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

Course Catalogue

2008

Requirements for Ph.D. Students of the Graduate School of Information Engineering:

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 *at least* two out of the following three basic courses "Applied Functional Analysis", "Applied Linear Algebra", and "Statistical Methods" during the first year of the Ph.D. program. Moreover, the third course is *strongly recommended* to all students.
3. After the first year, students are *strongly encouraged* 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.

Contents

1 3D Reconstruction from Images
(From Small Objects All the Way to Entire Cities)

Instructor: Frank Dellaert, School of Interactive Computing, Georgia Institute of Technology, Atlanta, Georgia, USA e-mail: `dellaert@cc.gatech.edu`

Aim: This course is intended to give students an overview and working knowledge of the current state in the art in 3D reconstruction from images, as used both in computer vision ("structure from motion") and robotics ("visual SLAM").

Topics:

- 2D and 3D projective geometry
- Camera models
- Direct linear transform (DLT) methods for resectioning and triangulation
- Sparse and dense Stereo
- Two-view geometry: the essential and fundamental matrix
- Multi-view geometry
- The Tomasi-Kanade factorization method for affine structure recovery
- Bundle adjustment
- Feature extraction and matching
- Wide-baseline matching
- Large-scale reconstruction: issues and trends

References:
Hartley and Zisserman, Multiple View Geometry, 2nd edition

Time table: Course of 16 hours. Lectures (two hours) on Monday and Wednesday 2:30 – 4:30 P.M.. First lecture on Monday, June 30, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Linear algebra, introduction to computer vision.

Examination and grading: 4 projects, one per week.

2 Applied Functional Analysis

Instructors: Prof. Paolo Ciatti, Dept. Metodi e modelli matematici per le scienze applicate, University of Padova, e-mail: `ciatti@dmsa.unipd.it` and Prof. G. Pillonetto, Dept. Information Engineering, University of Padova, e-mail: `giapi@dei.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:

1. *Review of some notions on metric spaces and Lebesgue integration:* Metric spaces. Open sets, closed sets, neighborhoods. Convergence, Cauchy sequences, completeness. Completion of metric spaces. Review of the Lebesgue integration theory. Lebesgue spaces.

2. *Normed spaces and Banach spaces:* Normed spaces and Banach spaces. Finite dimensional normed spaces and subspaces. Compactness and finite dimension. Bounded linear operators. Linear functionals. The finite dimensional case. Normed spaces of operators and the dual space. Weak topologies.

3. *Inner product spaces and Hilbert spaces:* Inner product spaces and Hilbert spaces. Orthogonal complements and direct sums. Orthonormal sets and sequences. Fourier series. Representation of functionals on Hilbert spaces. Hilbert adjoint operator. Self-adjoint operators, unitary operators.

4. *Fourier transform and convolution:* The convolution product and its properties. The basic L^1 theory of the Fourier transform. The inversion theorem. The L^2 theory and the Plancherel theorem.

5. *Compact linear operators on normed spaces and their spectrum:* Spectral theory in finite dimensional spaces. Spectral properties of bounded linear operators. Compact linear operators on normed spaces. Spectral properties of compact linear operators. Operator equations involving compact linear operators. Fredholm alternative.

6. *Spectral theory of bounded self-adjoint operators and their spectrum:* Spectral properties of bounded self-adjoint operators, positive operators, operators defined by a kernel, Mercer Kernels, Mercer's theorem, Reproducing Kernel Hilbert Spaces (RKHS): definition and basic properties, examples of RKHS, function estimation problems in RKHS, Tikhonov regularization, support vector regression and regularization networks, representer theorem.

References:

[1] E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley and Sons , 1978.

[2] M. Reed and B. Simon, *Methods of Modern Mathematical Physics, vol. I, Functional Analysis*, Academic Press, 1980.

Time table: Course of 28 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday, 10:30 – 12:30. First lecture on Tuesday October 7, 2008. 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.

4. A bit of linear algebra.

All the necessary material can be found in W. Rudin's book *Principles of Mathematical Analysis* (3rd ed., McGraw-Hill, 1976).
A summary of the relevant facts will be given in the first lecture.

Examination and grading: HW and final written examination.

3 Applied Linear Algebra

Instructors: Tobias Damm, TU Kaiserslautern, Germany
e-mail: `damm@mathematik.uni-kl.de`
Michael Karow, TU Berlin, Germany
e-mail: `karow@math.tu-berlin.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:

- *Matrix equations and inequalities:*
  Lyapunov and Riccati equations, stability and inertia, matrix functions
- *Krylov subspaces and numerical methods:*
  Arnoldi's algorithm, Ritz eigenvalues, iterative methods
- *Positive matrices and positive operators:*
  Perron-Frobenius theory, stochastic matrices, M-matrices and positive evolutions
- *Singular values and generalized inverse:*
  Polar form, singular value decomposition, generalized inverse, least squares problem, norms, low-rank approximation
- *Perturbation theory:*
  Eigenvalue perturbations, pseudospectra, μ-values

References:

[1] L. N. Trefethen and D. Bau *Numerical Linear Algebra.* SIAM, 2000.

