ENEE 769B **ADVANCED TOPICS IN CONTROL: Geometric Methods in Control and Information** (Mon Wed 2:00-3:15, Spring 2006, in PLS 1162)
Instructor: P. S. Krishnaprasad (krishna@umd.edu; 301-405-6843). Office is in A.V. Williams Building – room 2233. Office Hours: M 4:00-6:00 and Tue 5:00-7:00.
Class website: http://www.enee.umd.edu/courses/enee769b.S2006/

The study of nonlinear phenomena and associated control questions has led to the steady infusion into control theory of ideas and techniques from differential geometry and topology, Lie group theory, and dynamical systems on manifolds. In a parallel but less widely appreciated development, statisticians have investigated the rich geometry of spaces of probability distributions based on the concept of Fisher information. More recently specialists in signal processing have made effective use of dynamical systems on manifolds to understand the behavior of *adaptive filters* and algorithms for decoding. Some questions in quantum computing and control lead to investigations of flows on the Special Unitary group. When point clouds of data are presented in high dimensional spaces, it is important to discern whether the data is well-captured in a low-dimensional manifold. Researchers in the study of language learning and other data-intensive subjects are interested in the problem of *learning manifolds* embedded in high dimensional spaces. This course is aimed at a self-contained introduction to the diverse roles for ideas and techniques from geometry in the system sciences.

We will develop our subject in an orderly and example-rich style to maximize appreciation for the core theory and applications. The course will consist of the following segments: (a) manifolds, vector fields, differential forms; (b) Lie groups, group actions and symmetry; (c) the geometry of accessibility/controllability problems with applications in control and filtering; (d) the geometry of optimal control problems, maximum principle as a Hamiltonian system on a manifold, explicit integrability; (e) optimization problems on manifolds and associated convergence questions; (f) constructive control; (g) information geometry, Fisher-Rao metric and divergence measures; (h) flows on Stiefel and Grassman manifolds arising in signal processing algorithms; (i) unitary evolutions, efficient transfers and applications in quantum control; (j) statistical analysis of shape; (k) learning embedded manifolds.

Course Prerequisite: Background in control theory, probability theory, and mathematical maturity (ordinary differential equations, stability analysis). Contact instructor for further information.

References: There is no text-book for this course. A list of references will be made available on the first day of classes. Key papers will be provided in electronic form. Lecture notes will be made available *for each class*. Additional resources include the instructor's lecture notes for courses in control theory. Visit the websites http://www.enee.umd.edu/courses/enee661/ for nonlinear control, and http://www.enee.umd.edu/courses/enee664.S2004/ for optimal control.

Grading: Homework problems and a Semester Project will determine the grades.