Indian Institute of Science

Neural Networks and Learning Systems-I

Instructor: Shayan Srinivasa Garani
Homework #2, Fall 2021

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

Assigned date: Sep. 23^{rd}, 2021 **Due date:** Oct. 6^{th}, 2021, 11:59 pm

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PROBLEM 1: A student decided to use the multilayer perceptron (MLP) to solve the linear differential equation $\sum_{i=0}^{N-1} a_i \frac{d^i x}{dt^i} = y(t)$, $a_i \in \mathbf{R}$. You may assume that all the initial conditions are provided. How would you approach to set up and configure the MLP to solve this problem? Show all the details explicitly along with any assumptions made. (15 pts.)

PROBLEM 2: Consider a 3-variable extension of the XOR problem done in the class. The output $y = x_1 + x_2 \mod (3)$, where x_1 and x_2 take values 0, 1 and 2. This relation is the usual addition modulo(3) over ternary values. Sketch the points along with their outputs. Derive *analytically* a classifier based on the MLP using a nonlinear activation function of your choice. Your final neural network architecture must have the *least* number of neurons. Show the explicit decision boundaries analytically and sketch them. (20 pts.)

PROBLEM 3: Consider the Iris data set https://archive.ics.uci.edu/ml/datasets/iris. We are interested in constructing classifiers for this data.

(1) Derive from first principles the multiclass logistic regression algorithm based on ideas discussed in the class or otherwise. Write a software code from first principles based on the derived equations to configure and run the algorithm. Provide a plot of the error trajectory as a function of iterations towards convergence. Experiment with cross validation strategies using 70% and 80% training sets. What are your conclusions on classification rates? You may want to make a movie to demo your results using Matlab, Python or other software tools.

(2) In the second part, you will do the experiments based on the backpropagation algorithm you learnt in the class. From first principles, code up the back propagation algorithm. Experiment with the momentum learning rule learnt in the class. Carefully distill the learning parameters to optimize the performance. Provide a plot of the error trajectory over iterations. What are your conclusions on the classification rates?

(3) Comment on the classification rates both during training and testing by comparing the multiclass logistic regression model and the multilayer perceptron. What do you conclude?

(65 pts.)