Thermal Storage Design: Part 2

Deep Learning in
Scientific Computing
Due date: June 6, 2021

Training and testing data can be found on the Moodle page: `https://moodle-app2.let.ethz.ch/course/view.php?id=14817`

IMPORTANT INFORMATION

To get ETCS credits for the course Deep Learning in Scientific Computing you need to submit and obtain a passing grade on the project. The project consists of two parts and the submission deadline is the 6th of June for both of them. Each part accounts for several tasks where you will be asked to train a learning model and provide predictions on a testing set. Therefore, **the final submission consists of the predictions files together with a report of maximum 2000 characters** where you succinctly describe the procedure followed in the tasks. Those have to be collected in a zip folder named as *yourfirstname_yoursecondname_yourleginumber.zip*. **Only the students that submit the report and the prediction files will be graded. The others will NOT BE GRADED AND WILL NOT RECEIVE A FAIL. You do NOT need to inform us apriori if you are not going to submit the project.**

Task 4: Inference of Fluid Velocity

Let us assume that **noisy** measurements of the fluid temperature $\{(t_j, T^{L,*}_{f,j}),\ j = 1, ..., N\}$ are taken at the bottom end of the storage $x = L$ during the charging phase of the first cycle. The objective of this task is to infer the velocity of the fluid u^*_f generating the recorded measurements.

This can be done by minimizing a suitable cost function $G = G(u_f)$:

$$u^*_f = \arg\min_{u_f} G(u_f) \tag{1}$$

To this end you are provided with a training set $S = \{s_i,\ i = 1, ..., 1024\}$, with $s_i = (t_j, u_k, T^L_{f,jk})$, $j = 1, ..., 128,\ k = 1, ..., 8$, generated by solving with a finite difference scheme the system of equations (1, *Thermal Storage Design: Part 1*) for each value of the velocity $u_{f,k}$, $k = 1, ..., 8$ and collecting 128 randomly selected couples $(t_j, T^L_{f,jk})$, $j = 1, ..., 128$, at $x = L$. The training data can be found in the file **Task4/TrainingData.txt**, whereas the measured data are stored in the file **Task4/MeasuredData.txt**

Design a procedure and a suitable cost function G that, given the provided training set S and the measured data, allow you to infer the target velocity u^*_f.

Register the obtained value in a file called
yourfirstname_yoursecondname_yourleginumber/Task4.txt. **The format of the file has to be the same as the file Task4/SubExample.txt.**

Task 5: Design of Storage Geometry

In this task we are interested in the optimal design of the thermal storage. Formally, the aim of the task is to find the control parameters $y = (D, v)$, with $D \in [2, 20]$ being the diameter of the storage and $v \in [50, 400]$ its volume, such that the capacity factor is exactly $CF_{ref} = 0.45$. This can be done by solving the following minimization problem:

$$(D^*, v^*) = \arg\min_{D,v} G\big(CF(D, v)\big) \tag{2}$$

with $G\big(CF(D, v)\big)$ being a suitable *cost function*.

However, the resulting optimal control parameter (D^*, v^*) is not unique and it will depend on the initial guess (D_0, v_0) used to solve the minimization problem (2). Specifically, the minimizers of the cost function $G\big(CF(D, v)\big)$ correspond to points lying on a curve γ in the control parameter space $[2, 20] \times [50, 400]$ that can be defined by a function $v^* = v^*(D^*)$. The objective of this task is to find the optimal curve, namely to provide $N = 1000$ different minimizers (D^*_k, v^*_k), $k = 1, ..., N$ of the cost function $G\big(CF(D, v)\big)$, obtained by solving the minimization problem (2) with initial guesses $(D_{0,k}, v_{0,k})$, $k = 1, ..., N$.

To solve the task you are provided with a training set $S = \{(D_i, v_i, CF_i),\ i = 1, ..., 50\}$, with CF_i being the i-th realization of the capacity factor, stored in the file **Task5/TrainingData.txt**.
Register $N = 1000$ minimizers of the cost function in a file called
yourfirstname_yoursecondname_yourleginumber/Task5.txt. **The format of the file has to be the same as the file Task5/SubExample.txt.**