Computational Motor Control

Matlab exercise, Lab 5, GRADED LAB

Students: Names (please update)

Instructions: Update this file (or recreate a similar one, e.g. in Latex) to prepare your answers to the questions. Feel free to add text, equations and figures as needed. Hand-written notes, e.g. for the development of equations, can also be included e.g. as pictures (from your cell phone or from a scanner). Please submit both the source file (.doc) and a pdf of your document, as well as all the used and updated Matlab functions in a single zipped file called lab5_name1_name2_name3.zip where namei are the team member last names. This should be submitted on Moodle by **Monday April 10, midnight**. Please submit **only one report per team**!*

Question 7: Modeling the salamander CPG with phase oscillators.

Note: this Lab will count for 50% of the Matlab lab grade (with 50% for Lab 4). We added points to the questions to indicate which questions are more important than others. Total 50 points.

7.A Running the CPG model in Matlab (5 points). Complete the provided code for an oscillator-based model of the salamander CPG. The Matlab function in salam_cpg_osc.m implements the model itself. Simulation results can be rendered in a plot similar to Fig. 2 of the paper (Ijspeert et al. 2007) using the Matlab function in plot_salam_cpg.m. The inputs and outputs of these two Matlab functions are described at the beginning of the respective files.

Pick a CPG drive strength in the range corresponding to the swimming behavior. (The limb oscillators saturate for drive levels above 3, while body oscillators saturate for drive levels above 5. Swimming occurs only when the limb oscillators saturate.). Using this drive strength, run a 20 seconds simulation of the CPG activity with a timestep of 0.01 seconds. Record the output of the CPG oscillators, along with their instantaneous frequencies. Plot the outputs of the body and limb CPG oscillators, together with the oscillators' instantaneous frequencies. Show the plot and briefly discuss the results.

Repeat the previous steps using a drive strength corresponding to the walking behavior. (Walking occurs when neither the limb nor body oscillators saturate.). Observe the differences to the swimming case. Show the plot and briefly discuss the results.

Try a non-constant, linearly increasing drive strength covering both the walking and swimming behaviors. Observe the walking-swimming transition on the plot. Show the plot and briefly discuss the results.

7.B. Handling of perturbations and noise (10 points).

Think about possible perturbations and noise that could be applied to the CPG network and analyze how the system reacts. For instance, you could investigate:

- Adding noise to the drive signals (from the brain stem),
- Adding some perturbations to the state variables (i.e. setting it to a new random value at some point in time),
- Implementing sensory inputs to the oscillators (like the exercise of the lamprey network) with noise or perturbations.
- …

Out of these (or others that you can think of) choose two types of perturbation experiments, make some plots showing how the network behaves and discuss your results. Suggestion: start with small levels of noise/perturbation and increase them. What conclusions can you make about the stability/robustness of the network in terms of locomotion?

7.C. Playing with the model parameters (10 points)

The oscillation pattern produced by the model and the stability of the rhythm depend on the model parameters, in particular the weights and phase biases of the couplings and the intrinsic frequencies of the oscillators. Changing the values of these parameters and observing the results can give a better sense of what the parameters represent. Note that different values for the model parameters can also make numerical integration more difficult, requiring an adaptation of the integration time step.

Role of coupling weights. What happens if they are changed and/or set to zero (like in a lesion), e.g. those from limb to body oscillators? Which effect on phases and resulting frequencies? Make experiments, show graphs, and discuss.

Role of intrinsic frequencies. What happens if they are changed? For instance with larger difference between body and limb frequencies? Which effect on phases and resulting frequencies? Make experiments, show graphs, and discuss.

7.D. Discussion of the model (10 points). What do you think are the strengths and weaknesses of the model? In particular, discuss how close or not it represents the real salamander CPG, and how well it explains biological data.

7.E. Extensions and alternatives (5 points). How could you extend the model? Or which alternative models could you develop? Which additional questions could you address and which additional experiments could you perform? Discuss (no need to perform the experiments).