ENG ME/SE 704: Adaptive Control, Fall 2010

INSTRUCTOR

Prof. Sean Andersson

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Office hours: Tuesdays, 1-3 pm

MEETING TIME AND PLACE

Monday and Wednesday from 2-4 in SOC B27 (Sure hope to change the location.)

INTRODUCTION AND COURSE GOALS

Feedback, adaptation and learning are essential elements in 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. We will develop the subject of system identification (i.e. learning a model from empirical data) to the level necessary to understand and analyze the behavior of adaptive control schemes such as model reference adaptive control and self tuning regulators. Questions of convergence, stability, and robustness will be addressed. We will discuss various analytical methods central to the subject. Methods from averaging theory and singular perturbation will be developed. Results from advanced stability theory will be developed and applied to the analysis of adaptation schemes.

COURSE PREREQUISITES

ENG ME 501 (Dynamic System Theory) or a similar course or permission of the instructor. Exposure to nonlinear system theory (ENG ME 762) would be helpful but is not required. We develop the necessary tools from nonlinear control theory as needed.

COURSE OUTLINE

- Introduction
- Recursive parameter estimation
- Model reference adaptive control
- Adaptive pole placement control
- Robust adaptive control schemes
- Averaging-based analysis
- Adaptive control of nonlinear systems

TEXTBOOK (recommended)

- Petros Ioannou and Baris Fidan, Adaptive Control Tutorial, SIAM, 2006.

Note that this book can be purchased directly through SIAM (http://www.ec-securehost.com/SIAM/DC11.html). If you become a member of SIAM (which is free for BU students), the book is available at a significant discount.

REFERENCES

- K.J. Asrom and B. Wittenmark, Adaptive Control, 2nd Edition, Addison-Wesley, 1995.
- P.A. Ioannou and J. Sun, Robust Adaptive Control, Prentice-Hall, 1995. Available at

  `http://www-rcf.usc.edu/~ioannou/RobustAdaptiveBook95pdf/Robust_Adaptive_Control.pdf`

- K.S. Narendra and A.M. Annaswamy, Stable Adaptive Systems, Prentice-Hall, 1989.
- S.Sastry and M. Bodson, Adaptive Control, Prentice-Hall, 1989. Available at

  `http://www.ece.utah.edu/7Ebodson/acscr/index.html`

- M. Krstic, I. Kanellakopoulos, and P. Kokotovic, Nonlinear and Adaptive Control Design, Wiley-Interscience, 1995.
- H.K. Khalil, Nonlinear Systems, Prentice-Hall, Third Edition, 2002.

HOMEWORK, PROJECTS, AND GRADING

Homework will be assigned semi-weekly with a target of 8-10 sets for the semester. There will also be a mini project and a final project. *There will be no exams.*

It (almost) goes without saying that the work you submit should be your own. You are welcome to discuss the problems with your peers but you must sit down and do the work yourself. Many of the homework problems will be drawn from the Ioannnou and Fidan textbook. As we all know, it is often relatively easy to find solutions to such problems on the web; please avoid doing so. The way to learn the techniques we develop in the class is to diligently do the work.

For the mini project, each student will select a paper from a list provided by me. Accompanying each paper will be a topic that is related to adaptive control and to the paper but which is not explicitly covered in the course. The student will prepare a 30-40 minute presentation on the paper and topic. Further details will be provided during the semester.

For the final project, each student will propose a control system of interest and develop and apply (in simulation) an adaptive controller using the techniques developed throughout the course. Systems can be drawn from the student's research, from journal articles, or from textbooks. Further details will be provided during the semester.

The breakdown of the scoring is: homework (50%), mini-project (20%), and final project (30%).

COURSE WEBSITE

The course will be hosted on BU Blackboard. All documents will be posted there (including homeworks, solutions, and project information). I have also setup to discussion forums- one for asking questions about lecture material and one for asking questions about homework questions. Since it is almost certainly true that if you have a questions, there are several others in the course who have it as well, using the online forums will allow us to capture such questions and share the answers. I will check the forums regularly and encourage you to make use of them.

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Schedule for Fall 2010

Date	Notes	Title	Topics
9.6 9.8	No class	- INTRODUCTION	
9.13 9.15 9.20 9.22 9.27 9.29 10.4		SYSTEM ID	Parametric models, Gradient algorithms, Persistently exciting signals, State space ID, Discrete time ID, Robust ID
10.6 10.11 10.12 10.13 10.18	No class Monday schedule	MODEL REFERENCE ADAPTIVE CONTROL	Direct, indirect, discrete, robust
10.20 10.25 10.27		ADAPTIVE POLE PLACEMENT CONTROL	Polynomial, state space, discrete, robust
11.1 11.3		MIDTERM PROJECT PRESENTATIONS	
11.8 11.10 11.15 11.17		ADAPTIVE CONTROL OF NONLINEAR SYSTEMS	Feedback linearization, backstepping, adaptive backstepping, neuroadaptive control, adaptive output feedback
11.22 11.24 11.29 12.1	No class	USEFUL METHODS OF PROVING STABILITY	Averaging, singular perturbation theory
12.6 12.8		FINAL PROJECT PRESENTATIONS	