NETWORK SYNCHRONIZATION IN A NOISY ENVIRONMENT WITH TIME DELAYS

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ABSTRACT

The ability of a network to synchronize can change drastically when time delays are introduced. Nonzero time delays impose a limitation on the strength/frequency of communication regarding the synchronizability of the network. When synchronization is possible, there is a fundamental limit on how well the network can synchronize, even in the most optimal circumstances. These fundamental properties are apparent even in the most basic case of uniform time delays in stochastic, linearly-coupled synchronization problems. This basic model can be expanded to include the richer behavior of networks with multiple delays. Non-uniform time delays can arise when there are multiple sources of delay, e.g. the time to transmit and the time to process information. In this particular two-delay case, the primary limitation on network synchronization does not come from restrictions in the transmission of a node's state to its neighbors; rather it depends on the ability for each node to process and respond to the information about itself in the context of its local environment. Furthermore, given a network's structure, there are optimal delays for which the network remains synchronizable for longer processing delays. As a result, synchronization is not always improved – and in some cases can be totally destroyed – by minimizing the transmission delays. For special cases, one can also study the scaling function that quantifies synchronization, showing the limitation of synchronization in a noisy network.