iqr Tutorial 02-Cell Types, Synapses & Run-time State Manipulation_LONG

iqr tutorials will provide you with a practical introduction to using the neural simulation software and give you an insight into the principles of connectionist modeling. They are intended to be complementary to the detailed operation manual.
The home page of iqr is at iqr.sourceforge.net. Up to date information, documentation and tips and tricks ca be found in the iqr wiki (sourceforge.net/p/iqr/wiki/Home/).
The repository of iqr packages is here: sourceforge.net/projects/iqr/files/. iqr is open source software. You can browser the entire source code of iqr here: http://sourceforge.net/p/iqr/code/HEAD/tree/. Please contribute to iqr by reporting bug (sourceforge.net/p/iqr/bugs/) and requesting features (sourceforge.net/p/iqr/feature-requests/).

Aims

- Understand and assimilate the basic principles and concepts of iqr:
  - Neuron groups: Random spike, Linear threshold, Sigmoid, Integrate and Fire.
  - Neuron properties: threshold, excitatory gain, membrane persistence.
- Link multiple cell groups of different types using connections:
  - Synapses & connection properties (synapse type: 'uniform fixed weight', pattern map).
  - Connection plot

Introduction

In iqr models, the main difference between types of neurons (for mathematical formalization, please refer to the iqr manual) is the transfer-function between the inputs and the outputs, and how the inputs are integrated in the membrane potential.

- Linear threshold (LT): it sums up all the inputs with a certain gain (excitatory gain for excitatory connections or inhibitory gain for inhibitory connections). Then, there is a threshold. Once the integration of the inputs (what constitutes the membrane potential) is over the threshold, the output follows linearly the input, otherwise output is zero. The integration of the inputs can be also manipulated by a parameter called persistence. This parameter determines how much of the Membrane Potential in time t still remains in time t+1. This allows a neuron to integrate signals over time, not only instantaneously, therefore providing some sort of memory.
- Integrate and Fire (IF): it works very similar to LT neuron, but there is a big difference when the membrane potential reaches the threshold: the IF neuron spikes with maximum amplitude (usually is 1), independently of the input, and then resets the membrane potential to 0. Again, it is possible to use the membrane persistence to allow faster spiking activity.
- Sigmoid (S): In this case the transfer function is a sigmoid and there is not possible threshold to set. Persistence does matter again.

Building the System

Open the simulation you created in Tutorial 1. Then create a copy: to do this is use File → Save System As option in the main menu. Give it a name like 'Tutorial 2'. Change also the name of the process to something like 'Tut 2 process'.

Change the spiking probability of your original "RandomSpike" cell group slightly, e.g. to 0.1 (the exact number does not matter).

Create three more neuron groups of 1 single neuron. The types for these new groups must be: a Linear Threshold, an Integrate and Fire and a Sigmoid.

Now create excitatory connections from the RandomSpike cell group to each of your new cell groups, using the red connection creation button that appears in Figure 1. The result of the connection scheme is in Figure 2.

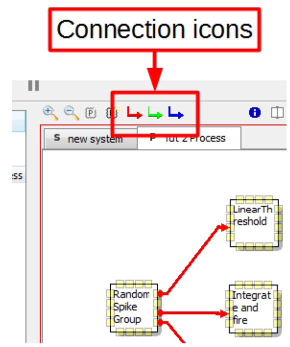

Figure 1: Connection Icons

Every red line represents a connection. Click right button over one of them and choose properties:

- Change the synapse type (it appears at the bottom of the Figure 2) for each connection to Uniform fixed weight. This means that the weight does not change during the simulation and it will be fixed to certain value (if it is set to '1', it means there is no gain or loose of potential during the connection).
- Set the pattern map to "all" instead of "center".
- Once you have changed that, press Apply and Accept. If apply is not pressed changes will not be stored.
- Click right button in the connection and select connection plot. It gives you a the idea of how each neuron is connected to the other one. This is a useful tool that you may want to use every time you create a new connection to check if the mapping you want is correctly set.

