Graduate School in Information Engineering: Ph.D. program
Department of Information Engineering
University of Padova

Course Catalogue

2007
Requirements for Ph.D. Students entering the Graduate School of Information Engineering in January 2007:

1. Students are required to take courses from the present catalogue for a minimum of 80 hours (20 credits) during the first year of the Ph.D. program.

2. Students are required to take for credit the basic courses “Applied Functional Analysis”, and “Applied Linear Algebra” during the first year of the Ph.D. program. Moreover, the course “Statistical Methods” is strongly recommended to all students.

3. After the first year, students are strongly encouraged (although not required) to take courses for at least 10 credits (possibly outside the present catalogue) according to their research interests.

Students have to enroll in the courses they intend to take at least one month before the class starts. To enroll, it is sufficient to send an e-mail message to the secretariat of the school at the address calore@dei.unipd.it

Students are expected to attend classes regularly. Punctuality is expected both from instructors and students.

Instructors have to report to the Director of Graduate Studies any case of a student missing classes without proper excuse.
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1 Analysis and Design of Nonlinear Control Systems

Instructor: Lorenzo Marconi, CASY-DEIS University of Bologna
e-mail: lmarconi@deis.unibo.it

Aim: The objective of the course is to present analysis and design tools for nonlinear systems. Basic fundamental results regarding the analysis of nonlinear systems and the study of dynamical interconnection will be presented as a basis to introduce latest developments in the field of robust stabilization and output regulation by state and output feedback.

Topics:


2. **Robust Global Stabilization of system in feedforward form.** Class of systems; ISS with restrictions and local small gain theorems; nested saturations and stabilization of feedforward systems; Robust stabilization and design procedures.

3. **High Gain Observers and Output Feedback Stabilization.** Observability of nonlinear systems; property of uniform observability and existence of a special observability form; the concept of uniform canonical flag; design of a nonlinear observer and analysis of the observation error; the nonlinear separation principle; semiglobal stabilization of nonlinear systems by output feedback;

4. **Robust output regulation for linear systems.** Problem formulation; necessary and sufficient conditions; regulator equations and “internal model property”; adaptive output regulation for relative degree 1 minimum-phase systems; canonical internal model and adaptive regulator; examples.

5. **Robust output regulation for nonlinear system.** Asymptotic Tracking and disturbance attenuation; output regulation for nonlinear systems; the steady-state response of a nonlinear systems; the asymptotic internal model property and a general design procedure; observers as nonlinear internal models; examples of design under immersion conditions.

References:


**Time table:** 16 hours. Lectures (2 hours) on Monday and Wednesday, 2:30–4:30 P.M. First lecture on Monday, April 30, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).
Course requirements: Basic notions of dynamical systems and knowledge of analysis and design tools for linear systems. Stability notion and high-gain stabilization tools for nonlinear systems.

Examination and grading: Homeworks.
2 Applications of Algebraic Geometry (in common with the Graduate School in Mathematics)

Instructor: Prof. A. Calabri, Dipartimento di Metodi e Modelli, Università di Padova, e-mail: calabri@dmmsa.unipd.it, and Prof. B. Chiarellotto, Dipartimento di Matematica, Università di Padova, e-mail: chiarbru@math.unipd.it

Aim: We intend to give the student the algebraic geometric tools in order to deal with some recents methods on splines, coding and cryptography. The course will be divided in two parts: the first on basic algebraic geometry the second on the applications.


References:

Time table: Course of 20 hours. Two lectures per week, each lecture two hours in length, for five weeks. Lectures will be on Tuesday Room 1C50, Math. Dept., (Torre Archimede Building) and Thursday Room 2A45, Math. Dept., (Torre Archimede Building), 4:15 – 6:15 P.M.. First lecture on Tuesday, Feb, 13, 2007.

Course requirements: Basic commutative algebra.

Examination and grading: Homeworks and advanced projects.
3 Applied Functional Analysis

Instructor: Prof. Paolo Ciatti, Dept. Metodi e modelli matematici per le scienze applicate, University of Padova, e-mail: ciatti@dmsa.unipd.it

Aim: The course is intended to give a survey of the basic aspects of functional analysis and operator theory in Hilbert spaces. First elements of Fourier analysis are also discussed.

