Master of Science
Intelligent Control Systems

Courses description

Advanced algorithms and control architectures

The course objective is to present advanced control algorithms and structures that removes the limitations of conventional control structures. The course presents elements of adaptive control systems – model reference adaptive control and selftuning, robust control, predictive control structures, nonlinear systems.
It treated both aspects of advanced simulation and implementation issues of the algorithms on microcontroller structures. The course provides analysis and design skills for advanced control structures design and skills for designed algorithms implementation.

Knowledge Management

The course is conceived to provide students a detailed image on how enterprises can efficiently use their resources of knowledge as an crucial asset for ensuring a proper evolution on the market, in the actual context of the knowledge-based society.
There are presented the main directions of interest in the field of knowledge management, the concept of evolution correlated with the evolution of manufacturing organizational paradigms, models and knowledge management architectures, into a unitary concept and based on case studies.
After graduating this course, the specific competences will be:

1. Understanding the basic principles of knowledge management
2. Understanding the role of both technology and organizational culture in the design and implementation of knowledge management strategies
3. Ability to develop a knowledge management strategy for a given context

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Parallel and distributed processing of data and knowledge

The course introduces basic notions on parallel computing architectures and parallel and distributed algorithms. It uses two types of architectures, with distributed and shared hierarchical memory, the latter targeting graphic processing units. The corresponding programming models are SPMD (Single Program Multiple Data), using communication through messages or the common memory, respectively. The actual programming is made via MPI (Message Passing Interface) and OpenCL, respectively. Parallel programming is studied through simple algorithm for basic operations with matrices and vectors, like scalar product, matrix-vector product, matrix product. The purpose of the course is to acquire the ability to program on a parallel architecture and to implement and evaluate programs on the multi-processor computers currently available.

Decision Support Systems

The course has the goal to familiarize students with basic concepts on decision processes, computer assisted decision and associated software support, with the purpose of giving them competencies on the design of such kind of systems and in the evaluation of cost/ benefit implied by their use.
There are defined concepts as Decision Support Systems (DSS) and Business Intelligence (BI) and there are presented different architectures and classes of methods and models used for their design and implementation. There are presented data oriented DSS, data warehouses, OLAP and data-minning techniques.

Neural networks

The course presents different types of neural network architectures feedforward and recurrent with implementation of supervised learning algorithms- backpropagation or unsupervised learning algorithms SOM (selforganizing map). It develops algorithms for identification and control based on neural networks. The course provides development of skills regarding the application of these neural networks architectures in signal processing applications, systems identification, as well as in scientific computing problems and opens the horizon for using unconventional computing structures in real-time applications.

Intelligent control systems

This course ensures a thorough understanding of the fundamentals of various intelligent control techniques - fuzzy systems, expert systems, neural networks and genetic algorithms. The course presents the main issues of intelligent control paradigms. This course develops the ability to choose the most appropriate technique or combination of them for a given application and the ability to write applications for real plant control by using different intelligent control techniques.

Multi-agent systems

This course is an introduction to the theory and practice of multi-agent systems considered from the perspective of distributed artificial intelligence and concerns problems involved when groups or societies of autonomous agents interact with each other in order to solve given tasks. Main taught concepts include: definitions of agent and multi-agent systens, knowledge and reasoning in agent based systems, interactions between agents, distributed problem solving, coordination and negotiation in multi-agent systems, organization and control of complex systems, and applications in information search, electronic commerce and virtual markets, distributed sensor networks, distributed planning and resource allocation, etc.
Laboratory activities have as objective to present how to develop an intelligent agent-based system. There will be presented various methods of developing multi-agent systems based applications.

