CSE 474 – Programming Assignment 1
Handwritten Digits Classification

Group 28
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1 Introduction

In this project, we had to implement a Multilayer Perceptron Neural Network and evaluate its performance in classifying handwritten digits. In addition, we had to use the same network to analyze a more challenging hand-drawn images dataset and compare the performance of the neural network against a deep neural networking using the TensorFlow library.

Our implementation of a Multilayer Perceptron Neural Network consists of handling Feed Forward and Back Propagation. By simulating our neural network numerous of times, we are able to determine the best network parameters: λ and the number of hidden nodes that impacts the performance in training time and accuracy.

2 Feature Selection

In the project description of 3.1, it states that we can observe that there are many features which values are exactly the same for all data points in the training set. With those features, the classification models cannot gain any more information about the difference (or variation) between data points. Therefore, we can ignore those features in the pre-processing step.

The saved indices of the features our group used are:
[12, 13, 14, 15, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398,

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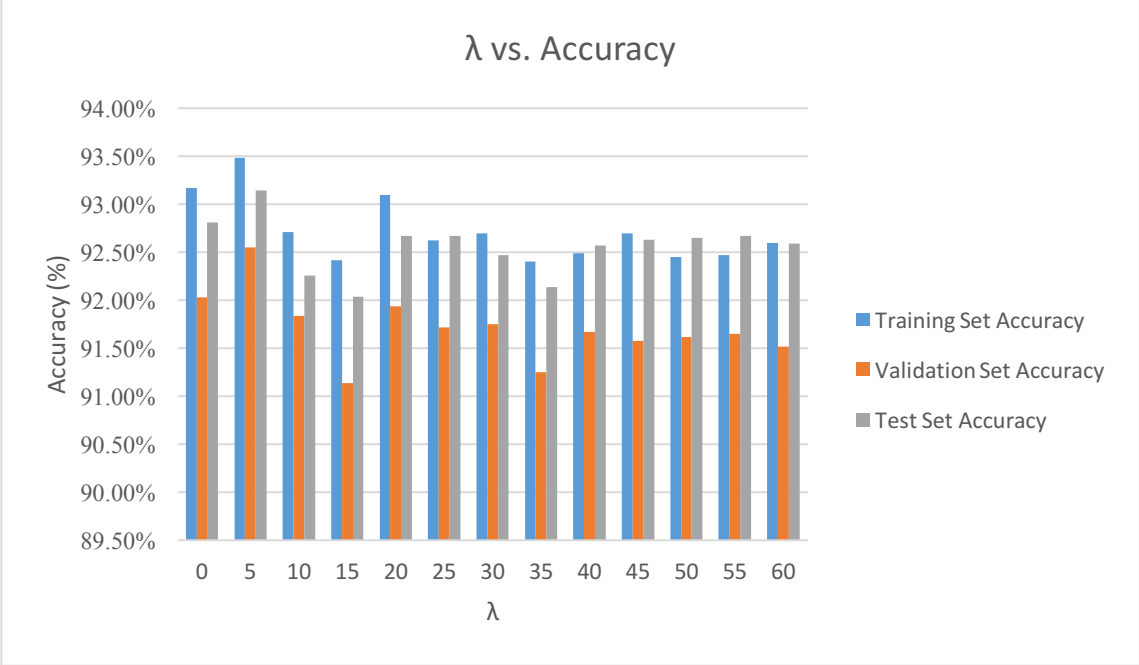
The ignored features are:
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 52, 53, 54, 55, 56, 57, 82, 83, 84, 85, 111, 112, 140, 141, 168, 476, 560, 644, 645, 671, 672, 673, 699, 700, 701, 727, 728, 729, 730, 754, 755, 756, 757, 758, 759, 780, 781, 782, 783]

3 Analysis of Performance

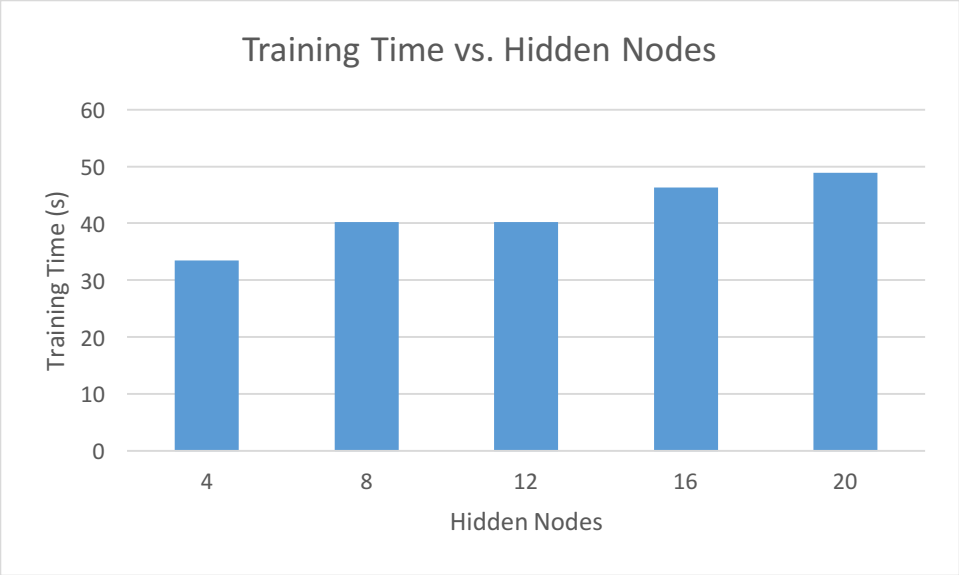
3.1 Analysis between λ and Neural Network Performance



