Title:

Optimal control of neuronal oscillations with applications to Communication Through Coherence

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Abstract:

Oscillatory patterns are commonly observed in the brain across different scales, spanning from individual neurons to entire populations. Remarkably, these oscillations manifest in various cognitive tasks, such as perception and attention, and are theorized to play a relevant role in facilitating Communication within the brain. The Communication Through Coherence (CTC) theory, proposed by Fries in 2005 and 2015, offers an explanation for this phenomenon. According to CTC, effective communication among neuron populations requires phase-locking at the appropriate phase of oscillation.

In this work, we investigate this phenomenon within excitatory-inhibitory neuron populations modeled through an exact mean-field model. Our aim is to achieve synchronization between populations using control techniques, where the control is the influence of a higher cortical area, thus mimicking a top-down mechanism. To accomplish this, we perturb two initially desynchronized "pre-synaptic" oscillatory populations (sender) projecting on a "post-synaptic" population (receiver). Our goal is to synchronize the receiving population with one of the two pre-synaptic populations.

To enhance synchronization and regulate the oscillation period, we implement a control on the receiving population. This control involves leveraging the phase-amplitude reduction of a limit cycle along with optimal-control techniques.