System (Process) Identification - Web course

COURSE OUTLINE

System / Process identification is an area that has tremendous impact in process modelling, control and process monitoring.

The main objective of this course is to teach the fundamental aspects of system identification, i.e., estimating dynamic models from sampled (experimental/operating) data.

In particular, the course will cover various aspects of identification such as:

1. Estimation of non-parametric and parametric models.
2. Notions of model quality (bias, variance, etc.).
3. Choosing model structures.
4. Methods for estimation of transfer function and state-space models.
5. Data pre-processing techniques for identification.

The scope of this course is primarily confined to development of linear time-invariant black-box models.

While the lectures cover the theory, the examples and case studies provide insights into the practicalities and subtleties of implementation.

Modelling aspects are presented in both time- and frequency-domains.

Identification of process models requires modelling of process disturbances and an appropriate representation of uncertainties, which is facilitated by the theory of random processes.

A module explaining the essential concepts of time-series analysis is included in this course.

MATLAB® and the System Identification toolbox (MATLAB) will provide the necessary computational support for this course.

Contents:

System Identification - motivation and overview: Models for discrete-time LTI systems.

Non-parametric models; Disturbance models; Parametric model structures; Linear regression problem; Least Squares formulation and its variants.

Maximum Likelihood Estimation; Estimation of non-parametric models; Notions of prediction and simulation.

Estimation of parametric models - prediction error methods and instrumental variable methods.

Model structure selection and diagnostics; Experiment design for identification; Subspace identification; Case studies.

COURSE DETAIL

S.No	Topics	No. of Hours

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Chemical Engineering

Pre-requisites:

Linear Systems Theory (recommended); Linear Algebra, Basic Calculus, Basic Probability and Statistics.

Additional Reading:

Y. Zhu. Multivariable System Identification for Process Control, Elsevier Science Ltd., Oxford, UK, 2001 (0-08-043985-3).

Hyperlinks:

http://homes.esat.kuleuven.be/~smc/daisy/ (System Identification Database).

Coordinators:

Dr. Arun K.Tangirala
Department of Chemical EngineeringIIT Madras

1	System Identification - Motivation and Overview.	1
2	Models of Discrete-Time LTI Systems - Convolution equation. Difference equations, Transfer functions, State-space models, Discretization, Sampling and Hold operations, Sampling theorem.	7
3	Non-parametric models - impulse response, step response and frequency response models.	2
4	Disturbance models - random processes, representation of stationary processes, white-noise process, auto-covariance function (ACF), ARMA models.	5
5	Parametric model structures - ARX, ARMAX, OE, Bj and PEM - structures.	2
6	Linear Regression - Least Squares estimates, Statistical properties of LS Estimates. Weighted Least Squares, Recursive Least Squares, Maximum Likelihood Estimation.	7
7	Estimation of non-parametric models - impulse / step response coefficients, frequency response models.	4
8	Estimation of parametric models - notions of prediction and simulation, predictors for parametric models, prediction-error methods, Instrumental Variable method.	8
9	Model Structure Selection and Diagnostics - estimation of delay and order, residual checks, properties of parameter estimates, model validation.	6
10	Experimental Design - input design for identification, notion of persistent excitation, identifiability.	4
11	Subspace Identification - classical and innovations forms, free and structured parametrizations. Least squares estimation, extended observability matrix, order determination through singular-value decomposition.	6
12	Case studies and topics for further study.	3
	Total	53

References:

Ljung, L., System Identification - A Theory for the User, Prentice-Hall, 1999.
T. Soderstrom and P. Stoica, System Identification, Prentice Hall International, 1994 (0-13- 127606-9).