CS454-554 Homework 3: Single-and Multi-Layer Perceptrons for Regression
Spring 2024/2025

In this homework, you will implement single- and multi-layer perceptrons for regression. As usual, you are provided with two dataset files and **train.csv** file will be used for training and **test.csv** file will be used for testing. Each row of the files corresponds to one input instance and its corresponding desired output value. You have 20 instances for training and 80 instances for testing.

For multi-layer perceptrons, the activation function of the hidden layer should be **tanh** and so you need to derive the learning rules accordingly.

You should implement the back-propagation algorithm to train the following four networks:

a) Single-layer perceptron
b) Multi-layer perceptron with one hidden layer of 2 hidden units,
c) Multi-layer perceptron with one hidden layer of 4 hidden units,
d) Multi-layer perceptron with one hidden layer of 8 hidden units.

You can use numpy or pandas but you are not allowed to use any machine-learning library such as PyTorch, Scikit-learn, and so on.

You will have to do some trial-and-error to adjust the number of epochs and the learning rate. Don't forget to include the bias nodes in the input layer and the hidden layer! You can implement online, minibatch, or batch learning.

Your output and report should contain:

a) The derivation of the update rules that use the tanh activation function,
b) Four figures for each network's output after convergence, plotted together with the training data. The output of the network should be shown as a function.
c) A figure of learning epochs vs MSE. The y axis should correspond to the MSE and the x axis corresponds to epochs. You can have different figures for each network or have one figure with four plots.
d) A figure of network complexity vs error. The y axis should correspond to the training/test MSE where the x axis corresponds the number of hidden units, with x=0 for the single-layer perceptron.

This homework is due **April 30th (Wednesday), 23:00**.
Your submission should include a short report of your findings, the plots, and your source code.
Upload your report **as a pdf file** to LMS alongside your .py code file.