**COMP 3710 Applied Artificial Intelligence**

**Seminar/Lab 7.**

**Backpropagation Neural Network**

1. Objectives

* Image recognition with a backpropagation neural network

1. We are planning to train a backpropagation neural network to recognize a symbol, ‘-’. The network has
   * Input layer – 2 nodes
   * Hidden layer – 2 nodes
   * Output layer – 2 nodes
   * Initial random weights – [0, 1]
   * Learning rate – 0.2
   * Error = correct value – output
   * The output of 0 and 1 is considered as ‘|’, and the output of 1 and 0 is considered ‘\_’.
   * Activation function: Step function just for this exercise.

Y(X) = 1 if X >= 0.7;

Y(X) = 0.5 else if X >= 0.4;

Y(X) = 0 otherwise;

Here is the algorithm.

For each training image, Image

Output\_I = Input = Image;

For each node, j, in the hidden layer

X\_H[j] = sum of (Weight\_IH[i][j] \* Output\_I[i]);

Output\_H[j] = activate(X\_H[j]);

For each node, j, in the output layer

X\_O[j] = sum of (Weight\_HO[i][j] \* Output\_H[i]);

Output\_O[j] = activate(X\_O[j]);

Output = Output\_O;

For each node, j, in the output layer

Error[j] = Expected[j] – Output[j];

For each node, j, in the output layer

Delta\_O[j] = Output\_O[j] \* (1 – Output\_O[j]) \* Error[j];

For each node, j, in the hidden layer

D[j] = sum of (Weight\_HO[j][k] \* Delta\_O[k]);

Delta\_H[j] = Output\_H[j] \* (1 – Output\_H[j]) \* D[j];

For each node, j, in the hidden layer

For each node, k, in the output layer

Weight\_HO[j][k] += Alpha \* Output\_H[j] \* Delta\_O[k];

For each node, j, in the input layer

For each node, k, in the hidden layer

Weight\_IH[j][k] += Alpha \* Output\_I[j] \* Delta\_H[k];

Here is a training data set.

|  |  |
| --- | --- |
| Pattern | Class |
| [1, 1] | [0, 1] |
| [1, 0] | [1, 0] |
| [0, 1] | [1, 0] |
| [0, 0] | [1, 0] |

Here are initial weights.

|  |
| --- |
| W\_IH[2×2] |
| [[0.3, 0.6],  [0.7, 0.4]] |

|  |
| --- |
| W\_HO[2×2] |
| [[0.9, 0.3],  [0.1, 0.7]] |

Let’s simulate the training of the above BNN. Just one epoch.

For Input[0]: [0, 1],

Forward feeding:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Input | O\_I | X\_H | O\_H | X\_O | O\_O | E |
| [0,  1] | [0,  1] | X\_H[0] = .3 \* 0 + .7 \* 1 = .7;  X\_H[1] = | O\_H[0] = 1;  O\_H[1] = | X\_O[0] = .9 \* 1 + .1 \* .5 = .95;  X\_O[1] = | O\_O[0] = 1;  O\_O[1] = | E[0] = 0 – 1 = –1;  E[1] = |

Backward propagation:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Weight\_IH | Weight\_HO | Delta\_H | D | Delta\_O |
| W\_IH[0][0] = W\_IH[0][0] + A \* O\_I[0] \* D\_H[0] = .3 + .2 \* 0 \* 0 = **.3**;  W\_IH[0][1] = W\_IH[0][1] + A \* O\_I[0] \* D\_H[1] = .6 + .2 \* 0 \* 0 = **.6**;  W\_IH[1][0] =  W\_IH[1][1] = | W\_HO[0][0] = W\_HO[0][0] + A \* O\_H[0] \* D\_O[0] = .9 + .2 \* 1 \* 0 = **.9**;  W\_HO[0][1] = W\_HO[0][1] + A \* O\_H[0] \* D\_O[1] = .3 + .2 \* 1 \* 0 = **.3**;  W\_HO[1][0] =  W\_HO[1][1] = | D\_H[0] = O\_H[0] \* (1 – O\_H[0]) \* D[0] = 1 \* (1 – 1) \* 0 = 0;  D\_H[1] = | D[0] = W\_HO[0][0] \* D\_O[0] + W\_HO[0][1] \* D\_O[1] = .9 \* 0 + .3 \* 0 = 0;  D[1] = | D\_O[0] = O\_O[0] \* (1 – O\_O[0]) \* E[0] = 1 \* 0 \* -1 = 0;  D\_O[1] = |

The values in the above example might not be correct.

Here is what you need to do.

* Complete the above tables. You should include the array names first. E.g., W\_HO[0][1] = W\_HO[0][1] + A \* O\_H[0] \* D\_O[1] = ...
* Continue the above simulation with the second image, [1, 1].

1. Submission
   * The title of the mail should include your name, id, and COMP 3710.

* You need to submit a document file for 2), not image of hand-written document.
  + Total marks: 10
  + Due: 6:00 PM, March 6, 2018