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| **Course Title:** | **Intelligent Systems** |
| **Course Number:** | **ELE 888** |
| **Semester/Year (e.g.F2016)** | **W2021** |
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| **Instructor:** | **Dr. Xiao-Ping Zhang** |

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| *Assignment/Lab Number:* | **Lab 3** |
| *Assignment/Lab Title:* | **Multilayer Neural Networks** |

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| *Submission Date:* | **Mar-28-2021** |
| *Due Date:* | **Mar-28-2021** |

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**Objective:**

To implement a multi-layer neural network using the backpropagation algorithm to classify linear non-separable data. Multi-layer neural network (MNN) implements the linear discriminant functions; however, the input patterns are mapped non-linearly. Utilizing simple equations where the form of nonlinearity can be learned through a training data indicates how powerful and easy neural networks are. A popular method for training the MNN is based on the gradient descent in error is known as backpropagation algorithm.

The sensitivity of unit *k* is given by

And the sensitivity for a hidden unit is given by

The objective of this laboratory estimate the weight vectors of the input-hidden and hidden-output layer for a given activation function. and are the non-linear functions.

**Observation:**

**XOR:**

Chart, line chart

Description automatically generated

Fig 1: XOR Learning Curve

Table 1: XOR with 20 iterations & Wine Training Accuracy of %98.6442

|  |  |  |
| --- | --- | --- |
| Weight Vector (wkj) | Weight Vector (wj1) | Weight vector (wj2) |
| -3.394 | 1.9315 | 2.898 |
| 3.9951 | 1.717 | -2.1641 |
| 2.6187 | 1.7861 | -2.8405 |

**Wine Dataset:**

Chart, line chart

Description automatically generated

Fig 2.1: Wine Dataset Learning Curve with 2 Iterations

Chart, line chart

Description automatically generated

Fig 2.2: Wine Dataset Learning Curve with 2 Iterations

Table 2: Wine Dataset with 2 iterations & Wine Training Accuracy of %99.9892

|  |  |  |
| --- | --- | --- |
| Weight Vector (wkj) | Weight Vector (wj1) | Weight vector (wj2) |
| 3.2224 | 1.9047e-06 | 0.65 |
| 6.0314 | 0.50007 | -0.7 |
| -5.6314 | 0.10001 | -0.9 |

Table 3: Wine Dataset with 2 iterations & Wine Training Accuracy of %99.9995

|  |  |  |
| --- | --- | --- |
| Weight Vector (wkj) | Weight Vector (wj1) | Weight vector (wj2) |
| 4.7114 | 5.5479e-06 | 0.65 |
| 8.324 | 0.50012 | -0.7 |
| -7.924 | 0.10002 | -0.9 |

**Conclusion**

The implemented a multi-layer neural network that uses a back-propagation algorithm that classifies non-separable data. For the first part of the lab, creating a 2-2-1 neural network solved for the XOR problem. The operation learning threshold was 0.001 and the weight vector was 0.1. The two inputs were two 4x1 vectors, with an accuracy of 98.6% after 20 epochs. The second portion consisted of a same 2-2-1 neural network. However, it was applied using a wine data set to classify non-separable data. Using the classes featured, the accuracy computed was 100%.