Topics:


References:


Time table: Course of 28 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday, 10:30 – 12:30 A.M.. First lecture on Tuesday October 2, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).
Course requirements:

1. The classical theory of functions of real variable: limits and continuity, differentiation and Riemann integration, infinite series, uniform convergence, and the notion of a metric space. Moreover, one needs to know a bit of Lebesgue integration theory - actually, not much more than the definitions and the statements of the two main convergence results: the monotone convergence theorem and the Lebesgue dominated convergence theorem.

2. The arithmetic of complex numbers and the basic properties of the complex exponential function.

3. Some elementary set theory.


A summary of the relevant facts will be given in the first lecture.

Examination and grading: HW and final written examination.
4 Applied Linear Algebra

Course co-sponsored by the Graduate School in Mathematics

Instructor: Tobias Damm, Fachbereich Mathematik, TU Kaiserslautern, Germany.
e-mail: damm@mathematik.uni-kl.de

Aim: Concepts and techniques of linear algebra will be studied, which are important for applications and computational issues. A wide range of exercises and problems will be presented such that a practical knowledge of tools and methods of linear algebra can be acquired.

Topics:

- **Singular values and generalized inverse:**
  Polar form, singular value decomposition, generalized inverse, least squares problem, norms, low-rank approximation.

- **Krylov subspaces:**
  cyclic subspaces and Jordanblocks, matrix polynomials, projections, numerical methods.

- **Matrix equations and inequalities:**
  Lyapunov and Riccati equations, stability and inertia, matrix functions.

- **Positive matrices and positive operators:**
  Perron Frobenius theory and generalization, stochastic matrices, M-matrices and positive evolutions.

References:


Course requirements: A good working knowledge of basic notions of linear algebra, as e.g. presented in [4].
**Time table:** 16 hours. Lectures (2 hours) on Tuesday and Thursday, 10:30-12:30 A.M. First lecture on Tuesday, September 4, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Examination and grading:** Grading will be based on homeworks or a written examination or both.
5 Basic and Advanced Topics in Broadband Wireless Networks

Instructor: Prof. Anthony Acampora, University of California, San Diego. e-mail: acampora@ece.ucsd.edu

Aim: This course provides an in-depth treatment of broadband wireless networks intended for universal access to the Internet, starting with basic fundamentals and progressing to advanced research topics at the leading edge of the field.

Topics:

1. Wireless access fundamentals: Cellular approaches, frequency re-use, bandwidth utilization efficiency, propagation impairments, diversity and basic outage avoidance strategies, one and visitor location registers.

2. The Physical Layer.

3. Multiple Access Techniques and Interference Avoidance.


5. The Network Layer: The Intelligent Network, Call handoff for macro- and micro-cellular systems, Signaling, Network management, Traffic engineering, Quality of service metrics and management.


8. Wireless LANS: IEEE 802.11 and IEEE 802.16.

9. 3G Systems and Beyond.


11. Free Space Optical Networks.


References:
**Time table:** 20 hours. Lectures (2 hours) on Tuesdays and Thursdays, 2:30–4:30 P.M., starting on Tuesday April 3, 2007. Lecture of May 1, 2007 is anticipated to Monday April 30, 10:30–12:30. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** There are no specific requirements, although some general knowledge of networking and protocols is recommended.

**Examination and grading:** The final grade will be computed based on two quiz tests (20% each) and a final term paper (60%).
6 Bioelectromagnetics

Instructor: Prof. Tullio A. Minelli, CIRMANMEC University of Padova, e-mail: minelli@pd.infn.it.


Topics:

1. Basics of bioelectromagnetics.
2. Neuroelectrical phenomena.
3. Chaos, fractals, solitons and neuroelectrical signals.
4. Mobile phone radiation and neuroelectrical phenomena.
6. Mathematical models of cell membrane dynamics.

References:

**Time table:** 12 hours. Lectures (2 hours) on Friday, 14:30–16:30 P.M. First lecture on January 12, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** None.

