CSE 574: Introduction to Machine Learning

Programming Assignment 2:

**Neural Networks**

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**Neural Networks:**

**Effect of Number of Hidden Nodes (lambda = 5)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| No. of Hidden Nodes | Training Set Accuracy | Validation set accuracy | Testing set accuracy | Final Optimization Parameter | Time Taken  (sec) |
| 0 | 11.48% | 10.0% | 11.35% | 3.25 | 3.80 |
| 4 | 61.44% | 60.13% | 61.28% | 1.72 | 26.58 |
| 8 | 88.82% | 88.29% | 88.46% | 0.79 | 27.32 |
| 12 | 91.85% | 90.93% | 91.81% | 0.61 | 28.28 |
| 16 | 92.31% | 91.39% | 91.62% | 0.59 | 30.70 |
| 20 | 93.63% | 92.65% | 93.08% | 0.49 | 30.53 |
| 30 | 94.61% | 94.19% | 94.21% | 0.43 | 44.02 |
| 40 | 94.86% | 94.26% | 94.58% | 0.41 | 45.22 |
| 50 | 95.31% | 94.86% | 95.05% | 0.38 | 53.52 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Lambda | Training Set Accuracy | Validation set accuracy | Testing set accuracy | Final Optimization Parameter | Time Taken  (sec) |
| 0 | 93.34% | 92.39% | 92.84% | 0.45 | 45.65 |
| 5 | 93.95% | 93.08% | 93.56% | 0.39 | 39.57 |
| 10 | 93.77% | 93.12% | 93.33% | 0.53 | 36.99 |
| 15 | 93.606% | 92.67% | 93.28% | 0.60 | 43.52 |
| 20 | 93.53% | 92.85% | 93.24% | 0.63 | 42.00 |
| 25 | 93.52% | 92.75% | 93.25% | 0.66 | 40.11 |
| 30 | 93.07% | 92.57% | 92.86% | 0.72 | 40.27 |
| 35 | 93.13% | 92.67% | 93.10% | 0.73 | 39.26 |
| 40 | 92.85% | 92.17% | 92.60% | 0.77 | 41.77 |
| 45 | 93.39% | 92.88% | 93.30% | 0.78 | 43.62 |
| 50 | 93.07% | 92.49% | 93.14% | 0.81 | 43.83 |
| 55 | 92.82% | 92.21% | 92.63% | 0.88 | 44.67 |
| 60 | 93.07% | 92.33% | 93.11% | 0.86 | 37.0 |

