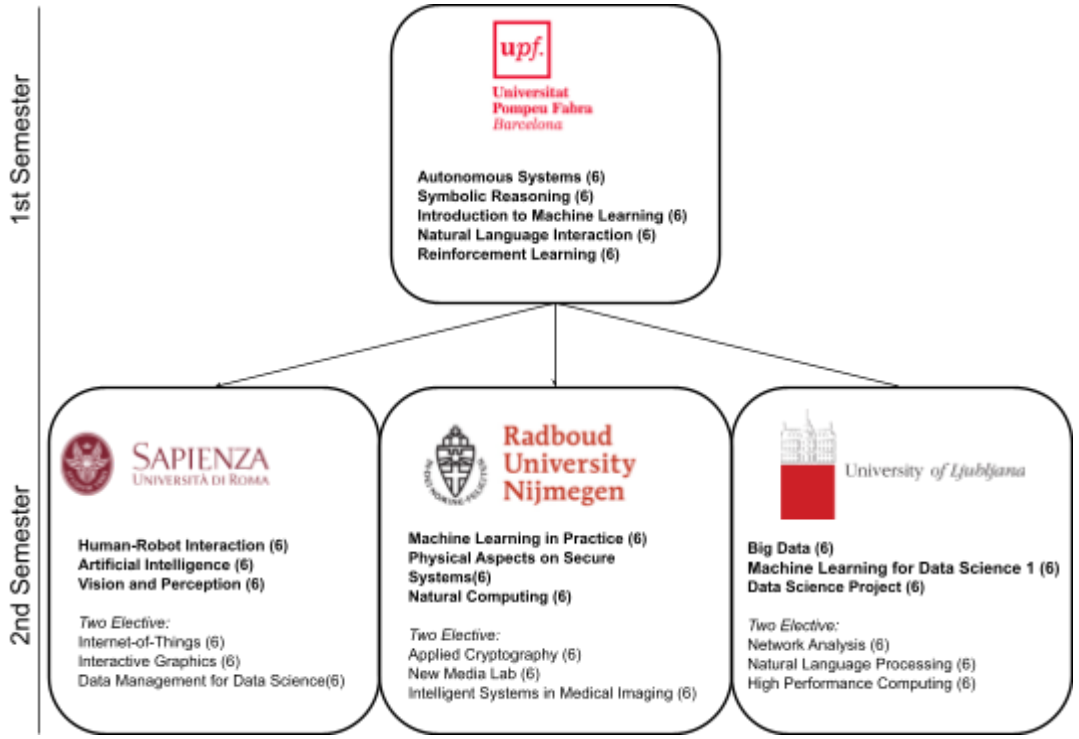
EMAI Study program (1st year)



1st Semester. Barcelona (30 ECTS)

Autonomous Systems (6 ECTS) *UPF (obligatory)*
Prof: Hector Geffner
The focus of this course is autonomous behaviour, and more precisely, the different methods for developing "agents" capable of making their own decisions in real or simulated environments. This includes characters in video-games, robots, softbots on the web, etc. The problem of developing autonomous agents is a fundamental problem in Artificial Intelligence, where three basic approaches have been developed: the programmer-based approach, where the agent responses are hardwired by a human programmer; the learning-based approach, where the agent learns to control its behaviour from experience or information obtained from a teacher, and the model-based approach, where the agent control is derived automatically from a model describing the goals, the actions available, and the sensing capabilities. In the course, we review the three approaches to developing autonomous systems, with emphasis on the model-based approach, which in AI goes under the name of planning. We study autonomy in dynamic, partially observable settings involving a single agent or multiple agents. The course involves theory and experimentation.

Symbolic Reasoning (6 ECTS) *UPF (obligatory)*
Prof. Jorge Lobo
Knowledge representation and reasoning are essential components of an intelligent system and are at the core of Artificial Intelligence research. The aim of this course is to provide the students with several computational concepts and tools that have been developed in logic programming to support symbolic reasoning. The material covered in the course will interleave the computational concepts of logic programming with applications of the concepts in knowledge representation and problem solving. The students will have the opportunity to learn the general framework of Answer Set Programming (ASP) that interprets logic programs under the Answer Set Semantics to solve tasks such as (1) Defeasible reasoning, (2) Solving combinatorial problems, (3) Solving optimization problems using preferences, (4) Reasoning about actions and change, (5) Developing Web-semantic tools, etc. The course will conclude by introducing basic notions of abduction as alternative framework to statistical machine learning for learning logic programs. Students will have the opportunity to put in practice the topics learned in class by solving simple problems using an ASP environment.

