Seminar Announcement / NTUST ME Department

Group Theory in Robot Design and Structural Biology

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Abstract

Physicists use group theory to characterize symmetries. A different approach is taken in engineering problems, in which a group is a configuration space on which mechanical systems evolve. This concept will be illustrated in this talk with a minimal number of equations and with concrete examples. These include mobile robot path planning, and robot-arm inverse kinematics, and the design of spherical motors. The topics of group theory (and stochastic processes on Lie groups) lead into the speaker's current work on the design of multi-robot teams capable of diagnosis and repair, information fusion, and self-replicating robots.

Videos of these robots developed by undergraduate student researchers and high school students during summer internships will be shown. These toy models in turn have led us to a deep mathematical investigation. Namely, in order to quantify the robustness of such robots, measures of the degree of environmental uncertainty that they can handle need to be computed. The entropy of the set of all possible arrangements (or configurations) of spare parts in the environment is such a measure, and has led us to study problems at the foundations of statistical mechanics and information theory.

Similar issues in the characterization of conformational entropy arise in computational and theoretical aspects of polymer science and structural biology. In this talk it will be shown how: (a) the analysis of workspaces of snakelike robotic manipulator arms is akin to ring-closure computations in DNA statistical mechanics; (b) the so-called "banana distribution" use to model odometry errors in mobile robots is similar to blurring kernels in macromolecular electron microscopy; (c) and it will be shown how robot motion planning methods can be used to address the phase problem in protein crystallography.

Speaker Biography

Gregory S. Chirikjian received undergraduate degrees from Johns Hopkins University in 1988, and the Ph.D. degree from the California Institute of Technology, Pasadena, in 1992. Since 1992, he has been on the faculty of the Department of Mechanical Engineering, Johns Hopkins University, where he has been a full professor since 2001. From 2004-2007 he served as department chair. His research interests include robotics, applications of group theory in a variety of engineering disciplines, and the mechanics of biological macromolecules. He is a 1993 National Science Foundation Young Investigator, a 1994 Presidential Faculty Fellow, and a 1996 recipient of the ASME Pi Tau Sigma Gold Medal. In 2008 he became a Fellow of the ASME, and in 2010 he became a Fellow of the IEEE. He is the author of more than 200 journal and conference papers and primary author on three books: Engineering Applications of Noncommutative Harmonic Analysis (2001) and Stochastic Models, Information Theory, and Lie Groups, Vols. 1+2. (2009, 2011).