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Autonomous robotics

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Exercise 4 Timing

Read the review article "Timing, Clocks, and Dynamical Systems" by Schöner (*Brain and Cognition* 2002, the paper is available as a pdf download on the course web page). You can safely drop section 3.1.

1. Make an illustration of the periodic solution generated by a neural limit cycle oscillator inspired by Figure 6 of the paper. If some perturbation were to shift the state of this oscillator such that activation, but not inhibition, is changed, what would that periodic solution look like, qualitatively? Would it return to the same phase relative to the unperturbed case? Argue based on information in the paper. [Another resource is `http://www.scholarpedia.org` where you should search for "Phase response curve".]

2. If two such oscillators are coupled and the same kind of perturbation is applied to only one of the two oscillators, illustrate qualitatively how the solutions would evolve over time. Does this picture differ from the one in the previous question, if you take the "unperturbed" solution as the solution of one oscillator, and the "perturbed" oscillation as the time course of the other oscillator. Argue based on the paper.

3. The "Amari oscillator" of Equations (6) and (7) can be understood by identifying the fixed points to which the system moves within each quadrant. To understand that, approximate the sigmoid function as a step function. For each quadrant (1) $u > 0$, $v > 0$, (2) $u > 0$, $v < 0$, (3) $u < 0$, $v < 0$, (4) $u < 0$, $v > 0$, the equation is thus linear with different constant offsets. Compute the fixed point (solution of $\dot{u} = \dot{v} = 0$) in each quadrant. For the right choices of the coupling parameters, the fixed point for each quadrant lies in the neighboring quadrant.The vector-field in each quadrant "points" toward the fixed point, which drives all initial values in that quadrant in the direction of the neighboring quadrant. Make a sketch of that vector-field and argue intuitively why a limit cycle may emerge. [A resource is the 1977 Amari paper available on the course web page]

4. Bonus (this will double the overall points): Get access to Matlab (available for free at RUB at

   `http://www.it-services.ruhr-uni-bochum.de/software/matlab`)

   and download two files from the course web page:

`singleNeuronInteractiveSim.m` and `sigmoid.m`

Alternatively, Download the Matlab package Cosivina here:

`http://www.dynamicfieldtheory.org/cosivina`

and find the code

`launcherTwoNeuronSimulator.m`

This is also an option for those who can't get access to Matlab (see instruction on the Cosivina page).

In both cases, run the simlator. Control with the sliders the resting levels and inputs of the two neurons to build the equations (6) and (7). One neuron plays the role of the exitatory, the other of the inhibitroy neuron. Try to make the two neurons oscillate. You can use the information in the appendix of the paper to find the right parameter values. Document your simulation results by writing a coherent account of the simulation experiments, stating your goal, the model, what you observed/looked at, what parametric manipulation you made, what the results where (how your observations depended on your parameter changes).