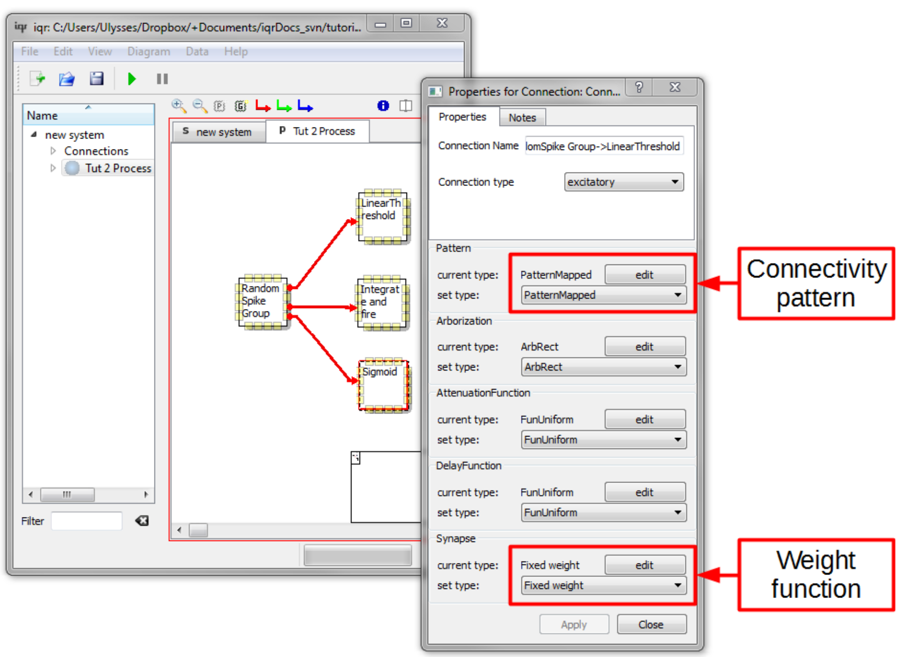

Figure 2: Excitatory connection scheme and Connection properties dialog

- Play with it. Click in both 'squares' that represent the neuron groups. Arrow shows the 'source' (origin of the arrow), and the 'target' (arrow end) of the connection. This means that one spike in a neuron (or group of neurons) of the source is propagated through the connection to another neuron (or group of neurons) of the target, making them to spike (according to the neuron transfer function, threshold, etc). Best thing is to create bigger groups of neurons and define different patterns to check this tool.

Exercise

1. Bring up space and time plots for each cell group and start the simulation. Every one has the name of the group, so check if you can identify each one. What do you see?

A. Connection between Random Spike (RS) and Linear Threshold (LT) groups.

- Q1. Space plot: is the cell spiking continuously?
- Q2. Time plot: is it following the source? Why? (Note: think of the pattern map and also in the definition of LT neuron.)

B. Connection between RS and Integrate and Fire (IF) groups.

- Q3. Space plot: why is all the time spiking?
- Q4. Time plot: is it following the source? Why?

C. Connection between RS and Sigmoid.

- Q5. Space plot: why is all the time spiking?
- Q6. Time plot: is it following the source? Why?

2. Inside the properties of the neuron groups, play with the excitatory gain, threshold and membrane persistence (check the time and space plots the option 'vm' that is the membrane potential:

- Q1. Explain what these parameters do:
- Q2. Explain what is the membrane potential and its relation with the input and the threshold.
- Q3. Explain also the role of persistence in the input, the membrane potential and the output.

3. Write down the parameters you have used:

Group name	LinTh	IntFire	Sigmoid
Size (cells)			
Cell Type	Linear threshold	Integrate & Fire	Sigmoid
Excitatory gain			
Probability			--------------
Membrane persistence			
Threshold			--------------
Membrane potential reset			
Spike amplitude			
Sigmoid midpoint	--------------	--------------	
Sigmoid slope	--------------	--------------	

4. Stop the simulation and change the PatternMapped to 'center'. Check again the connection plot.
   - Q1. Run the simulation watching the plots. What was the effect and why?
   - Q2. Play with the size of the neuron groups. One detail to take into account is whether the different sizes are even or odd. Play with this and use the connection plot and change the pattern maps between 'center' and 'all' to see what happens.
   - Q3. Try to explain what the difference is. Take a look to the manual if you do not know what is going on. Write down a brief explanation.