香港城市大學
City University of Hong Kong
混沌及複雜網絡研究中心
Centre for Chaos and Complex Networks

THE HONG KONG
POLYTECHNIC UNIVERSITY
Department of Electronic and Information Engrg.
香港理工大學 電子及資訊工程學系

IEEE Technical Co-sponsor: IEEE Hong Kong Section
Robotics and Automation/Control Systems Joint Chapter

Jointly presents

SEMINAR SERIES ON CHAOS, CONTROL AND COMPLEX NETWORKS

Optimal Adaptive Neurocontrol

Prof. Frank L. Lewis
University of Texas at Arlington, USA

Date and Time: Friday, 23 January 2009, 4:30pm – 5:30pm
Venue: Room **B**6605, City University of Hong Kong
Reception starts at 4:15pm
(Language: **English**)

Abstract

Naturally occurring and biological systems often have *optimal* behavior, for they have limited resources in terms of fuel/energy or reaction time. Likewise, many manmade systems, including electric power systems and aerospace systems, must be optimal due to cost and limited resource factors such as energy or fuel.

Optimal control design methods are well developed for linear systems, and rely on the solution of certain matrix design equations of the Riccati equation type. Design techniques are off-line, and require knowledge of the system dynamics, i.e. A and B matrices. Robust optimal methods such as LTR guarantee performance in the event of modeling uncertainties. Optimal design for nonlinear systems is problematic as it relies on the solution of design equations in the Hamilton-Jacobi class (HJB, HJI), which may not be solvable for general nonlinear systems. HJ solution also requires full knowledge of the system dynamics.

Adaptive Controllers use on-line parameter learning methods to produce feedback controllers with guaranteed performance for systems with unknown dynamics. However, adaptive controllers do not generally provide *optimal* control solutions. Indirect methods have been developed, which require system identification and then Riccati equation solution. Inverse optimal methods for general nonlinear systems do provide adaptation to minimize a resulting performance index (alfc- adaptive Lyapunov function candidate), though it is not of one's own choosing. Adaptive controllers generally minimize a least-squares type (tracking) error. Adaptive systems that optimize a prescribed general performance index of one's own selection are hard to come by.

In this talk we will explore a new class of *Optimal & Adaptive* feedback control structures for continuous-time systems that are based on reinforcement learning techniques, specifically policy iteration and Adaptive Dynamic Programming (ADP). Such techniques have primarily been developed in the past decades for discrete-state (Markov) or discrete-time systems. We will develop and rigorously analyze, in a continuous-time framework, learning and adaptation structures that allow the on-line design of feedback controllers that are optimal. Full knowledge of the system dynamics is not needed. Both linear and nonlinear systems are tractable.

Relations with the operation of some biological structures in the human brain will be drawn.

Inquiry: G. Ron Chen (gchen@ee.cityu.edu.hk) or Michael C. K. Tse (encktse@polyu.edu.hk)

About the Speaker

Dr. Lewis was born in Würzburg, Germany, subsequently studying in Chile and Gordonstoun School in Scotland. He obtained the Bachelor's Degree in Physics/Electrical Engineering and the Master's of Electrical Engineering Degree at Rice University in 1971. He spent six years in the U.S. Navy, serving as Navigator aboard the frigate USS Trippe (FF-1075), and Executive Officer and Acting Commanding Officer aboard USS Salinan (ATF-161). In 1977 he received the Master's of Science in Aeronautical Engineering from the University of West Florida. In 1981 he obtained the Ph.D. degree at The Georgia Institute of Technology in Atlanta, where he was employed as a professor from 1981 to 1990 and is currently an Adjunct Professor. He is a Professor of Electrical Engineering at The University of Texas at Arlington, where he was awarded the Moncrief-O'Donnell Endowed Chair in 1990 at the Automation & Robotics Research Institute. Fellow of the IEEE, Fellow of IFAC, Fellow of the U.K. Institute of Measurement & Control, Member of the New York Academy of Sciences. Registered Professional Engineer in the State of Texas and Chartered Engineer, U.K. Engineering Council. Charter Member (2004) of the UTA Academy of Distinguished Scholars and Senior Research Fellow of the Automation & Robotics Research Institute. Founding Member of the Board of Governors of the Mediterranean Control Association. Has served as Visiting Professor at Democritus University in Greece, Hong Kong University of Science and Technology, Chinese University of Hong Kong, National University of Singapore. Elected Guest Consulting Professor at both Shanghai Jiao Tong University and South China University of Technology.

Current interests include intelligent control, neural and fuzzy systems, wireless sensor networks, nonlinear systems, robotics, condition-based maintenance, micro-electro-mechanical systems (MEMS) control, and manufacturing process control. Author of 5 U.S. patents, 199 journal papers, 36 chapters and encyclopedia articles, 315 refereed conference papers, and 14 books including *Optimal Control*, *Optimal Estimation*, *Applied Optimal Control and Estimation*, *Aircraft Control and Simulation*, *Control of Robot Manipulators*, *Neural Network Control*, *High-Level Feedback Control with Neural Networks* and the IEEE reprint volume *Robot Control*. Editor of Taylor & Francis Book Series on Automation & Control Engineering. Served/serves on many Editorial Boards including *International Journal of Control*, *Neural Computing and Applications*, *Optimal Control & Methods*, and *Int. J. Intelligent Control Systems*. Served as Editor for the flagship journal *Automatica*. Recipient of NSF Research Initiation Grant and continuously funded by NSF since 1982. Since 1991 he has received $7 million in funding from NSF, ARO and other government agencies, including significant DoD SBIR and industry funding. His SBIR program was instrumental in ARRI's receipt of the US SBA *Tibbets Award* in 1996. Received Fulbright Research Award 1988, American Society of Engineering Education F.E. Terman Award 1989, Int. Neural Network Soc. *Gabor Award* 2008, three Sigma Xi Research Awards, UTA Halliburton Engineering Research Award, UTA Distinguished Research Award, ARRI Patent Awards, various Best Paper Awards, IEEE Control Systems Society Best Chapter Award (as Founding Chairman of DFW Chapter), and National Sigma Xi Award for Outstanding Chapter (as President of UTA Chapter). Received Outstanding Service Award from the Dallas IEEE Section and selected as Engineer of the year by Ft. Worth IEEE Section. Listed in Ft. Worth Business Press Top 200 Leaders in Manufacturing. Appointed to NAE Committee on Space Station in 1995 and IEEE Control Systems Society Board of Governors in 1996. Selected in 1998 as an IEEE Control Systems Society *Distinguished Lecturer*.