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

Course Catalogue

2015

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* one 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 other two courses are *strongly recommended* to all students.

3. After the first year, students are *strongly encouraged* to take courses (possibly outside the present catalogue) for at least 10 credits (or equivalent) 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 Advanced Topics in Computational Biology

Instructor: Fabio Vandin, e-mail: `vandinfa@cs.brown.edu`

Aim: To provide the students with an understanding of the computational problems that arise in selected areas of computational biology, and of the state-of-the-art methods to solve such problems. The course focuses on problems that arise in the analysis of high-throughput biological datasets.

Topics:

- Mutation Detection from Sequencing Data: sequencing technologies, the mutation detection problem, algorithms for mutations detection;
- Mutations and Diseases: finding single mutations associated with diseases; interaction networks and groups of mutations associated with diseases; *de novo* discovery of groups of mutations associated with diseases;
- Genetic Heterogeneity: genetic heterogeneity in populations and diseases; genetic heterogeneity and sequencing technologies; detecting genetic heterogeneity from sequencing data; reconstructing the evolution of cancer genomes;
- Inferring Haplotypes from Sequencing Data: inferring haplotype frequencies in populations; haplotype assembly from sequencing data.

References: The following articles provide basic background material:

[1] L. Ding, M. C. Wendl, J. F. McMichael, and B. J. Raphael. Expanding the computational toolbox for mining cancer genomes. *Nat. Rev. Genet.*, 15(8):556–70, 2014.

[2] M. Meyerson, S. Gabriel, and G. Getz. Advances in understanding cancer genomes through second-generation sequencing. *Nat. Rev. Genet.*, 11(10):685–96, 2010.

[3] R. Schwartz. Theory and algorithms for the haplotype assembly problem. *Communications in Information & Systems*, 10(1):23–38, 2010.

[4] W. W. Soon, M. Hariharan, and M. P. Snyder. High-throughput sequencing for biology and medicine. *Mol. Syst. Biol.*, 9:640, 2013.

Additional research articles for the specific topics will be made available on the course website.

Time table: Course of 20 hours (2 lectures per week, 2 hours per lecture). Class meets every Tuesday and Thursday from 2:30pm to 4:30pm. First lecture on Tuesday, October 6, 2015. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: basic knowledge of algorithms; basic knowledge of probability. (No biology background is assumed; necessary background will be introduced in lectures and reading.)

Examination and grading: Each student is required i) to present and lead the discussion of one or more research paper in class, and ii) to submit short reviews of the papers before they are presented and discussed in class. The grade is based on i) participation in class, ii) paper presentations, and iii) paper reviews.

2 Applied Functional Analysis

Instructor: 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, operator theory in Hilbert spaces, regularization theory and inverse problems.

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. *Banach and Hilbert 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. Inner product spaces and Hilbert spaces. Orthogonal complements and direct sums. Orthonormal sets and sequences. Representation of functionals on Hilbert spaces. Hilbert adjoint operator. Self-adjoint operators, unitary operators.
3. *Compact linear operators on normed spaces and their spectrum*: Spectral properties of bounded linear operators. Compact linear operators on normed spaces. Spectral properties of compact linear operators. Spectral properties of bounded self-adjoint operators, positive operators, operators defined by a kernel. Mercer Kernels and Mercer's theorem.
4. *Reproducing kernel Hilbert spaces, inverse problems and regularization theory*: Reproducing Kernel Hilbert Spaces (RKHS): definition and basic properties. Examples of RKHS. Function estimation problems in RKHS. Tikhonov regularization. Basic concepts of convex analysis. Primal and dual formulation of loss functions. Regularization networks. Support vector regression and classification. Support vector classification. Representer theorem.

Course requirements:

1. The classical theory of functions of real variable: limits and continuity, differentiation and Riemann integration, infinite series and uniform convergence.
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.

References:

[1] W. Rudin. Real and Complex Analysis, McGraw Hill, 2006
[2] E. Kreyszig. Introductory Functional Analysis with Applications, John Wiley and Sons , 1978
[3] G. Wahba. Spline models for observational data. SIAM, 1990
[4] C.E. Rasmussen and C.K.I. Williams. Gaussian Processes for Machine Learning. The MIT Press, 2006
[5] R.T. Rockafellar. Convex analysis. Princeton University Press, 1996

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 September 22nd, 2015. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Examination and grading: Homework assignments and final test.

3 Applied Linear Algebra

Instructor: Giorgio Picci, University of Padova, Italy e-mail: `picci@dei.unipd.it`

Aim: We study concepts and techniques of linear algebra that are important for applications with a special emphasis on linear Least Squares problems, their numerical treatment and their statistical interpretation. A wide range of exercises and problems will be an essential part of the course and constitute homework required to the student.