**Examination and grading:** Production of simple pedagogical circuits or measures and simulations of biophysical interest.
7 Correlated Source Coding

Instructor: Prof. Gianfranco Pierobon, Dipartimento di Ingegneria dell’Informazione, Università di Padova, e-mail: pierobon@dei.unipd.it

Aim: The course is intended to provide a survey of the basic coding problems for correlated discrete sources.

Topics:

Background material. Basic notions of information theory, entropy and information. Information measure. Fano inequality. Data processing theorem.


References:


Course requirements: Basics of Probability Theory and Communications.

Examination and grading: Six homeworks.
8 Digital Processing of Measurement Information

Instructor: Prof. Claudio Narduzzi, Dept. Ingegneria dell’Informazione (DEI), University of Padova, e-mail: narduzzi@dei.unipd.it

Aim: Whenever research involves experimental activities, there is a need to characterise measuring equipment, assess the accuracy of data and, most often, process raw data to extract relevant information. The course introduces essential measurement algorithms, together with the conceptual tools that allow their characterisation in a probabilistic framework. This will provide the student with the basic skills required to formulate a measurement problem, the tools and methods for processing information obtained from experimental data and the capability to correctly approach the analysis of uncertainty and its assessment.

Topics:

1. An outline of measurement theory.
2. Uncertainty, quantisation and the additive noise stochastic model.
3. Characterisation of waveform digitisers and data acquisition systems.
5. Resolution in model-based measurements.
7. Compensation of measurement system dynamics: inverse problems and ill-posedness.

References: Lecture notes and selected reference material will be handed out during the course.


Examination and grading: Final project assignment.
9 Diffraction Theory with Application to Optics and Information Transmission

Instructor: Prof. G. F. Nalesso, Università di Padova, e-mail: gianfranco.nalesso@unipd.it, and Prof. C. G. Someda, Università di Padova, e-mail: someda@dei.unipd.it

Aim: The aim of the course is to review the theory of em-wave diffraction and its impact with information transmission.


References:


Time table: Course of 12 hours. Lectures (2 hours) on Friday, 2:30–4:30 P.M. First lecture Friday, May 4, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Principles of electromagnetic fields propagation.

Examination and grading: Final exam.
**10 Distributed Applications and Protocols I**

**Instructor:** Dr. Albert F. Harris III, Department of Information Engineering, University of Padova, e-mail: harris@dei.unipd.it

**Aim:** This course is the first in a two-part series aimed at providing an advanced grounding in the theory, practice, and design of distributed systems, including their applications and protocols. This first course provides a solid foundation in distributed systems design while both combined study distributed system concepts in breadth and depth. The course will provide knowledge of how to design practical distributed systems using observations from natural phenomena and provide a chance to present a conference type paper with peer reviews. Best papers will be submitted to some of the top computer science conferences, giving students a chance to get published with the work from the course.

**Topics:** Main topics include: distributed system fundamentals, large distributed and peer-to-peer systems, large-scale sensor networks, and design methodologies for distributed systems.

Specifically, the first course will cover topics including but not limited to: fundamentals of distributed system design, decentralized systems (P2P), sensor networks, The Grid, and overlays and DHTs.

**References:** The course will use classic and recent research papers. All papers will be available online for download.

**Time table:** 20 hours. Lectures (2 hours) on Tuesday 10:30 – 12:30 AM. First lecture on Tuesday, January 9, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** Prefer introductory networking/operating systems course, but not required.

**Examination and grading:** Final project, final paper, paper reviews, presentation.
11 Distributed Applications and Protocols II

Instructor: Dr. Albert F. Harris III, Department of Information Engineering, University of Padova, e-mail: harris@dei.unipd.it

Aim: This course is the second in a two-part series aimed at providing an advanced grounding in the theory, practice, and design of distributed systems, including their applications and protocols. This course continues where "Distributed Applications and Protocols I" left off. Both together study distributed system concepts in breadth and depth, providing knowledge of how to design practical distributed systems using observations from natural phenomena and provide a chance to present a conference type paper with peer reviews. Best papers will be submitted to some of the top computer science conferences, giving students a chance to get published with the work from the course.

Topics: Main topics include: distributed system fundamentals, large distributed and peer-to-peer systems, large-scale sensor networks, and design methodologies for distributed systems.

