

CSE4/574 Introduction to Machine Learning

Programming Assignment 2 Report

Handwritten Digits Classification

Group 18

Members:-

SAI SANDEEP LANKISETTY (50469202)

DESIREDY SAI SANKEERTHANA(50465523)

HEMANTH KUMAR MUTTA(50475286)

1.) Selecting Hyper-Parameters using Neural Network Script:.

- The hyper parameters of the neural network are number of hidden units and lambda(regularization term).
- Here we executed nnScript.py file for different lambda values [0, 5, 10, 15, 20, 30, 40, 50, 60] and different values of hidden units (4, 8, 12, 16, 20, 30, 40, 50, 65, 80)
- We have chosen hyper parameters lambda= **15** and hidden_units = **50**.

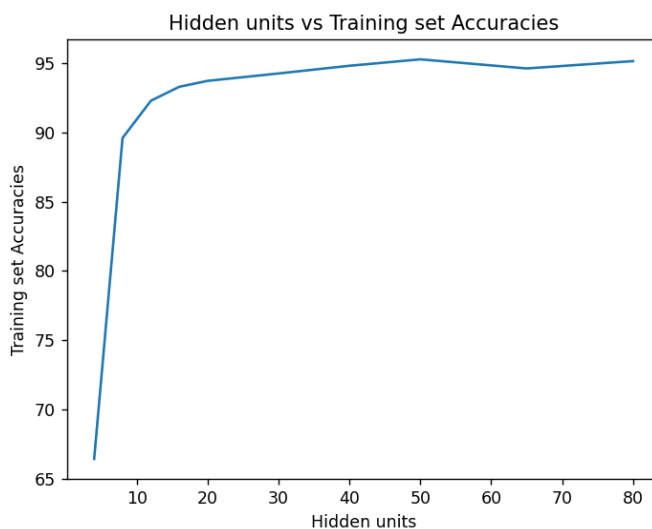
Tabular Values for Training set, Validation set and Test set accuracies at Lambda = 15.

Lambda	Hidden neurons	Training_set	Validation_set	Testing_set	Time taken
15	4	66.422	65.85	66.45	22.60484338
15	8	89.598	88.44	89.52	27.25284505
15	12	92.292	91.34	92.25	32.8477037
15	16	93.298	92.57	93.09	38.06909275
15	20	93.726	92.73	93.2	32.69259095
15	30	94.26	93.47	94.24	49.42695808
15	40	94.816	94.21	94.59	46.15179801
15	50	95.28	94.72	94.87	47.42526317
15	65	94.622	94.28	94.4	50.07215214
15	80	95.152	94.58	94.82	54.77851939

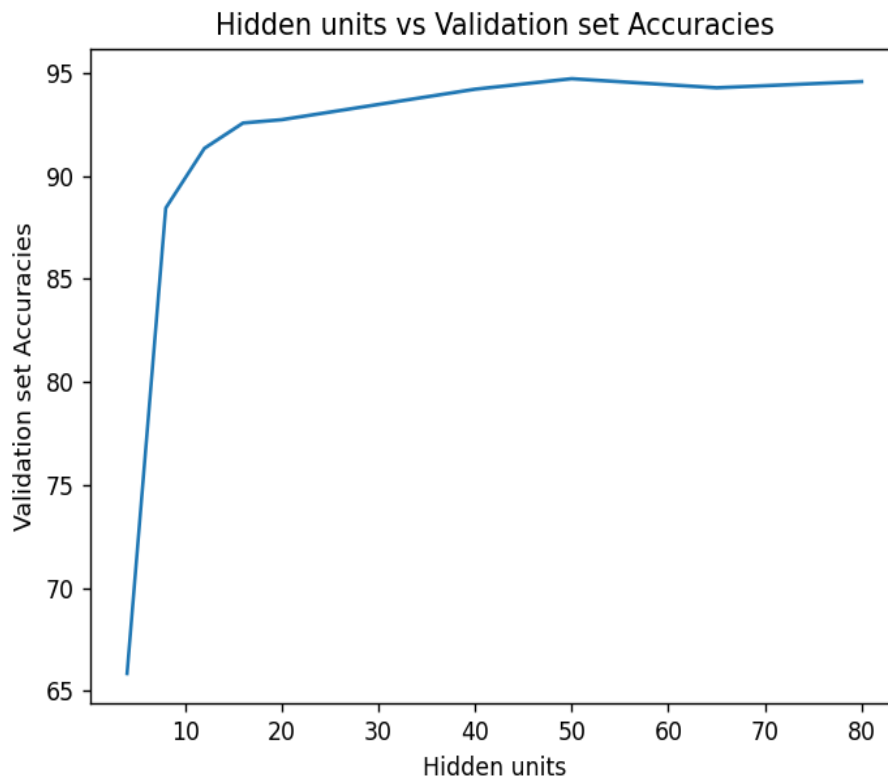
Observations:

