<16 Nov 2022>

EE5104 Adaptive Control Systems/
EE6104 Adaptive Control Systems (Advanced)

Module Lecturers

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Relevant Basic Information

- **This course aims to educate students and provide a strong foundation in the basic concepts and design methods of Adaptive Systems and Adaptive Control. The concepts underlying adaptive control schemes, such as Lyapunov-based direct adaptive control methodologies, self-tuning regulator and model reference adaptive control, will be studied in detail. Least squares estimation (on-line) and the issues related to parameter adaptation will also be introduced. To provide an understanding of an alternative to "adaptation", the concept and basic design of variable structure control will be discussed. Case studies of various engineering control problems will be used throughout the course to provide insights and useful design guideline. There will also be a hands-on CA mini-project where the methods studied will be investigated in the real-time control of a precision d.c. motor servomechanism. Previous students of the module have found that this is a great help in their careers and also in their further studies.**

- **The module will be of great use to postgraduate students interested in adaptive systems and the associated methodology, both for career development and for further studies.**

- **Very useful module for postgraduate studies leading to strong foundation for careers in DSTA/DSO; Hewlett Packard Technology Divisions; National Instruments U.S.A.; Agilent U.S.A.; Emerson Electric; Yokogawa; automation companies; high-precision instruments companies (including biomedical); disk-drive companies; etc.**

- **Module Syllabus: Please see next page.**

- **Two CA assignments; Reports will count towards continuous assessment (40 %). EE6104 students will have more advanced CA assignments.**

- **One hands-on CA mini-project assignment; Mini-project grade will count towards continuous assessment (30 %). EE6104 students will have more advanced requirements in this CA mini-project.**

- **Examination grade will contribute the other 30%. EE5104 and EE6104 examination papers will be suitably different, with more advanced requirements in EE6104.**

Remark: It is suggested that hardcopies of the down-loaded lecture notes be printed single-sided. Typically, from the experience of past batches of students, the blank sides have been found very useful for taking down additional notes of the material developed further in the lectures.

EE5104 Adaptive Control Systems

Pre-Requisites: **EE5101 Linear Systems; or**
Co-Requisites: **EE5101 Linear Systems; or Approval by Lecturers.**

<Knowledge of fundamental topics in Linear Dynamical Systems and State-Variables is a pre-requisite/co-requisite. The EE5101 Linear Systems module will be a sufficient pre-requisite/co-requisite. Alternatively, students who have already taken a suitable module with topics on Linear Dynamical Systems and State-Variables will also be suitably prepared. In case of doubts, please consult the module lecturers.>

Overview:

This course aims to educate students and provide a strong foundation in the basic concepts and design methods of Adaptive Systems and Adaptive Control. The concepts underlying adaptive control schemes, such as Lyapunov-based direct adaptive control methodologies, self-tuning regulator and model reference adaptive control, will be studied in detail. Least squares estimation (on-line) and the issues related to parameter adaptation will also be introduced. To provide an understanding of an alternative to "adaptation", the concept and basic design of variable structure control will be discussed. Case studies of various engineering control problems will be used throughout the course to provide insights and useful design guideline. There will also be a hands-on CA mini-project where the methods studied will be investigated in the real-time control of a precision d.c. motor servomechanism. Previous students of the module have found that this is a great help in their careers and also in their further studies.

Aims of subject:

This module has the objective of educating and training students in the advanced methodologies of Adaptive Systems and Adaptive Control. The module will be of great use to postgraduate students interested in adaptive systems and the associated methodology, both for career development and for further studies.

Detailed Syllabus

(Time allocations are approximate. Adjustments will be made depending on needs of class.)

	Contents	No. of Hours
1	**Introduction** Adaptive schemes. Adaptive control theory. Applications. Situations when constant Gain feedback is insufficient. Robust control. The adaptive control problem.	3
2	**Model Reference Adaptive Systems** The model following problem. MRAS based on stability theory. Model following when the full state is measurable. Direct MRAS for general linear systems. Prior knowledge in MRAS. MRAS for partially known systems. Use of robust estimation methods in MRAS.	8
3	**Self-Tuning Regulators** The basic idea. Indirect self-tuning regulators. Direct Self-tuning regulators. Linear Quadratic STR. Adaptive Predictive control. Prior knowledge in STR.	8
4	**Real-Time Parameter Estimation** Linear-in-the-parameters model. Least squares estimation. Experimental conditions. Recursive estimators. Extended least squares. Robust estimation methods (dead zone, projection). Implementation issues.	8
5	**Auto-Tuning** PID Control. Transient response methods. Methods based on relay feedback. Relay oscillations.	3
6	**Gain Scheduling** The Principle. Design of Gain-scheduling Regulators. Nonlinear Transformations. Applications of Gain-scheduling.	3
7	**Alternatives to Adaptive Control** Situations where adaptive control should not be used. Robust high gain feedback control. Self-oscillating adaptive systems. Variable structure systems.	3

Reference Books

- K.J. Astrom and B. Wittenmark, Adaptive Control, Addison Wesley, 1989/1995.
- K.S. Narendra and A.M. Annaswamy, Stable Adaptive Systems, Prentice-Hall, 1989.
- G.C. Goodwin and K.S. Sin, Adaptive Filtering, Prediction and Control, Prentice, 1984.