SYNCHRONIZATION AND CONTROL OF COMPLEX NETWORKS VIA CONTRACTION, ADAPTATION AND EVOLUTION

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22nd November 2010
2:15pm
LR7, IEB Building,
Engineering Science

Abstract

A large number of complex networked systems occur in nature and technology. Examples of these systems include communication networks and power grids, biological and physiological networks, swarming and flocking behaviour in animals and robots, sensor networks and neural networks.

The common thread in all of these examples is that they consist of many interacting agents communicating over a web of interconnections characterized by a complex topology. Three key essential ingredients are then needed to describe this type of systems: (i) a model of the dynamics of each agent in the system; (ii) a communication protocol (or interaction model) describing how agents communicate with each other and (iii) a graph (network) describing the topology of the interconnections between agents. The resulting model is a complex network of dynamical systems.

A fundamental problem in this context is that of studying the emergence of coordinated behaviour. Recently much attention has been focused on the problem of synchronizing or controlling a network of dynamical agents onto some common evolution. It has been shown that, not only the dynamics of each individual system in the network, but also the network topology itself can have a dramatic effect on the synchronization and control performance.

The aim of this talk is to discuss the problem of synchronizing and controlling complex networks. In particular, novel adaptive evolving strategies will be introduced to solve the synchronization and control problems. Firstly, a strategy will be considered where the network topology is fixed while neighbouring nodes can decide the strength of their mutual coupling on the basis of purely local information. Then, the network topology itself will be evolved on the basis of the agent dynamics. A possible approach to generate the network topology will be discussed and shown to effectively solve the control and synchronization problem. The resulting topologies will be analyzed and shown to guarantee certain performance criteria in the presence of different constraints. Contraction theory will be presented as an invaluable tool to obtain proofs of stability and convergence.