Introduction to Machine Learning (6 ECTS) *UPF (obligatory)*
Profs. Anders Jonsson & Vicenç Gómez
This is an introductory course in machine learning, covering fundamental topics such as supervised learning, unsupervised learning, Bayesian inference and reinforcement learning. The course objective is not only to learn how to apply common machine learning algorithms, but to provide students with sufficient knowledge to carry out research in machine learning or a related field. For this reason, the course describes the basic mathematical formulations that underlie machine learning.

Natural Language Interaction (6 ECTS) *UPF (obligatory)*
Prof. Leo Wanner
The course covers the central themes involved in the interaction with intelligent agents through the use of natural language, with emphasis on dialogue and language generation. We will also study planning techniques applied to the theory of speech acts and the use of rhetorical structures, both for controlled dialogues as for dynamic and non-cooperative dialogues. Regarding analysis and generation of language, students will learn robust and incremental techniques capable of dealing with partial, and even ungrammatical discourse, as it's typical of spontaneous dialogues. We will also look at the design of dialogue architectures, and analyse the use of dialogue in "chatbots" and videogames. The course also covers spoken interaction including aspects on automatic speech recognition, automatic speaker recognition, and text-to-speech synthesis.

Reinforcement Learning (6 ECTS) *UPF (obligatory)*
Prof. Gergely Neu
Reinforcement learning (RL) is a model-based theory of sequential decision-making under uncertainty. It is currently a dominant theoretical framework for understanding and building autonomous agents that can learn and act in the environment on their own. The objective of this course is to introduce students to the main challenges and techniques of modern RL, particularly focusing on computational aspects of dealing with the dynamic nature of the RL problem, and on the statistical challenges posed by the uncertainty of the environment. On both fronts, the goal is to provide a strong understanding of the most common methods and provide a basic algorithmic toolbox for building RL systems. The course puts a strong emphasis on crucial challenges that set RL problems apart from other machine learning problems. Students taking the course are expected to gain the capability to identify and tackle such challenges in various application domains.

2nd semester Courses at Sapienza University of Rome

Human-Robot Interaction (6 ECTS) *Sapienza (obligatory)*
Prof: Luca Locchi
The student will be introduced to the fundamentals of human-computer interaction and to discuss in detail the concept of usability for interactive systems as well as the user-centred design (UCD). The various topics will be examined under different perspectives, dealing with theoretical, methodological, technological and application-oriented aspects, looking at them both in the current scenario and in view of future developments. Along the course, the student should acquire theoretical skills, methodologies, and techniques to be applied in a concrete project to be developed following the user-centred design. In particular, Human-Computer Interaction will be studied in relation to robots.

Artificial Intelligence (6 ECTS) *Sapienza (obligatory)*
Prof: Daniele Nardi
The student will learn about advanced notions of automated problem solving that will be introduced including uninformed search, heuristic search and local search applied to constraints classical planning, partial order planning and hierarchical planning. Topics of knowledge representation and reasoning (then deepened through a specific course) will be provided, in particular propositional logic, first order logic, logic programming, semantic networks and frames, non-monotonic reasoning.

Vision and Perception (6 ECTS) *Sapienza (obligatory)*
Prof: Irene Amerini
The student will be introduced to the fundamental concepts of artificial vision and to the construction of autonomous systems of interpretation and reconstruction of a scene through images and video. In particular, they will acquire the basic elements of projective and epipolar geometry, methods for 3D vision and vision based on multiple views, and methods for metric reconstruction and image and video interpretation methods. Furthermore they will learn the main techniques for the recognition and segmentation of images and videos based on machine learning, applying these techniques through. the Python language and Tensorflow. The student acquires the ability to distinguish between what he can achieve with the tools he/she has learned, such as generating images or recognizing objects using deep learning techniques, and what is actually required for the realisation of an automatic vision system. In this way she/he is able to elaborate a critical judgement on the vision systems available to the state of art and to assess what can actually be achieved and what requires further progress in research.

