UUM540E – Engineering Project in Aerospace:

Artificial Intelligence with Applications to Aerospace Systems

Spring 2019

Project #2

Due Date: 23 April 2019, 17:00

(Please do not forget to hand in all associated code with your HW)

Project – 2: Deep Learning Algorithms

Problem Definition: *In this project, you are going to build neural network models to estimate fuel flow of a jet aircraft. You will work on two datasets: The first one is comprised of 10 flights of the same individual aircraft. The second dataset has 10 flights of the same aircraft type but 10 different tail-numbers. You are expected to separately train neural networks on these datasets and compare the results. The datasets that you are going to use are real flight data!*

Project Steps:

1. **Investigate the data:**
    a. Provide important visualizations for data and explain the correlations, problems, probabilistic distributions …etc.
    b. Clean the data if necessary.
    c. Complete the missing parts of the data if necessary.
2. **Build Train, Test and Validation Data Sets:**
    a. According to your choice, build your train-test or train-test-validation sets. (It is up to you to combine and rebuilt data sets or use them as is.)
    b. If you use some nonlinear transformation on your data sets provide this information and don't forget to apply the same operation on your test and validation data sets.
    c. Two datasets are provided to you to train and test the regression models.
        i. ***DataSet1*** has 10 complete flights of a single, unique aircraft.
        ii. ***DataSet2*** has 10 complete flights of the same aircraft type, but 10 different tail numbers.
3. **Train Neural Networks:**
    a. Build your machine learning models for regression task given below:
        i. For given flight conditions, aircraft have fuel flow rates in [kg/s]. Your goal is to estimate the total fuel flow from engines 1 and 2. They are denoted as *FF1* and *FF2* in the data.
        ii. In the first stage, include throttle positions in your feature set. Additionally, select at least 4 more features. Try to provide physical intuition for your feature extraction.
        iii. In the second stage, drop the throttle positions from your input set and train your neural network using the rest of features you used in the previous part.

iv. In the third stage, find or derive proper features to replace the throttle positions. Train your neural network and try to reduce the estimation error you calculated in the second part.
v. In the last stage, divide your trajectory set into 3 parts: Climb, Cruise and Descent. For instance, one of the parts will have only the trajectory points where the aircraft is ascending. (Hint: you can use the derivative of altitude). Train different neural networks for each flight phase.
vi. Train your neural networks for the data scaled by both standard and min-max scaling techniques.

b. Apply the process above to DataSet1 and DataSet2. Give all the results in a table format.
c. Tune the hyper parameters of the optimization algorithm you chose. Select proper activation functions and weight initialization techniques.
d. Explain the results and investigate underfitting or overfitting and how you resolve these problems.
e. Try to use different feature combinations with your model and explain the effects.
f. Try to include plots of evaluation of loss functions as epoch increases. (Hint: use PlotLossesKeras as callback)
g. **Your performance will be evaluated and graded by the estimation error on the test sets.**

4. **Report:**
   a. After completed your study, prepare a report which includes all your steps, outcomes and results in a great detail.
   b. Your code must be submitted as a python notebook.
   c. Your report must be in pdf format.
5. **The Datasets**

You can find the datasets and the template of python notebook in the link below. The details are indicated in the script through comment lines. We highly recommend you to use Google's Colab platform.

https://www.dropbox.com/sh/hvqpw4zd22ftfwy/AABf02thkwVMmUao1iaybZfVa?dl=0

Notes:

- ***Any form of plagiarism is strictly prohibited. Violation will be subjected to 'no credit' for the course.***
- ***All available deep learning frameworks can be used for this project. (Tensorflow, Pytorch, Caffee, Keras ..etc)***

Good Luck!

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