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.

Contents

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:

1. *Mathematical Preliminaries.* Mathematical Preliminaries. Lyapunov Stability and Analysis of Nonlinear Interconnection. Normal Forms and Local Design. Robust Semiglobal Stabilization of system in feedback form.

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:

[1] Isidori A., Nonlinear Control System, Springer-Verlag, NewYork, 1994.

[2] Isidori A., Nonlinear Control System II, Springer-Verlag, NewYork, 1999.

[3] H.K. Khalil, Nonlinear Systems, New York: Macmillan, 1992.

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

Topics: Affine varieties, ideals, Zariski Topology. Local rings. Grobner bases, Syzygies and free resolutions. Polytopes, Resultants, Integers programming and splines. Introduction to algebraic coding theory.

References:
D.Cox, J. little, D. O'Shea "Using Algebraic Geometry" , Spinger 2005.

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:

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. Square roots of a positive operator. Projection operators. Spectral measures. Spectral representation of a bounded self-adjoint operator. Extension of the spectral theorem to continuous functions.

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 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.

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.

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:

[1] A. Berman and R. J. Plemmons. *Nonnegative Matrices in the Mathematical Sciences*. Classics in Applied Mathematics. SIAM, 1994.

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

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

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

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

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

[7] P. Lancaster and L. Rodman. *Algebraic Riccati Equations*. Oxford, 1995.

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, ome and visitor location registers.

2. The Physical Layer.

3. Multiple Access Techniques and Interference Avoidance.

4. Bandwidth Conservation.

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

6. System Descriptions and Details: TDMA, CDMA, Associated Control Channels, Power Control, Soft Handoff.

7. Broadband Wireless Networks, Wireless Access to the Internet, and Performance Management.

8. Wireless LANS: IEEE 802.11 and IEEE 802.16.

9. 3G Systems and Beyond.

10. Performance management of Broadband Wireless Networks: Traffic engineering, Admission control and Quality-of-Service guarantees, Call dropping and blocking, Techniques for frequent handoff, Traffic classes, Multimedia traffic and capacity region.

11. Free Space Optical Networks.

12. Wireless Peer-to-Peer Networks: Self-organizing networks, Routing strategies, Energy minimizing approaches, Capacity maximizing approaches.

13. Performance bounds: an information-theoretic approach and a linear programming approach.

14. Cooperative Wireless Networks: MIMO Networks, cooperative base stations, Capacity region bounds, Dirty Paper Coding, Dependent queueing systems, Fixed point approximations.

References:

[1] Detailed Course Handouts.
[2] Research Papers.

Time table: 20 hours. Lectures (2 hours) on Tuesdays and Thrsdays, 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`.

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. Alzheimers disease: 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.

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.

Typical sequences. Strongly typical sets. Asymptotical equipartition properties. Conditionally typical sequences. Markovian Berger Lemma.

Some basic results. Noiseless source Shannon theorem. Noisy Shannon–Berger extension. Random Binning Principle. Random Coding Principle.

Correlated sources. Slepian–Wolf Theorem. Time–sharing concept. Cover's binning approach.

Side information coding. The Wyner–Ahlswede–Körner problem. Wyner–Ziv coding.

Source network coding. A unified theory of network source coding. Open problems.

References:

[1] T.M. Cover and J.A. Thomas, *Elements of Information Theory.* Wiley, 1990.

[2] R.W. Yeung, *A First Course in Information Theory.* Kluwer, 2002.

Time table: 16 hours. Lectures (2 hours) on Wednesdey, 10.30–12.30. First lecture Wednesdey September 19, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

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 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 Cramr-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 Monday and Wednesday, 10:30–12:30 A.M., first lecture on May 7th, 2007. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

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.

Topics: The scalar theory of diffraction. Vector formulation. The Fresnel and Fraunhofer diffraction regions. Example: rectangular apertue. Diffraction from circular aperture: parabolic antenna. Diffraction gratings. Diffraction in free space: Gaussian beams.

References:

[1] C.G. Someda, "Electromagnetic waves", Boca Raton, Florida, CRC Taylor & Francis, 2006.

[2] M. Born, E. Wolf, "Principles of optics" Cambridge, University Press, 1999.

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.

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

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:

[1] J. Lee, "A First Course in Combinatorial Optimization" Cambridge University Press, Cambridge, 2004.

[2] C. Papadimitriou, K. Steiglitz, "Combinatorial Optimization", Prentice Hall, Englewood Cliffs,1982

[3] L. A. Wolsey, "Integer Programming", Wiley Interscience, Chichester, 1998.

[4] Research papers.