[2] A. Berman and R. J. Plemmons. *Nonnegative Matrices in the Mathematical Sciences*. SIAM, 1994.

[3] R. Bhatia. *Matrix Analysis* Springer, New York, 1997.

[4] J. W. Demmel. *Applied Numerical Linear Algebra.* SIAM, Philadelphia, 1997.

[5] E. Gregorio and L. Salce. *Algebra Lineare.* Edizioni Libreria Progretto, Padova, 2005.

[6] R. A. Horn and C. R. Johnson. *Matrix Analysis.* Cambridge University Press, Cambridge, Massachusetts, 1985.

[7] R. A. Horn and C. R. Johnson. *Topics in Matrix Analysis.* Cambridge University Press, Cambridge, 1991.

Time table: Course of 16 hours. Classes on Tuesday and Thursday, 10:30 – 12:30. First lecture on Tuesday September 2, 2008. There will be no lecture on September 16 and 18. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: A good working knowledge of basic notions of linear algebra, as e.g. presented in [5].

Examination and grading: Grading will be based on homeworks or a written examination or both.

4 Biochips: Microdevices for Life Sciences

Instructor: Prof. Stefano Vassanelli, e-mail: `stefano.vassanelli@unipd.it`

Aim: The course provides an overview on applications of micro- and nanotechnologies to life sciences. Particularly, it will focus on the recent development of "Biochips" that are used as "Lab-on-chips" for the investigation and characterization of biomolecules (i.e. DNA) and living cells. Implantable biochips for monitoring and control of physiological functions "in vivo" (i.e. neuroprosthetic devices) are also addressed.

Topics:

1. DNA and protein microarrays.
2. Cells-on-chips: microfabrication, cell culture, biochemical and electrical manipulation and analysis of cells.
3. Single-cell manipulation and analysis.
4. Neurochips for the investigation of neuronal networks "in vitro".
5. Brain-chip interfaces "in vivo".
6. Implantable biochips for healthcare.

References:

[1] P. Fortina, D. Graves, C. Stoeckert, Jr., S. McKenzie, S. Surrey "Technology Options and Applications of DNA Microarrays" in Biochip Technology, (eds. J. Cheng,L. J. Kricka), pp. 185-216 (Harwood Academic Publishers, Philadelphia, 2001).

[2] M. Schena , D Shalon, R.W. Davis, P.O. Brown (1995). Quantitative monitoring of gene expression patterns with a complementary DNA microarray. Science. 270: 467-70.

[3] A. van den Berg, T.S.J. Lammerink in Microsystems Technology in Chemistry and Life Science (eds A. Manz, H. Backer) 21-49 (Springer, Berlin, 1998).

[4] J. El-Ali, P.K. Sorger, K.F. Jensen (2006) Cells on Chips. Nature 442:403-411.

[5] P. Fromherz, "Neuroelectronic Interfacing: Semiconductor Chips with Ion Channels, Nerve Cells and Brain" in Nanoelectronics and Information Technology (ed R. Waser) pp. 781-810 (Wiley-VCH, Berlin, 2003).

[6] C. Harland, T. Clark, R. Prance (2002) Electric Potential Probes- New Directions in the remote sensing of the human body. Measurement Science and Technology 13:163-169.

Time table: Course of 12 hours. Lectures (two hours) on Friday 2:30 – 4:30 P.M.. First lecture on Friday, February 8, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic courses of biology, chemistry and physics.
Examination and grading: Homework assignments and final test.

5 Bioelectromagnetics

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

Aim: Comprehension of bio-physics and bio-mathematical instruments underlying cell and tissue electromagnetic stimulation. A phenomena survey.

Topics:

1. Basics of bioelectromagnetics.
2. Neuroelectrical phenomena.
3. Chaos, fractals, solitons and neuroelectrical signals.
4. Mobile phone radiation and neuroelectrical phenomena.
5. Neurodegeneration: Bio-physical and bio-mathematical phenomenology.
6. Mathematical models of cell membrane dynamics.

References:

[1] C. Polk and E. Postow. CRC handbook of biological effects of electromagnetic fields. Boca Raton, CRC Press 1986.

[2] C.H. Durney and D.A. Christensen. Basic introduction to bioelectromagnetics. Boca Raton, CRC Press, 2000.

[3] S. Deutsch and A. Deutsch. Understanding the nervous system. An Engineering perspective. New York: IEEE, 1993.

[4] S.S. Nagarajan. A generalized cable equation for magnetic stimulation of axons. IEEE Transactions on biomedical Engineering, 43, 304-312, 1996.