APPENDIX:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Lambda | No. of Hidden Nodes | Training Set Accuracy | Validation set accuracy | Testing set accuracy | Final Optimization Parameter | Time Taken |
| 0 | 4 | 32.108% | 30.44% | 31.51% | 2.3477346986617 | 44.28 |
| 0 | 8 | 90.42% | 89.98% | 90.25% | 0.6584262333545 | 37.85 |
| 0 | 12 | 91.242% | 90.81% | 91.2% | 0.5907573502290 | 43.08 |
| 0 | 16 | 92.916% | 92.43% | 92.27% | 0.4759312832412 | 48.95 |
| 0 | 20 | 93.702% | 93.05% | 93.28% | 0.4279432621826 | 50.31 |
| 5 | 4 | 63.856% | 62.43% | 64.12% | 1.6753423309480 | 33.12 |
| 5 | 8 | 89.05% | 88.49% | 88.92% | 0.8035987000887 | 38.70 |
| 5 | 12 | 90.914% | 90.47% | 89.98% | 0.6744545417759 | 41.00 |
| 5 | 16 | 93.36% | 93.14% | 93.21% | 0.5113768604655 | 44.70 |
| 5 | 20 | 92.99% | 62.74% | 92.66% | 0.5346798266305 | 50.60 |
| 10 | 4 | 64.188% | 92.46% | 63.45% | 1.6186787153553 | 36.80 |
| 10 | 8 | 89.886% | 89.3% | 89.59% | 0.7979866690212 | 36.85 |
| 10 | 12 | 91.828% | 91.23% | 91.63% | 0.6728574649961 | 40.92 |
| 10 | 16 | 93.048% | 92.28% | 92.74% | 0.5735220919152 | 43.60 |
| 10 | 20 | 93.764% | 93.41% | 93.14% | 0.5354447614383 | 48.99 |
| 15 | 4 | 80.186% | 79.48% | 79.59% | 1.2701117346039 | 39.80 |
| 15 | 8 | 89.054% | 87.97% | 89.04% | 0.9189362907847 | 37.02 |
| 15 | 12 | 91.096% | 90.69% | 90.87% | 0.7867954657656 | 40.02 |
| 15 | 16 | 93.078% | 92.81% | 92.8% | 0.6329159014616 | 46.02 |
| 15 | 20 | 93.452% | 93.03% | 93.37% | 0.6100967749411 | 48.18 |
| 20 | 4 | 69.37% | 67.67% | 70.1% | 1.6841130407761 | 33.61 |
| 20 | 8 | 89.776% | 88.84% | 89.57% | 0.9049212859481 | 39.69 |
| 20 | 12 | 92.198% | 91.58% | 91.82% | 0.7545112440863 | 41.92 |
| 20 | 16 | 92.802% | 92.44% | 92.4% | 0.6866018935851 | 50.20 |
| 20 | 20 | 92.838% | 92.2% | 92.41% | 0.6995152865317 | 64.06 |
| 25 | 4 | 76.186% | 74.92% | 76.44% | 1.6138850635929 | 42.15 |
| 25 | 8 | 90.234% | 89.56% | 90.04% | 0.9706980752338 | 38.44 |
| 25 | 12 | 92.028% | 91.48% | 92.01% | 0.7788432994284 | 40.88 |
| 25 | 16 | 92.38% | 92.09% | 92.09% | 0.7613645045125 | 43.11 |
| 25 | 20 | 92.97% | 92.66% | 92.98% | 0.7068599817226 | 48.57 |
| 30 | 4 | 67.434% | 66.98% | 67.77% | 1.8482993652082 | 33.63 |
| 30 | 8 | 88.23% | 87.4% | 87.71% | 1.0626775002944 | 37,32 |
| 30 | 12 | 91.646% | 91.18% | 91.48% | 0.8473667718838 | 42.36 |
| 30 | 16 | 92.806% | 92.4% | 92.69% | 0.7580002204763 | 46.01 |
| 30 | 20 | 93.362% | 92.9% | 93.24% | 0.7250093505607 | 46.18 |
| 35 | 4 | 49.276% | 47.85% | 48.24% | 2.3330053230228 | 32.95 |
| 35 | 8 | 89.482% | 89.08% | 89.12% | 1.0478179375263 | 37.53 |
| 35 | 12 | 92.016% | 91.93% | 91.63% | 0.8335093769959 | 41.19 |
| 35 | 16 | 93.178% | 92.77% | 92.72% | 0.7820609219785 | 43.50 |
| 35 | 20 | 93.344% | 92.95% | 93.0% | 0.7387273611253 | 47.45 |
| 40 | 4 | 74.676% | 73.67% | 74.79% | 1.7036624290192 | 31.93 |
| 40 | 8 | 89.514% | 88.67% | 89.95% | 1.0713278422308 | 36.11 |
| 40 | 12 | 91.61% | 91.27% | 91.44% | 0.9156486257094 | 41.26 |
| 40 | 16 | 92.696% | 92.26% | 92.55% | 0.8123838791856 | 44.33 |
| 40 | 20 | 93.03% | 92.84% | 93.0% | 0.7940607512691 | 49.21 |
| 45 | 4 | 55.668% | 54.14% | 55.56% | 2.2750081806838 | 36.11 |
| 45 | 8 | 89.314% | 88.86% | 89.01% | 1.0961955678581 | 35.06 |
| 45 | 12 | 91.158% | 90.98% | 91.31% | 0.9612539288719 | 38.43 |
| 45 | 16 | 91.844% | 91.54% | 92.01% | 0.8838786762879 | 45.54 |
| 45 | 20 | 92.758% | 92.63% | 92.7% | 0.8235047057082 | 48.85 |
| 50 | 4 | 62.124% | 61.38% | 62.31% | 1.9074033209988 | 34.87 |
| 50 | 8 | 89.424% | 89.01% | 89.36% | 1.0945586595373 | 37.62 |
| 50 | 12 | 91.492% | 91.38% | 91.33% | 0.9425001713562 | 41.14 |
| 50 | 16 | 92.348% | 92.19% | 92.41% | 0.8813811195920 | 44.81 |
| 50 | 20 | 92.626% | 92.42% | 92.51% | 0.8650937653819 | 47.73 |
| 55 | 4 | 74.584% | 74.0% | 73.44% | 1.7459059067174 | 32.58 |
| 55 | 8 | 89.276% | 89.24% | 89.44% | 1.1900759745216 | 37.10 |
| 55 | 12 | 92.23% | 91.92% | 92.14% | 0.9352062711769 | 41.60 |
| 55 | 16 | 92.076% | 91.79% | 92.06% | 0.9367257219716 | 45.29 |
| 55 | 20 | 92.53% | 92.52% | 92.5% | 0.8874585117592 | 49.25 |
| 60 | 4 | 67.728% | 65.96% | 67.62% | 1.8748121272003 | 35.66 |
| 60 | 8 | 89.064% | 88.63% | 88.96% | 1.2057961310909 | 37.17 |
| 60 | 12 | 91.734% | 91.4% | 91.67% | 1.0119829915763 | 41.55 |
| 60 | 16 | 92.5% | 92.18% | 92.56% | 0.9143257063503 | 45.33 |
| 60 | 20 | 92.574% | 92.48% | 92.57% | 0.9028820317320 | 48.18 |