Adaptive synchronization of a network of chaotic oscillators

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Synchronization among networks of coupled chaotic systems is an interesting phenomenon with potential applications in sensor and communication networks. In order for a network of chaotic oscillators to admit a synchronous solution, each node must receive the same cumulative coupling from its peers. This constraint implies that the coupling matrix describing the network has a uniform row-sum. This condition is difficult to achieve in practice. Moreover, even if synchrony is attained, environmental drifts and other network perturbations can cause the coupling strengths to change, making it impossible to maintain synchrony over time.

We present here an adaptive control system [1] that overcomes these limitations. We experimentally show that the system can both acquire and maintain a state of global synchronization in a network of chaotic oscillators even when the coupling matrix is unknown and time-varying [2]. Each node in the network uses locally measured signals to construct a real-time estimate of its total input coupling strength. A suitable multiplicative scaling is then applied to the coupling signal to ensure that all nodes in the network receive the same cumulative coupling, thus making synchronization feasible.

The network is comprised of three optoelectronic nonlinear time-delayed feedback loops which exhibit high-dimensional chaotic dynamics [2, 3]. Each node is coupled to every other through a bidirectional fiber-optic link, and the coupling strengths are controlled using variable optical attenuators. Using the adaptive algorithm we successfully synchronize the network under time-varying coupling conditions. Furthermore, we show that from the computed scale factors obtained at each node, we can deduce the coupling matrix, thereby enabling us to both track and localize disturbances and perturbations in the network.

References:

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