Mathematical tools for phase control in transient-states of spiking neurons

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Abstract

Phase resetting curves (PRCs) constitute a powerful resource in time-control problems in biological processes. They predict the effect of a perturbation on the phase of an oscillator, assuming that all the dynamics can be explained by the phase variable. However, factors like the rate of convergence to the oscillator, strong forcing or high stimulation frequency may invalidate the above assumption and raise the question of how is the phase variation away from an attractor.

In this talk, I will present a numerical method to perform the effective computation of the phase advancement when we stimulate an oscillator which has not reached yet the asymptotic state (a limit cycle) using the concept of isochrons. To do so, we first perform a careful study of the theoretical grounds (the parameterization method for invariant manifolds), which allow us to describe the isochronous sections of the limit cycle. From it, we build up Phase Response Functions (PRF) and Amplitude Response Function (ARF) to control changes in the phase and the transversal variables, respectively. I will show some examples of the computations we have carried out for some well-known biological models. Finally, I will compare the predictions given by the PRC-approach (a 1D map) to those given by the PRF-ARF-approach (a 2D map), under pulse-train stimuli.

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