Topics:

1. Review of some basic concepts of L.A. and matrix theory
2. Deterministic Least Squares and the projection theorem
3. Statistical Least squares
4. Numerical treatment of Least Squares problems and regularization techniques

References:

[1] Gilbert Strang's linear algebra lectures, from M.I.T. on You Tube

[2] Notes from the instructor

Time table: Course of 20 hours. Class meets every Tuesday and Thursday, 10:30 – 12:30. First lecture on Tuesday, March 3-rd, 2015. 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 for example in [1]. Some proficiency in MATLAB.

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

4 Applied Machine Learning in Biomedicine

Instructor: Enrico Grisan, e-mail: `enrico.grisan@dei.unipd.it`

Aim: The course will introduce advanced topics in machine learning and pattern recognition and how they apply to real world problems. In this course we will present the mathematical background of some classification/regression tools, and show the pros and cons of their application to biomedical problems with extensive case studies.

Topics:

- Introduction to classical machine learning problems.
- Linear models for classification.
- Neural Networks
- Kernel methods and Support Vector Machine
- Sparse coding (if time allows)

References:

[1] Christopher M. Bishop, Pattern Recognition and Machine Learning (Information Science and Statistics), Springer 2007

[2] Kevin P. Murphy, Machine Learning - A probabilistic Perspective, MIT Press 2012

Time table: Course of 16 hours. Class meets every Monday and Wednesday from 10:30 to 12:30. First lecture on Monday, May 4th, 2015. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: Basics of probability theory. Basics of Matlab programming. The course "Bayesian Machine Learning" is suggested.

Examination and grading: Homework assignments and final project.

5 Bayesian Machine Learning

Instructor: Giorgio Maria Di Nunzio, e-mail: `dinunzio@dei.unipd.it`

Aim: The course will introduce fundamantal topics in Bayesian reasoning and how they apply to machine learning problems. In this course we will present pros and cons of Bayesian approaches and we will develop a graphical tool to analyse the assumptions of Bayesian approaches in practical problems.

Topics:

- Introduction of classical machine learning problems.
  - Mathematical framework
  - Supervised and unsupervised learning
- Bayesian decision theory
  - Two-category classification
  - Minimum-error-rate classification
  - Bayes risk
  - Decision surfaces
- Estimation
  - Maximum Likelihood Estimation
  - Bayesian estimation
- Graphical models
  - Bayesian networks
  - Two-dimensional probabilistic model
- Evaluation
  - Measures of accuracy
  - Statistical significance testing

References:

[1] J. Kruschke, *Doing Bayesian Data Analysis: A Tutorial Introduction With R and Bugs*, Academic Press 2010

[2] Christopher M. Bishop, *Pattern Recognition and Machine Learning (Information Science and Statistics)*, Springer 2007

[3] Richard O. Duda, Peter E. Hart, David G. Stork, *Pattern Classification (2nd Edition)*, Wiley-Interscienec, 2000

Time table: Course of 20 hours. Class meets every Tuesday and Thursday from 10:30 to 12:30. First lecture on Tuesday, 11th November, 2014. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: Basics of Probability Theory. Basics of R Programming.

Examination and grading: Homework assignments and final project.

6 Computational Inverse Problems

Instructor: Fabio Marcuzzi, Dept. of Mathematics, University of Padova e-mail: `marcuzzi@math.unipd.it`

Aim: We study numerical methods that are of fundamental importance in computational inverse problems. Real application examples will be given for distributed parameter systems. Computer implementation performance issues will be considered also.

Topics:

- definition of inverse problems, basic examples and numerical difficulties.
- numerical methods for QR and SVD and their application to the square-root implementation in PCA, least-squares, model reduction and Kalman filtering; recursive least-squares;
- regularization methods;
- numerical algorithms for nonlinear parameter estimation: Gauss-Newton, Levenberg-Marquardt, back-propagation (neural networks), adjoint model (VDA);
- examples with distributed parameter systems;
- HPC implementations and parallel implementations on GPUs;

References:

[1] F.Marcuzzi "Analisi dei dati mediante modelli matematici", http://www.math.unipd.it/~marcuzzi/MNAD.html

[2] CUDA programming guide, http://docs.nvidia.com/cuda/index.html

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 23th, 2015. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements:

- basic notions of linear algebra and, possibly, numerical linear algebra.
- the examples and homework will be in Python (the transition from Matlab to Python is effortless).

Examination and grading: Homework assignments and final test.

7 Digital Processing of Measurement Information

Instructor: prof. Claudio Narduzzi – Department of Information Engineering, University of Padua
e-mail: `claudio.narduzzi@unipd.it`

Aim: provide tools and methods for advanced analysis and accuracy assessment of measurement information obtained from experimental data.