[5] M. Balduzzo, F. Ferro Milone, T.A. Minelli, I. Pittaro Cadore and L. Turicchia: Mathematical phenomenology of neural synchronization by periodic fields, Nonlinear Dynamics, Psychology and Life Sciences 7, pp.115-137, 2003.

[6] A. Vulpiani. Determinismo e caos. La nuova Italia Scientifica, Roma, 1994.

[7] T.A. Minelli, M.Balduzzo, F. Ferro Milone and V.Nofrate: Modeling cell dynamics under mobile phone radiation. Nonlinear Dynamics, Psychology and Life Sciences, to appear.

[8] Report on the potential health risk of Radiofrequency Fields (the Royal Society of Canada, 2001-2003).

[9] C.P.Fall. Computational Cell Biology. Berlin, Springer, 2002.

[10] J.D. Murray. Mathematical Biology. Berlin: Springer-Verlag, 1993.

[11] Bioinitiative Report, 2007 in `http://www.bioinitiative.org/report/index.htm`

Time table: Course of 12 hours plus a visit to an electro-physiology laboratory. Lectures (2 hours) on Friday, 11:00 – 13:00. First lecture on January 11, 2008. 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.

6 Deconvolution of Physiological Signals

Instructor: Giovanni Sparacino, Department of Information Engineering (DEI), University of Padova. e-mail: `gianni@dei.unipd.it`

Aim: Deconvolution is an important indirect measurement tool in physiological system analysis. In fact, many signals of interest for the quantitative understanding of physiological systems (e.g. the secretion rate of a gland, the production rate of a substrate, the appearance rate of a drug in plasma after an oral administration) are not directly accessible to measurement, but can be modeled as input of (linear) dynamic systems whose output (e.g. concentration of the substance in plasma) can be directly measured. The major challenges posed by deconvolution in physiological system analysis are the ill-conditioning, the computation of realistic confidence intervals, the infrequent and nonuniform sampling, the nonnegativity constraints, and the development of efficient numerical algorithms. The course will provide a critical overview of some widely-used deconvolution techniques. In addition, some recent developments to cope with the specificity of the physiological setting will be presented. Numerical and implementation aspects will be extensively discussed.

Topics: Difficulty of the deconvolution problem in physiological systems analysis: ill-posedness, ill-conditioning, sparse/non-uniform sampling, impulse response uncertainty, computation of confidence intervals, presence of non-negativity constraints. State of the art (parametric methods, Phillips-Tikhonov regularization, truncated SVD, maximum entropy, regression splines, ...) and open problems. A Bayesian approach to the deconvolution of physiological signals (static and Wiener/Kalman formulation). Criteria for solving the bias-variance dilemma. Nonlinear extension of the bayesian approach. Coping with the nonnegativity constraint. Influence of the impulse response model. Numerical aspects. Application to real physiological case studies. Software implementation.

References: A set of lecture notes with a list of references will be provided at the beginning of the course.

Time table: Course of 12 hours (2 two-hours lectures per week): Classes on Wednesday and Friday 2:30 – 4:30 P.M.. First lecture on Wednesday September 10, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basics of: Signal & Systems, Probability Theory, and Linear Algebra.

Examination and grading: Homework and final exam.

7 Design Patterns in Software Development

Instructor: Gabriele Manduchi, Istituto Gas Ionizzati del CNR
e-mail: `gabriele.manduchi@igi.cnr.it`

Aim: Introduction of Design Patterns in software development. The course is centered around a case study in software development in ”e-Science”. A graphical front-end for browsing and visualizing scientific data is progressively refactored using important design patterns for object-oriented software. Object-oriented design patterns are taught in a real-world context which is relevant to computational science.

Topics:

1. **Advanced Java Programming**: the case study refers to a graphical waveform browser for networked scientific data.

2. **Design Patterns definition**: an overview of the basic design patterns is provided at the beginning of the course, and a significant subset will be used in refactoring the case study.

3. **UML Modelling**: a subset of UML will be used through the course to represent class organization and component relationships.

4. **Concurrent Systems**: in the final part of the course multithreading is considered. A few related problems are introduced and some patterns for concurrent systems are introduced.

References:

1. E. Gamma, R. Helm, R. Johnson, J. Vlissides: Design Patterns: Elements of Reusable Object Oriented Software, Addison Wesley 1995.

2. Henry Gardner, Gabriele Manduchi: Design Patterns for e-Science Springer, 2007.

Time table: Course of 16 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday, 8:30 – 10:30. First lecture on Tuesday June 3, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic Java programming, Object-Oriented terminology and methods

Examination and grading: A project will be assigned to students, and will represent the base of the final discussion

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 reasearch 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.
4. Analysis of signal processing algorithms: statistical properties of discrete Fourier transform-based spectral estimators, least squares regression and the Cramér-Rao bound.
5. Resolution in model-based measurements.
6. Evaluation of measurement uncertainty: the probability-based approach and the guidelines of the ISO Guide to the evaluation of uncertainty in measurement.
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.

