Course F. Nonlinear Control

Course Objectives:	To study the essentials of nonlinear control systems. Topics covered are those techniques which have already been found effective. Several new techniques which are potentially useful to the control applications and one detailed case study will also be discussed.
Prerequisite:	Completed undergraduate courses in engineering mathematics and linear control systems

Teaching Plan

Week	Topics	Text
1	Introduction to nonlinear control. Undesirable nonlinear system behaviour. Adding Extra Nonlinear Elements. Relay feedback. Nonlinear Differential Equations. Well known linear properties not found in nonlinear Systems. Unique characteristics of nonlinear systems. Methods available for analyzing nonlinear systems.	**Teng Chapter 1,2**
2	Linearizing approximations. Describing Function (DF) concept. Derivation of DF for common nonlinearities. Use of DF to predict Limit Cycle. A practical system with a nonlinear element is treated as a linear system. An example on the limit cycle prediction for a hard nonlinearity.	**Teng Chapter 3,4**
3	Introduction of adaptive control. An example of the design based on gain scheduling approach.	**Teng Chapter 5**
4	General procedure of gain-scheduled controller design for nonlinear systems.	**Teng Chapter 5**
5	Introduction of self tuning control. Parameters estimator. Self tuning minimum variance control. Self tuning pole-zero placement control.	**Teng Chapter 5**
6	Introduction of model reference adaptive control. Basic design of MRAC. System based on input/output model.	**Teng Chapter 5**
7	MRAC. System based on Lyapunov approach. Popov hyperstability theorem.	**Teng Chapter 5**
8	Introduction of feedback linearization.General structure	**Teng Chapter 6**

	of feedback linearization controller	
9	Input-state linearizable systems.	**Teng Chapter 6**
10	Input-Output linearization. Zero Dynamics. Basic differential geometry. Lie derivative and Lie Bracket. Design example: Coupled tank	**Teng Chapter 6**
11	Case study: Motion control of a robotic manipulator	**Teng Chapter 7**

Main Reference

F C TENG 2006 Nonlinear Control, unpublished course notes.

Additional Reference

1) P A Cook 1994, Nonlinear Dynamical Systems (2nd Edition), Prentice Hall
2) J E Slotine & WeiPing Li 1991, Applied Nonlinear Control, Prentice Hall
3) H K Khalil 2000, Nonlinear Systems, Pearson Education
4) F.C. Teng, G.F. Ledwich & G. Shannon. 1994 Adaptive Control Scheme for Robot Manipulator: Direct Decoupler and PID Controller. International Journal of Systems Science. , Vol 24, No 2, 315-327