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)

   Parametric estimation theory. Cramèr Rao inequality. Examples of unbiased minimum variance estimators. Introduction to asymptotic theory. Asymptotic Distribution. The Central Limit Theorem. The Delta Method. Consistency and asymptotic efficiency. Identifiability. Maximum likelihood (ML) estimator and its asymptotic properties. Approximation properties: ML and Kullback-Leibler divergence minimization. Statistical Simulation. Monte-Carlo methods.

   Parametric Estimators for Linear-Gaussian models. Least squares estimators and multi-stages linear least squares for linear statistical models. SVD, oblique projections, collinearity, ill-conditioning.

2. LINEAR STOCHASTIC MODELS AND STOCHASTIC PROCESSES

   Second order description of stationary stochastic processes. Linear models (State Space, ARX, ARMAX). Stochastic Realization. Stochastic Feedback and causality. Feedback Models. Invariance of the feedback model. Parametric Models, Identifiability. Ergodic 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

   The "subspace" approach. State construction: from stochastic realization to algorithms. Role of the Singular Value decomposition. Main algorithms: CCA, N4SID and MOESP. Main numerical routines: SVD and QSVD. The positivity issue. Discussion of the routines available in the literature. Numerical comparison of different methods on simulated examples. Subspace Identification with feedback. Connections between Subspace Identification and ARX modeling.

5. ASYMPTOTIC STATISTICAL PROPERTIES OF SUBSPACE ESTIMATORS

   Consistency and Asymptotic Normality. Asymptotic variance expressions and their computation. Asymptotic Statistical Efficiency. Improving the estimators.

6. OPEN (RESEARCH) QUESTIONS

   Computer simulations and case studies.

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

[1] T. Söderström, P. Stoica, *System Identification*, Prentice Hall 1989.

[2] L. Ljung *System Identification, Theory for the user* (2^a ed).

[3] A.W. van der Vaart *Asymptotic Statistics*, Cambridge University Press.

[4] T. Ferguson, *A Course in Large Sample Theory*, Chapman and Hall, 1996.

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 (3-rd 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.

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 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.

a) Fundamentals of quantum mechanics and semiconductor physics: Schrödinger equation, Ehrenfest theorem. Wavepackets. Crystals. Electrons in periodic structures. Doping. Scattering mechanisms.

b) Charge transport in semiconductors: Boltzmann transport equation. Momentum method. Hydrodynamic model. Drift-diffusion model. Non-isothermal drift-diffusion model. Velocity-field relations.

c) Numerical device simulation: Technology CAD. Input and output data for device simulation. Discretization of drift-diffusion equations. Boundary conditions. Physical models: bandgap narrowing, incomplete ionization, carrier mobility, generation-recombination effects, deep levels.

References:

[1] M. Lundstrom, "Fundamentals of carrier transport", Modular Series on Solid State Devices vol. X, Addison-Wesley Publ. Company, ISBN 0-201-18436-2, 1992.

[2] K. Hess, "Advanced theory of semiconductor devices", IEEE Press, ISBN 0-7803-3479-5, 2000.

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[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

5. *Probabilistic Graphical Models:* Bayesian networks, D-separation, trees and chains, belief propagation, exact and approximate inference, mixture models, expectation-maximization (EM) learning.

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

References:

[1] Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.

[2] Ian H. Witten and Eibe Frank, *Data Mining: Practical Machine Learning Tools and Techniques*, Second edition, Morgan Kaufmann, June, 2005. This book describes the Weka Toolkit.

[3] Larry A. Wasserman, *All of Statistics: A Concise Course in Statistical Inference*, Springer, 2004.

[4] Richard O. Duda, Peter E. Hart, and David G. Stork, *Pattern Classification*, Second edition, Wiley Interscience, 2000.

[1] http://www.cs.waikato.ac.nz/∼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 phisycal 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 Santagiustina, Università di Padova, e-mail: `marco.santagiustina@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.
3. Parametric, Brillouin and Raman amplification in optical fibers. Nonlinear optical amplifiers design.
4. Software laboratory (2 hrs).

References:

[1] G.P Agrawal, “Nonlinear fiber optics”, San Diego, Academic press, 2001.

[2] C. Headley, G.P. Agrawal, “Raman amplification in fiber optical communication systems”, Amsterdam, Elsevier, 2005.

[3] R. Boyd, “Nonlinear optics”, Amsterdam, Academic press, 2003.

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.

Time table: 20 hours. Lectures (2 hours) on Monday and Wednesday, 10:30–12:30 A.M.. First lecture on Monday, November 19, 2007. 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.

