From Static to Dynamic Couplings in Synchronization and Consensus

Peter Wieland
Institute for Systems Theory and Automatic Control
University of Stuttgart

Consensus and synchronization problems (CSP) have been a popular subject in systems and control for quite some while. They find applications in areas ranging from social sciences to engineering. Essentially, the problem is to reach agreement about some variable of interest or synchronize system trajectories.

The use of static, diffusive couplings is a standard approach to solve CSP. Examples include the classical consensus problem of integrator agents and synchronization of Kuramoto oscillators, which can to some extent be seen as a nonlinear analog to the classical linear consensus problem. Extensions exist for more general linear systems and nonlinear oscillators. They differ in the assumptions on the constraints imposed on the communications between the systems and in the assumption on the individual systems. As a common point, they all share the fact that the individual systems are coupled through static control laws that depend on relative information in some sense.

In this talk, we show different scenarios where dynamic couplings allow for relaxed assumptions on individual system dynamics or communication constraints in CSP. The most proximate example from a control point of view is the use of dynamic observers if reduced information is available to the individual systems. While the design of observers in CSP can be a challenging task, the benefit of dynamic couplings reaches well beyond state estimation. In particular, we will show how dynamic couplings enable synchronization of heterogeneous groups of linear systems as well as groups of identical nonlinear oscillators, both under uniformly connected communication graphs.