- Under fitting occurs when lambda and hidden units are large because of vast training process .
- So choosing of hyper parameters is done by looking at best validation accuracy and test accuracy.
- We have tried by increasing hidden units to **80** but there is no much improvement after 50. So we have took **50** as number of hidden units.
- We can see from above table that by increasing hidden units the accuracy in training set, validation set and test set increases.
- So final observation is optimal value of **Lambda = 15** and **Hidden units = 50**.
- The training set, validation set, test set accuracies when Lambda = 15 & hidden units = 50 are **95.28, 94.72, 94.87**.
- Time taken gradually increases with increase in number of hidden_units values.

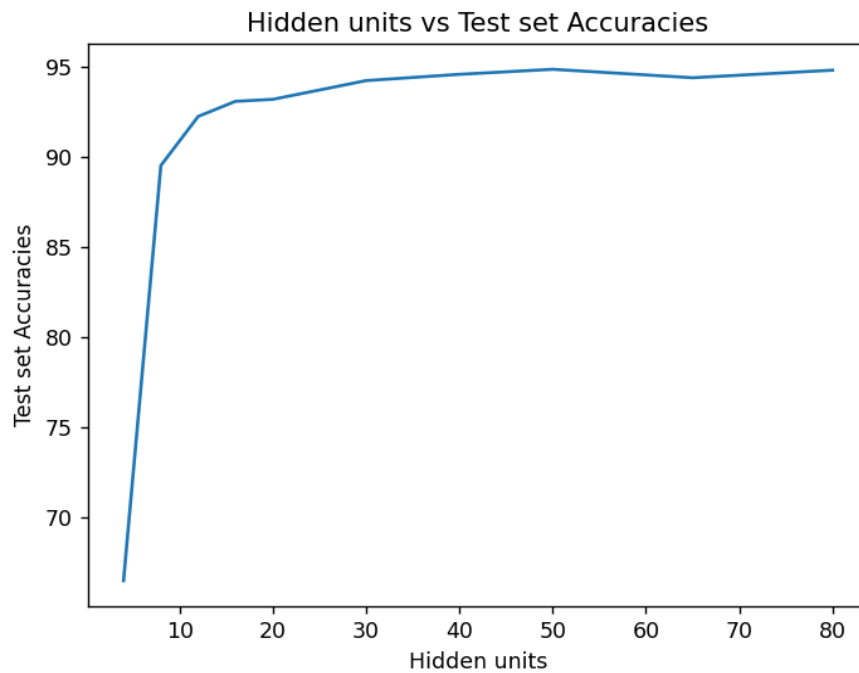
Plottings for Training set accuracies and hidden units value



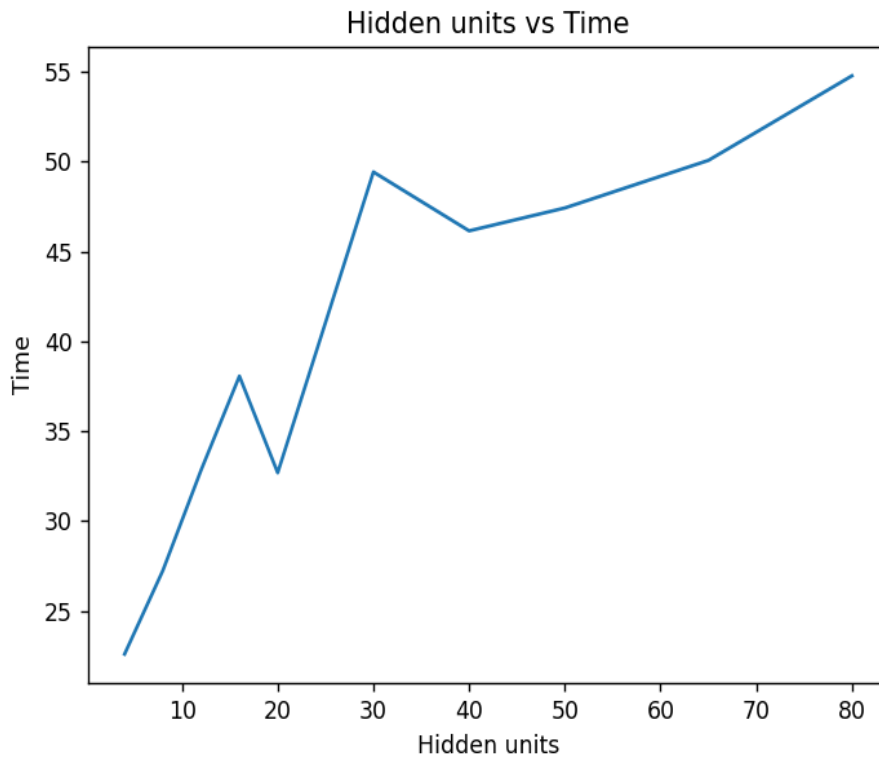
Plottings for Validation set accuracies and hidden_units value



