EE5600: Introduction to AI & ML, Fall 2018 (12)
Indian Institute of Technology Hyderabad
HW 2, Assigned: Wednesday 29.08.2018.
Due: Friday 07.09.2018 at 11:59 pm.

1 Theory

1. For the K-class linear discriminant classifier with the decision hyperplane between classes k and j defined by $\mathbf{w}_k^T\mathbf{x} + w_{k0} = \mathbf{w}_j^T\mathbf{x} + w_{j0}$, show that the region $\mathcal{R}_k$ corresponding to class k is convex. (5)
2. Formulate and solve the supervised learning problem for a two-class support vector machine model using the notation discussed in class. (5)
3. Formulate the supervised learning problem for a multilayer perceptron model using the notation discussed in class for the sum of squared error loss function. Derive the locally optimal solution and describe the *backpropagation* algorithm. (5)
4. Repeat the above for the cross entropy loss function. (10)

2 Programming

1. Implement the linear support vector machine. You are encouraged to use open-source convex solvers (for e.g., CVXPY). Train your hyperplane using the attached training data (*Xsvm.csv*, *ysvm.csv*) consisting of 500 two-dimensional points. Test on the following points: $\mathbf{x}^{501} = [2, 0.5]^T, \mathbf{x}^{502} = [0.8, 0.7]^T, \mathbf{x}^{503} = [1.58, 1.33]^T, \mathbf{x}^{504} = [0.008, 0.001]^T$. (30)
2. Implement the back-propagation algorithm to learn the weights of a perceptron with 2 input nodes, 2 hidden nodes and 1 output node. Train your network to learn the following binary operations:
   (a) XOR (10)
   (b) AND (10)
   (c) OR (10)

   Experiment with the number of training samples N and see how its affects performance. Add noise to the labels to generate more samples. Your code should make the number of nodes a configurable parameter.