Topics:

- uncertainty, quantisation and the additive noise stochastic model: a reappraisal
- characterisation of digitisers and data acquisition systems
- signal processing algorithms in measurement: statistical properties of discrete Fourier transform-based spectral estimators, least squares regression and the Cramer-Rao bound
- compensation of measurement system dynamics: dealing with inverse problems and ill-posedness
- an application of multi-resolution analysis in measurement - characterization of clock stability
- model-based measurement and compressive sensing
- evaluation of uncertainty in measurement: the probability-based approach and its recent developments

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

Time table: Course of 16 hours.

Class meets every Tuesday and Friday from 10:30 to 12:30. First lecture on Friday, April 10th, 2015. Meeting Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: no specific requirement.

Examination and grading: presentation of report on pre-assigned argument.

8 Fluid mechanics for the functional assessment of cardiovascular devices

Instructor: Francesca Maria Susin, Dept. ICEA, University of Padua,
e-mail: `francescamaria.susin@unipd.it`

Aim: The course is intended to give a survey of research approaches for the assessment of cardiovascular medical devices. Emphasis will be given to methods and techniques adopted for in vitro analysis of hemodynamic performance of prosthetic heart valves and total artificial heart.

Topics: Review of basic fluid mechanics concepts. Fluid mechanics of prosthetic heart valves (PHVs) and ventricular assist devices (VADs). Pulse duplicators for in vitro testing of PHVs and mock circulation loops for pre-clinical evaluation of VADs. Experimental techniques for the assessment of PHVs and VADs performance. CFD for functional assessment of PHVs and VADs.

References:

[1] M. Grigioni, C. Daniele, G. D'Avenio, U. Morbiducci, C. Del Gaudio, M. Abbate and D. Di Meo. Innovative technologies for the assessment of cardiovascular medical devices: state of the art techniques for artificial heart valve testing. *Expert Rev. Medical Devices*, 1(1) : 81-93, 2004.

[2] K.B. Chandran, A.P. Yoganathan and S.E. Rittgers. Biofluid Mechanics: the uman circulation. CRC Press, Boca Raton, FL, 2007.

[3] A.P. Yoganathan, K.B. Chandran and F. Sotiropoulos. Flow in prosthetic heart valves: state of the heart and future directions. *Annals of Biomedical Engineering*, 33(12) : 1689-1694, 2005.

[4] A.P. Yoganathan, Z. He and S. Casey Jones. Fluid mechanics of heart valves.

[5] A.P. Yoganathan and F. Sotiropoulos. Using computational fluid dynamics to examine the hemodynamics of artificial heart valves. *Business briefing: US cardiology 2004*: 1-5, 2004.

[6] V. Barbaro, C. Daniele and M. Grigioni. Descrizione di un sistema a flusso pulsatile per la valutazione delle protesi valvolari cardiache. ISTISAN Report 91/7, Rome, Italy, 1991 (in Italian).

[7] M. Grigioni, C. Daniele, C. Romanelli and V. Barbaro. Banco di prova per la caratterizzazione di dispositivi di assistenza meccanica al circolo. ISTISAN Report 03/21, Rome, Italy, 2003 (in Italian).

[8] M.J. Slepian, Y. Alemu, J.S. Soares. R.G. Smith, S. Einav and D. Bluestein. The Syncardia total artificial heart: in vivo, in vitro, and computational modeling studies. *Journal of Biomechanics*,46 (2013): 266-27, 2013.

Time table: Course of 16 hours. Lectures (2 hours) on Wednesday 4:00 – 6:00 PM, starting on Wednesday, November 5, 2014 and ending on Wednesday, December 17, 2014; plus the last

"Laboratory" lesson on Friday December 19, 2014. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: Fundamentals of Fluid Dynamics.

Examination and grading: Homework assignment with final discussion.

9 Information theoretic Methods in Security

Instructor: Nicola Laurenti, Department of Information Engineering, Univ. of Padova, e-mail: nil@dei.unipd.it

Aim: To provide the students with an information theoretic framework that will allow formal modeling, and understanding fundamental performance limits, in several security-related problems

Topics: Topics will be chosen, according to the students' interests from the following list:
Measuring information. Review of basic notions and results in information theory: entropy, equivocation, mutual information, channel capacity.

The Holy Grail of perfect secrecy. Shannon's cipher system. Perfect secrecy. Ideal secrecy. Practical secrecy. The guessing attack.

Secrecy without cryptography. The wiretap channel model. Rate-equivocation pairs. Secrecy capacity for binary, Gaussian and fading channel models.

Security from uncertainty. Secret key agreement from common randomness on noisy channels. Information theoretic models and performance limits of quantum cryptography.

A different approach. Secrecy capacity from channel resolvability. Secret-key capacity from channel intrinsic randomness.

The gossip game. Broadcast and secrecy models in multiple access channels. The role of trusted and untrusted relays.

