2nd-cycle (Laurea Magistrale) Degree Course
ARTIFICIAL INTELLIGENCE AND DATA ENGINEERING
A.Y. 2019/20

This MSc (*laurea magistralis*) provides a solid in-depth education that enables graduates to design and implement, on one side, systems for efficiently managing large amounts of data and extracting useful knowledge from these data, and, on the other, intelligent systems by exploiting artificial intelligence techniques. This MSc advances the student knowledge portfolio, in both computer infrastructures for intensive data management and methods for data analytics and artificial intelligence. These competences allow graduates to interact with professionals from different backgrounds in various domains and contexts, where data processing is required, as well as to complete their mastering of computer engineering.
Courses are delivered with both lectures and hands-on activities, with particular consideration at emerging applications that aim at processing big data in an efficient manner.

Knowledge requirements (international students)
Knowledge of basic methodologies of computer systems engineering is a mandatory prerequisite. In particular, candidates should be able to demonstrate background in algorithms and programming, operating systems, computer networks, and database systems. Degree Courses in Computer Engineering or Computer Science typically cover this knowledge.

Provisional study plan A.Y. 2019/20
The course schedule per year and semester reported in the following table is provisional, subject to final approval by the University bodies before the opening of the enrollment period.
Each student is bound to present her/his personal study plan to the Board of the Degree Course within one month of enrollment.

YEAR 1 (60 ECTS)

Course	ECTS	Semester
Data Mining and Machine Learning	12	1
Large-Scale and Multi-Structured Databases	9	1
Cloud Computing	9	2
Business and Process Management	9	2
Optimization Methods and Game Theory	6	2
Elective courses from Group A	15	1/2

YEAR 2 (60 ECTS)

Course	ECTS	Semester
Computational Intelligence and Deep Learning	6	1
Process Mining and Intelligence	6	1
Multimedia Information Retrieval and Computer Vision	9	1
Elective Course (free choice)	9	-
Symbolic and Evolutionary Artificial Intelligence	6	2
Final Examination (Thesis)	24	2

GROUP A (15 ECTS AT CHOICE)

Course	ECTS

***Computer Engineering* Area (advanced subjects)**	
Performance Evaluation of Computer Systems and Networks	9
Foundations of Cybersecurity	9
Mobile and Social Sensing Systems	6
Distributed Systems and Middleware Technologies	6
Internet of Things	9
***Computer Engineering* Area (basic subjects)**	
Sistemi Operativi	9
Reti Informatiche	9
Programmazione Avanzata	6
Basi di Dati	9
Algoritmi e Strutture Dati	6
***Information Engineering* area**	
Metodi di formazione e di elaborazione delle bioimmagini	6
Robotica e Macchine Intelligenti	6
***Business Management* area**	
Gestione dell'Innovazione	6
***Business Law* area**	
Diritto dell'Informatica	6
***Mathemathics* area**	
Statistica	6

LEARNING OBJECTIVES BY COURSE

Large-Scale and Multi-Structured Databases (9 ECTS)

Learning objectives: This course aims to provide the theory and practice of modern large-scale and multi-structured database systems. At the end of the course, students understand how a possibly very large set of complex multi-structured data can be managed and stored, and know the principles of several common large-scale data systems including their architecture, performance, and costs.
Language: English

Algoritmi e strutture dati (6 ECTS)

Learning objectives: Methodologies for 1) the object oriented programming, and 2) the evaluation of algorithms complexity.
Language: Italian

Basi di dati (9 ECTS)

Learning objectives: Methodologies for the design and management of data bases, and for query programming.
Language: Italian

Business and Project Management (9 ECTS)

Learning objectives:

- Learn analytical models in the theory of the firm
- Learn models of competitive strategy and strategic management

- Acquire the foundations and the main management tools and techniques in the most important business functions (product development, operations, logistics, marketing, finance and management accounting, quality) in a systemic and integrated way
- Acquire the theory and practice of Project Management
- Develop an integrated offer of digital technologies (HW, SW and systems) as a response to business requirements related to strategic issues and/or business functions, following the use case approach, adopting the most advanced Project Management techniques and developing the proposal for a tender
- Develop entrepreneurial opportunities

Language: English

Cloud Computing (9 ECTS)

