Approximate and Identical Synchronization in Coupled Systems

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Abstract: In this lecture, I shall present a mathematical framework for investigating approximate synchronization of coupled systems and coupled network systems under general coupling scheme with delays. The units comprising the coupled systems are allowed to be non-identical. Both delay-dependent and delay-independent criteria for approximate synchronization are derived, based on an approach termed sequential contracting. Sequential contracting is an iterative argument for concluding asymptotic behaviors in dynamical systems. With a preliminary estimation on the globally attracting set for the coupled system, the dissipative structure or degradation terms in the equations is utilized to estimate the attracting interval for each component of the system successively and iteratively. Analyzing the asymptotic behavior will then be converted into solving a linear system of algebra equations. Condition for the convergence of Gauss-Seidel iteration for this linear system then leads to synchronization criteria. We shall show how the synchronization error, the distance between the asymptotic state and the synchronous set, decreases with respect to the differences between subsystems and some factors in the coupling structure. This error vanishes when these factors decay to zero, and approximate synchronization becomes identical synchronization for the coupled system. Applications of the present theory to a model on segmentation clock genes and coupled FitzHugh-Nagumo neurons will be illustrated.