Secrets in a crowd. Information theoretic secrecy in a random network with random eavesdroppers. Secrecy graphs and large networks secrecy rates.

A cipher for free? Information theoretic security of random network coding.

Who's who? An information theoretic model for authentication in noisy channels. Signatures and fingerprinting.

Writing in sympathetic ink. Information theoretic models of steganography, watermarking and other information hiding techniques.

The jamming game. Optimal strategies for transmitters, receivers and jammers in Gaussian, fading and MIMO channels.

Leaky buckets and pipes. Information leaking and covert channels. Timing channels.

The dining cryptographers. Privacy and anonymity. Secure multiparty computation.

Information theoretic democracy. Privacy, reliability and verifiability in electronic voting systems.

Alea iacta est. Secure and true random number generation. Randomness extractors and smooth guessing entropy.

The Big Brother. An information theoretic formulation of database security: the privacy vs utility tradeoff.

References:

[1] Y. Liang, H.V. Poor, and S. Shamai (Shitz), *Information Theoretic Security,* Now, 2007.

[2] M. Bloch, J. Barros, *Physical-Layer Security: from Information Theory to Security Engineering* Cambridge University Press, 2011.

A short list of reference papers for each lecture will be provided during class meetings.

Time table: Course of 20 hours (two lectures of two hours each per week). Class meets every Tuesday and Friday from 2:30 to 4:30, starting on Tuesday, November 11-th, 2014. Meeting Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic notions of Information Theory.

Examination and grading: Each student must submit a project, and grading will be based on its evaluation. I encourage students to work from an information theoretic point of view on a security problem related to their research activities.

10 Introduction to Quantum Optics, Quantum Information and Quantum Communications

Instructors: Paolo Villoresi, e-mail: `paolo.villoresi@unipd.it`
Giuseppe Vallone, email: `vallone@dei.unipd.it`

Aim: The Course is intended to provide the basic concepts of Quantum Information and Quantum Communications. It will start with review of the underlying concepts of quantum physics. It will be followed by the discussion of entanglement, quantum interference, quantum computation, and quantum communication. Specifics of practical implementation of quantum bits and quantum logic gates in different physical environments will be considered. Existing problems of experimental implementation associated with detrimental effects of decoherence will be discussed. The second part of this course is intended to provide the overview of novel technological approaches based on the use of quantum correlations and quantum entanglement. Specifics of optical implementation of qubits and linear-optical quantum gates will be discussed. This course will review specific concepts of quantum-optical state engineering and design of non-traditional quantum measurement devices that outperform their classical counterparts. Several such novel approaches as quantum imaging, super-resolution quantum phase measurement, dispersion cancelation, and correlated imaging and microscopy will be discussed.

The Course is the organized within the research group *QuantumFuture*
web: quantumfuture.dei.unipd.it.

Topics:

1. Review of Quantum Mechanics;
2. quantization of EM field;
3. statistics of radiation;
4. entanglement: definition and measure;
5. quantum interferometry;
6. principles of quantum computation and quantum key distribution.
7. Generation and tomography of entangled states;
8. linear-optical quantum state engineering;
9. teleportation and entanglement swapping
10. integrated quantum optics: example of quantum algorithm
11. Propagation of single photon beam along long channels and toward the Space.
12. Quantum Communications in Space.

References:

C. Gerry, P. Knight, “Introductory Quantum Optics”, (Cambridge 2005)

Vlatko Vedral “Introduction to Quantum Information Science” (Cambridge 2006)

Additional reading:

M. A. Nielsen and I. L. Chuang “Quantum Computation and Quantum Information” (Cambridge 2010)

A. V. Sergienko ed. “Quantum Communications and Cryptography”, (CRC Press, Taylor & Francis Group 2006).

Time table: Course of 20 hours. Class meets every Tuesday and Friday from 2:30 to 4:30. First lecture on Tuesday, March 10, 2015. Meeting Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: Basic concept of Quantum Physics.

Examination and grading: Homeworks on selected topics.

11 Mathematical modeling of cell Biology

Instructor: Morten Gram Pedersen, Department of Information Engineering, University of Padova, e-mail: `pedersen@dei.unipd.it`

Aim: The aim of this course is to provide an introduction to commonly used mathematical models of cellular biology. At the end of the course, the students should be able to build models of biological processes within the cell, to simulate and analyze them, and to relate the results back to biology. The focus will be on electrical activity and calcium dynamics in neurons and hormone-secreting cells, but will also discuss models of other cellular processes occurring in other cell types.

Topics: Biochemical reactions; Ion channels, excitability and electrical activity; Calcium dynamics; Intercellular communication; Spatial and stochastic phenomena (if time allows); Contractions in muscles; Circadian rhythms; Qualitative analysis of nonlinear differential equations.

