UE Modeling and system identification

Niveau d'étude
Bac +5

ECTS
3 crédits

Composante
UFR PhITEM (physique, ingénierie, terre, environnement, mécanique)

Période de l'année
Automne (sept. à dec./janv.)

- **Langue(s) d'enseignement:** Anglais
- **Ouvert aux étudiants en échange:** Oui
- **Code d'export Apogée:** PAX9MIAC

Présentation

Description

Feedback control design, diagnostic/supervision and process optimization typically require a specific modeling approach, which aims to capture the essential dynamics of the system while being computationally efficient. The first part of the class details the guiding principles that can be inferred from different physical domains and how multi-physics models can be obtained for complex dynamical systems while satisfying the principle of energy conservation. This leads to algebro-differential mathematical models that need to be computed with stability and computational efficiency constraints. System identification constitutes the second part of the class, to include knowledge inferred from experimental data in the input/output map set by the model. It provides methods to evaluate the model performance, to estimate parameters, to design "sufficiently informative" experiments and to build recursive algorithms for online estimation.

Lesson	Topic
1	**Introduction to Modeling**
	Systems and models, examples of models, models for systems and signals.
	PHYSICAL MODELING
2	**Principles of Physical Modeling**

	The phases of modeling, the mining ventilation problem example, structuring the problem, setting up the basic equations, forming the state-space models, simplified models.
3	**Some Basic Relationships in Physics**
	Electrical circuits, mechanical translation, mechanical rotation, flow systems, thermal systems, some observations.
4	**Bond Graphs:**
	Physical domains and power conjugate variables, physical model structure and bond graphs, energy storage and physical state, free energy dissipation, ideal transformations and gyrations, ideal sources, KirchhoffÂ's laws, junctions and the network structure, bond graph modeling of electrical networks, bond graph modeling of mechanical systems, examples.
	SIMULATION
5	**Computer-Aided Modeling**
	Computer algebra and its applications to modeling, analytical solutions, algebraic modeling, automatic translation of bond graphs to equations, numerical methods - a short glance.
6	**Modeling and Simulation in Scilab**
	Types of models and simulation tools for: ordinary differential equations, boundary value problems, difference equations, differential algebraic equations, hybrid systems.
	SYSTEM IDENTIFICATION
7	**Experiment Design for System Identification:**
	Basics of system identification, from continuous dynamics to sampled signals, disturbance modeling, signal spectra, choice of sampling interval and presampling filters.
8	**Non-parametric Identification:**
	Transient-response and correlation analysis, frequency-response/Fourier/spectral analysis, estimating the disturbance spectrum.
9	**Parameter Estimation in Linear Models:**
	Linear models, basic principle of parameter estimation, minimizing prediction errors, linear regressions and least squares, properties of prediction error minimization estimates.
10	**System Identification Principles and Model Validation**
	Experiments and data collection, informative experiments, input design for open-loop experiments, identification in closed-loop, choice of the model structure, model validation, residual analysis.
11	**Nonlinear Black-box Identification**
	Nonlinear state-space models, nonlinear black-box models: basic principles, parameters estimation with Gauss-Newton stochastic gradient algorithm, temperature profile identification in tokamak plasmas
	TOWARDS PROCESS SUPERVISION
12	**Recursive Estimation Methods**

	Recursive least-squares algorithm, IV method, prediction-error methods and pseudolinear regressions, Choice of updating step

Heures d'enseignement

UE Modeling and system identification - CM	CM	24h

Période : Semestre 9

Bibliographie

- L. Ljung and T. Glad, "Modeling of Dynamic Systems", *Prentice Hall PTR*, 1994.
- S. Stramigioli, "Modeling and IPC Control of Interactive Mechanical Systems: A Coordinate-free Approach", *Springer*, LNCIS 266, 2001.
- S. Campbell, J-P. Chancelier and R. Nikoukhah, "Modeling and Simulation in Scilab/Scicos", *Springer*, 2005.
- L. Ljung, "System Identification: Theory for the User", 2nd Edition, *Information and System Sciences, (Upper Saddle River, NJ: PTR Prentice Hall)*, 1999.
- O. Hinton, "Digital Signal Processing", Chapter 6 - Describing Random Sequences, EEE305 class material, 2003.

Infos pratiques

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