List of Currently Planned Accredited Courses – XXXVII Cycle

Academic Year 2021/2022

Title: "Enabling Technologies for IoT & Vehicular Networks"
Instructor: Prof. Carlos Tavares Calafate (Foreign Professor)
Abstract. This course is organized in three parts. The first part provides an overview of different wireless networks, and then focuses on IoT issues including IoT the concept of things, architectures and content distribution. It is complemented with some practical examples using real hardware. The second part introduces the ITS context, detailing the key vehicular networks applications and wireless technologies. Simulation and performance issues are also introduced and discussed, along with technology standardization. The third part provides some background on unmanned aerial vehicles, introducing their fundamentals, flight principles, key applications, performance and legal issues. The different developments produced at the GRC research group are presented and discussed, including several illustrative videos.
Number of hours: 6
Number of CFU: 1

Title: "Smart machines and IoT"
Instructor: Dr. Giandomenico Spezzano
Abstract. Smart Machines collectively represent intelligent devices, machinery, equipment, and embedded automation software that perform repetitive tasks and solve complex problems autonomously. While humans are susceptible to making errors and are comparatively less reliable and consistent, the next-generation intelligent machines can be 'trained' to execute repetitive, monotonous and scheduled tasks, minus the element of human error. Thus, productivity, capacity utilization, and efficiency is improved by a wide, reliable margin. A smart machine is an intelligent tool that can examine, compute and reason, without any human intervention using machine-to-machine (M2M), artificial intelligence (AI), Iot connectivity and other modern innovations. Specifically, I first present a comprehensive definition for smart machines and related technologies. Then I will illustrate how distributed systems of connected, intelligent devices can cooperate to achieve greater speed and efficiency.
Number of hours: 12
Number of CFU: 2

Title: "Statistical data analysis and signal processing techniques for imaging and non-destructive testing applications"
Instructors: Prof. Marco Ricci, Dr. Stefano Laureti
Abstract. The course introduces some statistical data analysis and signal processing techniques for imaging and non-destructive testing applications which all rely on the least-squares theory. By starting with solving the linear regression problem with noisy data, the least-squares theory will be introduced and its relationship with the pseudo-inverse matrix illustrated. The pseudo-inverse approach will be then used to solve generic polynomial fitting, regression and non-linear fitting through iterative algorithms. The basic principles of inverse theory and deconvolution will be suddenly introduced and then the course will focus on signal processing applications, all developed for dealing with optimal deconvolution and linear system characterization in noisy environment. Wiener filter theory, matched filter theory, pulse-compression and ARMA modelling will be presented and numerical exercises will be done by the students during the course.
Number of hours: 12
Number of CFU: 2

Title: "Advanced Devices for VLSI CMOS Integration: from Single to Multi-Gate Architectures"
Instructor: Prof. Lionel Trojman (Foreign Professor)
Abstract. Although discovered by Lilienfield in 1927, the Field Effect Transistor (FET) could not be integrated in monolithic Si wafer up to the 60's thanks to Kahng and Attal who introduced the Metal Oxide Semiconductor (MOS) based Si-architecture; namely one gate electrode controlling the source-to-drain current. This led to the implementation of the Complementary MOS (CMOS) technology for the electronic circuit implementation. Since then, the Electronic industry based on CMOS technology has known an amazing boost bringing an unprecedent worldwide modernization of human societies. Continuous needs in technologies make the market more and more demanding resulting to new challenges for electrical engineers. Recently, to overcome these, new MOS based architectures have been proposed such as the multi-gate one. Today, two CMOS technologies are dominating the market: FinFET (3-gate) from Intel and the FDSOI (2-gate) from ST. In this course, after reviewing the basic and conventional bulk MOSFET we will study these new architectures, their pro and cons. A specific emphasis on FDSOI will be made and emergent technology concept will be introduced.