Specifically, the second course will cover topics including but not limited to: advanced peer-to-peer concepts, security, the future of sensor networks, and system design paradigms.

References: The course will use classic and recent research papers. All papers will be available online for download.


Course requirements: Distributed Applications and Protocols I, or prior approval from instructor.

Examination and grading: Final project, final paper, paper reviews, presentation.
12 Effects of Ionizing Radiation on Electronic Components: From Space Applications to Sea Level Effects

Instructor: Prof. Alessandro Paccagnella, Dipartimento di Ingegneria dell’Informazione (DEI), Università di Padova, e-mail: paccag@dei.unipd.it

Aim: Aim of the course is to illustrate the wide interdisciplinary field of ionizing radiation effects on electronic components, involving issues proper of radiation physics, electronic devices and circuits, and reliability. This course will not explore only the classical problems arising in space or high energy physics applications, but also at sea level in commercial devices.

Topics:

1. Interaction between particles and matter: energy deposition, charge recombination and collection in semiconductors and insulators. The concept of Linear Energy Transfer. Different types of radiation damage in electronic components: total dose, displacement, single ion effects. (4 hours)

2. Radiation effects: solar radiation and cosmic rays for space environments. Atmospheric neutrons for avionic applications. Ground level sources: from natural radioactive contaminants to radiogenic machines. The High Energy Physics experiments. (2 hours)

3. Displacement damage on the lattice of crystalline and amorphous materials. The NIEL factor. Case studies: solar cells, semiconductor detectors. (2 hours)

4. Total dose effects: MOS components; recovery mechanisms and the temperature role; the ELDR case on bipolar components; test methodologies and qualification procedures. (4 hours)

5. Single event effects on components and circuits: soft error; bit-flip and stuck bit in DRAM and SRAM; Soft Error Rate in digital components; non-volatile memories; catastrophic phenomena; latch-up; gate oxide breakdown. (6 hours)

6. Technologic evolution of CMOS circuits and techniques to reduce and mitigate radiation damage. (2 hours)

References: Lecture notes and selected reference material will be handed out during the course.

Time table: Course of 20 hours. Lectures (2 hours) on Wednesday and Friday, 10:30–12:30 A.M. First lecture on Wednesday, February 14, 2006. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic courses of Electronics (including Electronic devices).

Examination and grading: Oral examination.
13 Integer Programming Methods for Design and Management of Telecommunications Networks

Instructor: Prof. Lorenzo Brunetta, DEI, e-mail: brunetta@dei.unipd.it

Aim: The first half course is intended to provide an introduction to those integer programming models and algorithms that have been successfully applied to several optimization problems deriving from application in telecommunications networks. In the second part particularly significant results on real world applications will be presented and discussed.

Topics:

1. Polytopes and Linear Programming
2. Model Formulations
3. Optimality, Relaxations and Bounds.
4. Dynamic Programming
5. Branch and Bound
6. Cutting plane Algorithms
7. Matroids and the Greedy Algorithm
8. Heuristic and GRASP Algorithms
9. From theory to solutions
10. Optimizing frequency assignment in GSM
11. Optimizing network loading and design
12. Optimizing base station location and configuration in UMTS networks
13. Optimizing frequency assignment in DVB-T

References:


**Time table:** Course of 20 hours. Lectures (2 hours) on Monday and Thursday, 10:30–12:30. First lecture on Monday, March 5, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** Linear Programming and some general knowledge on graphs.

**Examination and grading:** Homework and final exam.
14 Identification techniques

Instructor: Professor Alessandro Chiuso, Dept. Tecnica e Gestione dei Sistemi Industriali, University of Padova, e-mail: chiuso@dei.unipd.it

Aim: This course is intended to provide a deep comprehension of modern method for identifications of multivariable (MIMO) systems.

Topics:

1. BACKGROUND OF STATISTICS AND PARAMETER ESTIMATION (Brief Overview)

2. LINEAR STOCHASTIC MODELS AND STOCHASTIC PROCESSES

3. REVIEW OF PARAMETRIC IDENTIFICATION FOR ARX, ARMAX MODELS AND STATE SPACE MODELS (Brief Overview).
   ML (Maximum Likelihood) and PEM (Prediction error methods) for multivariable ARX, ARMAX and SS models. Iterative Algorithms for the minimization of the mean quadratic error in general ARMAX models. Quasi-Newton method. Main complications: identifiability in multivariable models. Canonical forms, local minima, over-parameterization and ill-conditioning.
   State space models: Data Driven Local Coordinates and EM Based Approaches.

