Assignment 01 Component 02

Submit Assignment

Due Sep 24 by 11:59pm **Points** 5 **Submitting** a file upload **File Types** pdf

Assignment 01 - Component 2:

In class, we covered a multiple linear regression using our polynomial curve fitting example. In that example, the objective function used was the Least Squares objective and the basis function used for each input value was the polynomial basis function, i.e., $\phi(x) = [x^0, x^1, \ldots, x^M]$ where M is the polynomial model order. In this assignment, we will explore the use of radial basis functions (RBFs) instead of the polynomial basis function. The RBF with a (single) fixed mean and variance is:

$$\phi_j(x) = \exp\left\{-\frac{(x-\mu_j)^2}{2s^2}\right\} \; where\; x \in R^1$$

To have a M-dimensional feature vector, M RBFs with M mean and variance values can be used:

$\phi(x) = [\phi_1(x), \phi_2(x), \ldots, \phi_M(x)]$. Note: you can include append a "1" to the feature vector to add a bias term if you choose, $\phi(x) = [1, \phi_1(x), \phi_2(x), \ldots, \phi_M(x)]$.

In this assignment, the mean values for the M RBFs will be defined and compared in two ways:

1. The mean values will be evenly spaced across the range of x values (i.e., -4 to 4). So, for example, if you want to have M=3, then you would divide the range between -4 to 4 in three intervals and have a mean value to represent each interval - i.e., $\mu_1 = -3;\ \mu_2 = 0;\ \mu_3 = 3.$

2. Each of the training points will defined ones of the RBF mean values (i.e., M=N where N is the number of training data points). In this case, if you are investigated M < N, then you would randomly sample training data points to use as the mean values.

In this assignment you should complete the following items:

- Implement the least squares solution and the both of the basis functions described above for solving for the weights.
- Your implementation should be in Python using the starter code template provided. Starter code can be obtained from here: [(https://classroom.github.com/a/oHn8iqSk)](https://classroom.github.com/a/oHn8iqSk) [https://classroom.github.com/a/a_S2UnIQ (https://classroom.github.com/a/a_S2UnIQ)](https://classroom.github.com/a/a_S2UnIQ)
- Your code should produce at least five plots (at least four from the first bullet point below and one from the second bullet point below):
  - Plots showing following across a variety of M values. In the case where M < N (where N is the number of training points), randomly sample M training data points from for the RBF with training data points as the mean values. When generating these plots, use an x-axis ranging from -4.5 to 4.5; y-axis ranging from -2 to 2, using the best "s" values that you can find. Let s be fixed and equal across all of the RBFs.:
    - A scatter plot of the training data where the x-axis corresponds to the input data value x (train_data[:,0]) and the y-axis corresponds to the desired value t (train_data[:,1]).
    - A line corresponding to the estimated function using the least squares solution with the RBF basis function with evenly spaced means
    - A line corresponding to the estimated function using the RBF basis with the training data means
    - A line corresponding to the true function
  - One plot plotting the M value on the x-axis and the absolute error (|y-t|) on the Test data on the y-axis using the two RBF methods. Select a range of s values and evaluate the performance for both methods across choices of s.

- Submit a (typed) PDF file that contains the plots described above in Canvas to this assignment. In your PDF include short answers for each of the following questions. You can provide additional plots to justify your response if you would like (but it is not required):

1) Do the RBFs outperform (in terms of error between predicted and desired) the polynomial basis function with the same M value on the provided training and testing data? Why or why not?

2) Do any of the generated plots show indication of overfitting in any of your results? Why or why not?

3) What is the role of the parameter s and how does the choice of s effect results?

- Submit your code for this assignment using Github classroom by pushing your code to the create Github repository. Your code should be in the file hw01.py. When we run hw01.py, it should generate the plots that you have used in your PDF file.

<table>
<tr><th colspan="6">Assignment 01 Component 01 Rubric</th></tr>
<tr><th>Criteria</th><th colspan="4">Ratings</th><th>Pts</th></tr>
<tr><td>Code Implementation of Part 2</td><td>2.0 pts
Full Marks
Code runs and produces figures provided in PDF</td><td colspan="2">1.0 pts
Lacking plots
Code submitted and runs without error. However it does NOT produce plots provided in PDF (or does not produce any plots).</td><td>0.0 pts
No Marks
Code does not run or is not submitted/empty code.</td><td>2.0 pts</td></tr>
<tr><td>PDF/Plots of Part 2</td><td>3.0 pts
Full Marks
All plots submitted, correct answers provided to three questions which are justified by provided plots and experiments. Good experimental design (in terms of train/test/validation splits as needed). Complete and clear explanation of assignment provided.</td><td>2.0 pts
Minor errors in questions/plots
Minor errors in question responses or plot generation/discussion</td><td>1.0 pts
Major Errors
PDF submitted - however, major errors in plot generation/discussion OR major errors in experimental design OR major errors in the three question responses OR incomplete submission</td><td>0.0 pts
No Marks
No PDF submitted</td><td>3.0 pts</td></tr>
<tr><td colspan="6" align="right">Total Points: 5.0</td></tr>
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