References: The following books will provide the core material, which will be supplemented by research articles:

1. C.P. Fall, E.S. Marland, J.M. Wagner, J.J. Tyson. *Computational Cell Biology.* Springer, NY, USA (2002).
2. J. Keener, J. Sneyd: *Mathematical Physiology.* Springer, NY, USA (2004).

Time table: Course of 20 hours (2 two-hours lectures per week). Class meets every Monday and Wednesday from 10:30 to 12:30. First lecture on Tuesday, October 5, 2015. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: Basic courses of linear algebra and ODEs. Basic experience with computer programming. Knowledge of cellular biology is not required.

Examination and grading: Final project.

12 Physics and operation of heterostructure-based electronic and optoelectronic devices

Instructors: G. Meneghesso, E. Zanoni, M. Meneghini, F.A. Marino, Dept. Ingegneria dellInformazione (DEI), University of Padova, e-mail: `gauss@dei.unipd.it, zanoni@dei.unipd.it`

Aim: this course provides an introduction to the physics and operating principles of advanced electronic and optoelectronic devices based on compound semiconductors. These devices are particularly important for several applications: high electron mobility transistors (HEMTs) represent excellent devices for the realization of high frequency communication systems, radars, satellite applications, and high efficiency power converters. On the other hand, LEDs and lasers are high-efficiency monochromatic light sources, that can be used both for lighting applications (with a considerable energy saving), in the biomedical field, and in in photochemistry.

To understand the capabilities of this technology, and to be able to design advanced systems based on LEDs, lasers and HEMTs, it is important to study the physics and the operating principles of these devices. This course will focus on the main aspects related to the physics of heterostructures, on the recombination processes in semiconductors, on carrier transport in heterostructures, on the structure and operating principles of MESFET, HEMTs, GITs, on the trapping and reliability in compound semiconductor devices, on the operating principles of LEDs and lasers, and on parasitics and reliability in LEDs and lasers

Topics:

1. physics of heterostructures, band diagrams, carrier transport in heterostructures;

2. recombination processes in semiconductors;

3. properties of compound semiconductors;

4. basic structure of heterojunction transistors, MESFET, HEMT, GIT;

5. trapping, parasitics and reliability in heterojunction based transistors;

6. operating principles of LEDs and lasers;

7. parasitics and reliability in LEDs and lasers;

8. methods for advanced characterization of heterojunction based devices;

References:

[**1**] Umesh Mishra, Jasprit Singh, Semiconductor Device Physics and Design, Springer, 2008
[**2**] Ruediguer Quay, Gallium Nitride Electronics, Springer 2008.
[**3**]Tae-Yeon Seong, Jung Han, Hiroshi Amano, Hadis Morko, III-Nitride Based Light Emitting Diodes and Applications, Springer 2013.

Time table: Course of 20 hours (2 two-hours lectures per week): Classes on Monday and Thursday 2:30 – 4:30. First lecture on Monday January 19, 2015. Room DEI/G, 3-rd floor, Dept. of Information Engineering, via Gradenigo Building.

Course requirements: Introductory course of device physics: Microelectronics, Optoelectronic and Photovoltaic Devices

Examination and grading: Written test at the end of the course

13 Real-Time Systems and applications

Instructor: Gabriele Manduchi, Consiglio Nazionale delle Ricerche
e-mail: `gabriele.manduchi@igi.cnr.it`

Aim: The course will provide an insight in the realm of real-time system. Knowledge in this field is normally fragmented and scattered among different engineering disciplines and computing sciences, and the the aim of the course is present aspects related to theory and practice in a way which is holistic enough to prepare graduates to embark on the development of real-time systems, frequently complex and imposing safety requirements. For this reason, after presenting in the first part of the course a surveys of related topics, including scheduling theory and real-time issues in operating systems, the control system of a Nuclear Fusion experiment will be presented as Use Case and analyzed in the second part of the course.

Topics:

- Concurrent Programming Concepts: the role of parallelism and multithreading, deadlocks, interprocess communication, network communication.
- Real-time scheduling analysis:task-based scheduling, schedulability analysis based on utilization, schedulability analysis based on response time analysis, task interaction and blocking.
- Internal structures and operating principles of Linux real-time extensions.
- Data Acquisition systems: general concepts and architectures.
- An introduction of massive parallel operation in real-time applications using GPUs.
- Analysis of a real-time control system for nuclear fusion experiment.

References:

[1] I C Bertolotti, G Manduchi. Real-Time Embedded Systems. Open Source Operating Systems Perspective. CRC Press, 2012

[2] G C Buttazzo. Hard Real-Time Computing Systems. Predictable Scheduling Algorithms and Applications. Springer 2005.

