Question 5

testPenData Accuracy

|  |  |
| --- | --- |
| Max | 0.906232132647 |
| Average | 0.904345340194 |
| Standard Deviation | 0.001969030916 |

testCarData Accuracy

|  |  |
| --- | --- |
| Max | 0.875654450262 |
| Average | 0.866884816754 |
| Standard Deviation | 0.007728057288 |
|  | |
|  | |

After running 5 iterations of both testPenData and testCarData with default parameters, the above results were produced. The pen data scored higher than the car data in every aspect: higher maximum and average accuracy and lower standard deviation. I originally expected the car data to perform better than pen data because there are significantly more parameters and possible values for each parameter in the pen data than in the car data. I believe this is because the default parameter for testPenData has more hidden layer perceptrons than testCarData has, so adding more perceptrons for the car data may make it perform better.

Question 6

testPenData

|  |  |  |  |
| --- | --- | --- | --- |
| Hidden Layer Perceptrons | Max Accuracy | Average Accuracy | Standard Deviation |
| 0 | 0.801600914808 | 0.801200686106 | 0.000291539137 |
| 5 | 0.853630646083 | 0.839508290452 | 0.009441063218 |
| 10 | 0.899085191538 | 0.894110920526 | 0.004661120806 |
| 15 | 0.902801600915 | 0.898913664951 | 0.005413891624 |
| 20 | 0.906518010292 | 0.904116638079 | 0.001360248971 |
| 25 | 0.906232132647 | 0.897827329903 | 0.007394456131 |
| 30 | 0.905946255003 | 0.903201829617 | 0.002850760632 |
| 35 | 0.908233276158 | 0.904974271012 | 0.002913147902 |
| 40 | 0.903945111492 | 0.902458547742 | 0.001381709088 |
|  | | | |

When running testPenData, I expected and noticed a very sharp increase until 10 hidden layer perceptrons were used. Afterwards, accuracy just seemed to flat line. There was some variation as more perceptrons were used, but it was consistently hovering at about 90% accuracy. I believe its accuracy had simply reached its asymptote, but I was surprised to see that happen so quickly at only 10 perceptrons.

testCarData

|  |  |  |  |
| --- | --- | --- | --- |
| Hidden Layers Perceptrons | Max Accuracy | Average Accuracy | Standard Deviation |
| 0 | 0.791884816754 | 0.790837696335 | 0.000523560209 |
| 5 | 0.861910994764 | 0.856282722513 | 0.006681805769 |
| 10 | 0.863874345550 | 0.859554973822 | 0.004333231769 |
| 15 | 0.861910994764 | 0.859816753927 | 0.001125958805 |
| 20 | 0.858638743455 | 0.855759162304 | 0.003274868064 |
| 25 | 0.863874345550 | 0.856675392670 | 0.005553194617 |
| 30 | 0.861910994764 | 0.853141361257 | 0.005608451645 |
| 35 | 0.857329842932 | 0.850523560209 | 0.004675542173 |
| 40 | 0.852748691099 | 0.850000000000 | 0.002282146044 |
|  | | | |

Running testCarData gave slightly different results. For some reason though, 10 to 15 hidden layer perceptrons gave the best results while additional perceptrons seemed to cause accuracy to decrease. Since it’s so slow of decrease, it could just be an anomaly from my test results. However, the decrease in accuracy is very consistent as more perceptrons are used. This result surprised me in that I expect most neural networks to be more reliable as more perceptrons are used.

Question 7

I tested my XOR data set with 0 to 100 hidden layer perceptors, running 10 iterations each time. The graph above plots the average accuracy of the 10 iterations at each number of hidden layer perceptors. I had expected the average accuracy to steadily increase as more perceptors were used, but my results seem to show a maximum at about 45 perceptors. More surprisingly, accuracy appears to be decreasing as more perceptors are used beyond that point. Unfortunately, I expected much more consistent success than I had observed. I am unsure whether or not these results were to be expected or if something is wrong with my implementation of the XOR function.

Full Data:

