Neural Network Theory and Applications
Homework Assignment 2

March 23, 2010
Due at April 11, 2010

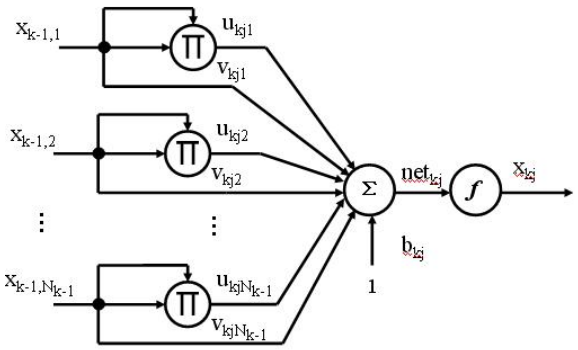
Suppose the output of each neuron in a multilayer quadratic perceptron (MLQP) network is

$$x_{kj} = f\left(\sum_{i=1}^{N_{k-1}} (u_{kji} x_{k-1,i}^2 + v_{kji} x_{k-1,i}) + b_{kj}\right)$$

$$\text{for } k = 2, 3, \cdots, M \text{ and } j = 1, 2, \cdots, N_k$$

where both u_{kji} and v_{kji} are the weights connecting the ith unit in the layer $k-1$ to the jth unit in the layer k, b_{kj} is the bias of the jth unit in the layer k, N_k is the number of units in the k ($1 \le k \le M$), and $f(.)$ is the sigmoidal activation function.

The structure of the unit is shown as the following figure.



1. Please derive the corresponding back propagation algorithms in both on-line learning mode and batch learning mode.
2. Write programs to realize these two BP algorithms for training MLQPs with one hidden layer.
3. Run your two BP programs on the two-spiral data set, which is the same as homework one, and plot the decision boundaries formed by the trained MLQPs. You can choose 10 hidden units in this problem.

4. Run your two BP programs on an image segmentation task from the UCI benchmark. It is a seven-class pattern classification problem. The training file and test file are /materials/image_tr.txt and /materials/image_ts.txt. Please refer the file "/materials/image_info.txt" for detail of this task.

5. Run your two BP programs on the following function approximation problem,

$$f(x, y) = \frac{1 + \sin(6(x^2 + y^2))}{2}$$

where $(x, y) \in [0, 1]^2$. Plot the input-output mapping formed by the trained MLQPs. You can choose 6 hidden units in this problem.

*For the questions 3, 4, and 5, your submission should include the following three points,

1. try 3 different learning rates.

2. try 3 different initial values.

3. discuss the algorithm convergence.