Homework # 4 (Neural Networks)

1- Consider the following training data set

$$\left\{\mathbf{p}_1=\begin{bmatrix}5\\0\end{bmatrix},t_1=0\right\},\left\{\mathbf{p}_2=\begin{bmatrix}4\\-1\end{bmatrix},t_2=0\right\},\left\{\mathbf{p}_3=\begin{bmatrix}6\\0\end{bmatrix},t_3=0\right\},\left\{\mathbf{p}_4=\begin{bmatrix}5\\-1\end{bmatrix},t_4=0\right\}$$

$$\left\{\mathbf{p}_5=\begin{bmatrix}2\\-1\end{bmatrix},t_5=1\right\},\left\{\mathbf{p}_6=\begin{bmatrix}1\\-2\end{bmatrix},t_6=1\right\},\left\{\mathbf{p}_7=\begin{bmatrix}2\\-2\end{bmatrix},t_7=1\right\},\left\{\mathbf{p}_8=\begin{bmatrix}1\\-3\end{bmatrix},t_8=1\right\}$$

a- Train a perceptron to classify the data set into two classes. Plot points and decision boundaries.

b- Use a single neuron with sigmoid activation function to do this classification problem. Plot the points and decision boundary and compare the results to part a.

2- Consider the dynamical system

$$\ddot{x} = -0.1x^3 + f(x)$$

where $f(x) = x^2 + \sin(x)$.

a) Approximate the function *f*(*x*) using an MLP neural network and plot the function and the estimation on the same graph.

b) Simulate the system response for exact *f*(*x*) and the approximation. Use different initial conditions. Compare the results.

For the following two questions, download the breast cancer data from your blackboard and load it into your MATLAB session. This file contains a matrix called data of size 683 × 11, which represents 9 measurements (various geometric features) taken from images of 683 cells in breasts. data(j,1) is the Id. number of the jth cell, data(j,2:10) contains those 9 measurements of the jth cell, and data(j,11) contains the diagnosis by the doctors, i.e., benign if this value is 2; malignant if this value is 4.

You can also download the data from the following link.

https://elearn.uta.edu/webapps/portal/frameset.jsp?tab_group=courses&url=%2Fwebapps%2Fblackboard%2Fexecute%2Fcontent%2Ffile%3Fcmd%3Dview%26mode%3Ddesigner%26content_id%3D_2958631_1%26course_id%3D_213182_1%26framesetWrapped%3Dtrue

3- Use a multilayer perceptron to classify the data set into two classes and Compute the false-positive rate and false-negative rate of your classification results. These are defined as:

false-positive rate =

$$\frac{\text{Number of benign cells incorrectly classified as “malignant”}}{\text{Total number of benign cells}}$$

false-negative rate :=

$$\frac{\text{Number of benign cells incorrectly classified as “benign”}}{\text{Total number of malignant cells}}$$

4- Assume that the data points in question 3 are not labeled, i.e. assume the 11^{th} column in breast cancer data set does not exist. Use a self-organizing map neural network to cluster the data into two classes and compute the false-positive rate and false-negative rate of your clustering results using the same definitions as in question 3.