Time table: Course of 20 hours. Class meets every Tuesday and Thursday from 8:30 to 10:30. First lecture on Tuesday, January 20, 2015. Room DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Course requirements: Basic knowledge of Operating System concepts.

Examination and grading: Each student will develop a case study, possibly related to his/her own research activity, addressing some topic presented in the course.

14 Resonant converters and inverters: topologies and modeling

Instructor: Giorgio Spiazzi, e-mail: `spiazzi@dei.unipd.it`

Aim: the increased demand for more efficient and compact power supplies for a variety of applications together with the availability of faster switching devices, has pushed the switching frequency of modern power supply from tens of kilohertz toward the megaherz range. At such frequency values, the corresponding switching losses become unacceptable and soft-commutations become mandatory. In this contest, resonant converter and inverter topologies have been rediscovered as valid alternative to classical PWM topologies. The aim of this course is to provide basic knowledge of resonant converter topologies, their operation as well as their modeling and control, together with suggestions on the best design procedures for different applications.

Topics:

1. Switching losses in Pulse Width Modulated converters.
2. Basic dc-dc resonant converter topologies.
   - state-plane analysis;
   - fundamental component analysis.
3. LLC resonant converter.
4. Bidirectional resonant converters (Dual Active Bridge).
5. LCC resonant inverter for fluorescent lamps.
6. Modeling of resonant converters and inverters.

References:

[1] lecture notes and written material on specific topics

Time table: Course of 20 hours. Class meets every Tuesday and Fryday from 10:30 to 12:30. First lecture on Tuesday, June 4^{rd}, 2015. Meeting room DEI/G, 3^{rd} floor, Dept. of Information Engineering (via Gradenigo building).

Course requirements: basic knowledge of Power Electronics.

Examination and grading: homework and final examination.

15 Statistical Methods

Instructor: Lorenzo Finesso, Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni, IEIIT-CNR, Padova, e-mail: `lorenzo.finesso@unipd.it`

Aim: The course will present a small selection of linear statistical techniques which are widespread 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 of a probability measure and informational divergence (Kullback-Leibler distance) between two probability measures.

Divergence minimization problems. Three divergence minimization problems will be posed and, on simple examples, they will be connected with basic methods of statistical inference: ML (maximum likelihood), ME (maximum entropy), and EM (expectation-maximization). We will solve some instances of the ME problem to show the interplay between linear and exponential families of probability measures.

Multivariate analysis methods. Linear regression analysis: OLS ordinary least squares and related methods: GLS (generalized least squares), TLS (total least squares). Connection with ML under Gaussian assumptions and the Gauss Markov theorem. PCA (principal component analysis) for empirical data and random vectors: position of the problem, derivation of the solution, geometrical interpretation. Applications of PCA to least squares: PCR (principal component regression) and PLS (partial least squares). Approximate matrix factorization and PCA, with a brief detour on the approximate Nonnegative Matrix Factorization (NMF) problem. Canonical Correlations (CC): position of the problem and derivation of the solution. Factor Analysis: position of the problem. For most of these methods there is a natural interpretation in terms of divergence minimization which will be reviewed.

EM methods. The Expectation-Maximization method will be introduced as an algorithm for the computation of the Maximum Likelihood (ML) estimator with partial observations (incomplete data) and interpreted as an alternating divergence minimization algorithm *à la* Csiszár Tusnády.

Hidden Markov models. We will introduce the simple yet powerful class of HMM (hidden Markov models) and discuss parameter estimation for HMMs via the EM method.

References: A set of lecture notes and a list of references will be posted on the web site of the course.

Time table: Course of 24 hours (two lectures of two hours each per week). Class meets every Monday and Wednesday from 2:30 to 4:30, starting on Monday, April 20-th, 2015. Meeting 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.

16 The FFT and its use in digital signal processing

Instructor: Prof. S. Pupolin, Dept. Information Engineering, University of Padova,
e-mail: `pupolin@dei.unipd.it`

Aim: The course is intended to give a survey of the basic aspects of signal domains and the effects in digital signal processing in terms of signal distortion.

Topics:

1. Review of some notions on Fourier Transform in different time domains (continuous and discrete; aperiodic and periodic). The FFT.
2. Definitions and properties of signal energy, convolution, correlation in the time domains and their Fourier transforms
3. Signal transformations. Linear transformations. Elementary transformations: sampling and interpolation. Up- and Down-Periodization
4. Numerical computation of the Fourier transform of a continuous-time finite energy signal via FFT
5. Numerical computation of the convolution (correlation) of two continuous-time finite energy signals via FFT.
6. Bandlimited continuous time signal filtering: from analog filters to a mix of analog and digital filters.
7. Example of applications: OFDM modulation and cyclic prefix.
8. Estimate of power spectrum for finite power signals. From definitions to numerical computation.

Course requirements:
Basic knowledge of signals and systems.

