Assignment 2 -- Neural Networks

Hyperparameter Tuning

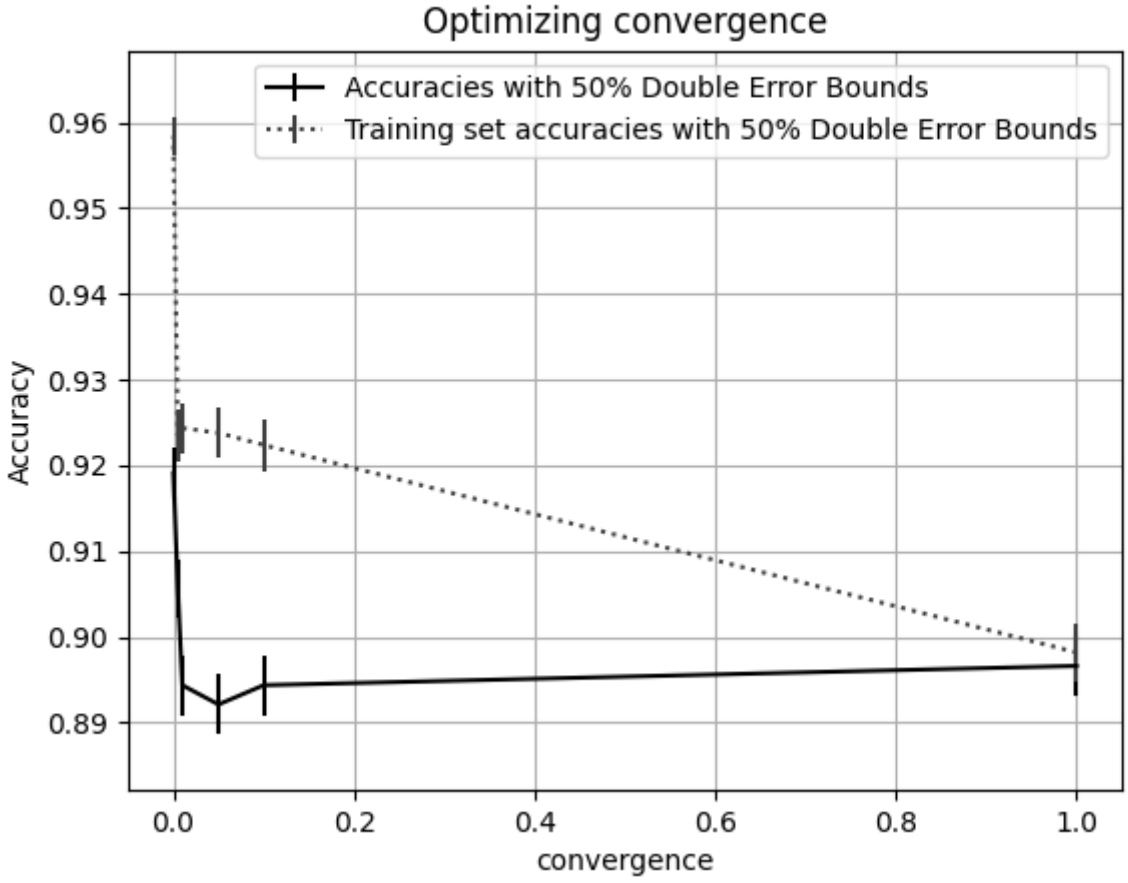
Single Layer Network

Tuning Convergence

`stepSize=0.1`

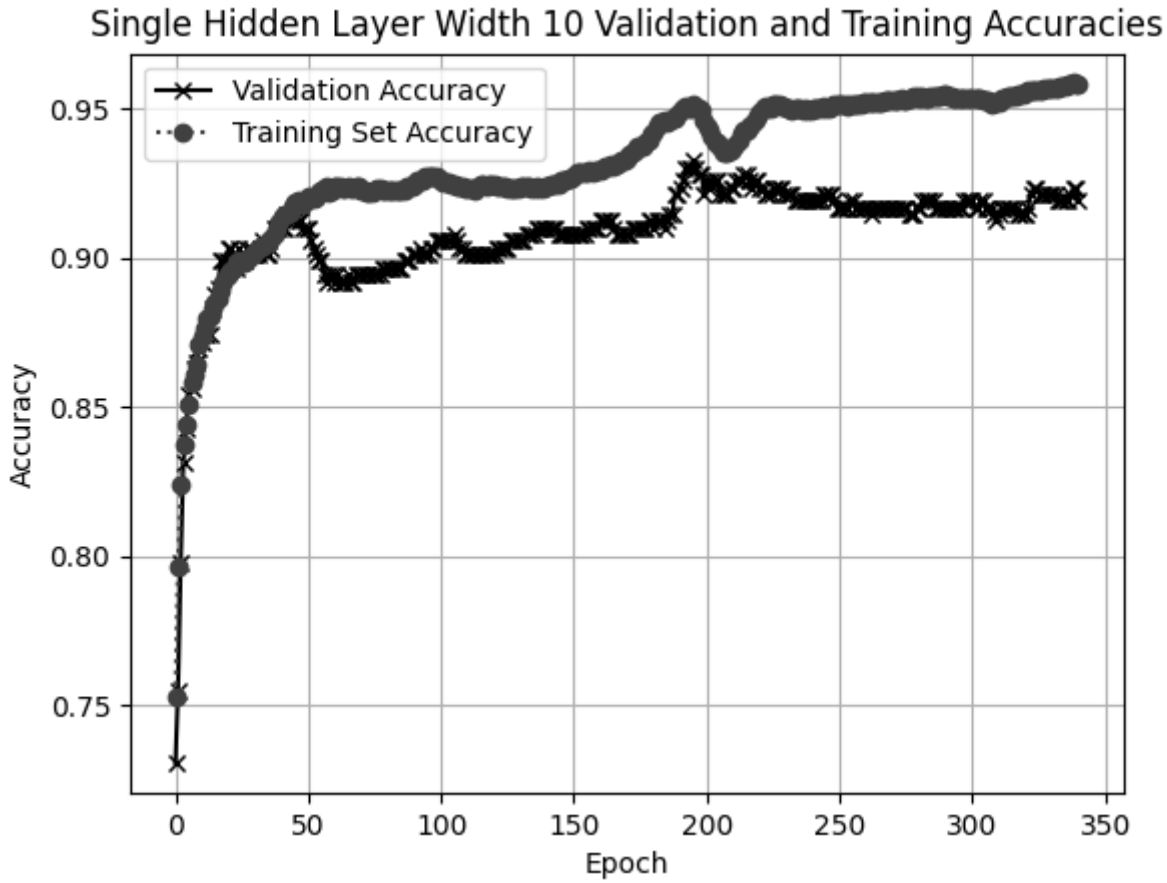
`10 Neurons in Middle Layer`

convergence	accuracy	lower bound	upper bound	runtime
1	0.896629	0.893209	0.90005	53.7957
0.1	0.894382	0.890929	0.897835	138.869
0.05	0.892135	0.888649	0.89562	140.002
0.01	0.894382	0.890929	0.897835	147.494
0.005	0.905618	0.902333	0.908903	271.21
0.0001	0.919101	0.916037	0.922165	645.184



After tinkering a little with stepSize on the original hidden layer configuration (only 2 nodes in a single layer), I decided to go ahead and try 10 nodes with an acceptable value of stepSize (0.1) and do a sweep over convergence. As seen above my best resulting hyperparameters from this sweep was a convergence of 0.0001. This gave me an accuracy of 0.9191, which easily exceeds the criteria laid out in the assignment prompt (0.85). This fit converged in 341 epochs.