|  |  |  |  |
| --- | --- | --- | --- |
| Hidden Layers Perceptrons | Max Accuracy | Average Accuracy | Standard Deviation |
| 0 | 0.75 | 0.525 | 0.134629 |
| 1 | 0.75 | 0.5 | 0.158114 |
| 2 | 0.75 | 0.575 | 0.114564 |
| 3 | 0.75 | 0.55 | 0.1 |
| 4 | 0.5 | 0.5 | 0 |
| 5 | 0.5 | 0.5 | 0 |
| 6 | 0.75 | 0.525 | 0.075 |
| 7 | 0.75 | 0.575 | 0.114564 |
| 8 | 0.75 | 0.55 | 0.1 |
| 9 | 1 | 0.6 | 0.165831 |
| 10 | 0.75 | 0.525 | 0.075 |
| 11 | 0.75 | 0.5 | 0.111803 |
| 12 | 1 | 0.6 | 0.165831 |
| 13 | 0.75 | 0.525 | 0.075 |
| 14 | 0.75 | 0.55 | 0.1 |
| 15 | 0.75 | 0.55 | 0.15 |
| 16 | 1 | 0.575 | 0.160078 |
| 17 | 0.75 | 0.575 | 0.114564 |
| 18 | 1 | 0.6 | 0.165831 |
| 19 | 0.75 | 0.55 | 0.1 |
| 20 | 0.75 | 0.525 | 0.075 |
| 21 | 1 | 0.6 | 0.2 |
| 22 | 0.75 | 0.6 | 0.122474 |
| 23 | 0.75 | 0.575 | 0.114564 |
| 24 | 0.75 | 0.55 | 0.1 |
| 25 | 0.75 | 0.525 | 0.134629 |
| 26 | 0.75 | 0.55 | 0.1 |
| 27 | 1 | 0.575 | 0.160078 |
| 28 | 0.75 | 0.575 | 0.114564 |
| 29 | 1 | 0.65 | 0.165831 |
| 30 | 1 | 0.675 | 0.195256 |
| 31 | 0.75 | 0.625 | 0.125 |
| 32 | 1 | 0.6 | 0.165831 |
| 33 | 0.75 | 0.6 | 0.122474 |
| 34 | 1 | 0.65 | 0.165831 |
| 35 | 1 | 0.725 | 0.207666 |
| 36 | 1 | 0.6 | 0.165831 |
| 37 | 0.75 | 0.675 | 0.114564 |
| 38 | 0.75 | 0.625 | 0.125 |
| 39 | 1 | 0.675 | 0.195256 |
| 40 | 1 | 0.725 | 0.134629 |
| 41 | 1 | 0.775 | 0.175 |
| 42 | 1 | 0.6 | 0.165831 |
| 43 | 0.75 | 0.625 | 0.125 |
| 44 | 0.75 | 0.6 | 0.122474 |
| 45 | 1 | 0.7 | 0.15 |
| 46 | 1 | 0.75 | 0.158114 |
| 47 | 1 | 0.8 | 0.15 |
| 48 | 0.75 | 0.65 | 0.122474 |
| 49 | 1 | 0.75 | 0.193649 |
| 50 | 0.75 | 0.7 | 0.1 |
| 51 | 1 | 0.65 | 0.165831 |
| 52 | 1 | 0.675 | 0.160078 |
| 53 | 1 | 0.65 | 0.2 |
| 54 | 1 | 0.7 | 0.187083 |
| 55 | 0.75 | 0.6 | 0.122474 |
| 56 | 0.75 | 0.725 | 0.075 |
| 57 | 1 | 0.625 | 0.167705 |
| 58 | 1 | 0.775 | 0.175 |
| 59 | 1 | 0.7 | 0.187083 |
| 60 | 1 | 0.675 | 0.160078 |
| 61 | 1 | 0.75 | 0.223607 |
| 62 | 1 | 0.675 | 0.195256 |
| 63 | 0.75 | 0.6 | 0.122474 |
| 64 | 1 | 0.725 | 0.134629 |
| 65 | 1 | 0.675 | 0.160078 |
| 66 | 1 | 0.675 | 0.160078 |
| 67 | 1 | 0.65 | 0.165831 |
| 68 | 0.75 | 0.6 | 0.122474 |
| 69 | 1 | 0.65 | 0.165831 |
| 70 | 0.75 | 0.725 | 0.075 |
| 71 | 0.75 | 0.675 | 0.114564 |
| 72 | 0.75 | 0.65 | 0.122474 |
| 73 | 0.75 | 0.65 | 0.122474 |
| 74 | 0.75 | 0.725 | 0.075 |
| 75 | 0.75 | 0.65 | 0.122474 |
| 76 | 0.75 | 0.7 | 0.1 |
| 77 | 0.75 | 0.675 | 0.114564 |
| 78 | 0.75 | 0.575 | 0.114564 |
| 79 | 1 | 0.65 | 0.165831 |
| 80 | 0.75 | 0.65 | 0.122474 |
| 81 | 0.75 | 0.6 | 0.122474 |
| 82 | 0.75 | 0.7 | 0.1 |
| 83 | 0.75 | 0.55 | 0.1 |
| 84 | 0.75 | 0.6 | 0.122474 |
| 85 | 0.75 | 0.6 | 0.122474 |
| 86 | 0.75 | 0.6 | 0.122474 |
| 87 | 1 | 0.675 | 0.160078 |
| 88 | 0.75 | 0.65 | 0.122474 |
| 89 | 0.75 | 0.625 | 0.125 |
| 90 | 0.75 | 0.65 | 0.122474 |
| 91 | 0.75 | 0.65 | 0.122474 |
| 92 | 0.75 | 0.6 | 0.122474 |
| 93 | 0.75 | 0.6 | 0.122474 |
| 94 | 0.75 | 0.65 | 0.122474 |
| 95 | 0.75 | 0.625 | 0.125 |
| 96 | 0.75 | 0.575 | 0.114564 |
| 97 | 0.75 | 0.625 | 0.125 |
| 98 | 0.75 | 0.55 | 0.1 |
| 99 | 0.75 | 0.625 | 0.125 |
| 100 | 0.75 | 0.6 | 0.122474 |