Title: "3D data structures and physics-based animation"

Course held by Prof. Jacopo Aleotti

E-mail reference professor: jacopo.aleotti@unipr.it

4 CFU

Semester: second

Short program:

Part 1) 3D collision detection algorithms. Algorithms for the intersection test between 3D primitives. 3D data structures for collision detection (Bounding Volumes, Bounding Volumes, Hierarchies, Octree, K-d tree, BSP-tree).


Title: An introduction to power systems

Course held by Prof. Roberto Menozzi

E-mail reference professor: roberto.menozzi@unipr.it

4 CFU

Semester: first

Short program:

The generation of electric energy; Introduction to power systems; The transmission of electric energy; The utilization of electric energy; Power system control

Title: Quantum Computing

Course held by Prof. Michele Amoretti

E-mail reference professor: michele.amoretti@unipr.it

3 CFU

Semester: second

Short program:

Title: Detection over unknown channels

Course held by Prof. G. Colavolpe

E-mail reference professor: giulio.colavolpe@unipr.it

2 CFU

Semester: first

Short program:

First part (overlapped with some lectures of the course Digital Communication, Master degree in Communication Engineering)

Introduction to the problem of sequence detection in the presence of unknown parameters.

Sequence detection in the presence of unknown parameters: channel models, sufficient statistics, optimal strategy in the presence of an unknown stochastic parameter, memory truncation. Examples: noncoherent sequence detection; receivers based on linear prediction.


Second part (specific for PhD students) (this part requires some basic knowledge on Factor graphs and the sum-product algorithm)

Detection for unknown channels based on graphical models

Title: Machine Learning for pattern recognition

Course held by Prof. A. Bononi / S. Cagnoni
E-mail reference professor: alberto.bononi@unipr.it

8 CFU

Semester: second

Short program:

Course covers

A. Bononi:

1) a review of probability and the Bayesian statistical analysis underlying ML (regression, classification)
2) extensions to generalized linear models as a basis to neural networks and other kernel-based methods.
3) supervised learning for both regression and classification.

S. Cagnoni:

4) some elements of unsupervised learning.
5) some programming of ML algorithms based on Weka software.

Details can be found at: http://www.tlc.unipr.it/bononi/didattica/ML_PhD/ML_PhD.html

Title: MATLAB FOR ELECTRONICS

Course held by Prof. Valentina Bianchi

E-mail reference professor: valentina.bianchi@unipr.it

4 CFU

Semester: first

Short program:

The course aims to provide students with the knowledge of the main features of the MATLAB/SIMULINK software in order to use it as a support tool to the electronic design through application examples. The students will learn how to use MATLAB and SIMULINK in typical applications of electronics, electrical engineering and signal processing. The students will learn to automatically generate C or VHDL code for Microcontrollers or FPGAs. He/she will learn how to communicate and document the choices made through a well written and documented code. Topics include: 1. Solving Equations 2. Continuous LTI Systems Analysis 3. Digital LTI Systems Analysis 4. FIR and IIR Filters Design 5. FFT 6. Automatic Code Generation 7. Hardware Connection
Title: Introduction to Model-Based Design

Course held by Prof. Alessandro Soldati

E-mail reference professor: alessandro.soldati@unipr.it

4 CFU

Semester: Second

Short program:

- Abstraction levels, system partitioning and the V-model
- Unit testing, static code analysis and automatic test-benches and documentation
- Version Control Systems
- Numerical analysis for real-time computation
- Benchmarking of processing units and algorithms
- Data processing in MATLAB for embedded programming
- Optimizers and solvers
- Model-based design and system validation with MIL/SIL/PIL/HIL

Title: “Embedded System”

Course held by Prof. Guido Matrella and Prof. Carlo Concari

E-mail reference professor: guido.matrella@unipr.it – carlo.concari@unipr.it

4 CFU

Semester: second

Short program:

The aim of the course is to provide to SDIA students, coming from all three different areas of Information (Electronic, Informatics, Telecommunication), an overview of the main high performance Embedded Systems design methodologies.

The crucial issue of the Hw/Sw partition of an Embedded System will be illustrated and how an Embedded System can be implemented using different approaches: 1. Completely by SW, 2. By SW but using specific DSP processors, 3. By SW but using HW circuits “ad hoc” developed on FPGA.

“Programming standards” and “functional safety techniques” will be mentioned.

Examples of HW/SW design activities will be carried out, also using HDL languages and automatic code generation techniques.
Title: Optimization using Graphical Models

Course held by Prof. M. Locatelli, G. Colavolpe, A. Vannucci, L. Consolini

E-mail reference professor: giulio.colavolpe@unipr.it

2 CFU

Semester: second

Short program:

**Topic 1: Basics on convex optimization (Locatelli)**


**Topic 2: Bayesian inference and graphical models (Colavolpe)**

Bayesian Networks and Markov Random Fields: Inference in general Graphs. Variational Inference techniques in Machine Learning and Artificial Intelligence: Belief Propagation (BP) and Loopy Belief Propagation. Factor graphs and sum product algorithm: general framework and applications to communications.

**Topic 3: Variational Inference and the Free Energies methods of Physics (Vannucci)**


**Topic 4: Graphical models for optimization - Trajectory planning and power control (Consolini)**

Speed and trajectory planning problems, dynamic programming. Power control in radio systems. Reduction of previous problems to a standard form and definition of the associated graph. Graph-based solution algorithms.

