Student names: . . . (please update)

Instructions: Update this file (or recreate a similar one, e.g. in Word) 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). ***This lab is not graded. However, the lab exercises are meant as a way to familiarise with dynamical systems and to study them using Python to prepare you for the final project.*** *This file does not need to be submitted and is provided for your own benefit. The graded exercises will have a similar format.*

The file `lab#.py` is provided to run all exercises in Python. When a file is run, message logs will be printed to indicate information such as what is currently being run and and what is left to be implemented. All warning messages are only present to guide you in the implementation, and can be deleted whenever the corresponding code has been implemented correctly.

Coupled leaky integrator neurons

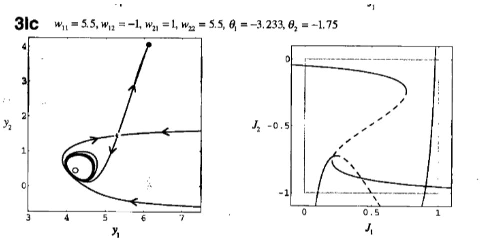
The lab of today is based on a network of two coupled leaky-integrator neurons with self- connections as seen in the lecture, and as analyzed in the 4 paper: Beer, R.D. (1995). On the dynamics of small continuous-time recurrent neural networks. Adaptive Behavior 3(4):469-509. By looking at the Figures 4a-4d of that paper, you should be able to reproduce several interesting dynamical regimes and answer the questions below. See the file `lab3.py`

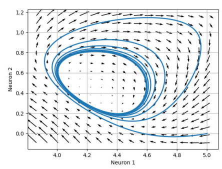
5.a Set the parameters of the network such as to create a dynamical system with *three* fixed points: two stable fixed points and one saddle node (check Beer 1995 for ideas and parameter values). Show figures that illustrate that behavior. Show or demonstrate the stability of the fixed points.

5.b Set the parameters of the network such as to create a dynamical system with a limit cycle behavior and a single unstable fixed point. Show figures that illustrate that behavior. Look also at the behavior of the crossing of a Poincaré map (a line in this case). Discuss similarities and differences of this neural oscillator with the Hopf oscillator.

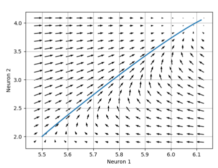
5.c Set the parameters of the network such as to create a dynamical system with a limit cycle behavior and three fixed points: a single unstable fixed point, a single saddle node, and a single stable fixed point. Show figures that illustrate that behavior. Discuss similarities and differences with the Hopf oscillator. Discuss whether such a system could have interesting properties for motor control.

5c:





InitCond: (5,0)



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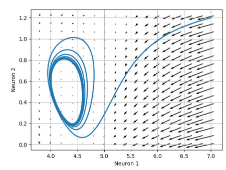

InitCond: (7,1.2)

Diff/Similarities w/ Hopf: 1 limit cycle like Hopf, and an unstable fixedd point ([0,0] in Hopf). Hopf possesses a stable fixed point in terms of radius, which is sqrt(mu), the radius of the limit harmonic cycle to which we converge to (if we begin outside the limit cycle) or diverge to (if we begin from inside the limit cycle).

Interesting props for motor control:

A limit cycle implies an oscillatory movement, which is what the central pattern generator does. The stable fixed point might serve as an extreme not to reach for the extensions/flexions of our limbs ? (breakpoint for muscles?) The saddle node might indicate a border point: If you go towards it from the stable cycle you will reach the extreme stable point, if you go towards it from outside the limit cycle you join the limit cycle