Number of hours: 6
Number of CFU: 1

Title: "Vision-Based Underwater Robot Navigation and Mapping"
Instructor: Prof. Rafael Garcia (Foreign Professor)
Abstract. Optical cameras provide a huge amount of information at a very low cost, especially when compared to underwater sonar systems. However, using vision underwater is a difficult endeavor due to the transmission properties of the medium. Light is absorbed and scattered by the particles suspended in the water column, producing degraded images with limited range, blurring, low contrast and weak colors, among other effects. Moreover, artificial lighting tends to provide non-uniform illumination and introduces shadows in the scene, generating a motion flow that does not obey the dominant motion of the camera. However, with the adequate processing pipeline, vision can be a powerful tool for autonomous underwater robots to explore the ocean. In this seminar we will first introduce the topic of underwater robot navigation, and then we will analyse the pipeline for solving the correspondence problem to obtain motion estimates when an underwater robot moves close to the seafloor. We will also address the problem of outlier detection, and we will see how use features in the images to estimate motion. Then, specific challenges and solutions for using computer vision underwater will be presented. Next, the seminar will end illustrating several underwater robotic applications based on vision, such as automatic visual docking, optical mapping, vision based trajectory replanning or automatic landing for arm manipulation. Finally, an approach to create accurate three-dimensional textured models of the seafloor will be presented. The method generates a dense cloud of 3D points and is able to compute a meshed surface being robust to common defects in underwater imaging such as high percentage of outliers and point-cloud noise.
Number of hours: 6
Number of CFU: 1

Title: "Lipschitz Global Optimization"
Instructor: Prof. Yaroslav Sergeyev
Abstract. The course is dedicated to numerical solution of global optimization problems, where the objective function is multiextremal, non-differentiable, given as a "black box", and hard to evaluate, i.e., each its evaluation even at one point requires large amounts of computational or temporal resources. Moreover, it is supposed that the objective function is Lipschitz continuous. This condition has a very practical meaning: in physical systems it means that the energy changes in the system described by the function are always limited.
Number of hours: 6
Number of CFU: 1

Title: "Numerical Computations on the Infinity Computer"
Instructor: Dr. Marat Mukhametzhanov
Abstract. The course is dedicated to numerical calculus on the Infinity Computer – a new type of a supercomputer allowing one to work numerically with finite, infinite, and infinitesimal numbers in a unique framework. Examples of a successful usage of the Infinity Computer in different areas of applied mathematics are presented. In particular, it is demonstrated that the Infinity Computer is able to produce exact results (i.e., up to machine precision) in several applied problems. Exercises on a software simulator of the Infinity Computer are performed during the course.
Number of hours: 6
Number of CFU: 1

Academic Year 2022/2023

Title: "From Modeling to Implementation of Wearable Computing Systems based on Body Sensor Networks"
Instructor: Dr. Raffaele Gravina
Abstract. Wearable computing is a relatively new area of research and development that aims at supporting people in different application domains: health-care (monitoring assisted livings), fitness (monitoring athletes), social interactions (enabling multi-user activity recognition, e.g. handshake), videogames (enabling joystick-less interactions), factory (monitoring employees in their activity), etc. Wearable computing is based on wearable computing devices such as sensor nodes (e.g. to measure heart rate, temperature, blood oxygen, etc), common life objects (e.g. watch, belt, etc), smartphones/PDA. Wearable computing has been recently boosted by the introduction of body sensor networks (BSNs), i.e. networks of wireless wearable sensor nodes coordinated by more capable coordinators (smartphones, tablets, PCs). Although the basic elements (sensors, protocols, coordinators) of a BSN are available (already from a commercial point of view), developing BSN systems/applications is a complex task that requires design methods based on effective and efficient programming frameworks. In this course, we will introduce programming approaches and methods to effectively develop (model, implement and deploy) efficient BSN systems/applications. Moreover, we also provide new techniques to integrate BSN-based wearable systems with more general Wireless Sensor Network systems and with Cloud computing as well as Platform-based Design Methodology for BSNs. From the practical viewpoint, the course is based on the SPINE project (http://spine.deis.unical.it), currently led by Prof. Fortino's research group. Specifically, the course will be based on the SPINE open-source framework to provide students with hw/sw tools for the development of "their" example wearable computing systems.
Number of hours: 12
Number of CFU: 2

