Neural Network

Assignment 1

Zhao Shenjian 5110309748

Part I: Back-propagation Algorithms

1.1 On-line learning

Case 1: Neuron j is an Output Node

Because I don't have enough time to write the entire derivation, I only write the final result. It's definitely right, because I have check it using my program.

$$\begin{aligned}\delta_j(n) &= e_j(n)f_j'(net_j) = e_j(n)f(net_j)(1-f(net_j))\\ \Delta u_{ji}(n) &= \eta\delta_j(n)x_i^2(n)\\ \Delta v_{ji}(n) &= \eta\delta_j(n)x_i(n)\\ \Delta b_j(n) &= \eta\delta_j(n)\end{aligned}$$

f is sigmoid activation function, $net_j = \Sigma u_{kji}x_{k-1,i}^2 + v_{kji}x_{k-1,i} + b_{kj}$

Case 2: Neuron j is a Hidden Node

$$\begin{aligned}\delta_j(n) &= f_j'(net_j)\Sigma_k(\delta_k(n)(2u_{kj}(n)x_j + v_{kj}(n)))\\ \Delta u_{ji}(n) &= \eta\delta_j(n)x_i^2(n)\\ \Delta v_{ji}(n) &= \eta\delta_j(n)x_i(n)\\ \Delta b_j(n) &= \eta\delta_j(n)\end{aligned}$$

1.2 Batch learning

Case 1: Neuron j is an Output Node

$$\begin{aligned}\delta_j(n) &= e_j(n)f_j'(net_j) = e_j(n)f(net_j)(1-f(net_j))\\ \Delta u_{ji}(n) &= \frac{\eta}{N}\Sigma_n(\delta_j(n)x_i^2(n))\\ \Delta v_{ji}(n) &= \frac{\eta}{N}\Sigma_n(\delta_j(n)x_i(n))\\ \Delta b_j(n) &= \frac{\eta}{N}\Sigma_n\delta_j(n)\end{aligned}$$

Case 2: Neuron j is a Hidden Node

$$\delta_j(n) = f_j'(net_j)\Sigma_k(\delta_k(n)(2u_{kj}(n)x_j + v_{kj}(n)))$$
$$\Delta u_{ji}(n) = \frac{\eta}{N}\Sigma_n(\delta_j(n)x_i^2(n))$$
$$\Delta v_{ji}(n) = \frac{\eta}{N}\Sigma_n(\delta_j(n)x_i(n))$$
$$\Delta b_j(n) = \frac{\eta}{N}\Sigma_n\delta_j(n)$$

Part II: C++ implementation

In order to master every detail of neural network and gain efficiency, I use c++ to solve this problem. The source code is in src folder. Please read the README to build and run the program.

However I use matlab to plot the result image, it doesn't matter.

Part III: Test results

3.1 Correctness

First to say, my result is correct. The misclassification is 0 for both online learning and batch learning. The following two pictures shows the results.

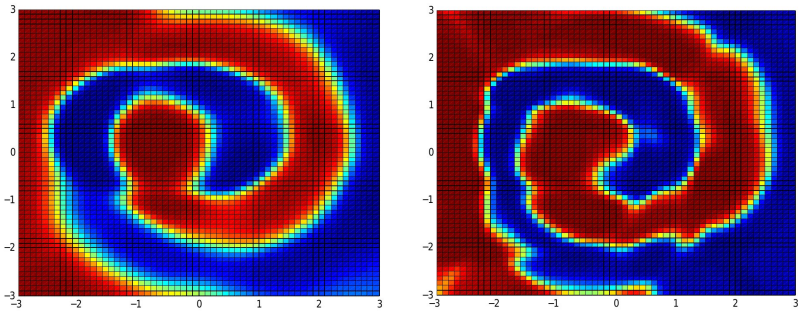

Figure 1: Batch result(left) and Online result(right)

3.2 Efficiency

Although the results are both correct, the online learning is more efficient according to my test result. The learning rate in batch mode should be much larger than online learning. I don't why. And I have tried many learning rate, the total epochs of batch mode is 10 times more than online learning.

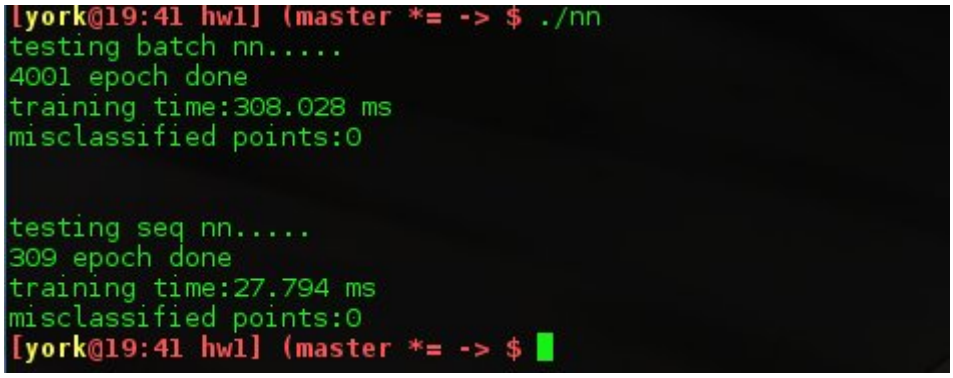

Figure 2: Running time comparison