CSE 574 Introduction to Machine Learning

Programming Assignment 1

Handwritten Digit Classification using Neural Networks

Group 39

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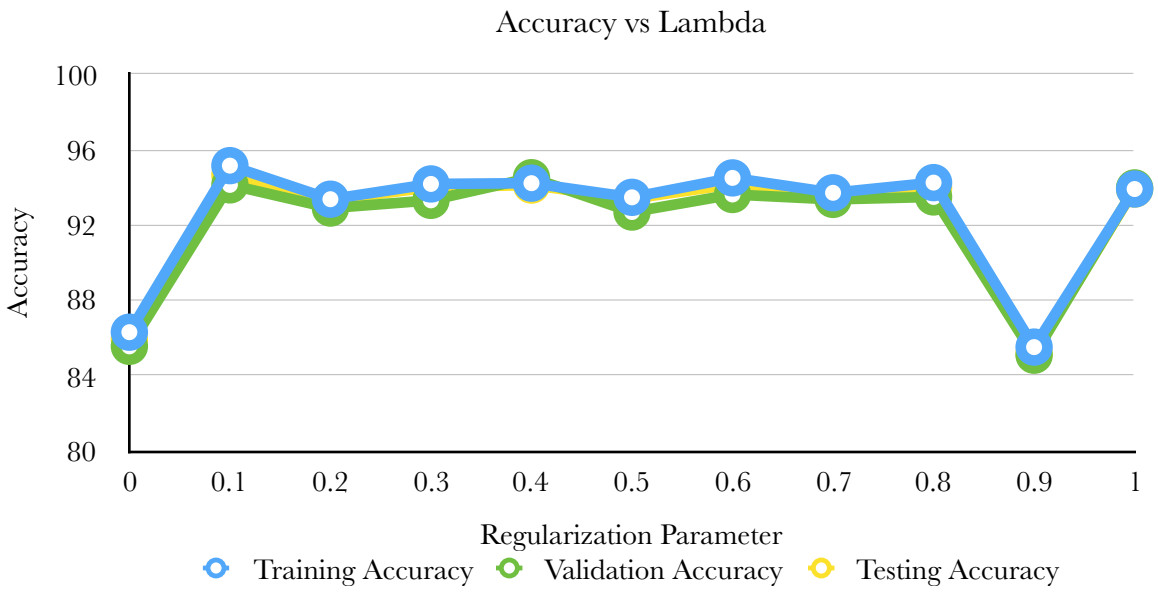
- **Introduction**

We have implemented a Handwritten Digit Classification system using Feed Forward and Back Propagation on Neural Networks. We have also implemented Feature Selection and Regularization to estimate the efficiency of our system. The neural network is first trained on the training data set and then its learning is tested on validation data set.

- **Accuracy with respect to Regularization parameter Lambda**

Regularization is used to avoid the overfitting problem in a model. The value of regularization parameter should be such that it makes the network better at generalizing beyond the training set. In our assignment, we have varied lambda value from 0 to 1 with 0.1 interval for fixed number of hidden nodes (in this case 50). We observed that our system achieved maximum accuracy of 95.14% for lambda = 0.1 and generally performed better for lambda values in the middle (0.4 & 0.6) than at either ends, i.e 0 & 0.9.