Plottings for Test set accuracies and hidden_units value



Plottings for Time taken and hidden units value



2.) Accuracy of classification method on the handwritten digits test data

- From final observations we can see that optimal value of **Lambda = 15** and **Hidden units = 50**.
- The training set, validation set, test set accuracies when Lambda = 15 & hidden units = 50 are **95.28, 94.72, 94.87**

3.) Accuracy of classification method on the CelebA data set:

- Here we executed facennScript.py file for different lambda values [0, 5, 10, 15, 20, 30, 40, 50, 60] and different values of hidden units (4, 8, 12, 16, 20, 30, 40, 50, 65, 80).

Tabular Values for Training set, Validation set ,Test set accuracies and Time Taken when Lambda = 20 and different Hidden units

Lambda	Hidden neurons	Training_set	Validation_set	Testing_set	Time taken
20	4	85.92890995	84.44090056	85.71461014	26.521492
20	8	85.87677725	85.0412758	85.22255867	31.94171429
20	12	85.25592417	83.82739212	85.88190765	34.31059456
20	16	85.31279621	83.75234522	85.54125662	38.89752698
20	20	84.65402844	83.60225141	84.89780469	39.35181236
20	30	85.00947867	83.78986867	85.23845572	40.34894252
20	40	85.73933649	84.61538462	86.0333081	43.96941447
20	50	86.28909953	85.36585366	86.44965935	46.64411926
20	65	84.67772512	83.90243902	85.23845572	53.63694549
20	80	85.492891	83.93996248	85.42770628	50.59535718

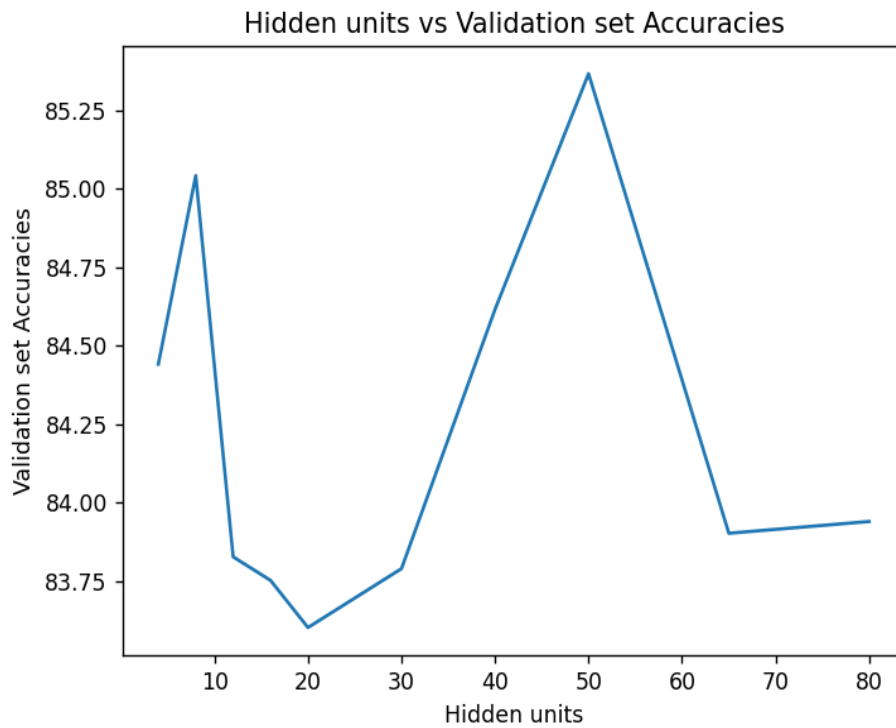
Observations:

- The best accuracy in facennScript.py file is observed at lambda= **20** and hidden_units = **50**.
- We can see from table that by increasing hidden units the accuracy in training set, validation set and test set increases.
- We have also tried by increasing hidden units to **80** by keeping lambda value to 20 but there is no much improvement after 50. So we have took **50** as number of hidden units.
- The training set, validation set, test set accuracies when Lambda = 20 & hidden units = 50 are **86.28, 85.36, 86.44**.
- Time taken gradually increases with increase in number of hidden_units values.

