ENEE 765 **ADAPTIVE CONTROL -** (Fall 2009, Tu Th, 2:00-3:15 pm, in CSI 1122)
Instructor: P. S. Krishnaprasad (krishna@umd.edu; 301-405-6843). Office is in A.V. Williams Building – room 2233. Office Hours: M 5:00-7:00 and Tu 5:00-7:00.

Feedback, adaptation and learning are essential elements in complex biological and engineered systems. Rigorous understanding of these processes is a subject of continuing study. This is a course on the *general principles of adaptive control and learning*, concentrating on deterministic aspects, while including *some stochastic models and methods*. Salient aspects of adaptive systems include: (a) automatic variation of gain parameters in feedback loops according to specific adaptation rules; (b) on-line identification (i.e. learning) of parameters of a system as a precursor to using knowledge of parameter estimates in control laws; (c) nonlinear dynamics and multiple time scales in the *combination* of system (plant) and adaptive controller; (d) data-driven learning of strategies of action through examination of payoffs. These are also salient aspects of a class of signal processing algorithms known as *adaptive filters* which play an important role in biology, communication technology and robotics.

In this course, we will (i) study system identification (i.e. learning a model from empirical data) to a level needed to analyze the behavior of adaptive control schemes such as model reference adaptive control and self-tuning regulators; (ii) answer questions of convergence, stability, and robustness, using various analytical tools (e.g. perturbation and averaging theory, advanced stability theory, design principles for informative input signals etc.); (iii) discuss methods from machine learning theory (e.g. approaches based on reproducing kernel Hilbert spaces (RKHS), etc.); (iv) provide an introduction to reinforcement learning and game-theoretic learning. Illustrative applications in engineering and economics will be covered.

Additional Topics: Time permitting we will explore some examples from biology, and some techniques from statistical learning theory, with additional applications.

Course Prerequisite: Background in control theory and mathematical maturity (ordinary differential equations, stability analysis). Familiarity with the material in ENEE 660 (system theory), ENEE 661 (nonlinear control), and ENEE 620 (Probability and Stochastic Processes) would be an asset. Contact instructor for further information.

References: **No required textbook.**
(a) P. S. Krishnaprasad, *Lecture Notes on Adaptive Control*, 2001/2005/2007/(now on-line at http://www.ece.umd.edu/class/enee765.F2009/ and to be updated and enhanced).
(b) Recent papers on machine learning (will be on-line).
(c) H. K. Khalil, *Nonlinear Systems*, Prentice Hall, 3rd ed., Englewood Cliffs, 2002.
(d) S. Sastry and M. Bodson, *Adaptive Control: Stability, Convergence and Robustness*, Prentice Hall, 1989-1994 (available now as a free downloadable item from http://www.ece.utah.edu/~bodson/acscr/index.html).
(e) S. Sastry, *Nonlinear Systems: Analysis, Stability and Control*, Springer, NY, 1999.

Grading: About five homework sets and a Semester Project will determine the grades.

(over for grading policy etc.)

The entire set of homework assignments will include reading assignments as well, and grades in the homework sets will count towards 50% of your semester grade. Discussion of homework assignments among the students in class and the instructor is permitted. Consultation of library material is permitted. Acknowledgement of such consultation is expected. All submitted work however should reflect individual effort and understanding. The Semester Project will count towards 50% of the semester grade. Selection and start of work on a Semester Project will be expected to take place no later than October 15. Completion of the project (including submission of a typeset report of about 10 pages) is required by the last day of exams in the announced fall semester schedule (Saturday December 19). Questions about format and content of the report of the Semester Project will be answered in class. **There will be no incomplete grades allowed except for health reasons or dire emergencies**.

Statement about Honor Code

The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit http://www.shc.umd.edu.

To further exhibit your commitment to academic integrity, remember to sign the Honor Pledge on all examinations and assignments: "I pledge on my honor that I have not given or received any unauthorized assistance on this examination (assignment)."