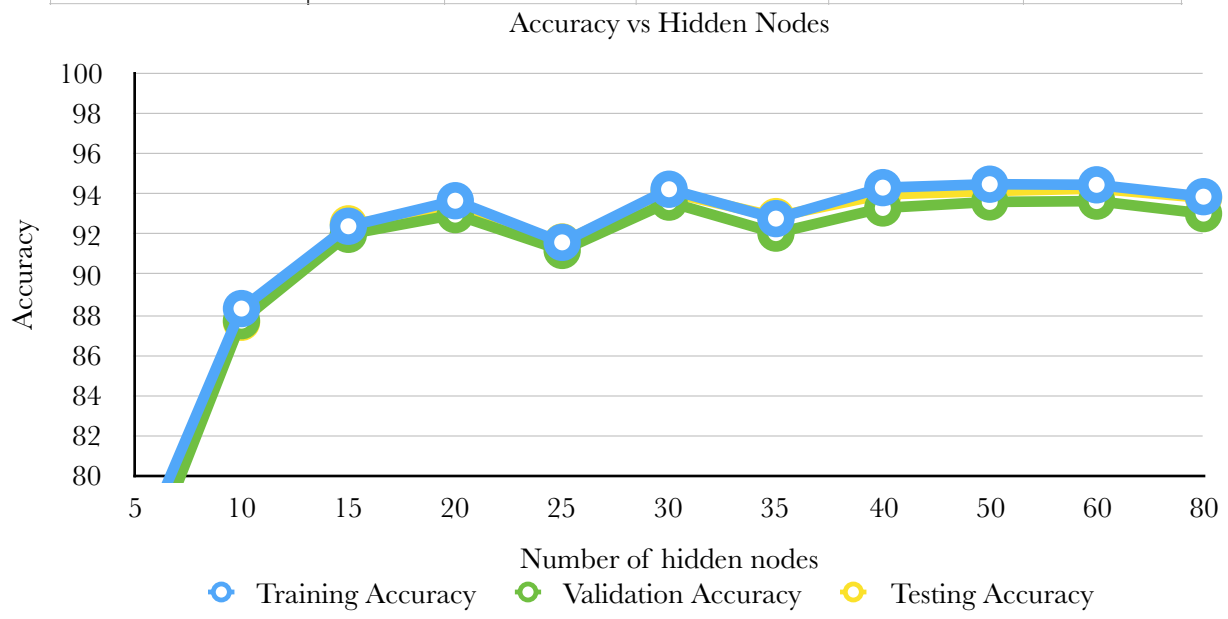
Regularization Parameter Lambda	Hidden Nodes	Training set Accuracy (%)	Validation set Accuracy (%)	Testing set Accuracy (%)	Runtime (s)
0	50	86.31	85.56	85.94	97.38
0.1	50	95.14	94.12	94.65	100.30
0.2	50	93.36	92.89	93.31	94.09
0.3	50	94.17	93.3	94.0	97.47
0.4	50	94.21	94.5	94.11	92.56
0.5	50	93.46	92.68	93.39	93.17
0.6	50	94.49	93.61	94.15	85.22
0.7	50	93.70	93.35	93.58	91.20
0.8	50	94.24	93.48	93.98	101.00
0.9	50	85.52	85.09	85.19	88.75
1	50	93.90	93.96	93.9	95.7



- **Accuracy with respect to number of hidden nodes:**

Complexity of the system increases with increase in number of hidden nodes. We have observed that run time is directly proportional to number of hidden units and hence increases to upto 196s for high value of hidden nodes. Accuracy also increases with hidden nodes to some extent and then starts decreasing after a point. We observed maximum training set accuracy of 94.29% for lambda = 0.6 and number of hidden nodes = 60.

Regularization Parameter Lambda	Hidden Nodes	Training set Accuracy (%)	Validation set Accuracy (%)	Testing set Accuracy (%)	Runtime (s)
0.1	5	72.10	71.33	72.25	67.05
0.1	10	90.04	89.56	89.88	78.69
0.1	40	93.35	92.97	93.5	107.74
0.1	60	94.15	93.55	94.16	196.92
0.4	5	69.08	67.23	68.38	60.92
0.4	10	92.01	90.79	91.81	73.28
0.4	20	92.61	91.39	92.44	76.025
0.4	40	93.91	93.76	93.66	84.64
0.4	60	93.6	93.15	93.71	100.29
0.6	5	82.64	80.91	82.85	69.38
0.6	10	90.43	89.82	90.23	68.64
0.6	40	93.1	92.18	93.19	129.73
0.6	60	94.29	93.52	94.11	96.34



- **Conclusion:**

Thus, we have successfully implemented a Handwritten Digit Classification system and studied how regularization parameter and hidden units affect the accuracy and run times of our system. We achieved maximum accuracy of 95.14% for lambda = 0.1, hidden nodes = 50 and run time = 100.30s.