Internet-of-Things (6 ECTS) *Sapienza (elective)*
Prof: Chiara Petrioli
Students will get the basic skills to design, implement and test a pervasive system, namely a system that allows users to access services of interest always and everywhere. They will study technologies, protocols, functionalities and algorithms to realise a pervasive system capable to provide specific services (e.g. services for mobile users, services for the IoT etc.) subject to the constraints and challenges of the wireless links and the limited resources of the devices connected to form the pervasive system (e.g. energy constraints, mobility, noise, limited CPU power, limited bandwidth, etc.)

Interactive Graphics (6 ECTS) *Sapienza (elective)*
Prof: Marco Schaerf
The students will acquire the basics of 3D graphic programming with particular emphasis on animation and interactive visualisation techniques. In particular, the topics covered include: Fundamentals of computer graphics, interactive rendering and animation, graphics pipeline, transformations, visualisations, rasterization, lighting and shading, texture-mapping, animation techniques based on keyframes, physical simulations, particle systems and animation of characters. An introduction to computing on specialised graphics hardware (GPGU) will also be provided. In order to make the student familiar with the mathematical techniques underlying 3D graphics, as well as the ability to program complex and interactive environments in 3D graphics, the OpenGL library or one of its variants will be introduced in addition to web technologies such as HTML5 and WebGL.

Data management for data science (6 ECTS) *Sapienza (elective)*
Prof: Domenico Lembo and Prof. Riccardo Rosati
Students will be familiar with the basic concepts of managing information systems at large scale. Two specific topics will be investigated in detail, namely information models for Big Data Management, and information integration. Both topics are extremely relevant in the data-driven society, where virtually all information systems of reasonably sized organisations need to both manage large data sets, and to interact with several data sources. After the course the student will have a good knowledge on the differences and similarities between the relational model and the various classes of NoSQL data models. Moreover, the students will understand the theoretical issues in data integration and exchange, and will have a good knowledge about the various architectures of information integration systems.

2nd semester Courses at Radboud University Nijmegen

Machine Learning in Practice (6 ECTS) *RU (obligatory)*
Prof: dr. T.M. van Laarhoven
Machine learning addresses the fundamental problem of developing computer algorithms that can harness the vast amounts of digital data available in the 21st century and then use this data in an intelligent way to solve a variety of real-world problems. Examples of such problems are recommender systems, (neuro) image analysis, intrusion detection, spam filtering, automated reasoning, systems biology, medical diagnosis, microarray genomics, and many more. The goal of this course is to learn how to tackle specific real-life problems through the selection and application of state-of-the-art machine learning algorithms, by entering international machine learning competitions organised at Kaggle.

Physical Attacks on Secure Systems (6 ECTS) *RU (obligatory)*
Prof: dr. Lejla Batina and Ileana Buhan
Our daily business relies on the devices we carry on us, such as bank, ID and transportation cards, car keys, and mobile phones. All those devices use secret (cryptographic) keys that are not accessible from the outside. Getting a hold of the key allows a hacker to steal our data or take control of a self-driving car or a pacemaker. The majority of real-world attacks on security implementations use side-channel analysis, i.e. they measure and process physical quantities, like the power consumption or electromagnetic emanations of a chip, or reaction time of a process.
This course treats security issues for embedded cryptographic devices and attack techniques that often use machine learning and also countermeasures.

Natural Computing (6 ECTS) *RU (obligatory)*
Prof: dr. Elena Marchiori
The field of Natural Computing concerns the development of algorithms inspired by Nature, including Biological, Social and Physical systems. These algorithms draw metaphorical inspiration from various aspects of nature, including the operation of biological neurons, processes of evolution, and models of social interaction amongst organisations. They are used to tackle complex real-world problems. This course provides a description of core Natural Computing approaches, like evolutionary algorithms, immunocomputing and cellular automata, which can be used by the students to tackle a real-world problem.

Applied Cryptography (6 ECTS) *RU (elective)*
Prof: Bart Mennink and Simona Samardjiska
The goal of the course Applied Cryptography is to learn the ideas and workings of public-key and secret-key cryptography as employed in the IT security sector. The course contains an overview description of the most relevant cryptographic concepts, such as encryption, authentication, signature schemes, key encapsulation mechanisms, and cryptographic hashing. Security of these concepts will be discussed. Finally, the course contains a discussion of the use of cryptography in real-world protocols such as TLS.

