Project 1 (20 pts)

The goal of this simple project is to build and simulate a small mechanoreceptor network of the kind we discussed in the first day of class. Download the following book excerpt and read it:

https://dl.dropboxusercontent.com/u/2816627/Touch-inPrinciplesNeuralSci%28third%20ed.%29KandelEt.Al.Eds.366-377.pdf

You will reproduce the network and the behavior shown in Fig 26-8 using the templates for simple spiking rate cells (with Naka Rushton functions) that we have discussed in class. Carefully and methodically work through these small steps in order, which guide you to the end.

1) Look at Fig. 26-8 and write out a list of the neural cells you will build, whether they are inhibitory or excitatory, and which cells they connect to. There is a cell body shown as a large circle for each cell.

2) Use the Chapter 6 scripts and the `rate_network` template builder they use to construct models of the cells based on your list. Re-use some of the parameters we used in those scripts, unless you want to tweak them yourself. Use a different name for every cell, but use a naming pattern that helps you remember which is which. E.g. use "R1" for the first receptor cell, "E1" for the first excitatory "dorsal column nucleus" cell, "I1" for the first inhibitory interneuron.

Each receptor (R) cell should take a constant "bias" input only, call them K1 – K3. These parameter values can be changed from zero to a small integer (somewhere from 3 to 6) to represent the strength of stimulus. The E cells should also be provided a small constant bias input to give them a non-zero level of background activity. All other connections are synaptic connections.

3) Add the commands to add the synapses, making sure to use the correct sign for excitatory or inhibitory. Use small integers for the coupling strengths. Make the network symmetric, so that E -> I and I -> E coupling is the same on both sides.

4) Set up and test the following three piecewise stimulation conditions *in the same script*:

> **Stimulus 1**: Center ON for 200ms, surround always OFF.
> **Stimulus 2**: Center ON for 500ms, one surround cell ON after 100 ms for 200ms (similar to the timing indicated in panel B2 of the book figure).
> **Stimulus 3**: As stimulus 2, but with both surround cells ON in the same period.

In all cases, leave all the stimuli OFF for the first 300 ms, and again at the end for a further 300 ms. See the axon labeled "Recording" in the book's diagram, and plot that spike rate through time. While you are getting the network to behave correctly, you might also plot the other E cell spike rates in the same figure, and maybe the I cells in a different figure.

Plot time traces under each stimulus to see if responds roughly as indicated in the book's figure. *You probably won't get the behavior right first time*. Alter the coupling strengths and try again. You should be able to get it to work using integer values for the coupling somewhere between 2 and 6. Try to think about how the network is working to choose the values effectively, rather than just picking at random.

5) Add comments to your code to indicate which cells are which, and label the axes and titles of all your plots. If your code is not commented in a meaningful and plots not labeled you will lose a couple of points!

6) Write a short report briefly describing what you have modeled (summarize some ideas from the book text) and how you understand the stimulus 2 and 3 protocols to work. Save and embed all three matplotlib figures for the time traces of spike rate from the cell recorded. (Use the example project report I posted on the class web page for ideas for how to present your work.)

7) Paste your script's code at the end of the report. Format it using a mono-space font such as Courier, slightly reducing its size if necessary to fit 80 columns across.

8) Submit your report and your .py scripts by email, before **Friday 5th October at midnight**.

For graduate students only:

Using the examples from previous scripts, add adaptation variables to the E cells with an appropriate time constant so that you can show that an extended stimulus of 1s or more leads to a restoration of baseline activity. Describe this effect as part of your report.

Start this project as soon as possible, so that you can visit me in office hours and/or email me to ask questions about completing this in time. You may ask your colleagues for general advice about programming and setup *only*. Don't submit work that is *at all* identically written or coded to that of your colleagues, and do not let others use the parameter values that you have found by yourself! (See the syllabus for the rules and consequences of plagiarism.)