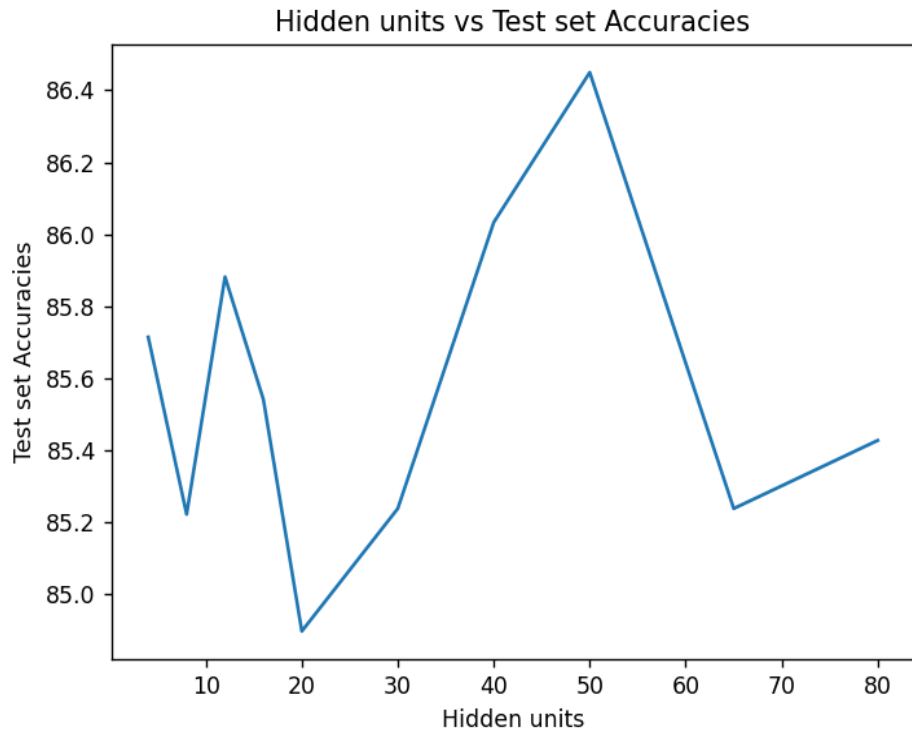
Plottings for Training set accuracies and hidden units value



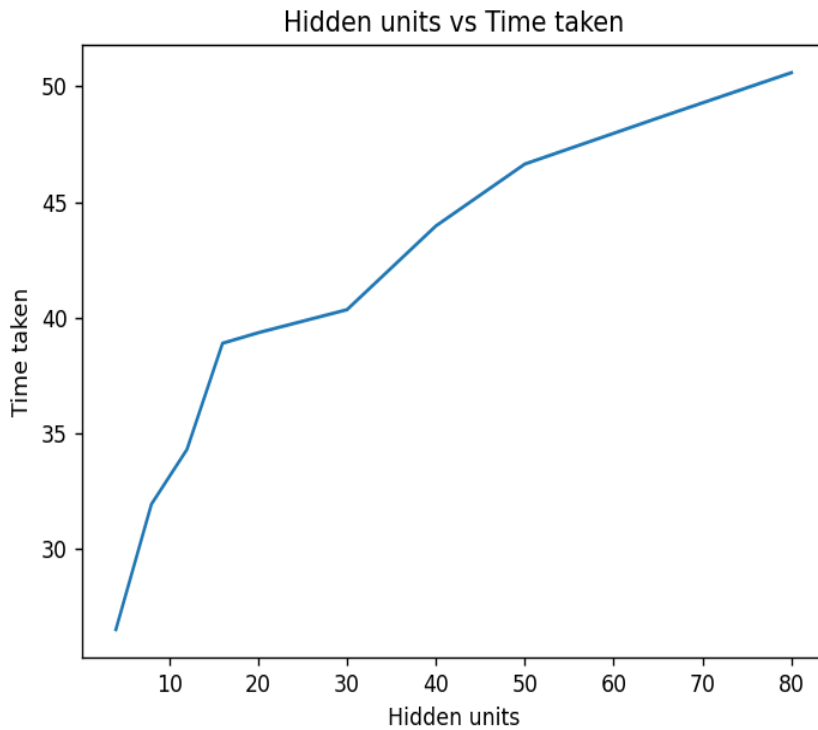
Plottings for Validation set accuracies and hidden units value



