

## John Baillieul and the Development of Modern Control Theory

John Baillieul made early and lasting contributions to nonlinear control theory, the control of complex mechanical systems, and more recently, to information-based control. His PhD dissertation, completed at Harvard University in 1975, was an early work dealing with connections between optimal control theory and what has come to be called sub-Riemannian geometry. The set of ideas that were explored in Baillieul's thesis and subsequent publications has provided an important foundation for recent work on both spin systems in quantum physics and work on the controlled dynamics of elastic continua. After publishing a number of papers developing geometric methods for nonlinear optimal control problems, Baillieul made early contributions to the control of nonlinear systems modeled by homogeneous polynomial differential equations. Such systems describe, for example, the controlled dynamics of a rigid body. His basic controllability theorem uses the concept of finiteness embodied in the Hilbert basis theorem to develop a controllability condition for nonlinear systems that could be verified by checking the rank of a matrix. In response to renewed interest in power systems, Baillieul collaborated with C.I. Byrnes on the bifurcation and stability theory of large-scale electric energy system dynamics. A significant discovery was that solutions to the lossless load-flow equations could be exactly enumerated as a result of identifying and isolating some spurious solutions of dimension higher than zero. During the mid 1980's, Baillieul collaborated with M. Levi to develop a control theory for rotating elastic systems. Baillieul and Levi's basic results on the stability of equilibrium configurations of rotating elastic spacecraft have provided the foundation for a great deal of subsequent research in the area. At about the same period, Baillieul, sometimes in collaboration with others, wrote a number of papers on motion planning and control of kinematically redundant manipulators. Combined with the spacecraft work, this led naturally to work on problems associated with anholonomy in planning motions for robots which have elastic joints and other components which store energy.

Baillieul's most recent research has treated control problems in which constraints on the communication and processing of feedback information are crucial factors in determining control system performance. Together with Keyong Li, he has explored source coding of feedback signals which are designed to provide optimally robust performance in the face of time-varying feedback channel capacity. Graph theory is now regarded as perhaps the single most important new idea for the design of decentralized control algorithms for networks of mobile robots. John was among the most effective early users of these techniques, applying ideas from the theory of graph combinatorics to cooperative control of multiple autonomous mobile robot formations. The work on formation control that has followed the 2003 CDC paper of Baillieul and Suri is an

important testimony to this. Baillieul's most recent work deals with decision making in mixed teams of humans and intelligent automata and in particular in laying the foundation of action-mediated communication within such teams. Recent papers with students as well as several written in collaboration with W.-S. Wong detail this work.

We may also call attention to Baillieul's long record of service to the discipline of automatic control and to Boston University. Notable items include his service as editor-in-chief of two leading control journals V the IEEE Transactions on Automatic Control (1992 V 1998) and the SIAM Journal on Control and Optimization (2006 V Present). He served as President of the IEEE Control Systems Society, and he has served for two years as IEEE Vice President of Publication Services and Products. Most recently, he was General Co-Chair of the very successful combined 48th IEEE Conference on Decision and 28th Control and Chinese Control Conference, held in Shanghai, China (December, 2009). At Boston University he has held professorial appointments in three departments, Aerospace/Mechanical Engineering, Electrical and Computer Engineering and Manufacturing Engineering and has served as Chairman of several of these departments as well as having been Associate Dean for Academic Programs in the College of Engineering.

Roger W. Brockett, Harvard University