References:
All the necessary material can be found in G. Cariolaro book: "Unified Signal Theory", (Springer-Verlag, London 2011).

Time table: Course of 20 hours (2 two-hours lectures per week): Classes on Monday 2:30 – 4:30 and Wednesday, 10:30 – 12:30. First lecture on November 10-th, 2014. There will be no lecture on November 19-th and 26-th. Room 318 DEI/G (3-rd floor, Dept. of Information Engineering, via Gradenigo Building).

Examination and grading: Homeworks and final exam.

17 Tissue Engineering: Principles and Applications

Instructor: Andrea Bagno, Department of Industrial Engineering, 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 16 hours (2 two-hours lectures per week). Classes on Monday and Wednesday, 10:30 – 12:30. First lecture on January 26, 2015. Meeting 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.

November 2014

October 2014						
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November 2014						
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December 2014						
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- Ph.D. Courses: Room DEI/G
- Festività italiane

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
27	28	29	30	31	1 Ognissanti	2
3	4	5 16:00 Prof. Susin	6	7	8	9
10 14:30 Pupolin	11 10:30 Di Nunzio 14:30 Laurenti	12 10:30 Pupolin 16:00 Prof. Susin	13 10:30 Di Nunzio	14 14:30 Laurenti	15	16
17 14:30 Pupolin	18 10:30 Di Nunzio 14:30 Laurenti	19 16:00 Prof. Susin	20 10:30 Di Nunzio	21 14:30 Laurenti	22	23
24 14:30 Pupolin	25 10:30 Di Nunzio 14:30 Laurenti	26 16:00 Prof. Susin	27 10:30 Di Nunzio	28 14:30 Laurenti	29	30

December 2014

November 2014						
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December 2014						
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January 2015						
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Ph.D. Courses: Room DEI/G
Festività italiane

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1 14:30 Pupolin	2 10:30 Di Nunzio 14:30 Laurenti	3 10:30 Pupolin 16:00 Prof. Susin	4 10:30 Di Nunzio	5 14:30 Laurenti	6	7
8 Immacolata Concezione	9 10:30 Di Nunzio 14:30 Laurenti	10 10:30 Pupolin 16:00 Prof. Susin	11 10:30 Di Nunzio	12 14:30 Laurenti	13	14
15 14:30 Pupolin	16	17 16:00 Prof. Susin	18	19 10:30 Prof. Susin	20	21
22	23	24	25 Natale	26 Santo Stefano	27	28
29	30	31	1 Primo dell'anno	2	3	4

January 2015

December 2014						
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January 2015						
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February 2015						
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- Ph.D. Courses: Room DEI/G
- Festività italiane

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
29	30	31	1 Primo dell'anno	2	3	4
5	6 Epifania	7	8	9	10	11
12	13	14	15	16	17	18
19 14:30 Prof. Meneghesso	20 08:30 Prof. Manduchi	21	22 08:30 Prof. Manduchi 14:30 Prof. Meneghesso	23	24	25
26 10:30 Prof. Bagno 14:30 Prof. Meneghesso	27 08:30 Prof. Manduchi	28 10:30 Prof. Bagno	29 08:30 Prof. Manduchi 14:30 Prof. Meneghesso	30	31	1

February 2015

January 2015

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February 2015

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March 2015

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- Ph.D. Courses: Room DEI/G
- Festività italiane

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
26 10:30 Prof. Bagno 14:30 Prof. Meneghesso	27 08:30 Prof. Manduchi	28 10:30 Prof. Bagno	29 08:30 Prof. Manduchi 14:30 Prof. Meneghesso	30	31	1
2 10:30 Prof. Bagno 14:30 Prof. Meneghesso	3 08:30 Prof. Manduchi	4 10:30 Prof. Bagno	5 08:30 Prof. Manduchi 14:30 Prof. Meneghesso	6	7	8
9 10:30 Prof. Bagno 14:30 Prof. Meneghesso	10 08:30 Prof. Manduchi	11 10:30 Prof. Bagno	12 08:30 Prof. Manduchi 14:30 Prof. Meneghesso	13	14	15
16 10:30 Prof. Bagno 14:30 Prof. Meneghesso	17 08:30 Prof. Manduchi	18 10:30 Prof. Bagno	19 08:30 Prof. Manduchi 14:30 Prof. Meneghesso	20	21	22
23 10:30 Prof. Marcuzzi	24	25 10:30 Prof. Marcuzzi	26	27	28	1

March 2015

February 2015

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March 2015

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April 2015

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Ph.D. Courses: Room DEI/G
Festività italiane

