**ECE 595 Homework 7 (Optional) Due: April 25, 5 PM**

1. Consider the two-class XOR problem with the training examples and targets as:  , ,  , . Using a 2 – 2 – 1 multilayer perceptron architecture excluding bias, i.e., two units at input, two units in the first hidden layer and one unit in the output layer, obtain the final synaptic weights for the network using the backpropagation algorithm. Note that after the linear combiner output (the *v* output) from each neuron in layer 2, you need the sigmoid activation function to get the activation potential (the *a* output) that goes to the output layer neuron as input. There are 3\*2 + 3\*1 = 9 weights to be determined. Use an initial a learning rate of 0.1. You may also try other learning rates. Also, try with +1 and -1 for the output, instead of 1 and 0. Do a few iterations by hand so that you can verify the results from MATLAB and modify your code if needed. (a) Plot the cost function after each epoch as given by



Since there are two classes, try using two units in the output layer so that the output will be [0 1] for class 0, and [1 0] for class 1. This architecture will require 12 weights to be determined. You may also try with regularization, i.e., try to minimize all theta values (other than those for the bias at each layer).

1. Apply your implementation of the backpropagation learning algorithm for the two-class training data, *hm7.mat* with a learning rate in the range of 0.01 to 0.5. (Observe a plot of the data.) Use at least three learning rates. Use +1 and -1 for target outputs (instead of binary 1 and 0). Be sure to shuffle the data after each epoch. You may use the *randperm* function. (a) How many iterations did your code take to converge? Show a plot of the total squared error against the number of epochs. Be aware that without regularization, it may take a lot more epochs to converge, i.e., reach a low cost-function value, than with regularization. (b) What are the final weights? (c) Show the decision boundary on the plot of the input vectors. (d) What is the accuracy of classification of the test data, *hmtest7.mat*? Include with your code figures and answers. (e) Learn to use a MATLAB function for backpropagation and show the code and results with resulting plots, epochs, etc. Compare the decision boundary plot with your results in (a) through (d).