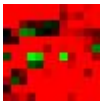
Accuracy Plot



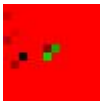
Visualization of Single Layer Network

Neuron 0

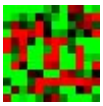
Neuron 1



Neuron 2



Neuron 3



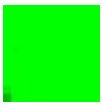
Neuron 4

Neuron 5

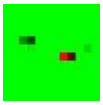
Neuron 6

Neuron 7

Neuron 8



Neuron 9



Double Layer Network

Tuning StepSize

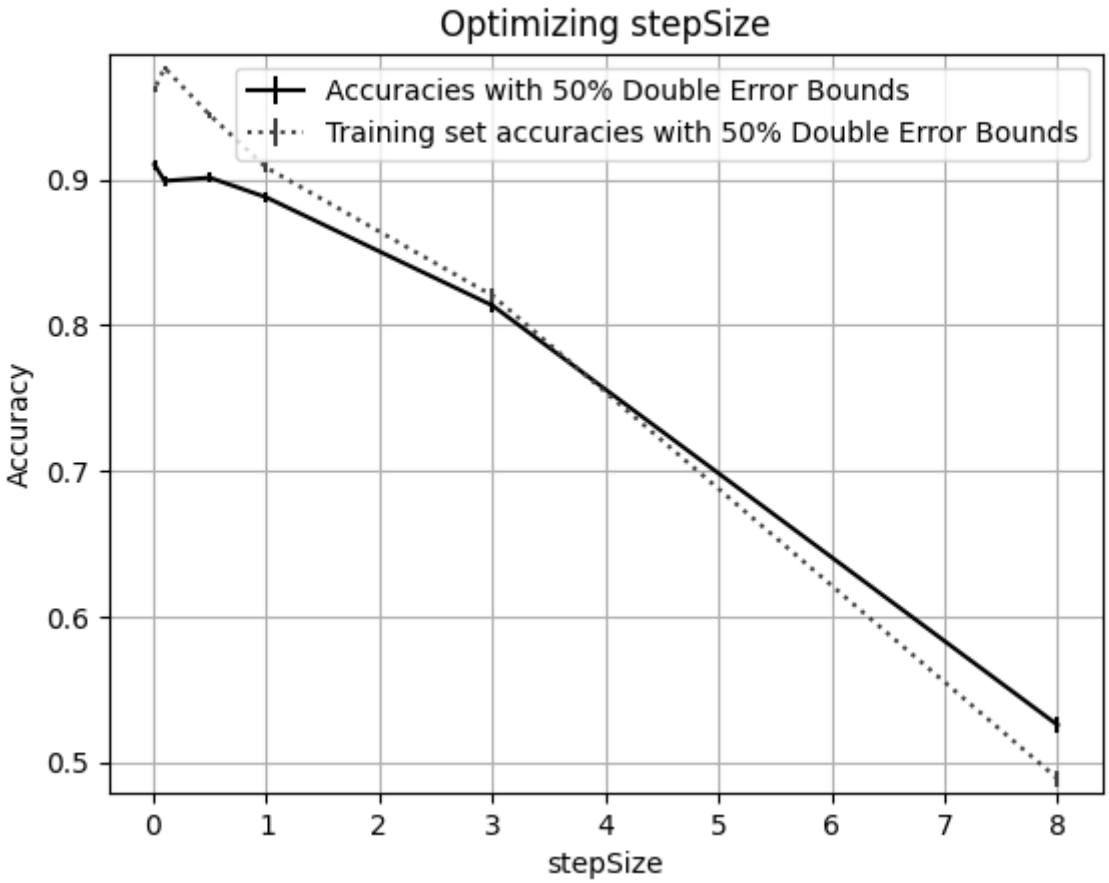
```
convergence = 0.0001

10 Neurons in Both Layers

maxEpochs = 1000
```

stepSize	accuracy	lower bound	upper bound	runtime
8	0.525843	0.520232	0.531453	87.0139
3	0.813483	0.809107	0.81786	3334.93

stepSize	accuracy	lower bound	upper bound	runtime
1	0.88764	0.884092	0.891189	3340.79
0.5	0.901124	0.89777	0.904477	3258.73
0.1	0.898876	0.895489	0.902264	3284.91
0.01	0.910112	0.906899	0.913326	3304.52



