Neural Network Theory and Applications
Homework Assignment 1

March 8, 2018
Due at March 22, 2018

1 Problem 1

One variation of the perceptron rule is:

$$\mathbf{W}^{new} = \mathbf{W}^{old} + \alpha \mathbf{e}\mathbf{p}^T$$
$$\mathbf{b}^{new} = \mathbf{b}^{old} + \alpha \mathbf{e}$$

where α is the learning rate. Prove convergence of this algorithm. Does the proof require a limit on the learning rate? Explain.

2 Problem 2

Suppose the output of each neuron in a multilayer perceptron 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 ($1 \leq k \leq M$), and $f(.)$ is the sigmoidal activation function.

The structure of the unit is shown as the following figure, and this network is called multi-layer quadratic perceptron (MLQP).

Please derive the back-propagation algorithms for MLQPs in both on-line learning and batch learning ways.

3 Problem 3

In problem 3, you should program a deep neural network with TensorFlow to solve an emotion recognition task.

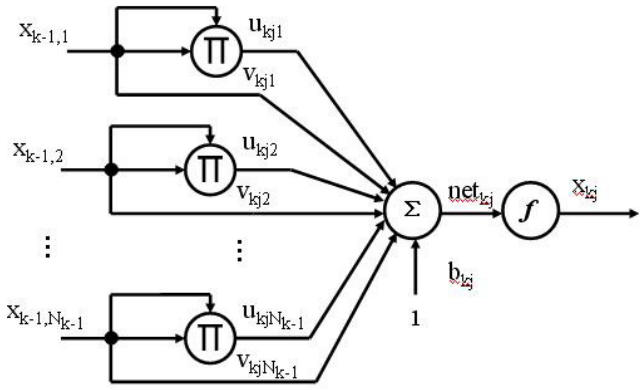

Figure 1: The structure of MLQP

3.1 Model structure

The deep neural network for this task is a three layer network: an input layer, an hidden layer, and an output layer. The nerons in the input layer should be the same as input feature dimensions. The number of hidden neurons is a hyper-parameter which is choosen by yourself. And there are 3 units in the output layer since we are classifying 3 emotion categories. In addition, a $softmax$ function could be applied to the output, transforming outputs to probalities. And you can use *crossentropy* to calculate losses.

3.2 Data description

The provided data contains diferential extropy (DE) features extracted from emotional EEG signals, and emoional EEG signals are collected while the subject watching emotional movie clips (positive, neutral, and negative).

The data can be downloaded from http://202.120.38.76:8000/d/247abb08cf/. Four files are contained in the .zip file: train_data.mat, test_data.mat, train_label.mat, and test_label.mat. Both training data and test data are of 310 dimensions.

3.3 Questions

Run your programs to classify the emotion recognition problem and compare the training time and generalization performance of different hidden units and learning rates.