Laboratory Assignment: Implementing Liquid State Machines (LSMs)

Solve the following assignment, whose completion is required to access the oral examination. Send the assignments all-together (once you have completed all the labs, not only this single one) as a compressed folder including one subfolder for each laboratory.

The subfolder for this lab should be called “spiking-lab2” (Spiking Neurons lab 2) and should include the Matlab scripts and the other files as requested in the assignment below. You can organize the code as you wish, implementing all the helper functions that you need provided that these are included in the subfolder and are appropriately called in the scripts.

Bonus track assignments are meant to be for those who finish early, but they are not formally required for completing the Lab Assignment.

Supporting material for this assignment is listed below:

Izhikevich’s Model
[1] E.M. Izhikevich, "Simple model of spiking neurons." IEEE Transactions on neural networks 14.6 (2003): 1569-1572.
Available online at: http://izhikevich.org/publications/spikes.pdf
Web page: http://www.izhikevich.org/publications/spikes.htm

IMPORTANT (use it, customize it)
The Liquid of the LSM should be implemented by using the pattern of connectivity and the parameters (at least initially) following the code by Izhikevich, which can be found at
http://www.izhikevich.org/publications/net.m
(you will need to vary the number of excitatory and inhibitory neurons)

[2] E.M. Izhikevich, "Which model to use for cortical spiking neurons?." IEEE transactions on neural networks 15.5 (2004): 1063-1070.
Available online at: http://izhikevich.org/publications/whichmod.pdf
Web page: http://izhikevich.org/publications/whichmod.htm

Matlab documentation
Matlab User’s Guide https://www.mathworks.com/help/index.html
Matlab Neural Network Toolbox User’s Guide http://it.mathworks.com/help/pdf_doc/nnet/index.html
Matlab documentation using the help command (e.g. `help train`)

Assignment – Valve fluid flow dataset (Valve)

This task is an input-output time series task. At each time step the goal is to estimate the value of the output given the history of the input until that time step.

Input represents the percentage of valve opening, target output is the fluid flow from the pipe.

Import the dataset from Matlab (`load valve_dataset`). The input and target (output) sequences are in valveInputs and valveTargets, respectively. You can use cell2mat for manipulating these data (e.g. cell2mat(valveInputs) is a row matrix).

The dataset contains a total number of 1801 time-steps, which should be separated properly into training, validation and test sets:

- Training set: the first 1500 time steps
- Test set: the last 301 time steps of the dataset
- Validation set: the last 500 time steps of the training set

Solve this regression task with a LSM, where:

- The liquid is given by a layer of interconnected Izhikevich neurons
  (e.g. the input is added as external applied current)
- The readout is a single neuron, trained by pseudo-inversion
  `Wout = trainTargets * pinv(trainStates)`

Use a hold-out model selection scheme to choose a suitable number of excitable and inhibitory neurons in the liquid.

The output of the assignment should then consist in the following data, pertaining only to the selected hyper parametrization:

- The script .m file(s)
- Training, validation and test errors
  The error function to consider should be the Mean Absolute Error (MAE)
  e.g. `mean(abs(outputTraining-targetTraining))`
- Note: you should achieve a MAE on the test set < 40
- Target vs output plot, both for training and test data (.fig or .png file, a total number of 2 figure files)

Bonus Track Assignment

1) Try implementing a different spiking neuron model for the liquid (e.g. integrate-and-fire).
2) Try implementing a different readout (e.g. a MLP).