Time table: Course of 16 hours (2 two-hours lectures per week): Classes on Tuesday and Thursday, 10:30 – 12:30. First lecture on Thursday April 3, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Examination and grading: Final project assignment.

9 Dose, effect, threshold

Instructor: Prof. Andrea Trevisan, Dipartimento di Medicina Ambientale e Sanità Pubblica, Univ. di Padova, e-mail: `andrea.trevisan@unipd.it`

Aim: understanding of biological mechanisms that are the basis of the effect of chemical, physical and biological agents in humans. To supply a critical evaluation of the reference data on biological effects of electromagnetic fields.

Topics: General introduction to cell biology and mechanisms of pharmacokinetics. The dose and the significance of threshold. The effect (response) of the dose. Methods to define the threshold. The significance of cancer and the threshold problem. Electromagnetic fields and general aspects related to the dose and the effect.

References: Handouts provided by the instructor.

Time table: Course of 12 hours. Lectures (2 hours) on Thursday 10:30 – 12:30. First lecture on Thursday, May 8, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: None.

Examination and grading: Oral exam.

10 Electrostatic Discharge in Integrated Circuits

Instructor: Gaudenzio Meneghesso, Dept. Ingegneria dell'Informazione (DEI), University of Padova, e-mail: `gaudenzio.meneghesso@unipd.it`

Aim: This course is intended to provide an introduction coverage of the Electrostatic Discharge (ESD) problem in modern Integrated Circuits (ICs). There are several reasons that indicate the ESD problem as one of the most critical issues in modern ICs to be faced, among others: a) with the continuous technology scaling down, in the deca-nanometer dimension, devices can not sustain voltages larger than 1 V, hence these devices are extremely sensitive to electrostatic discharge and an adequate ESD protection become quite difficult to provide; b) very high speed RF circuits need ESD protection devices that do not affect their RF performances by altering the input/output matching, so suitable ESD protection elements must be developed; c) automotive industry is making very comfortable and secure cars by filling them with as much electronics as possible working in a very hostile ambient, a suitable ESD protection of these devices is not trivial. These are only few examples that however give an impression of how much critical will be the ESD aspect in the future ICs.

Topics:

1. Basics of the Electrostatic Discharge phenomena;
2. Test Methods;
3. Active and passive ESD protection;
4. Device Physics of the most common ESD protection elements;
5. Characterization of ESD protection elements;
6. Failure Modes, Reliability Issues and Case Studies;
7. Circuit Simulation basics: approaches and applications.

References:

[1] Amerasekera, C. Duvvury, ESD in Silicon Integrated Circuits, Wiley 2002 (Second Edition).

[2] Z. H. Wang, On Chip ESD Protection for Integrated Circuits, Kluwer Academic Publisher, 2002.

[3] S. Dabral, T. J. Maloney, Basic ESD and I/O Design, Wiley Interscience, 1998.

Time table: Course of 20 hours (2 two-hours lectures per week): Classes on Monday 2:30 – 4:30 P.M. and Friday, 10:30 – 12:30. First lecture on November 3, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic notions on device physics.

Examination and grading: Design and SPICE verification of an ESD protection network.

11 Introduction to Quantum Control Theory

Instructor: Domenico D'Alessandro, Department of Mathematics, Iowa State University, U.S.A., e-mail: `daless@iastate.edu`

Aim: The objective of the course is to present the basic techniques and notions of the theory of control and analysis of quantum dynamics using a Lie algebraic approach. At the end of the course the students will have an elementary knowledge of quantum mechanics and will be able to analyze dynamics of quantum control systems in particular for what concern their controllability. They will be able to design control algorithms for quantum systems and analyze several examples including nuclear magnetic resonance experiments and implementations of information processing.

Topics:

1. Introduction to quantum mechanics. States, operators and dynamics of quantum systems. Evolution as quantum information processing.
2. Modeling of quantum systems. The system of particles and electromagnetic field as a quantum control system.
3. Introduction to Lie algebras and Lie groups. Lie transformation groups in connection with quantum dynamics.
4. Controllability of quantum experiments. Tests of controllability for the state, the evolution operator and the density matrix. Decomposition of quantum dynamics.
5. Survey of methods to control quantum systems. Lie group decompositions, Optimal control, Lyapunov control, Adiabatic Control.
6. Examples of applications. Nuclear magnetic resonance, implementation of quantum information processing, quantum walks.

References: D. D'Alessandro, *Introduction to Quantum Control and Dynamics*, CRC Press, Boca Raton, FL, 2007.

