Control of synchronization bistability in oscillatory networks

Irmantas Ratas and Kestutis Pyragas

January 2, 2015

Recently it was observed that the order parameter, which defines synchronization in an oscillatory network, can be bistable. It means that the incoherent and partially synchronized stable states coexist at a particular range of parameters. Globally coupled phase oscillators whose natural frequency distribution is bimodal [1] or sum of two distributions with the same peak frequency [2], globally coupled oscillators with repulsive and attractive interaction [3] or oscillators connected by scale free network [4] – all these systems demonstrate synchronization bistability. The problem of synchronization control is relevant in neuroscience as pathological synchronization cause symptoms of various diseases. We propose two algorithms, which can be used to switch the synchronized system to the incoherent state. The first algorithm uses a periodic external force with the frequency equal to the frequency of the network's mean field. When the system synchronizes with the external force its phase is suddenly reversed by π. As a consequence of phase change, the network will try to synchronize with the external force again trough a transitional process. If the transitional process goes through or near incoherent state, at a particular moment one can turn off the external force and the system will be attracted to the desynchronized state. The moment of external force disconnection should be determined empirically. The second suggested algorithm uses exponentially decaying high-frequency force. By high-frequency we mean that the frequency of the force is larger than the frequency of the mean field of the synchronized network. Suggested algorithms were numerically tested on globally coupled phase oscillators, the Landau-Stuart oscillators and the FitzHugh-Nagumo neuron models.

References

[1] E. A. Martens, E. Barreto, S. H. Strogatz *et al.* *Phys. Rev. E* **79** 026204 (2009).

[2] O. E. Omel'chenko, M. Wolfrum *Phys. Rev. Lett.* **109** 164101 (2012).

[3] H. Hong, S. Strogatz *Phys. Rev. Lett.* **106** 054102 (2011).

[4] J. Gómez-Gardeñes, S. Gómez, A. Arenas *et al.* *Phys. Rev. Lett.* **106**, 128701 (2011).