Day 2, Hands-on Exercise: # 2

2. (a) Simulate the network from question 1(d-e) by numerically solving the equations (do *not* use your results from question 1 here; the point is to "blindly" simulate these equations and confirm that you get the same answer you found analytically in question 1):

$$\tau \frac{dr_1}{dt} = -(1 - w_{self})r_1 + w_{other} r_2 + I_1$$

$$\tau \frac{dr_2}{dt} = -(1 - w_{self})r_2 + w_{other} r_1 + I_2$$

For initial conditions, set **r**(t=0) = **I**, i.e. start out the network at the firing rate values that would have been obtained in steady-state if there were no recurrent connections.

Plot r_1 and r_2 as a function of time for long enough to see them reach steady state. On the same set of axes, plot the eigenvectors $\xi^1$and ξ^2. Check that the steady state values that you get are the same as those you calculated analytically in pen & paper 1.

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(b) Modify the above network so that it integrates a quantity proportional to the difference between I_1 and I_2. What is the condition on w_{self} and w_{other} for this to occur? Also observe what happens when the inputs I_1 and I_2 equal zero. Do you observe persistent neural activity? (For comparison, set I_1 and I_2 equal to zero in part (a)).

For this question, don't worry that firing rates can become negative. You can consider **r** to be the firing rate relative to a background level.

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(c) *Winner-take-all networks.* For a more extreme example of the rivalry between inputs observed in part (a), see what happens if w_{other} is a large negative value. For this network, add constraints on your neurons such that firing rates that become negative get thresholded to zero. Experiment with various initial conditions and input values.

What is the condition for one of the neurons to be driven to zero firing rate? What additional condition (on the synaptic weights) will lead the winner to exhibit runaway growth? (If you wish to explore this part of the model's parameter space, you can prevent runaway growth from occurring by adding saturation to the model. This is most simply done by imposing a maximum firing rate constraint such that neurons do not increase their firing rates beyond a fixed level r_{max}). This model is commonly used as a simple description of phenomena such as perceptual rivalry.