M15 : The use of Poisson Processes in Modeling and Nonlinear Control

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Course description:

To a larger and larger extent, stochastic models are being turned to as the most effective description of control problems especially in highly autonomous systems, where learning may be involved, and in financial engineering when gaussian models are often inappropriate. Often the combination of Markov models and ordinary differential equations provide natural and effective descriptions. This course will take the student through the steps needed to formulate problems of this type and to make relevant calculations. A basic tool will be the stochastic calculus for Poisson counters. This subject will be developed assuming only a background in elementary probability and experience with ordinary differential equations but the latter parts will be based on recent research. Both theory and applications will be discussed, including a discussion of Markov decision problems and hidden Markov models and their use in applications. Part of each day will be devoted to problem solving.

Outline:

Part 1: Poisson Counters and stochastic differential equations involving Poisson counters. Computing expectations, moments and probability densities. An application in neuroscience.
Part 2: Estimation Theory. Calculation of the conditional density, prediction and smoothing, the Baum-Welch algorithm.
Part 3: Optimal control, dynamic programming and Markov decision problems. Relationship with linear quadratic Gaussian control and other explicitly solvable control problems.
Part 4: Nonlinear control based on finite state controllers. The stabilization problem, finite state observers and controllability conditions.
Part 5: Assorted applications in queuing, physics, biology and financial engineering.

Roger Brockett received his B.S. in 1960 from the Case Institute of Technology. There he was awarded an M.S. degree in 1962 and Ph.D. in 1964. From 1963 to 1967 Dr. Brockett was an Assistant Professor of Electrical Engineering at Massachusetts Institute of Technology and an Associate Professor in the same department from 1967 to 1969. From there he became a Gordon McKay Professor of Applied Mathematics at Harvard University, and was named to the An Wang Chair in Electrical Engineering and Computer Science in 1989. He has held a variety of consulting positions from 1965 to the present, including work at Lincoln Laboratory, Martin Marietta Company, U.S. Army Material Command, Scientific Systems, Inc., U.S. Army Night Vision Laboratory and General Electric Corporate Research Labs.

Dr. Brockett is a member of the National Academy of Engineers, a fellow of the IEEE, and member of the AMS, SIAM, Sigma Xi, and Tau Beta Pi. He has been a member of the IEEE Control Society Advisory Committee (1972-1975), Automatic Control Group's Information Dissemination Committee (1966-1969), and Program Chairman for the Joint Automatic Control Conference (1971).
He has held a Guggenheim fellowship for the study of mathematical system theory, was awarded the American Automatic Control Council's Richard E. Bellman Control Heritage Award in 1989 and the IEEE Field award in Systems Science and Engineering in 1991.

Dr. Brockett's research interests are in system theory, robotics and computer vision.