4. SUBSPACE IDENTIFICATION FOR MULTIVARIABLE STATE SPACE MODELS

5. ASYMPTOTIC STATISTICAL PROPERTIES OF SUBSPACE ESTIMATORS
6. OPEN (RESEARCH) QUESTIONS

Computer simulations and case studies.

References: For the first part of the course references are:


For the second part of the course the instructor will provide specific material (journal and conference papers, etc.).

Time table: Course of 20 hours (two two-hours lectures per week): Classes on Tuesday and Thursday from 16:30 to 18:30, first lecture on Tuesday April 17, 2007. Room DEI/G (3rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic knowledge on probability theory, discrete-time linear systems, Bayesian statistical estimation, modeling of systems and MATLAB/SIMULINK control toolbox.

Examination and grading: Homework assignments and final test on identification and validation of a model with data provided by instructor.
15 Numerical Models for Fields Analysis in Biological Beings

Instructor: Prof. Fabrizio Dughiero, Dept. Ingegneria Elettrica, University of Padova, e-mail: fabrizio.dughiero@unipd.it

Aim: The course will deal with the main analytical and numerical methods for the evaluation of electromagnetic and thermal fields in biological beings from the macroscopic point of view.


References: Lectures notes prepared by the teacher and a list of reference books and papers will be available at the beginning of the course.

Time table: Course of 20 hours (two 2-hours lectures per week): Classes on Wednesday and Friday, 10:30 to 12:30, first lecture on Wednesday March 28, 2007 (there will be no class on April 25). Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Electrotechnics, Electromagnetism, Numerical Methods.

Examination and grading: Final project assignment.
16 Physical models for the numerical simulation of semiconductor devices

Instructor: Gaudenzio Meneghesso, Department of Information Engineering, University of Padova. e-mail: gauss@dei.unipd.it

Aim:

This course is intended to provide an introductory coverage on charge transport in semiconductors and on the physical models underlying the semiconductor device simulators, which are nowadays routinely adopted for the design and optimization of device fabrication processes (Technology Computer Aided Design or TCAD).

Topics: The course will cover the following topics.


References:


Time table: Course of 20 hours (one two-hours lecture per week): Classes on Friday, 14:30 to 16:30, first lecture on October 19, 2007, last lecture December 21, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Background at a graduate level on semiconductor devices.

Examination and grading: Final test.
17 Pattern Recognition and Machine Learning

Instructor: James M. Rehg, College of Computing, Georgia Institute of Technology, e-mail: rehg@cc.gatech.edu

Aim: Introduction to the topics of pattern recognition and machine learning. The course will adopt a modern Bayesian perspective and provide an introduction to the use of standard software packages. In particular, we will use the Weka package\textsuperscript{1} in several example projects.

Topics:

1. Review of Probability and Statistics: standard distributions, conditioning, chain rule, Bayes theorem, expectations, loss functions, decision theory, sufficient statistics, kernel density estimation, polynomial curve fitting

2. Linear Models for Regression and Classification: linear basis function models, bias-variance decomposition, discriminant functions, logistic regression, Bayesian regression, Bayesian model comparison and BIC

3. Neural Networks and Gaussian Processes: feed-forward network models, error backpropagation, numerical optimization, radial basis function networks, gaussian process regression, relevance determination, gaussian process classification

4. Sparse Kernel Machines: Maximum margin classifiers and risk minimization, learning theory, VC dimension, Support Vector Machine (SVM), implementation issues, multiclass SVM, sparsity


6. Combinations of Models: Bayesian model averaging, bagging, variance reduction, PAC learning, boosting, loss functions, AdaBoost algorithm, tree-based models, conditional mixture models

References:


\textsuperscript{1}http://www.cs.waikato.ac.nz/\tilde{}ml/weka/
Time table: Course of 12 hours. Two lectures per week, each lecture two hours in length, for three weeks. Lectures correspond approximately to topic list given above. Lectures will be on Tuesday and Thursday, 2:30 – 4:30 P.M.. First lecture on Tuesday, June 12, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic probability theory, linear algebra, and statistics (see Topic 1). The early chapters of [1] and [3] are also a good source of background material.

