Faculty 20th Anniversary Distinguished Lecture

Optimal Design for Cooperative Control Synchronization and Games on Communication Graphs

Date : November 10, 2011 (Thursday)
Time : 4:30 p.m. - 5:30 p.m.
Venue : Room 215, William M. W. Mong Engineering Building, CUHK
Speaker: Prof. F.L. Lewis
The University of Texas at Arlington, USA

Abstract

Distributed systems of agents linked by communication networks only have access to information from their neighboring agents, yet must achieve global agreement on team activities to be performed cooperatively. Examples include networked manufacturing systems, wireless sensor networks, networked feedback control systems, and the internet. Sociobiological groups such as flocks, swarms, and herds have built-in mechanisms for cooperative control wherein each individual is influenced only by its nearest neighbors, yet the group achieves consensus behaviors such as heading alignment, leader following, exploration of the environment, and evasion of predators. It was shown by Charles Darwin that local interactions between population groups over long time scales lead to global results such as the evolution of species.

In this talk we present design methods for cooperative controllers for distributed systems. The developments are for general directed graph communication structures, for both continuous-time and discrete-time agent dynamics. Cooperative control design is complicated by the fact that the graph topology properties limit what can be achieved by the local controller design. Thus, local controller designs may work properly on some communication graph topologies yet fail on other topologies. Our objective is to provide local agent feedback design methods that are independent of the graph topology and so function on a wide range of graph structures. An optimal design method for local feedback controllers is given that decouples the control design from the graph structural properties. In the case of continuous-time systems, the optimal design method guarantees synchronization on any graph with suitable connectedness properties. In the case of discrete-time systems, a condition for synchronization is that the Mahler measure of unstable eigenvalues of the local systems be restricted by the condition number of the graph. Thus, graphs with better topologies can tolerate a higher degree of inherent instability in the individual node dynamics. A theory of duality between controllers and observers on communication graphs is given, including methods for cooperative output feedback control based on cooperative regulator designs.

In Part 2 of the talk, we discuss graphical games. Standard differential multi-agent game theory has a centralized dynamics affected by the control policies of multiple agent players. We give a new formulation for games on communication graphs. Standard definitions of Nash equilibrium are not useful for graphical games since, though in Nash equilibrium, all agents may not achieve synchronization. A strengthened definition of Interactive Nash equilibrium is given that guarantees that all agents are participants in the same game, and that all agents achieve synchronization while optimizing their own value functions.

Biography

Dr. F.L. Lewis, Fellow IEEE, Fellow IFAC, Fellow U.K. Institute of Measurement & Control, PE Texas, U.K. Chartered Engineer, is Distinguished Scholar Professor and Moncrief-O'Donnell Chair at University of Texas at Arlington's Automation & Robotics Research Institute. He obtained the Bachelor's Degree in Physics/EE and the MSEE at Rice University, the MS in Aeronautical Engineering from Univ. W. Florida, and the Ph.D. at Ga. Tech. He works in feedback control, intelligent systems, distributed control systems, and sensor networks. He is author of 6 U.S. patents, 216 journal papers, 330 conference papers, 14 books, 44 chapters, and 11 journal special issues. He received the Fulbright Research Award, NSF Research Initiation Grant, ASEE *Terman Award*, Int. Neural Network Soc. *Gabor Award* 2009, U.K. Inst Measurement & Control *Honeywell Field Engineering Medal* 2009. Received Outstanding Service Award from Dallas IEEE Section, selected as Engineer of the year by Ft. Worth IEEE Section. Listed in Ft. Worth Business Press Top 200 Leaders in Manufacturing. Received the 2010 IEEE Region 5 Outstanding Engineering Educator Award and the 2010 UTA Graduate Dean's Excellence in Doctoral Mentoring Award. He served on the NAE Committee on Space Station in 1995. He is an elected Guest Consulting Professor at South China University of Technology and Shanghai Jiao Tong University. Founding Member of the Board of Governors of the Mediterranean Control Association. Helped win the IEEE Control Systems Society Best Chapter Award (as Founding Chairman of DFW Chapter), the National Sigma Xi Award for Outstanding Chapter (as President of UTA Chapter), and the US SBA Tibbets Award in 1996 (as Director of ARRI's SBIR Program).

***** ALL ARE WELCOME *****

Enquiries: Miss Winnie Wong (Tel: 2609 8337)