Plottings for Test set accuracies and hidden_units value



Plottings for Time taken and hidden_units value



4.) Comparison of Simple Neural Network with Deep Neural Network:

Neural Network type	Hidden Layers	Test Data accuracy in %	Training time in secs
Simple Neural Network	1	86.44	46.6
Deep Neural Network	2	84.7	102.2
Deep Neural Network	3	81.8	120.5
Deep Neural Network	5	74.7	150.36
Deep Neural Network	7	55.2	200.4

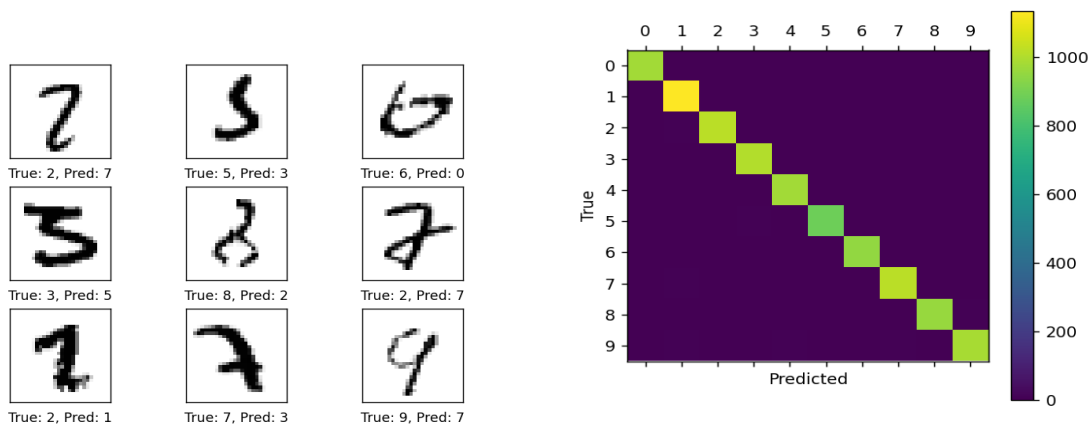
Observations:

- We can see that in Deep Neural Network accuracy decreases with increase in number of hidden layers due to over-fitting.
- As per above observations Simple Neural Network with one hidden layer for optimized values of hyper-parameters has an accuracy of **86.44%** on CelebA data set where as Deep Neural Network has maximum accuracy of **84.7%** on celebA data set with 2 hidden layers.
- Also time taken in Simple Neural Network is less when compared to Deep Neural Network. As number of layers increase , time increases due to increased complexity and computation of feedforward and backpropagation.

5.) Convolutional Neural Network in terms of Accuracy and Training time:

Iterations	Test Set Accuracy in %	Training Time in secs
9	98.7	388.01
15	98.9	619.08

Results after 15 iterations:-



Confusion Matrix:

```
[[ 976    0    0    1    0    0    2    0    1    0]
 [    0 1133    1    0    0    0    1    0    0    0]
 [    4    5 1016    0    1    0    0    4    2    0]
 [    1    1    0 1002    0    3    0    1    2    0]
 [    0    1    0    0 978    0    1    0    0    2]
 [    2    0    0    5    0 881    3    0    1    0]
 [    3    2    0    1    1    2 949    0    0    0]
 [    0    7    4    2    0    0    0 1014    1    0]
 [    2    2    1    2    1    1    0    3 957    5]
 [    1    7    0    2    7    3    0    6    0 983]]
```

Observations:

- As per above observations , in increasing number of iterations Test set accuracy increases.
- Training Time also increases along with increase of iterations.

Comparison of Deep Neural Networks vs Convolutional Neural Networks on MINST dataset:

Deep Neural Network (with learning rate = 0.002):

Hidden Layers	Testing data accuracy in %	Training Time in secs
2	92.1	206
3	91.8	212.62

Convolutional Network:

Iterations	Test Set Accuracy in %	Training Time in secs
9	98.7	388.01
15	98.9	619.08

Observations:-

- Above results clearly states that **CNN is more efficient than DeepNN** by observing accuracy. This is because CNN operates by applying filters on identified important features.