Technical University of Crete

School of Electrical & Computer Engineering

Courses & research topics offered to the incoming Erasmus+ students during the Academic Year 2017-18

A. Postgraduate courses

A.1 Autumn Semester:

1) **Introduction to Probabilistic Graphical Models & Inference Algorithms – TEL 606 (Assoc. Prof. A. Bletsas) / 7 ECTS units:** Probability theory review. Directed Acyclic Graphs (DAGs). (Bayesian Nets) Factorization Theorem. Directed Acyclic Graph Semantics (I-map, d-separation, P-map). Undirected Graphs (Markov Networks: Markov Blanket, Hammersley-Clifford Theorem). Factor Graphs: techniques for converting graphs. Gaussian Graphical Models. Exact Inference: Elimination Algorithm. Exact Inference on Trees: Sum-Product (BP). Sum-product vs. Max-product in Factor Graphs. Examples in Dynamic Models: HMMs and Kalman Filtering. Exact Inference: Junction Tree Algorithm. Approximate Inference: Loopy BP. Approximate Inference: Sampling Methods (Monte Carlo, Metropolis-Hasting). Approximate Inference: Introduction to Variational Methods. Introduction to Learning: known or unknown structure. Missing data.

A.2 Spring Semester:

2) **Parallel and Distributed Computer System Architecture - ACE 605 (Prof. D. Pnevmatikatos) / 7 ECTS units:** Introduction to parallel computer architectures: execution models and the Flynn taxonomy, SIMD and MIMD architectures, shared memory and message passing systems, computer networks. Shared memory architectures and cache coherence, memory consistency models. Networks, clusters of workstations and grid computers as parallel computers. Parallel computer architecture performance evaluation and benchmarks, parallel and distributed software development issues, programming models for parallel computers. Input/Output (I/O) systems for parallel computers.

3) **Convex Optimization – TEL 609 (Prof. A. Liavas) / 7 ECTS units:** Vectors, lines, curves, surfaces. Functions of several variables: definition, graph, partial derivatives, gradient, directional derivative, tangent, second derivative (Hessian) - Taylor approximations. Convex sets (definition, basic properties, examples). Convex functions (definition, basic properties, examples). Convex optimization problems: global and local optimal points, characterization of optimal solutions for differentiable functions. Optimization of differentiable convex functions without constraints: characterization of optimal

solutions, descent methods, gradient method, accurate line search for quadratic functions, line search with backtracking, convergence analysis for strictly convex functions, algorithm Newton, convergence analysis, numerical algorithms complexity. Optimization with constraints - Farkas Lemma - equations Fritz John (FJ) - constraint qualification - Karush-Kuhn-Tucker equations (KKT). Duality: Lagrangian, Lagrange dual function, weak/strong duality, geometric interpretation of primal and dual problem, the Lagrange multipliers as sensitivity parameters. Optimization with linear equality constraints - conditions KKT – convex quadratic problem with linear equality constraints - Newton algorithm starting from feasible point, Newton step starting from infeasible point - primal-dual algorithm, convergence analysis. Optimization with convex inequality constraints - KKT conditions - logarithmic barrier function - interior point method, finding initial feasible point, primal-dual method. Applications: Linear programming, Semi-definite Programming, Sparse approximations. Simplex method for linear programming.

4) **Quantum Technology – PHYS 602 (Assoc. Prof. D. Angelakis) / 7 ECTS units:** Introduction to Quantum Mechanics and the basics of quantum computation and cryptography. Dirac notation, linear quantum operators and observables, Hilbert space. Quantum mechanics postulates: quantum states, time evolution and Schrödinger equation, quantum measurements. Quantum bits and Bloch sphere. Quantum gate for one and two qubits. Entanglement. Quantum circuits and applications: superdense coding and quantum teleportation. Quantum computing and quantum parallelism. Quantum algorithms: Deutch, Deutch-Jozsa. The quantum Fourier transform. Grover's algorithm for search. Basics of quantum cryptography: the Ekert91 and BB84 protocols. Quantum implementation technologies review. The De Vincenzo criteria. The spin-qubit, Rabi oscillation and single qubit gates. Two qubit gates with spin qubits. Summary of the basics of quantum technologies based on linear optics, cold ions, Cavity QED systems, NMR, solid state and superconducting circuits.

5) **Special Topics in the Design of Analog CMOS Integrated Circuits - ACE 604 (Assoc. Prof. M. Bucher) / 7 ECTS units:** Introduction to the design of low-voltage (LV), low-power (LP), radio-frequency (RF) analog CMOS integrated circuits (ICs). Introduction to nanometer-scale CMOS technology. The scaling of CMOS technology according to Moore's law. Single- and multi-gate CMOS technology, SOI technology, FinFET technology. Introduction to foundry Process Design Kits (PDKs) and compact models (EKV3, BSIM6). Charge-based description of MOS Transistor (MOST) operation for LV-LP-RF CMOS IC design. The operation of MOSTs in weak, moderate, and strong inversion. Efficient charge- and current-based description of MOST operation, from static to dynamic, high-frequency operation, noise, and statistical variability. Process variations, local mismatch. Design and simulation tools for analog/RF IC design. Design examples of Operational Transconductance Amplifiers (OTAs), Low Noise Amplifiers (LNAs).

6) **Special Topics in Electronic Energy Management Systems - ENE 602 (Assoc. Prof. E. Koutroulis) / 7 ECTS units:** Design of DC-DC and DC-AC power converters. Battery structures for electric energy storage. Electronic systems for maximizing power production (Maximum Power Point Tracking – MPPT). Smart meters. Special sensors, actuators and controllers for energy management and energy saving in Smart Homes/Buildings. Electronic energy management systems for Renewable Energy Sources, Smart Grids, Microgrids and electric vehicles. Electronic systems for wireless power transmission and energy harvesting.

B. Supervision of diploma thesis (for undergraduate students) and MSc/PhD thesis (for postgraduate students) during the Autumn and Spring Semesters, in the following fields:

1) Computer Architecture, data-center processing, parallel programming, FPGA Design. **(Prof. D. Pnevmatikatos)**

2) Power Electronics, Microelectronic Energy Management Systems, Renewable Energy Sources, Sensors & Electronic Measurement Systems. **(Assoc. Prof. E. Koutroulis)**

3) Electrophysiological signal analysis, Biomedical image processing, Biomolecular Imaging, Genomic data analysis and interactions, Image processing for surveillance applications. **(Prof. M. Zervakis)**

4) Implementation of Quantum Computation with cavity QED or Superconducting Circuits or Integrated Photonic Chips, Different projects in implementation of Quantum Simulations and Quantum Computing in Quantum Technologies. **(Assoc. Prof. D. Angelakis)**

5) Design of analog integrated circuits for low-power, low-voltage, low-noise analog/RF applications. Variation-aware, reliability-aware integrated circuit design. Semiconductor device physics, advanced nanoscale CMOS technology. Power semiconductor devices and applications. Analysis, characterization, and compact modeling of active and passive elements at low and high frequencies. Development of Computer Aided Design (CAD) tools. **(Assoc. Prof. M. Bucher)**