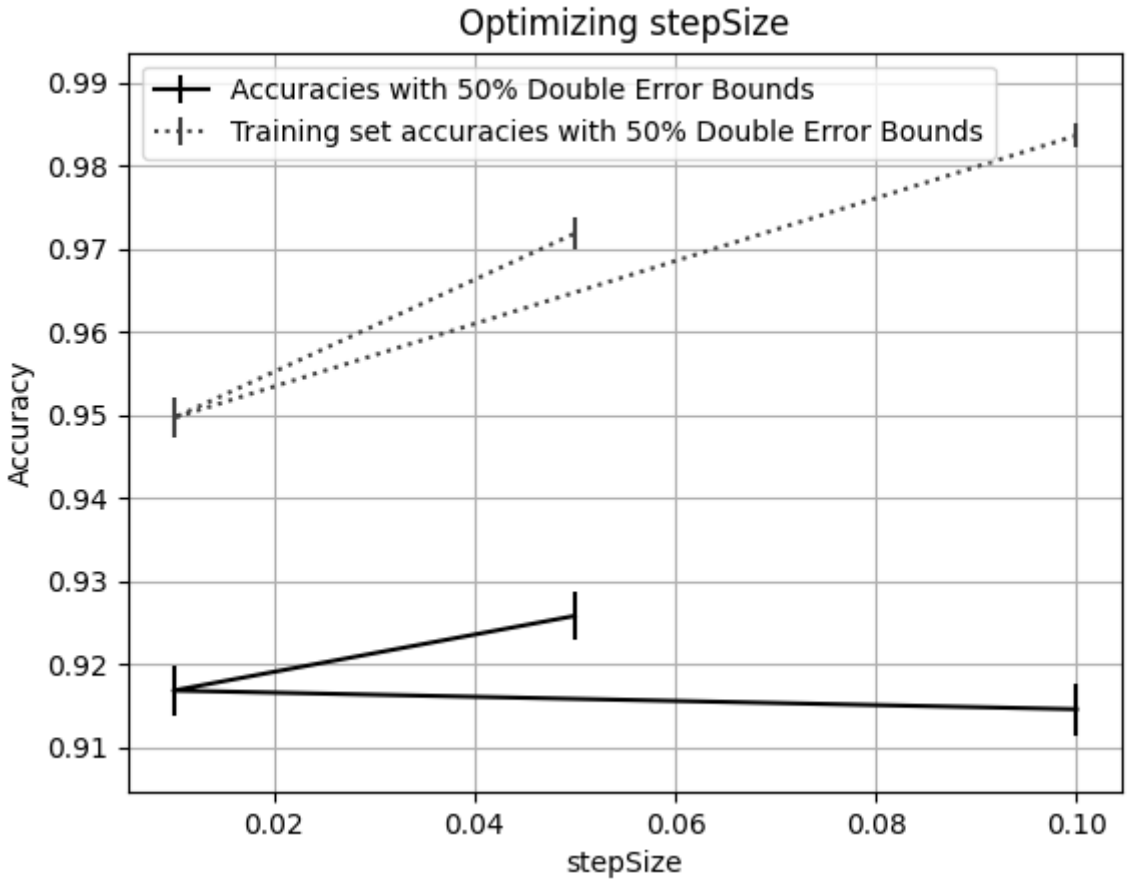
For double layer, I went ahead and used my best value of convergence from my single layer hyperparameter sweep and applied it to two layers of 10 nodes. Unfortunately, as seen in the chart above (look at runtimes) I had my maxEpochs value too low to reach convergence. I increased my maxEpochs value to 50000, decreased the layers to 5 nodes each, and tried again (with the best values of stepSize).

```
convergence = 0.0001
```

```
5 Neurons in Both Layers
```

