Synchronization: From Formation Flying iPhones to Neural Oscillators for Flapping Flying MAVs

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Abstract
What do formation flying swarms of spacecraft have in common with synchronous fireflies? This talk presents successful applications of biological inspiration toward intelligent control and navigation of complex aerospace systems such as formation flying spacecraft and engineered flapping flight for micro aerial vehicles. Inspired by stable and hierarchical combinations of biological systems, contraction nonlinear stability theory provides a systematic method to reduce arbitrarily complex systems into simpler elements. This talk presents one of the first proofs of synchronization control of highly nonlinear dynamics such as multiple Lagrangian systems with applications to spacecraft swarms and multi-robot systems. Concurrent synchronization that exploits the multiple timescale behaviors from two types of inputs (a virtual leader and local couplings) permits construction of a complex time-varying network where multiple groups of fully synchronized spacecraft coexist. Such concurrent synchronization seems pervasive in biology, and in particular, in the brain where multiple rhythms coexist and neurons can exhibit many qualitatively different types of oscillations.

Engineered flapping flight holds promise for creating biomimetic micro aerial vehicles (MAVs) flying in low Reynolds number regimes where rigid fixed wings drop substantially in aerodynamic performance. The talk introduces a novel neurobiologically inspired control method based on the hypothesis that the adaptive control and synchronization of coupled nonlinear oscillators, inspired by central pattern generators (CPGs) found in animal spinal cords, can effectively produce and control biomimetic flapping flight. Rigorous mathematical theory as well as experimental work with the 10-DOF robotic bat is presented.

Bio
Soon-Jo Chung is an Assistant Professor of Aerospace Engineering at UIUC. His research has been motivated by complex nonlinear aerospace systems such as cooperative control of multi-vehicle systems, flight mechanics, stability, and control of highly agile micro aerial vehicles, and vision-based navigation. Dr. Chung received his MS (2002) and ScD degrees from MIT (2007) with a major in estimation and control and a minor in optics. His honors include AFOSR young Investigator award, JPL summer faculty fellowship, and two best paper awards from AIAA and IEEE. He is a PI of grants from AFOSR, ARO, and ONR, while he is closely working with JPL on a DARPA project. http://netfiles.uiuc.edu/sjchung/www

An informal coffee & cookie reception will be held prior to the lecture at 2:30 p.m. in the AAE/ARMS undergraduate lounge (directly in front of ARMS 3rd floor elevators)