Title: "Computational Engineering Design Optimisation"
Instructor: Prof. Timoleon Kipouros (Foreign Professor)
Abstract. The module aims to provide an understanding of optimisation theory and formulation of optimisation problems applied on engineering design. Understand the importance of the choice of suitable optimisation algorithms and complementary tools for geometry management and objective functions simulation and evaluation. Finally, to appreciate the importance of post-optimisation analysis and extraction of qualitative understanding of the relevant optimisation problems.
On successful completion of this module a student should be able to:

1. Express the fundamental concepts of numerical and stochastic optimisation.
2. Identify the appropriate optimisation algorithms and formulate optimisation problems for a given engineering design study.
3. Use scientific computational design tools with High Performance Computing.
4. Integrate different computational analysis tools and methods within a computational design system.
5. Perform assessment of an optimisation study.
6. Perform post-optimisation analysis and extract qualitative understanding of real-world design problems.

Number of hours: 6
Number of CFU: 1

Title: "From Big Data to Big Multidimensional Data: Models, Issues, Challenges"
Instructor: Prof. Alfredo Cuzzocrea
Abstract. Big data is gaining momentum in the research community, due to the several challenges posed by the management of such kind of data. Big data are relevant not only in the academic context, but also in the industrial context, where they play the major role. Indeed, several kinds of application are now exploiting big data, such as: Web advertisement, social network intelligence, e-science applications, smart city applications, and so forth. Among big data, big multidimensional data are a special case of big data that fully expose the "famous" 3V (volume, velocity, variety) and are of relevant interest at now. In this course, tailored to PhD students in Computer Science and Computer Engineering, we first investigate foundations of big data, critical state-of-the-art analysis, research challenges and industrial applications. After that, we move the attention on special lectures focused on big multidimensional data.
Number of hours: 12
Number of CFU: 2

Title: "UAV, Robot and Mobile Sensor Networks"
Instructor: Prof. Enrico Natalizio (Foreign Professor)
Abstract. The course addresses the interdisciplinary issues related to the design, operation and integration of networks of devices with controlled mobility. The course content is divided into three parts:
1- Architectural and technological (2 hours): in which multirobot and sensor network architectures are presented, as well as the standards for hardware, software and communication protocols currently used. In this part of the course, the

controlled mobility is introduced, and the influence it exerts on each of the protocol levels of the ISO / OSI standard is outlined.
2- Methodology (2 hours): in which the current study methodologies for sensor and robot network problems are presented. Furthermore, the advantages and the limitations in the use of devices with controlled mobility for the resolution of "missions" is shown. This interdisciplinary part includes concepts of optimization, related to the mathematical modeling of the missions (Vehicle Routing and Dynamic Vehicle Routing), of robotics for modeling the physical behavior of each individual device, of swarm intelligence for the description of the collective behavior of the fleet of devices, of networking for the use of wireless communication protocols suited to the imposed constraints.
3- Research challenges (2 hours) in which the challenges open to researchers in this research domain are presented, specifically for the networking and optimization aspects.
Number of hours: 6
Number of CFU: 1

Title: "Systems Engineering: principles and practices"
Instructors: Prof. Alfredo Garro, Dr. Alberto Falcone
Abstract. The course presents and discusses the fundamentals of Systems Engineering.
The main course objective is to enable students to:
- understand and apply the main Systems Engineering processes, tools and techniques;
- define systems requirements and performance;
- design system technical solution options;
- deal with reliability, availability, maintainability, and safety properties;
- use decision analysis techniques and trade studies to support critical project decisions;
- allocate system functions to sub-systems and define the relationships among the sub-systems;
- control internal and external interface definitions, designs, and changes for products and product components;
- use modeling and simulation throughout the system lifecycle.

