ENG ME/SE 704: Adaptive Control, Fall 2012

INSTRUCTOR

Prof. Sean Andersson

Office: ENG 421, 110 Cummington Street
E-mail: sanderss@bu.edu Phone: 353-4949
Office hours: TBD

MEETING TIME AND PLACE

Monday and Wednesday from 2-4 in Pho 201

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. 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
- Adaptive control of nonlinear systems
- Other topics may be included as time permits

TEXTBOOK (recommended)

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

  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. You don't need to purchase it but you may find it helpful to have a copy.

- Ioan Doré Landau, Rogelio Lozano, Mohammed M'Saad, and Alireza Karimi, Adaptive control: algorithms, analysis and applications, Second edition, Springer, 2011.

  I will also be drawing somewhat from this text. There is significant overlap with the Ionannou and Fidan text but there are some differences. One of the biggest differences is the cost- a hard copy is $229 and an e-book copy is $179.99. I recommend getting this book only if you get quite excited about adaptive control and intend to continue working in this area.

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/~bodson/acscr`
- 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.

Please note that many of the older references often use a different notation that has been unified and modified in the recommended textbooks.

HOMEWORK, PROJECTS, AND GRADING

Homework will be assigned semi-regularly with a likely total of 4-6 sets for the semester. There will also be a two-part project. There will be no exams.

The project content will center on an application of an adaptive control algorithm to a system of interest. Early in the semester, students will propose said system of interest. Approximately mid-way through the semester, a report and presentation on that system will be due. These must include results from a working simulation (in, for example, Matlab) as well as control requirements and possible approaches. At the end of the semester, an adaptive controller should have been implemented and demonstrated (in simulation). A final report and presentation will be given.

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. Details will be given during the course.

The breakdown of the scoring is straightforward: homework (50%) and project (50%).

COURSE WEBSITE

The course will be hosted on BU Blackboard. All documents will be posted there (including homeworks, solutions, and project information).

(Tentative) Schedule of Lectures

Date	Number	Topic	Notes
9.5	1	Introduction and background	-
9.10	2	Background	-
9.12	2	Parametric models	-
9.17	3	Parameter ID (gradient)	-
9.19	4	Parameter ID (persistent excitation)	-
9.24	5	Parameter ID (alternatives)	-
9.26	6	Parameter ID (state space)	-
10.1	7	Parameter ID (discrete time)	-
10.3	8	Parameter ID (robust)	-
10.8	-	No class (holiday)	-
10.9	10	Project presentations	Monday schedule of classes
10.10	11	Project presentations	-
10.15	12	Model reference adaptive control (MRAC)	-
10.17	13	MRAC	-
10.22	14	MRAC	-
10.24	15	Robust MRAC	-
10.29	16	Adaptive pole placement control (APPC)	-
10.31	17	Robust APPC	-
11.5	18	Adaptive feedforward compensation of disturbances	-
11.7	19	Adaptive feedforward compensation of disturbances	-
11.12	20	Multimodel adaptive control	-
11.14	21	Some practical aspects	-
11.19	22	Nonlinear systems: Adaptive backstepping	-
11.21	-	No class (Thanksgiving recess)	-
11.26	23	Nonlinear systems: Adaptive feedback linearization	-
11.28	24	Nonlinear systems: Neuroadaptive control	-
12.3	25	Project presentations	-
12.5	26	Project presentations	-
12.10	-	No class	At CDC
12.12	-	No class	At CDC