Time table: Course of 20 hours. Lectures (two hours) on Monday 10:30 – 12:30, and Tuesday 4:30 – 6:30 P.M.. First lecture on Tuesday, June 3, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic knowledge of algebra, linear algebra and differential equations. Basic notions of control theory.

Examination and grading: Based on Homework.

12 Modelling of Propagation Channels in Wireless Communication Systems

Instructor: Prof. Silvano Pupolin, DEI, Università di Padova e-mail: `pupolin@dei.unipd.it`

Aim: The objective of the course is to give the notion of channel model and of its usage in the design of wireless communication systems.

Topics: Introduction to wireless systems, Introduction to radio propagation, The cellular concept, Cell coverage and cell size, Representation of bandpass signals, Representation of time varying channels, Time delays and doppler spread, Channel functions and their relationships, Statistical channel model, Slowly time varying channels, Coherence bandwidth and coherence time, Fading duration, Channel models, Omnidirectional receive antennas channel models, MIMO Spatial Channel Characterization, Stochastic Space-Time Vector Channel Model, Example of channel models, Applications to wireless communication systems.

References: M. Nawrocki, M. Dohler, A.H. Aghvami, Understanding UMTS radio network, Wiley 2006.

Time table: Course of 16 hours (2 two-hours lectures per week): Classes on Monday and Wednesday, 10:30 – 12:30. First lecture on Monday February 4, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: A basic knowledge of signal theory and electromagnetic propagation is recommended.

Examination and grading: Grading will be based on a project consisting in design of a channel model and its simulation.

13 Monte Carlo Methods

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 an overview of Monte Carlo methods and their potential use in several areas of Engineering, including Signal and Image Processing, Estimation and Identification, Optimization etc.

Topics:

1. MONTE CARLO METHODS

   Fundamental problems in scientific computations: integration, optimization, and simulation. Simulation in statistical mechanics: the Metropolis algorithm. Basic Markov Chain theory.

   Markov Chain Monte Carlo: Metropolis-Hasting, Gibbs, Slice. Rejection Sampling, Importance Sampling.

   Application to Optimization: Simulated Annealing.

   Exact Sampling: Coupling from the Past (CFTP).

2. SEQUENTIAL MONTE CARLO METHODS (Particle Filters).

   Sequential Importance Sampling and application to state estimation and filtering of dynamical systems.

   Effective Sample Size, Resampling schemes.

   Rao-Blackwellization.

   Convergence issues.

References: TBA

Time table: Course of 20 hours. Lectures (two hours) on Monday and Wednesday 2:30 – 4:30 P.M.. First lecture on Monday, April 28, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

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

Examination and grading: Homework assignments and final project.

14 Numerical Models for Fields Analysis in Biological Beings

Instructor: Prof. Fabrizio Dughiero, 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.

Topics: Electromagnetic and thermal characteristics of biological tissues with particular reference to human body. Outline about measurements methods for evaluation of tissues characteristics. Blood perfusion: behaviour and modelling. Outline about the main procedures for 2D and 3D domains acquisition from diagnostic images (CT, PET, NMR). Analytical and numerical methods for fields analysis. Main numerical methods for the evaluation of electromagnetic and thermal fields in human body: FEM, FDTD, MoM, Cells method. Examples of application: Ablation therapy (Hyperthermia); evaluation of SAR in a human body in a 27,12 MHz Electromagnetic field.

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

Time table: Course of 20 hours (2 two-hours lectures per week): Classes on Monday and Friday, 10:30 – 12:30. First lecture on Monday April 7, 2008. Lectures of Friday April 25 and Friday May 2 (bank holidays) are rescheduled on May 12 and 14. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Electrotechnics, Electromagnetism, Numerical Methods.

Examination and grading: Homework, project.

15 Optimization Libraries

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

Aim: The course is intended to provide an introduction to those software libraries that implement linear, integer and non–linear programming models and algorithms that have been successfully applied to several optimization problems. Significant results on real world applications will be presented and discussed.

Topics:

1. Model Formulations and Linear Programming
2. Integer Programming, Branch and Bound, Relaxations and Bounds.
3. An introduction to linear, integer and non–linear programming libraries
4. An introduction to GAMS
5. An introduction to MPL and CPLEX
6. Integer Programming: example of applications (Air Traffic Management)

References:

1. M. Fischetti, "Lezioni di ricerca operativa", Progetto, Padova, 1999.
2. F. Hillier e G. Lieberman, "Ricerca Operativa 8ed" The McGraw-Hill Companies, Milano, 2005
3. L. A. Wolsey, "Integer Programming", Wiley Interscience, Chichester, 1998.
4. Lecture notes
5. Research papers.

Time table: Course of 12 hours. Lectures (two hours) on Wednesday and Thursday 10:30 – 12:30. First lecture on Wednesday, March 5, 2008. Room DEI/G (3-rd oor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Linear Programming, some general knowledge on Integer Programming.

Examination and grading: 2 homeworks and final project.

