Decoupling of oscillatory ensembles by mixed nonlinear delayed feedback

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Synchronization processes are of crucial importance for brain function. Well-coordinated synchrony within and between neuronal populations appears to be an important mechanisms for neuronal signaling and information processing. In contrast, pathologically strong synchronization may severely impair brain function. For instance, resting tremor in Parkinson's disease is caused by a synchronized population of oscillatory neurons which collectively fire in a periodic manner. There is a significant clinical need for effective techniques for deep brain stimulation, which restore desynchronized - i.e., normal - dynamics in networks of oscillatory neurons.

We present nonlinear delayed feedback stimulation as a technique for effective desynchronization [1]. This method is robust with respect to system and stimulation parameter variations and demonstrates broad applicability tested on different generic oscillator networks [2]. Nonlinear delayed feedback restores the natural frequencies of the individual oscillators and enables to strongly detune the macroscopic frequency of the collective oscillation. We propose nonlinear delayed feedback for decoupling and desynchronization of two oscillatory networks interacting according to the drive-response coupling scheme [3]. The response ensemble, which gets synchronized because of strong forcing from the intrinsically synchronized driving ensemble, is stimulated with mixed nonlinear delayed feedback constructed from the mixed macroscopic activities of both ensembles. We show that the suggested method can effectively decouple the interacting ensembles from each other, where the natural desynchronous dynamics can be recovered in a demand-controlled way either in the stimulated ensemble, or in both, stimulated and not stimulated populations. We suggest our method for control of pathologically synchronous neuronal dynamics characteristic, e.g., for Parkinsons disease.

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3. O. V. Popovych, C. Hauptmann, and P. A. Tass. Desynchronization and decoupling of interacting oscillators by nonlinear delayed feedback. *Int. J. Bif. Chaos*, **16**(7), 1977–1987 (2006).