Learning objectives: The objective of the course is to teach topics in cloud computing, including also hands-on technical knowledge. Foundation principles of cloud computing and advanced technologies are discussed, covering concepts of the cloud infrastructure as well as cloud platforms. Cloud programming models and practical examples of cloud application deployments are also covered. At the end of the course, students are expected to develop in-depth knowledge of the cloud computing infrastructure and platforms, required to design current and future cloud infrastructures and applications.
Language: English

Computational Intelligence and Deep Learning

Learning objectives: The course aims to offer students the opportunity to learn the basic concepts and methods of computational intelligence, to have a thorough knowledge of the associated computational techniques, i.e., artificial neural networks, fuzzy systems and genetic algorithms, and to know how to apply them to a wide variety of application areas. The further objective of the course is to introduce the main techniques, algorithms and applications of deep learning. Upon successful completion of this course, the student will be able to apply methods of computational intelligence and deep learning techniques to a wide variety of real-world problems and to deal with problems that are difficult or impossible to solve with traditional computational approaches.
Language: English

Data Mining and Machine Learning

Learning objectives: The course aims to introduce the main concepts and techniques used in data mining and machine learning for extracting knowledge from data. In particular, the course will focus on: data preprocessing, frequent pattern mining, sequential pattern mining, classification, prediction, object and graph clustering, outlier detection, data stream mining, distributed data mining. The course will deal in sequence with the following aspects related to data mining and machine learning. Preliminary data analysis and data visualization. Data preprocessing. Frequent pattern mining. Classification. Object clustering. Outlier detection. Graph clustering. Sequential pattern mining. Data stream mining. Frameworks for distributed data mining.
Language: English

Diritto dell'Informatica (IUS/01)

Learning objectives: The course aims at analyzing the impact of Internet and the Web, in connection with the recent developments of Artificial Intelligence, on the legal rules and the use of legal rules to regulate activities and behaviors in the Network, with particular reference to the relations between individuals and companies. Specific attention is given to the Data Protection rules and Big Data legal problems, to B2B and B2C contracts and the circulation of information in the technological society, as well as to torts and breaches of contract in Internet.
Language: Italian

Distributed Systems and Middleware Technologies (6 ECTS)

Learning objectives: The course is aimed at providing students with the proper conceptual and technological tools for the development of modern distributed applications. After the introduction of models, paradigms and algorithms for distributed software, various classes of middleware systems are presented, focusing on the issues they have been designed to deal with. Students will learn to design, implement, and integrate distributed software, possibly made of heterogeneous components; moreover, they will acquire the ability to choose and apply the most suitable middleware solutions to address practical problems in distributed enterprise applications.
Language: English

Foundations of Cybersecurity (9 ECTS)

Learning objectives: The aim of the course it to provide students with the knowledge and related expertise about the basic methodologies for the design and implementation of secure distributed protocols and applications. In particular, the course will present basic methodologies for threat analysis, risk modelling, and secure programming. Furthermore, the course will introduce the main modern cryptographic schemes which the students will learn to correctly use to protect data “at rest” or “in transit” and of which the students will learn to evaluate impact on performance. Concepts will be exemplified by discussing real cases. Students will apply methodologies in hands-on activities.
Language: English

Gestione dell’Innovazione (6 ECTS)

Learning objectives:

- Learn analytical models aimed at understanding the role of innovation in the industrial dynamics of firms
- Develop complex diagnostics and problem solving capabilities applied to business
- Acquire a toolbox of management techniques to manage the innovation process from the initial stage (fuzzy front end, or idea generation) to idea selection, to design, prototyping and testing of new products until the marketing stage (B2C and B2B)
- Learn the theory and practice of management of intellectual property (IP)
- Understand the role of digital technologies in the disruption and redesign of business models.