16 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 chemical and physical risks in work environment: organic and inorganic dusts, fibres, metals, solvents, 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 12 hours (2 two-hours lectures per week): Classes on Monday and Wednesday from 4:30 to 6:30 P.M.; first lecture on January 14-th, 2008; last lecture on January 30-th, 2008. Room DEI/G (3-rd floor, Department of Information Engineering, via Gradenigo Building).

Course requirements: None.

Examination and grading: Homework assignment and final examination.

17 Positron Emission Tomography (PET)

Instructor: Prof. Maria Carla Gilardi, University of Milano Bicocca,
e-mail: `mariacarla.gilardi@hsr.it`

Aim: The aim of the course is to provide a survey of technological issues and applications in Positron Emission Tomography (PET)

Topics:
1. State of the art PET systems.
2. Quantification issues in PET.
3. 4D PET and radiotherapy.

References:

[1] Bailey, D.L., Townsend, D.W., Valk, P.E., Maisey, M.N. (Eds.) Positron Emission Tomography, 2005.

[2] Muehllehner G et al. Positron emission tomography. 2006 Phys. Med. Biol. 51 R117-R137.

[3] Alessio A, Kinahan P, Cheng P, Vesselle H, Karp J PET/CT scanner instrumentation, challenges, and solutions. Radiologic Clinics of North America, 42 (6): 1017-103.

[4] Dawood M, Buther F, Lang N. Respiratory gating in positron emission tomography: a quantitative comparison of different gating schemes. 2007 Med Phys 34(7): 3067-3076.

[5] Endo M et al. Four-dimensional Computed Tomography (4D) concepts and preliminary development. 2003 Radiation medicine 21(1):17-22.

Time table: Course of 12 hours (2 two-hours lectures per week): Classes on Thursday 2:30 – 4:30 P.M., and Friday, 8:30 – 10:30. First lecture on Thursday, April 3, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: None.

Examination and grading: Grading will be based on a written examination

18 Sampling, Counting, Mixing and Balancing: Advanced Probabilistic Methods in Algorithms

Instructor: Eli Upfal, Computer Science Department, Brown University, e-mail: `eli@cs.brown.edu`

Aim: We'll cover some recent developments in the applications of probabilistic techniques to the design and analysis of algorithms.

Topics:

- Approximate counting and the reduction to approximate sampling.
- The Monte Carlo Markov Chain methods.
- Variation distance and mixing time.
- Coupling of Markov chains.
- Path coupling.
- Coupling from the past.
- The power of two choices paradigm.
- Recent results.

References:

- Mitzenmacher and Upfal. Probability and Computing: Randomized Algorithms and Probabilistic Analysis. Cambridge University Press 2005.
- Recent papers.

Time table: 16 hours. Lectures (2 hours) on Wednesday, 2:30 – 4:30 P.M. First lecture on Wednesday March 5, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Probability and Computing or basic courses in Probability and Algorithms Theory.

Examination and grading: Homework and presentation.

19 Spectral Analysis and the Theory of Moments

Instructor: Prof. Tryphon T. Georgiou, University of Minnesota, Department of Electrical & Computer Engineering, e-mail: `tryphon@umn.edu`

Aim: The goal of this class is, first, to expose the students to certain classical concepts and tools that are being used in time-series analysis, and then, to develop a modern viewpoint that aims in quantifying modeling errors, resolution, and uncertainty. Due to the centrality of time-series analysis to modern science and engineering, the subject remains always timely and an active area of research. The course will conclude with a brief overview of recent trends and research directions.

Topics:

1. Rudiments of the theory of stationary random processes
   - Spectral representations and the geometry of a stochastic process
   - Optimal prediction and Toeplitz forms
   - Partial realizations, orthogonal polynomials and the trigonometric moment problem
   - Smoothing and other topics
2. Generalized moments & inverse problems
   - Positive cones & convex geometry
   - Inverse problems: entropy functionals and parametrization of solutions
   - High resolution analysis and tradeoffs
3. Statistics from data: likelihood & consistency
   - Maximum likelihood, Burg's approach, and model based alternatives
4. Distance metrics between distributions
   - Information geometry and the Fisher information metric
   - Spectral and other metrics, or, how to compare rainbows?
5. Applications
   - Snippets from model identification, sensing, radar, speech, and image processing.

References: The course will be based on recent research publications. Other reference material for the course includes:

[1] Grenander & Szego, Toeplitz Forms and their Applications, Chelsea.

[2] Stoica & Moses, Spectral Analysis of Signals, Prentice Hall.

Time table: Course of 20 hours (2 two-hours lectures per week): Lectures on Tuesday and Friday, 10:30 – 12:30. First lecture on Tuesday May 13, 2008. Last lecture is anticipated on Thursday June 12, 2:30 – 4:30 P.M., instead of Friday June 13. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: It is expected that students have background, or taken basic courses, in linear algebra, probability, and signal and systems. The needed material in these areas will be reviewed briefly and as needed.