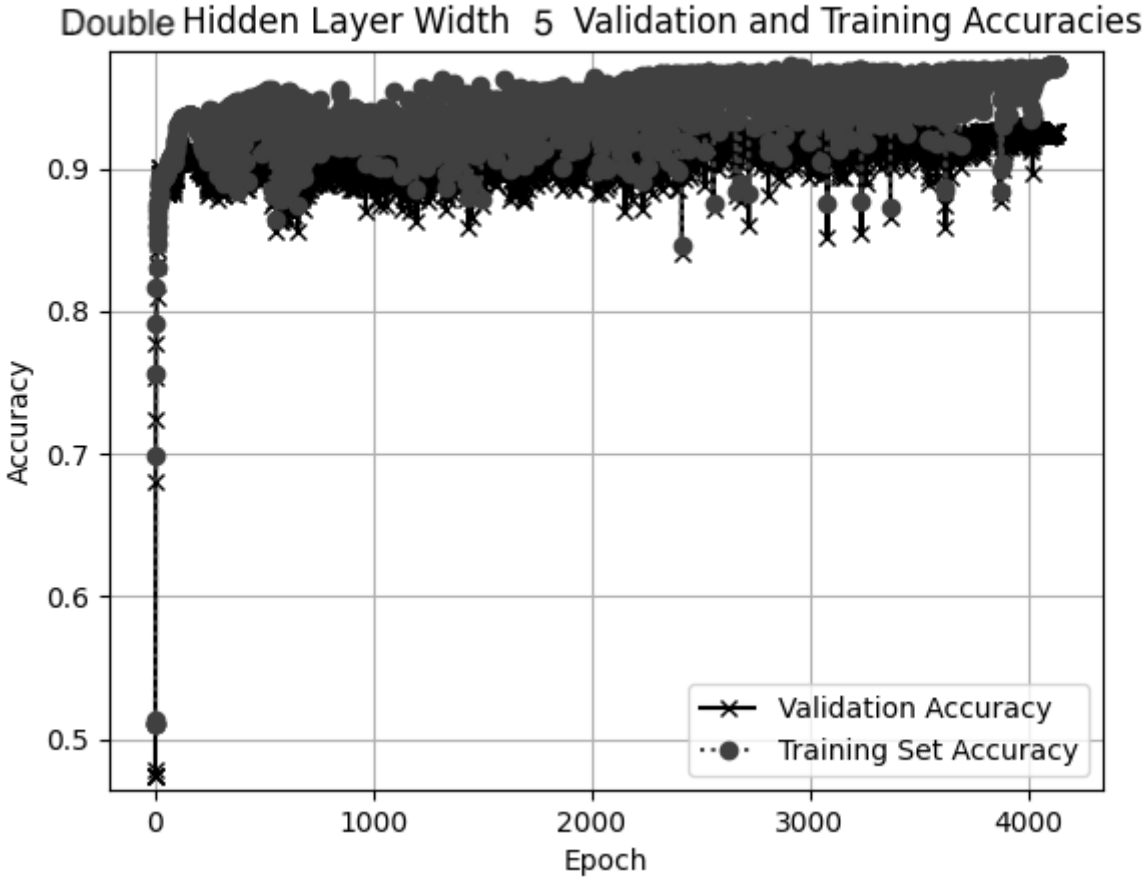
```
maxEpochs = 50000
```

stepSize	accuracy	lower bound	upper bound	runtime
0.1	0.914607	0.911467	0.917747	7654.76
0.01	0.916854	0.913752	0.919956	906.938
0.05	0.925843	0.922899	0.928787	5199.8



(Sorry for the weird plot here) Looking at the results above, the best stepSize is 0.05, producing an accuracy of 0.9258. As this exceeds the specifications in the problem statement, I will be using these hyperparameters (stepSize = 0.05, convergence = 0.0001, and 2 hidden layers with width 5) moving forward.

Accuracy Plot


Double Hidden Layer Width 5 Validation and Training Accuracies
Accuracy
Epoch
0.5
0.6
0.7
0.8
0.9
0
1000
2000
3000
4000
Validation Accuracy
Training Set Accuracy