Quantifying topology transfer in interconnected networks of phase oscillators using relaxation time

Nicolás Deschle and Andreas Daffertshofer

Abstract: In the last decade or so, the study of interconnected complex networks gained much interest across the scientific community. In neuroscience, in particular, systems are often composed of many networks that interact on different spatial and temporal scales. This may result in activity that is synchronized within and/or across networks, in its simplest form in-phase oscillations. We studied numerically the synchronizability of two interconnected oscillator networks of finite-size. In contrast to other studies that assessed synchronizability by the asymptotic state of (local) Kuramoto order parameter, we quantified is by the (local) relaxation time towards that asymptotic state. In view of finite-size effects, the latter was expected to be quite erratic which motivated using a statistical approach often employed to quantify stochastic dynamics: We determined the serial-lag auto-correlation function of the simulated time series of the networks? order parameters. The envelope of the auto-correlation function decayed exponentially (as in the case of a linear response system), which allowed for estimating the relaxation time. We first tested procedures in the case of two fully connected, symmetric networks and compared. Our numerical estimates of the relaxation times closely resembled the analytically known bifurcation scheme. Next we changed the topology of one of the networks to be random (Erd?s-R?nyi), scale free (Barab?si-Albert) and small world (Newman-Watts) by guarantying that the asymptotic value of local synchronization in that that network remained constant. Dependent of the relation of average degree and within-network vis-?-vis between-network coupling strength, topology transferred from one network to the other. Quantifying synchronizability through the (local) relaxation time appears a useful tool when it comes to interactions between oscillator networks.