Examination and grading: The grade for the class will be based on a set of homework/project assignments (weekly), one midterm quiz (given in class) and a takehome final exam. These will be weighed as follows:
Homework/projects 30%
Quiz 30%
Final 40%

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.

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

Time table: Course of 24 hours. Lectures (two hours) on Monday and Wednesday 10:30 – 12:30. First lecture on Monday, November 10, 2008. The lecture of December 8 (holiday) is rescheduled on December 9, 10:30 – 12:30. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basics of Probability Theory and Linear Algebra.

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

21 Tissue Engineering: Principles and Applications

Instructor: Andrea Bagno, Department of Chemical Process Engineering (DPCI), University of Padova, e-mail: `andrea.bagno@unipd.it`

Aim: The course will provide the basic knowledge of materials and methods for tissue engineering (TE) techniques. The course will also present some practical applications with regard to the production of engineered tissues.

Topics:
1. Fundamentals of TE.
2. Engineering biomaterials for TE.
3. Biomimetic materials.
4. Regeneration templates.
5. TE of biological tissues (cartilage, hearth valves, bone).

References:

[1] B. Palsson, J.A. Hubbel, R. Plonsey, J.D. Bronzino (Eds). Tissue engineering. CRC Press, Boca Raton, 2003.

[2] K.C. Dee, D.A. Puleo, R. Bizios. An introduction to tissue-biomaterials interactions. Wiley, Hoboken, New Jersey, 2002.

[3] J.B. Park, J.D. Bronzino, Biomaterials. CRC Press, Boca Raton, 2003.

Other material and research papers will be available online for download.

Time table: Course of 12 hours (2 two-hours lectures per week): Classes on Monday 10:30 – 12:30 and Friday 2:30 – 4:30 P.M.. First lecture on Monday January 14, 2008. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic courses of chemistry, biology and physiology, biomaterials.

Examination and grading: Homework assignments and final test.

January 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
31	1	2	3	4	5	6
7	8	9	10	11 11:00 Minelli	12	13
14 10:30 Bagno 16:30 Bartolucci	15	16 16:30 Bartolucci	17	18 11:00 Minelli 14:30 Bagno	19	20
21 10:30 Bagno 16:30 Bartolucci	22	23 16:30 Bartolucci	24	25 11:00 Minelli 14:30 Bagno	26	27
28 10:30 Bagno 16:30 Bartolucci	29	30 16:30 Bartolucci	31	1 11:00 Minelli 14:30 Bagno	2	3

February 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
28 10:30 Bagno 16:30 Bartolucci	29	30 16:30 Bartolucci	31	1 11:00 Minelli 14:30 Bagno	2	3
4 10:30 Pupolin	5	6 10:30 Pupolin	7	8 11:00 Minelli 14:30 Vassanelli	9	10
11 10:30 Pupolin	12	13 10:30 Pupolin	14	15 11:00 Minelli 14:30 Vassanelli	16	17
18 10:30 Pupolin	19	20 10:30 Pupolin	21	22 14:30 Vassanelli	23	24
25 10:30 Pupolin	26	27 10:30 Pupolin	28	29 14:30 Vassanelli	1	2

March 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
25 10:30 Pupolin	26	27 10:30 Pupolin	28	29 14:30 Vassanelli	1	2
3	4	5 10:30 Brunetta 14:30 Upfal	6 10:30 Brunetta	7 14:30 Vassanelli	8	9
10	11	12 10:30 Brunetta 14:30 Upfal	13 10:30 Brunetta	14 14:30 Vassanelli	15	16
17	18	19 10:30 Brunetta 14:30 Upfal	20 10:30 Brunetta	21	22	23
24	25	26 14:30 Upfal	27	28	29	30
31	1	2 14:30 Upfal	3 10:30 Narduzzi 14:30 Gilardi	4 08:30 Gilardi	5	6

April 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
31	1	2 14:30 Upfal	3 10:30 Narduzzi 14:30 Gilardi	4 08:30 Gilardi	5	6
7 10:30 Dughiero	8 10:30 Narduzzi	9 14:30 Upfal	10 10:30 Narduzzi 14:30 Gilardi	11 08:30 Gilardi 10:30 Dughiero	12	13
14 10:30 Dughiero	15 10:30 Narduzzi	16 14:30 Upfal	17 10:30 Narduzzi 14:30 Gilardi	18 08:30 Gilardi 10:30 Dughiero	19	20
21 10:30 Dughiero	22 10:30 Narduzzi	23 14:30 Upfal	24 10:30 Narduzzi	25 Holiday	26	27
28 10:30 Dughiero 14:30 Chiuso	29 10:30 Narduzzi	30 14:30 Chiuso	1 Holiday	2	3	4