New Media Lab (6 ECTS) *RU (elective)*
Prof: dr. T. Bosse
The course focuses on designing, building and deploying new media technologies as instruments for conducting research. The research questions addressed stem from different academic fields as well as from industry and range from data collection (e.g. experience sampling), through coaching and behavioural change, up to validation of applications of Artificial Intelligence.The student is expected to follow, in a multi-disciplinary student team, a research cycle consisting of the following steps: Define the research question, target user group, functionality and study protocol; Conceptualize an interactive application, create mock-ups and preliminary walk-throughs; Develop the application, distribute it and implement the study protocol; Conduct and analyse the empirical study using this application. The course will address necessary topics to follow the proposed research cycle.

Intelligent Systems in Medical Imaging (6 ECTS) *RU (elective)*
Prof: Francesco Ciompi
In the first part of the course, students will learn basic concepts of digital image processing, medical imaging, machine learning and deep learning through a series of weekly practical assignments. The second part of the course is dedicated to the development of a CAD system based on deep learning, in the form of a final project, in which teams of students will apply the concepts and techniques learned in the first part of the course, and compete in ongoing grand challenges in medical imaging.

2nd semester Courses at University of Ljubljana

Big Data (6 ECTS) *UL (obligatory)*
Prof: Matjaž Kukar
Introduction to big data. Characteristics of big data. Big data and data science. Relational databases and big data. Distributed data systems. Hadoop ecosystem.Big data management. Structured and semi-structured data models. Non-relational (NoSQL) data models. Data models and database systems for big data. Domain-specific languages for big data. Monitoring big data systems.Big data processing. Querying and retrieval.Paradigms for computing with data. Processing pipelines and aggregators. Basic algorithmic building blocks and patterns. Hadoop. Spark.Data analytics with big data. Data analytics tools. Basic statistics. Clustering. Associations. Predictive modelling. Spark machine learning library MLib.Big data and graph analytics. NoSQL graph databases for big data. Neo4j graph database. Graph querying with CYPHER. Basic graph analytics with Neo4j and CYPHER.Practical aspects of big data analytics. Processing heterogeneous data. Processing data streams.

Machine Learning for Data Science 1 (6 ECTS) *UL (obligatory)*
Prof:Blaž Zupan
Linear models (linear regression, linear discriminant analysis, logistic regression, gradient descent, stochastic gradient descent). The machine learning approach (cost functions, empirical risk minimization, maximum likelihood estimation, model evaluation, cross-validation). Feature selection (search-based feature selection, regularisation). Tree-based models (decision trees, random forest, bagging, Gradient tree boosting). Clustering (k-means, Expectation Maximisation). Non-linear regression (basis functions, splines, support vector machines, kernel trick). Neural networks (perceptron, activation functions, backpropagation).

Project (6 ECTS) *UL (obligatory)*
Prof: Jure Demšar
The main goal of the course is for students to apply the knowledge obtained in other courses on a relevant data science project. The students learn how to select and use the most appropriate tools and approaches to solve a real problem. They learn and practise how to work in groups and how to defend their project outcomes. Students select a project theme and work in groups to complete the project. Students present their midterm progress and results. Students complete the Project with a public presentation of their work. Project themes are compiled by the lecturer from proposals by faculty members and industry.

Network Analysis (6 ECTS) *UL (elective)*
Prof: Lovro Šubelj
The goal of the course is to introduce the basic concepts and methods of network analysis, and to enable the students to perform analyses of network data by themselves.

Natural Language Processing (6 ECTS) *UL (elective)*
Prof: Marko Robnik Šikonja
The course introduces a selection of modern statistical natural learning techniques and their practical use. The lectures introduce the main tasks and techniques, explain their operation and theoretical background. During practical sessions and seminars the gained knowledge is applied to language practical task using open source tools. Student investigate and solve assignments, based on real-world problems form English and Slovene languages.

High Performance Computing (6 ECTS) *UL (elective)*
Prof: Uroš Lotrič
The course will cover the architecture of HPC systems and appropriate software interfaces to use them efficiently, with focus on learning how to make multithreaded programs, OpenMP programs for shared memory systems, exploit general-purpose graphics processing units with OpenCL, and OpenMPI library for working with distributed memory systems. The course will also describe the traps of parallel and distributed systems in order to identify them and find ways to avoid them. The student will familiarise with the typical parallel programming patterns and learn how to use them. The practical part of the course will make use of the Slovenia's supercomputing systems. At the end of the course, the student will be able to select the most appropriate hardware platform and write an efficient parallel program for a problem at hand.