Indian Institute of Science

Neural Networks and Learning Systems-I

Instructor: Shayan Srinivasa Garani
Home Work #1, Fall 2020

Late submission policy: Points scored = Correct points scored $\times e^{-d}$, d = # days late

Assigned date: Oct. 30th, 2020   **Due date:** Nov. 13th, 2020, 11:59 pm

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PROBLEM 1: Sketch the following activation functions (a) sigmoid (b) logistic (c) ReLu and (d) leaky ReLu. Assume any scaling constants in the above functions to be unity. How does the derivative of the above activation functions behave near zero?   (5 pts.)

PROBLEM 2: Solve problems 1.1 and 1.2 from Haykin's book (3rd edition).   (10 pts.)

PROBLEM 3: Consider a 3-class classification problem, comprising labels ω_i, $i = 1, 2, 3$ corresponding to data points which are uniformly distributed over $[-1, 1]$, $[-2, 2]$ and $[-4, 4]$ respectively. The corresponding *apriori* probabilities for the classes are $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{1}{6}$. Are the points linearly separable? Determine the optimum thresholds and provide a Bayes decision rule to decide the label for a point randomly sampled from the interval $[-4, 4]$. Compute the probability of misclassification error.

    (10 pts.)

PROBLEM 4: We shall consider a 3-class problem comprising 2D data points that are clustered uniformly within circles of radius 1 unit centered at points $(0, 4)$, $(-3, 0)$ and $(3, 0)$. We are interested in constructing linear classifiers for this data.

(1) Generate 100 random data points corresponding to each class above. Provide a scatter plot of the points.
(2) Devise a procedure to construct a perceptron-based algorithm to classify the points.
(3) Configure the procedure in (2) to operate in online and batch modes. Provide a plot of the error trajectory as a function of iteration steps/epochs for both online and batch modes. Sketch the final decision boundaries after convergence. Do you expect the decision boundaries to be collinear? Justify your reasoning. Experiment your results by shuffling the data points every epoch with different learning rates and random weight initializations. What are your conclusions?
(4) Suppose you grow the circle radii of all the clusters by 4 units with centers fixed, experiment the algorithm you developed. Sketch the decision boundaries after 50 epochs. What are your conclusions?

    You may want to make a movie to demo your results using Matlab or other software tools.

    (25 pts.)