# System Identification, CDS 270

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**Prerequisites:** Basic understanding of nonlinear dynamics, Lyapunov stability theory, numerical methods, and MATLAB.

**Course Outline**: The main goal of the course is to give a self-contained mathematical treatment of System Identification (ID) theory and methods. Throughout the course both off-line and on-line system ID methods will be presented. Effectiveness of the design methodology will be demonstrated using static maps and dynamic systems, in continuous and discrete time domains. Students will be asked to run a course project (system ID related) using models of their choice.

**Project:**
Project may consist of a survey of papers from the literature (current state of the art), or of an independent investigation of a topic related to the course, with simulation examples. Students are responsible for the selection of the topic of their project and are encouraged to discuss topics early on with the instructor. A formal / written project report is due the week before last and an oral presentation is to be given by each student at the last week of the semester.

**Grading Policy**: **Pass (score 85% or higher) / Fail (otherwise)**,
Based on:

a) class attendance ……... 20 %
b) project report …….. 55 %
c) oral presentation of project results ……. 25 %

**Course material is organized as follows:**

1. Introduction: Basic approaches to System ID, off-line and on-line parameter estimators, state prediction, adaptive observers, motivating examples.
2. Review of Lyapunov Stability Theory.
3. State-space models. Linear-in-parameters estimation.
4. Gradient and normalized gradient estimation algorithms.
5. Least-squares and modified least-squares algorithms. Parameter estimation methods using exponential forgetting and Projection Operator.

6. Identification of dynamical systems.
7. Adaptive predictors and state observers.
8. Parameter convergence, and Persistency of Excitation (PE) conditions.

**Main Textbooks**:

1. P.A. Ioannou & B. Fidan, Adaptive Control Tutorial, SIAM, 2006.
2. J.J. Slotine, W. Li, Applied Nonlinear Control, Prentice Hall, 1995.

**Recommended Books**

1. K.S. Narendra and A.M. Annaswamy, Stable Adaptive Systems, Dover, 2005.
2. S. Sastry and M. Bodson, Adaptive Control: Stability, Convergence, and Robustness, Prentice-Hall, 1989, electronic copy available in PDF form at: http://www.ece.utah.edu/~bodson/acscr
3. H.K. Khalil, Nonlinear Systems, 3rd Edition, Prentice Hall, New Jersey, 2002.
4. G.C. Goodwin and K.S. Sin, Adaptive Filtering, Prediction, and Control, Prentice-Hall, 1984.