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
23 10:30 Prof. Marcuzzi	24	25 10:30 Prof. Marcuzzi	26	27	28	1
2 10:30 Prof. Marcuzzi	3 10:30 Prof. Picci	4 10:30 Prof. Marcuzzi	5 10:30 Prof. Picci	6	7	8
9 10:30 Prof. Marcuzzi	10 10:30 Prof. Picci 14:30 Proff. Vallone and Vil-loresi	11 10:30 Prof. Marcuzzi	12 10:30 Prof. Picci	13 14:30 Proff. Vallone and Vil-loresi	14	15
16 10:30 Prof. Marcuzzi	17 10:30 Prof. Picci 14:30 Proff. Vallone and Vil-loresi	18 10:30 Prof. Marcuzzi	19 10:30 Prof. Picci	20 14:30 Proff. Vallone and Vil-loresi	21	22
23	24 10:30 Prof. Picci 14:30 Proff. Vallone and Vil-loresi	25	26 10:30 Prof. Picci	27 14:30 Proff. Vallone and Vil-loresi	28	29
30	31 10:30 Prof. Picci 14:30 Proff. Vallone and Vil-loresi	1	2 10:30 Prof. Picci	3	4	5 Pasqua

April 2015

March 2015						
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April 2015						
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- Ph.D. Courses: Room DEI/G
- Festività italiane

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
30	31 10:30 Prof. Picci 14:30 Proff. Vallone and Vil-loresi	1	2 10:30 Prof. Picci	3	4	5 Pasqua
6 Lunedì dell'Angelo	7	8	9	10 10:30 Prof. Narduzzi 14:30 Proff. Vallone and Vil-loresi	11	12
13	14 10:30 Prof. Narduzzi 14:30 Proff. Vallone and Vil-loresi	15	16	17 10:30 Prof. Narduzzi 14:30 Proff. Vallone and Vil-loresi	18	19
20 14:30 Prof. Finesso	21 10:30 Prof. Narduzzi	22 14:30 Prof. Finesso	23	24 10:30 Prof. Narduzzi	25 Festa della Liberazione	26
27 14:30 Prof. Finesso	28 10:30 Prof. Narduzzi	29 14:30 Prof. Finesso	30	1 Festa del lavoro	2	3

May 2015

April 2015

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May 2015

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June 2015

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Ph.D. Courses: Room DEI/G
Festività italiane

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
27 14:30 Prof. Finesso	28 10:30 Prof. Narduzzi	29 14:30 Prof. Finesso	30	1 Festa del lavoro	2	3
4 10:30 Prof. Grisan 14:30 Prof. Finesso	5 10:30 Prof. Narduzzi	6 10:30 Prof. Grisan 14:30 Prof. Finesso	7	8 10:30 Prof. Narduzzi	9	10
11 10:30 Prof. Grisan 14:30 Prof. Finesso	12	13 10:30 Prof. Grisan 14:30 Prof. Finesso	14	15	16	17
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June 2015

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Ph.D. Courses: Room DEI/G
Festività italiane

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2 Festa della Repubblica	3	4 10:30 Prof. Spiazzi	5 10:30 Prof. Spiazzi	6	7
8	9	10	11 10:30 Prof. Spiazzi	12 10:30 Prof. Spiazzi	13	14
15	16	17	18 10:30 Prof. Spiazzi	19 10:30 Prof. Spiazzi	20	21
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July 2015

June 2015						
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- Ph.D. Courses: Room DEI/G
- Festività italiane

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29	30	1	2 10:30 Prof. Spiazzi	3 10:30 Prof. Spiazzi	4	5
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August 2015

July 2015						
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August 2015						
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Ph.D. Courses: Room DEI/G

Festività italiane

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September 2015

August 2015

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September 2015

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October 2015

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Ph.D. Courses: Room DEI/G
Festività italiane

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October 2015

September 2015

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October 2015

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November 2015

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- Ph.D. Courses: Room DEI/G
- Festività italiane

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
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5 10:30 Prof. Pedersen	6 14:30 Prof. Vandin	7 10:30 Prof. Pedersen	8 14:30 Prof. Vandin	9	10	11
12 10:30 Prof. Pedersen	13 10:30 Prof. Pillonetto 14:30 Prof. Vandin	14 10:30 Prof. Pedersen	15 10:30 Prof. Pillonetto 14:30 Prof. Vandin	16	17	18
19 10:30 Prof. Pedersen	20 10:30 Prof. Pillonetto 14:30 Prof. Vandin	21 10:30 Prof. Pedersen	22 10:30 Prof. Pillonetto 14:30 Prof. Vandin	23	24	25
26 10:30 Prof. Pedersen	27 10:30 Prof. Pillonetto 14:30 Prof. Vandin	28 10:30 Prof. Pedersen	29 10:30 Prof. Pillonetto 14:30 Prof. Vandin	30	31	1 Ognissanti

November 2015

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November 2015

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December 2015

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Ph.D. Courses: Room DEI/G
Festività italiane

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