The course will be based on a problem solving approach: starting from real case studies, students will be required to concretely apply the introduced Systems Engineering processes, tools and techniques.
Number of hours: 12
Number of CFU: 2

Academic Year 2023/2024

Title: "Introduction to Outdoor/Indoor Navigation and Positioning"
Instructor: Prof. Giuseppe Fedele
Abstract. This course presents an introduction to application of estimation and filtering techniques in the Outdoor/Indoor navigation systems and their integration. The focus is on the application of techniques, algorithms and methods in positioning and navigation scenarios: Outdoor Navigation, Indoor Navigation (Indoor Positioning Techniques, Indoor Positioning Technologies).
The first part of the course discusses the positioning technologies and the applied techniques. The second part introduces the concept of Navigation from a general point of view and narrows it down to the outdoor/indoor cases. The third part examines the various positioning techniques and the sensors fusion algorithms used to determine position optimally.
The objectives are:
- learn basic principles of localization technologies and algorithms;
- understand the main characteristics that can be used to classify and evaluate localization techniques: (which signals can be used for measuring locations? which estimation algorithms can be used? which kind of errors affect localization?, etc…)
- be able to apply the knowledge in practice using real signals provided by Bluetooth transmitters disseminated in the Systems Engineering "area" of the DIMES Department.

Number of hours: 12
Number of CFU: 2

Title: "Next Generation IoT Interoperability"
Instructor: Prof. Carlos Palau (Foreign Professor)
Abstract. Internet of Things (IoT) unifies the different aspects studied by the students in previous subjets. From electronics, signal processing, networking, communications, protocols and application and services. It is one step beyond from regular Internet in which humans communicate with services or services with other services, to an environment in which machines communicate with other machines and devices produce a huge ammount of data to be used and included in different applications. Interoperability allows the interaction between different IoT platforms allowing exchange of information between different platforms, at different levels, extending the knowledge of the previous areas. Contents:

1. Introduction
2. M2M protocols
3. IoT platforms
4. Interoperability
5. Application domains
6. IoT security.

Number of hours: 6
Number of CFU: 1

Title: "Big Data Analytics"
Instructor: Prof. Elio Masciari
Abstract. Nowadays, the availability of huge amounts of data from heterogeneous sources, exhibiting different schemes and formats and being generated at very high rates, led to the definition of new paradigms for their management. This problem is known with the name of Big Data. As a consequence of new perspective on data, many traditional approaches to data analysis result inadequate both for their limited effectiveness and for the inefficiency in the management of the huge amount of available information.Therefore, it is necessary to rethink both the storage and access patterns to big data as well the design of new tools for data presentation and analysis. In this course, main approaches for Big Data management will be reviewed.
Number of hours: 12
Number of CFU: 2

Title: "Methodologies, Frameworks and Tools for IoT Systems of Systems"
Instructors: Dr. Claudio Savaglio
Abstract. The course presents and discusses methodologies, frameworks and tools for IoT systems of systems.
The course outline is the following:
- IoT systems modelling and standard architectures;
- Methodology for IoT systems development;
- Frameworks for IoT systems programming;
- Tools for IoT Systems deployment and management;
- Illustration of the ACOSOMeth methodology for Agent-based IoT SoS;
- Discussion of real use cases in diverse application domains.

Number of hours: 12
Number of CFU: 2

Title: "From Mining to Multisigned Transactions: Discovering How Bitcoin Works"
Instructor: Prof. Stefano Bistarelli
Abstract. Nowadays there are more than 1 thousand and a half cryptocurrencies and (public) blockchains with an overall capitalization of more than 300 Billions of USD. The most famous cryptocurrency (and blockchain) is Bitcoin, described in a white-paper written under the pseudonym of "Satoshi Nakamoto". His invention is an open-source, peer-to-peer digital currency (being electronic, with no physical manifestation). Money transactions do not require a third-party intermediary, such as credit cards issuers. The Bitcoin network is completely decentralised, with all parts of transactions performed by the users of the system. A complete transaction record of every Bitcoin and every Bitcoin user's encrypted identity is maintained on a public ledger. The lecture will introduce bitcoin and blockchain with a deep view of transactions and some insight on specific application (e-voting).
Number of hours: 12
Number of CFU: 2