Title: Electronics for Internet of Things

Course held by Prof. Mora Niccolò

E-mail reference professor: niccolo.mora@unipr.it

3 CFU
Semester: first

Short program:
Power supply and power profiling of IoT devices;
Good practices in the design and manufacturing of IoT devices: analysis of specifications, components and PCB production;
Signal acquisition and conditioning: the analog domain (circuits and architecture review);
The digital domain: filtering, signal enhancement, data exploration and analysis;

Title: ICT for Health and Wellbeing

Course held by Prof. Paolo Ciampolini
E-mail reference professor: paolo.ciampolini@unipr.it
Duration: 8 CFU (recommended part: 4 CFU)

Semester: I

Short program:
Introduction and motivation
Telemedicine, e-health and m-health
Biosignals: classification and main features
Signal acquisition: sensors and acquisition architectures
Activity and behavioral monitoring
Data analytics: classification, statistical techniques, machine learning techniques
Data protection and interoperability: concepts and main standards.
Healthcare systems organization
Topical seminars (research, industry).

Laboratory: teamwork, aimed at multidisciplinary, user-centered design in health and Active and Healthy Ageing use-cases (supported by IBM Research). (4 CFU)

(Ph.D. Students may also decide to attend the laboratory part only [boldface], jointly managed by UNIPR and IBM Research, if interested)

Title: Methods of Probabilistic Robotics

Course held by Prof. Dario Lodi Rizzini
E-mail reference professor: dario.lodirizzini@unipr.it

2 CFU

Semester: Second
Short program:

The goal of this course is to provide an overview of the concepts of probabilistic robotics and of the main localization and mapping methods. Practical demonstrations with software tools used by research community will support the exposition. The main program is organized as follows: definitions and estimation methods, localization and mapping problems, data association, and sensor registration.

1. Representation of Uncertainty
   - Motivation and examples
   - Probability density functions, function of random variables, normal distribution
   - Propagation of uncertainty
2. Bayesian filters
   - State estimation for localization and mapping
   - ML and MAP criteria
   - Parametric filters: Kalman filters, EKF, UKF (hints)
   - Derivation of KF
   - EKF for localization and SLAM
3. Graphical models
   - Full SLAM problem: derivation
   - Least-square SLAM
   - Models for graphical formulation: landmark-based, pose graph, perturbation operator
   - Practical: graphical SLAM backend g2o
4. Localization and Mapping Issues
   - Map models: landmarks, occupancy grid maps
   - Data association methods: NN, JCBB, correspondence graphs
   - Practical: data association

**Title: Applied Security**

*Course held by Prof. Luca Veltri*

*E-mail reference professor: luca.veltri@unipr.it*

*3 CFU*

*Semester: Second*

Short program:

This is a laboratory course that has the objective of providing practical knowledge on the use of security algorithms and protocols for protecting data and communications.

The course is formed by a series of laboratory activities and assignments, consists in both programming and security tool exercises, that will allow the student to learn and improve his/her knowledge on how to use standard security mechanisms.
The following topics will be considered: symmetric cryptography (stream and block ciphers); secure hash functions; password hashing and message authentication code; brute force attacks, asymmetric cryptography (public-key encryption and digital signature); digital certificates; protection of network communications through TLS and VPNs; vulnerability scanning; firewalls.

For the programming exercises, Java with its standard security library will be used as reference programming language; however other languages like C/C++, Python, Go, etc, can be used by the students for their exercises and assignments.

Basic knowledge of cryptography and communication protocols (TCP/IP) is required.

Title: Edge Computing & Microservices for the Next Generation of Internet of Things Architectures

Course held by Prof. Marco Picone

E-mail reference professor: marco.picone@unipr.it

3 CFU

Semester: First

Short program:

1. - Internet of Things Overview and (Re)View
   ○ Introduction
   ○ Internet of Things Definition & Vision
   ○ From WSN and M2M to IoT
   ○ IoT Characteristics
   ○ IoT Protocol Stack
   ○ IoT Applications

2. - Do not reinvent the wheel ... Design and Make it Standard !
   ○ Pub/Sub
   ○ RESTful
   ○ CoAP
   ○ MQTT

3. - IoT Heterogeneity, Interoperability and Web of Things
   ○ Service and Resource Discovery
   ○ Protocol Translation and Standardization Solutions
   ○ Web of Things
   ○ Digital Twin
   ○ People & Things Challenges and Opportunity

4. - Edge/Fog Computing: A new Architectural approach for the IoT
   ○ Edge Computing principles
   ○ IoT & Edge Computing
Cloud, Edge and Hybrid Architectures
The IoT Hub

5. Monolithic vs Microservice oriented Architectures for the IoT
   - Microservices and Service Mesh
   - IoT and Microservices
   - Microservices composition and orchestration in Distributed Environments

6. Make it real! Tools, Projects and Resources to join the IoT Community
   - Hardware Platform & Operating System
   - Software Libraries
   - IoT Eclipse Foundation Projects
   - Open Source Projects

7. Projects & Evaluation

Title: Subspace-based identification methods

Course held by Prof. Luca Consolini

E-mail reference professor: luca.consolini@unipr.it

2 CFU

Semester: second

Short program:
1) Singular value decomposition.
2) Elements of realization theory.
3) Elements of model reduction.
4) Identification of deterministic systems.
5) Identification of systems affected by noise.

Title: Wireless Communication Channel Models

Course held by Prof. Riccardo Raheli

E-mail reference professor: riccardo.raheli@unipr.it

3 CFU

Semester: first

Short program:
1. Channel models
   1.1 Review of radio propagation
   1.2 Path loss models
      Free space
      Flat earth
      Empirical models
      Ray tracing
1.3 Shadowing model
Lognormal distribution

Title: Elements of Electric Drives

Course held by Prof. Carlo Concari

E-mail reference professor: carlo.concari@unipr.it

2 CFU

Semester: second

Short program:

1) Structure and components of an electric drive
2) Main parameters of electric drives
3) DC electric machine: structure and operating principles
4) DC electric machine: control