 10.2%, Avg loss: 2.302679

Confusion Matrix:
[[ 956    0    2    1    0    4   12    1    4    0]
 [   0 1113    4    2    1    1    3    0   11    0]
 [   9    2  959   13    8    0    5   12   23    1]
 [   1    2   13  949    0   11    0   10   17    7]
 [   0    2    4    1  936    0   14    2    3   20]
 [   6    1    2   29    5  818   13    1   13    4]
 [   6    3    1    0    9   10  926    1    2    0]
 [   0   10   26    5    4    1    0  942    3   37]
 [  10    4    7   24   10    8    7   10  879   15]
 [   6    6    6   12   24    5    0   16    6  928]]
```

Comparison of performance of single vs deep neural network:

No. of hidden layers vs Time Taken

As we can see from the above figure that compared to other hidden layers facenn does take the least amount of time. Also, it can be noticed when we increase the no. of hidden layers the more time it takes for the task to be completed.

Comparison between performance of Deep Neural Network and Convolutional Neural Network in terms of accuracy on Training time and Test data:

Below are the two figures shown which gives us a better idea on how the performance has been conducted on each neural network and how we compare them.

CNN vs Deepnn in terms of Test Accuracy

CNN vs Deepnn in terms of Training Time(s)
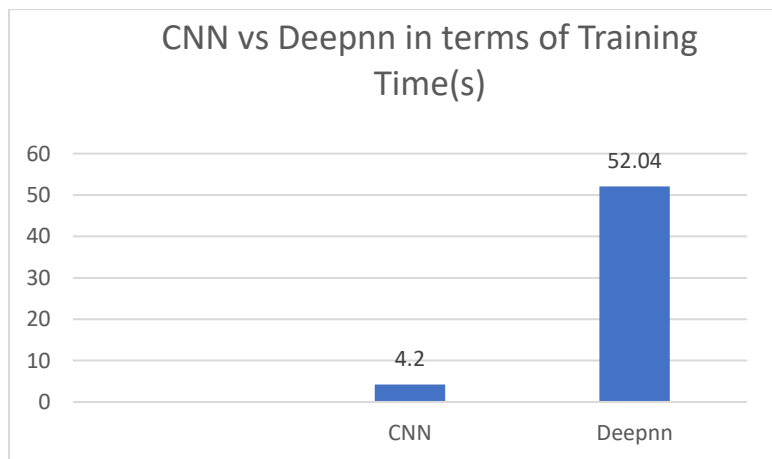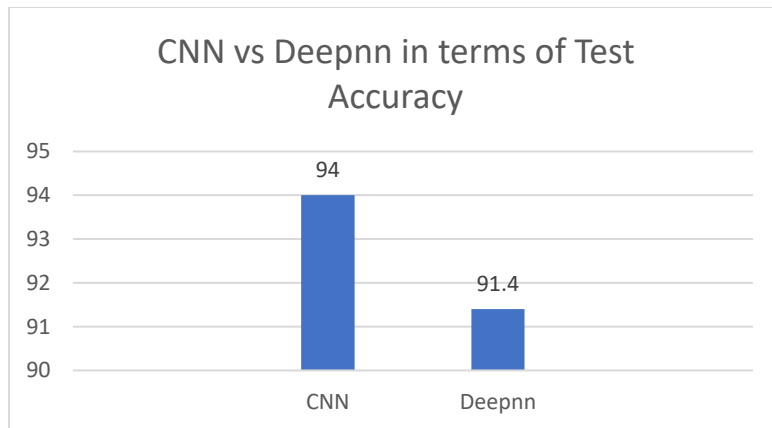
From the above comparison it is clear that when it comes to Test Accuracy that CNN has a higher accuracy to Deepnn when conducting a test and in terms of Training time CNN takes way less of time than Deepnn by a huge margin.