Advanced Techniques for Decision Processes

The main objective of this course is to help students acquire practical knowledge of the methods and techniques available for the modeling of the decisional process under uncertainty. The course ultimately aims at building the students' capacity of developing decision systems and applications.
The decision problem is formulated from the perspective of Decision Theory and Artificial Intelligence; basic concepts for its resolution are introduced. The general stages of the decisional process are presented, with an emphasis on decision making in conditions of uncertainty. Next, classic techniques for decision modeling are reviewed: the Bayesian probabilistic model, techniques for utility evaluation, decision rules.

Advanced probabilistic techniques for the modeling of the decision process under uncertainty are presented, such as decision tree and decision diagrams. A particular attention is given to Bayesian networks, as these graphical techniques have become more and more popular for the modeling of reasoning under uncertainty, combining both the Decisional Theory and Artificial Intelligence. The medical domain is used for exemplification.

Embedded systems design - Cyber-Physical Systems

Cyber-Physical Systems master course presents an integrated vision on CYBER systems taking into account all aspects regarding computer science, communications and management of physical processes, viewed as an unitary system with specific performances. The course presents architectures and representative models from different areas.

After graduating this course, the specific competences will address:

- Ability to conceive and design complex systems, taking into consideration all aspects regarding communication and information processing in the particular context of physical processes;
- Ability to conceive and design network control systems, taking into account the dynamics of both processes and network;
- Ability to design complex architectures that effectively integrate computers and communication systems with physical processes at different scales of time and space.

Cognitive robotics

This course is an introduction to the topic of cognitive science and cognitive systems, followed by theoretical and practical aspects concerning the design of control systems for cognitive robots. The course objectives are as follows:

1. understanding the scope of cognitive science;
2. presentation of the human cognitive abilities and of the classical theories of intelligence;
3. understanding the correlations between brain functioning and localization of cognitive abilities;
4. introduction to the scope of mobile robotics, both from hardware and software points of view;
5. defining the scope of cognitive robotics;
6. detailed presentation of the control architectures for cognitive robots;

7. application of cognitive robots.

Laboratory work has as objectives developing control programs for mobile robots, both in simulation and on real robots from the Laboratory of Natural Comopting and Robotics (natural.buiu.net).

Hybrid Systems

The course is presenting an alternative systems theory approach, appropriate for these systems whose functioning cannot be completely modeled by one of the two basic formalisms: continuous and discrete event based.

The presentation of Hybrid Systems theory is made with respect to those of Continuous and Discrete Event-based ones respectively, emphasizing the similarities and differences in modeling, performance evaluation and control. There are mentioned the most known techniques of interfacing continuous and discrete-event based components of the overall system as well as the impact they have on system's functioning and implementation of the control policies. There are presented the most used techniques of hybrid systems modeling: hybrid automata and hybrid Petri nets. A special attention is given to hybrid Petri nets as the instrument with the maximal modeling capability.

The theoretical approach is completed with case studies which emphasize the adequacy of some methods for solving given classes of problems.

Intelligent Manufacturing Systems

The course is intended for familiarizing students with the characteristics and fundamentals of functioning and objectives for Intelligent manufacturing Systems.

Based on these concepts, the course includes the presentation of main approaches in controlling this class of systems, with their respective architectures and functionalities and with respect with their adequacy to the physical systems.

The main objective of the course is to provide the necessary competencies for identifying the necessity of the intelligent approach in manufacturing, for selecting and adapting the most appropriate control architecture and for the definition of the necessary steps of implementation.

Research activities

The objective of the research activity as defined at the level of the program is to provide the required competencies for defining a project with a concrete objective and to fulfill this objective, in an independent manner, through all the stages, from documentation to implementation and validation.

The activity scheduled on the four semesters will (broadly) follow the steps of:

- Problem definition and documentation (state of the art in the field) - 1st semester
- Selection of the most promising/ adequate approach for problem solving and generic solution specification – 2nd semester
- Objective detailed specification and research for obtaining a new or improved solution with respect to the already existing ones – 3rd and eventually a part of the 4th semester
- Implementation and validation; evaluation of the solution with respect to the state of the art in the field – 4th semester