Max Iterations: 50, Fixed Hidden Node: 16

Based on the figure above, there is no significant difference in accuracies by the change of lambda. A possible reason for little to no significant differences are due to similarities in training data and the test set. Therefore, an optimal lambda we can choose based off this graph is $\lambda = 40$ because starting at $\lambda = 40$ to $\lambda = 60$, the accuracies have been near constant.

3.2 Analysis between Hidden Nodes and Training Time



Based on the figure above, the training time increases as the number of hidden nodes increases. This means that the increase of hidden nodes causes reliance on more gradients and weights for computation which resulted in incrementing training times.

3.3 Comparison between our Neural Network and the Neural Network using Tensor Flow Library

Our Neural Network implementation results:

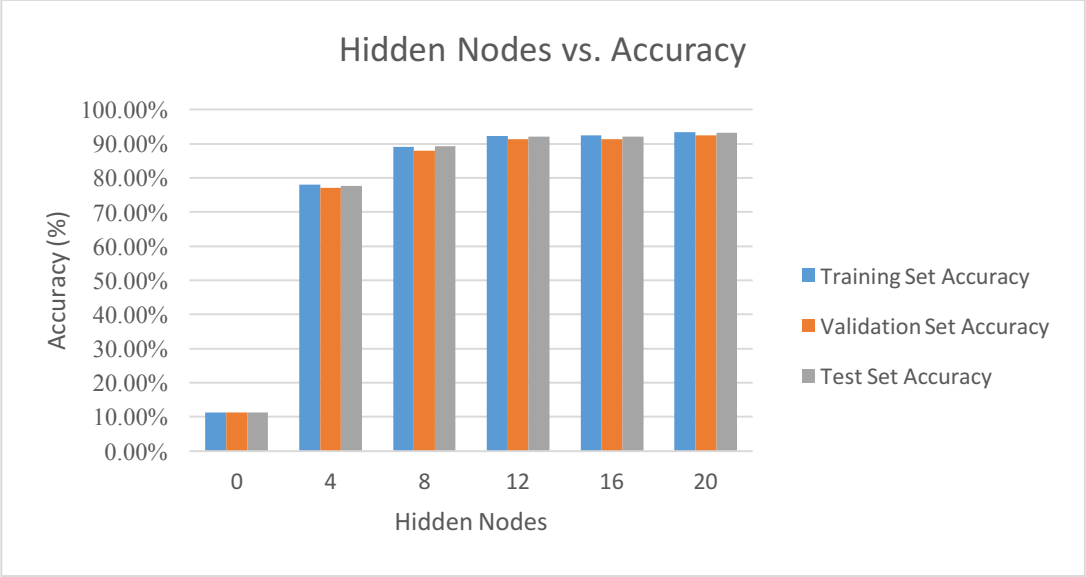
Training Set Accuracy	Validation Set Accuracy	Test Set Accuracy	Evaluation Time
87.65473829%	86.1462477548%	87.2316853632%	381.45

Neural Network using TensorFlow Library:

Number of Hidden Layers	Training Time	Accuracy
2	354.86	77.239%
3	290.63	76.2351%
5	342.38	74.8132%
7	351.43	73.8591%

After comparing both our neural network and the neural network using the TensorFlow library, our neural network is more efficient in accuracy. While training time for both neural networks are very similar to each other.

3.3 Analysis between Hidden Nodes and Neural Network Performance



Max Iterations: 50, Fixed Lambda: 40

Based on the figure above, the performance improves as the hidden nodes increases as shown through the increasing accuracies. At hidden node = 0, the accuracy rate is quite low. However, one can see the accuracy rate increasing from hidden node = 4. From hidden node = 8 to hidden node = 16, the rate of accuracy has been near constant. Therefore, based on this analysis, the optimal hidden node would be 16.