January 2007

Ph.D. Courses: Room DEI/G

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

February 2007

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
29	30 10:30 Harris-1	31	1	2 14:30 Minelli	3	4
5	6 10:30 Harris-1	7	8	9 14:30 Minelli	10	11
12	13 10:30 Harris-1 16:15 Calabri-Chiarel-lotto TORRE ARCHIMEDE BUILDING	14 10:30 Paccagnella	15 16:15 Calabri-Chiarel-lotto TORRE ARCHIMEDE BUILDING	16 10:30 Paccagnella 14:30 Minelli	17	18
19	20 10:30 Harris-1 16:15 Calabri-Chiarel-lotto TORRE ARCHIMEDE BUILDING	21 10:30 Paccagnella	22 16:15 Calabri-Chiarel-lotto TORRE ARCHIMEDE BUILDING	23 10:30 Paccagnella	24	25
26	27 10:30 Harris-1 16:15 Calabri-Chiarel-lotto TORRE ARCHIMEDE BUILDING	28 10:30 Paccagnella	1 16:15 Calabri-Chiarel-lotto TORRE ARCHIMEDE BUILDING	2 10:30 Paccagnella	3	4

March 2007

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
26	27 10:30 Harris–1 16:15 Calabri–Chiarel-lotto TORRE ARCHIMEDE BUILDING	28 10:30 Paccagnella	1 16:15 Calabri–Chiarel-lotto TORRE ARCHIMEDE BUILDING	2 10:30 Paccagnella	3	4
5 10:30 Brunetta	6 10:30 Harris–1 16:15 Calabri–Chiarel-lotto TORRE ARCHIMEDE BUILDING	7 10:30 Paccagnella	8 10:30 Brunetta 16:15 Calabri–Chiarel-lotto TORRE ARCHIMEDE BUILDING	9 10:30 Paccagnella	10	11
12 10:30 Brunetta	13 10:30 Harris–1 16:15 Calabri–Chiarel-lotto TORRE ARCHIMEDE BUILDING	14 10:30 Paccagnella	15 10:30 Brunetta 16:15 Calabri–Chiarel-lotto TORRE ARCHIMEDE BUILDING	16 10:30 Paccagnella	17	18
19 10:30 Brunetta	20	21	22 10:30 Brunetta	23	24	25
26 10:30 Brunetta	27	28 10:30 Dughiero	29 10:30 Brunetta	30 10:30 Dughiero	31	1

April 2007

Ph.D. Courses: Room DEI/G

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

May 2007

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
30 10:30 Acampora 14:30 Marconi	1 Holiday	2 10:30 Dughiero 14:30 Marconi	3 14:30 Acampora 16:30 Chiuso	4 14:30 Nalesso-Someda	5	6
7 10:30 Narduzzi 14:30 Marconi	8 10:30 Harris-2 14:30 Capobianco-St.Giustina 16:30 Chiuso	9 10:30 Narduzzi 14:30 Marconi	10 16:30 Chiuso	11 10:30 Capobianco-St.Giustina 14:30 Nalesso-Someda	12	13
14 10:30 Narduzzi 14:30 Marconi	15 10:30 Harris-2 14:30 Capobianco-St.Giustina 16:30 Chiuso	16 10:30 Narduzzi 14:30 Marconi	17 16:30 Chiuso	18 10:30 Capobianco-St.Giustina 14:30 Nalesso-Someda	19	20
21 10:30 Narduzzi 14:30 Marconi	22 10:30 Harris-2 14:30 Capobianco-St.Giustina 16:30 Chiuso	23 10:30 Narduzzi 14:30 Marconi	24	25 10:30 Capobianco-St.Giustina 14:30 Nalesso-Someda	26	27
28 10:30 Narduzzi	29 10:30 Harris-2 14:30 Capobianco-St.Giustina	30 10:30 Narduzzi	31	1 10:30 Capobianco-St.Giustina 14:30 Nalesso-Someda	2 Holiday	3

June 2007

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
28 10:30 Narduzzi	29 10:30 Harris-2 14:30 Capobianco-St.Giustina	30 10:30 Narduzzi	31	1 10:30 Capobianco-St.Giustina 14:30 Nalesso-Someda	2 Holiday	3
4	5 10:30 Harris-2	6	7	8 14:30 Nalesso-Someda	9	10
11	12 10:30 Harris-2 14:30 Rehg	13 Holiday	14 14:30 Rehg	15	16	17
18	19 14:30 Rehg	20	21 14:30 Rehg	22	23	24
25	26 14:30 Rehg	27	28 14:30 Rehg	29	30	1

July 2007

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
25	26 14:30 Rehg	27	28 14:30 Rehg	29	30	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	1	2	3	4	5

August 2007

Ph.D. Courses: Room DEI/G

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
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	1	2

September 2007

Ph.D. Courses: Room DEI/G

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

October 2007

Ph.D. Courses: Room DEI/G

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

November 2007

Ph.D. Courses: Room DEI/G

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

December 2007

Ph.D. Courses: Room DEI/G

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