Examination and grading: One small project per week based on Weka package. Final project due one month after end of course.
18 Pollution and Prevention

**Instructor:** Prof. Giovanni Battista Bartolucci, Department of Environmental Medicine and Public Health, Occupational Medicine - University of Padova e-mail: giovannibattista.bartolucci@unipd.it

**Aim:** Knowledge of legislation and prevention measures in the field of life and work environment; understanding of procedures for exposure and risk evaluation.

**Topics:** Principal laws for protection in life and work environment. Procedures for risk assessment and risk management. The evaluation of exposure. Air quality in life environment: the example of fine dusts and benzene. Principal physical risks: microclimate, noise, vibrations (methods of measure and health risks). The individual and collective prevention measures.

**References:** Handouts provided by the instructor.

**Time table:** Course of 8 hours (2 two-hours lectures per week): Classes on Monday and Wednesday from 16:30 to 18:30, first lecture on January 8-th, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

**Course requirements:** None.

**Examination and grading:** Oral exam.
19 Selected Topics In Photonics Devices

Instructors: Dr. Antonio D. Capobianco, Università di Padova, e-mail: adc@dei.unipd.it, and Dr. Marco Santagiustinia, Università di Padova, e-mail: marco.santagiustinia@unipd.it

Aim: The aim of the course is to review some of the most recent advancements and applications of photonics devices for optical communications.

Topics:
1. Review of medium nonlinearities: effects in nonlinear quadratic and cubic media.
2. Second Harmonic Generation through Quasi Phase Matching technique in photonic devices; periodically poled LiNbO$_3$ fabrication methods (special seminar by Prof. Cinzia Sada from Physics Department, University of Padova); modeling and numerical simulations of conversion efficiency in real devices.
4. Software laboratory (2 hrs).

References:


Time table: Course of 16 hours (2 two-hours lectures per week): Classes on Tuesday 14:30 to 16:30 and Friday from 10:30 to 12:30, first lecture on May 8, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Principles of electromagnetic fields propagation.

Examination and grading: Final exam and laboratory report.


20 Statistical Methods

Instructor: Lorenzo Finesso, Istituto di Ingegneria Biomedica, ISIB-CNR, Padova

e-mail: lorenzo.finesso@isib.cnr.it

Aim: The course will present a survey of statistical techniques which are important in applications. The unifying power of the information theoretic point of view will be stressed.

Topics:

Background material. The noiseless source coding theorem will be quickly reviewed in order to introduce the basic notions of entropy and informational divergence (Kullback-Leibler distance) of probability measures. The analytical and geometrical properties of the divergence will be presented.

Divergence minimization problems. Three basic minimization problems will be posed and, on simple examples, it will be shown that they produce the main methods of statistical inference: hypothesis testing, maximum likelihood, maximum entropy.

Multivariate analysis methods. Study of the probabilistic and statistical aspects of the three main methods: Principal Component Analysis (PCA), Canonical Correlations (CC) and Factor Analysis (FA). In the spirit of the course these methods will be derived also via divergence minimization. Time permitting there will be a short introduction to the Nonnegative Matrix Factorization method as an alternative to PCA to deal with problems with positivity constraints.

EM methods. The Expectation-Maximization method was introduced as an algorithm for the computation of Maximum Likelihood (ML) estimator with partial observations (incomplete data). We will present the EM method as an alternating divergence minimization algorithm (à la Csiszár Tusnády) and show its application to the ML estimation of Hidden Markov Models.

The MDL method. The Minimum Description Length method of Rissanen will be presented as a general tool for model complexity estimation.

Monte Carlo methods. The basic ideas of the Monte Carlo methods, including Markov Chain Monte Carlo, will be presented in the context of deterministic and stochastic problems.

References: A set of lecture notes and a list of references will be handed out on first day of classes.


Course requirements: Basics of Probability Theory and Linear Algebra.

Examination and grading: homework assignments and take-home exam.
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