May 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
28 10:30 Dughiero 14:30 Chiuso	29 10:30 Narduzzi	30 14:30 Chiuso	1 Holiday	2	3	4
5 10:30 Dughiero 14:30 Chiuso	6	7 14:30 Chiuso	8 10:30 Trevisan	9 10:30 Dughiero	10	11
12 10:30 Dughiero 14:30 Chiuso	13 10:30 Georgiou	14 10:30 Dughiero 14:30 Chiuso	15 10:30 Trevisan	16 10:30 Georgiou	17	18
19 14:30 Chiuso	20 10:30 Georgiou	21 14:30 Chiuso	22 10:30 Trevisan	23 10:30 Georgiou	24	25
26 14:30 Chiuso	27 10:30 Georgiou	28 14:30 Chiuso	29 10:30 Trevisan	30 10:30 Georgiou	31	1

June 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
26 14:30 Chiuso	27 10:30 Georgiou	28 14:30 Chiuso	29 10:30 Trevisan	30 10:30 Georgiou	31	1
2 Holiday	3 08:30 Manduchi 10:30 Georgiou 16:30 D'Alessandro	4	5 08:30 Manduchi 10:30 Trevisan	6 10:30 Georgiou	7	8
9 10:30 D'Alessandro	10 08:30 Manduchi 10:30 Georgiou 16:30 D'Alessandro	11	12 08:30 Manduchi 10:30 Trevisan 14:30 Georgiou	13 Holiday	14	15
16 10:30 D'Alessandro	17 08:30 Manduchi 16:30 D'Alessandro	18	19 08:30 Manduchi	20	21	22
23 10:30 D'Alessandro	24 08:30 Manduchi 16:30 D'Alessandro	25	26 08:30 Manduchi	27	28	29
30 10:30 D'Alessandro 14:30 Dellaert	1 16:30 D'Alessandro	2 14:30 Dellaert	3	4	5	6

July 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
30 10:30 D'Alessandro 14:30 Dellaert	1 16:30 D'Alessandro	2 14:30 Dellaert	3	4	5	6
7 14:30 Dellaert	8	9 14:30 Dellaert	10	11	12	13
14 14:30 Dellaert	15	16 14:30 Dellaert	17	18	19	20
21 14:30 Dellaert	22	23 14:30 Dellaert	24	25	26	27
28	29	30	31	1	2	3

August 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

September 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2 10:30 Damm-Karow	3	4 10:30 Damm-Karow	5	6	7
8	9 10:30 Damm-Karow	10 14:30 Sparacino	11 10:30 Damm-Karow	12 14:30 Sparacino	13	14
15	16	17 14:30 Sparacino	18	19 14:30 Sparacino	20	21
22	23 10:30 Damm-Karow	24 14:30 Sparacino	25 10:30 Damm-Karow	26 14:30 Sparacino	27	28
29	30 10:30 Damm-Karow	1	2 10:30 Damm-Karow	3	4	5

October 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
29	30 10:30 Damm-Karow	1	2 10:30 Damm-Karow	3	4	5
6	7 10:30 Ciatti-Pillonetto	8	9 10:30 Ciatti-Pillonetto	10	11	12
13	14 10:30 Ciatti-Pillonetto	15	16 10:30 Ciatti-Pillonetto	17	18	19
20	21 10:30 Ciatti-Pillonetto	22	23 10:30 Ciatti-Pillonetto	24	25	26
27	28 10:30 Ciatti-Pillonetto	29	30 10:30 Ciatti-Pillonetto	31	1 Holiday	2

November 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
27	28 10:30 Ciatti-Pillonetto	29	30 10:30 Ciatti-Pillonetto	31	1 Holiday	2
3 14:30 Meneghesso	4 10:30 Ciatti-Pillonetto	5	6 10:30 Ciatti-Pillonetto	7 10:30 Meneghesso	8	9
10 10:30 Finesso 14:30 Meneghesso	11 10:30 Ciatti-Pillonetto	12 10:30 Finesso	13 10:30 Ciatti-Pillonetto	14 10:30 Meneghesso	15	16
17 10:30 Finesso 14:30 Meneghesso	18 10:30 Ciatti-Pillonetto	19 10:30 Finesso	20 10:30 Ciatti-Pillonetto	21 10:30 Meneghesso	22	23
24 10:30 Finesso 14:30 Meneghesso	25	26 10:30 Finesso	27	28 10:30 Meneghesso	29	30

December 2008

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1 10:30 Finesso 14:30 Meneghesso	2	3 10:30 Finesso	4	5 10:30 Meneghesso	6	7
8 Holiday	9 10:30 Finesso	10 10:30 Finesso	11	12	13	14
15 10:30 Finesso	16	17 10:30 Finesso	18	19	20	21
22	23	24	25	26	27	28
29	30	31	1	2	3	4