Language: Italian

Internet of Things (9 ECTS)

Learning objectives: This course aims to provide the theoretical background on the Internet of Things (IoT) and the basic methodologies for developing IoT applications. It enables students to design and implement applications, based on the IoT paradigm, in several application domains, including smart cities, smart buildings, smart energy, smart industry, etc.
Language: English

Metodi di formazione e di elaborazione delle bioimmagini

Learning objectives: Prepare the student to know the methods of reconstruction, filtering and extraction of features applied to biomedical images. The theory will be supported by exercises developed in the matlab environment starting from real and simulated images.
Language: Italian

Mobile and Social Sensing Systems (6 ECTS)

Learning objectives: The course is aimed at providing students with an overview of issues, solutions, methods and technologies related to mobile, wearable and social networking systems. Key principles and ad-

vanced techniques are discussed covering the collection, filtering and analysis of information from both mobile and social platforms, with a specific focus on data from physical and human sensors. At the end of the course, students are expected to develop the knowledge and skills required to design and implement smart applications in a wide range of domains, from personalized e-health to the analysis of social information streams.
Language: English

Multimedia Information Retrieval and Computer Vision (9 ECTS)

Learning objectives: The course aims at providing students with solid background on Multimedia Information Retrieval, Content-Based Retrieval, Similarity Search, Computer Vision, Multimedia Data Mining, leveraging on solutions coming from Artificial Intelligence. Students will understand the challenges and issues related to effectiveness, efficiency, and scalability when dealing with very large (web scale) multimedia collections. The course will cover issues and solutions to Similarity Search, Multimedia Content-Based Retrieval, Object Detection and Recognition, Multimedia Content Analysis and Description, Multimedia Content-Based Indexing, Multimedia Data Mining and Classification, Text Retrieval, Audio retrieval, Scalable Access Methods for Similarity Searching, Deep Learning techniques applied to multimedia.
Language: English

Optimization Methods and Game Theory (6 ECTS)

Learning objectives: The course aims to introduce the basic theoretical concepts and the main algorithmic techniques to solve optimization and game theory problems. In particular, the course will focus on the following aspects: nonlinear optimization theory, local and global optimization methods, applications to Support Vector Machines for solving classification and regression problems, theory and methods for multi-objective optimization problems, non-cooperative games and Nash equilibria, relationships between non-cooperative games and optimization, optimization software.
Language: English

Performance Evaluation of Computer Systems and Networks

Learning objectives: The objective of the course is to enable students to model and analyze computer systems, networks, services, mastering both analytical techniques (specifically, queueing theory) and discrete-event simulation. In order to achieve this, a first part of the course will cover all the prerequisites from applied probability and statistics that are needed for both queueing theory and simulation. A second part will cover the principles of discrete-event simulations, including an analysis of the simulation workflow, data structures used in simulation, random number generation, transient elimination and output data analysis. A third part will explore both the theory and application of queuing theory, covering single-queue systems, and queueing networks.
Language: English

Process Mining and Intelligence (6 ECTS)

Learning objectives: The course aims to provide knowledge and experience essential for developing Process Intelligence (PI) systems. A PI system analyzes a business process or operational workflow, performs a data-driven modeling of complex organizations, with its abstractions and interfaces, its metrics. In this context, the metrics mainly considered are productivity, interpretability, robustness, adaptability, scalability, maintenance costs, modularity, with respect to the complexity of the problem and to the actors involved. Process Intelligence is a modern approach for setting up, simulating, performing, monitoring organization's processes, with goals such as improved productivity, reduced costs, increased agility, integration, interoperability and coordination between actors and systems involved.
Language: English

Programmazione avanzata (6 ECTS)

Learning objectives: The teaching wants to explain the use of high-level programming language to solve software development problems also in presence of concurrency.

Language: Italian

Reti Informatiche (9 ECTS)

Learning objectives: The teaching wants to give a basic knowledge of computer networks, scheduling distributed applications, administration of a network informatics system.
Language: Italian

Robotica e Macchine Intelligenti (6 ECTS)

Learning objectives: The student will have fundamental notions and tools for the analysis, design and development of methodologies and algorithms for motion planning for autonomous robots and for the management of multi-robot systems, in industrial and service applications.
ECTS: 6
Language: Italian

Sistemi Operativi (9 ECTS)

Learning objectives: Basic knowledge of the organisation of multiprogrammed operating systems.
Language: Italian

Symbolic and Evolutionary Artificial Intelligence (6 ECTS)

Learning objectives: This course aims at providing students with a unifying overview about modern artificial intelligence. First of all symbolic artificial intelligence is introduced, along with the depth-first and breadth-first exploration methods. Then the concept of agent is covered, together with the introduction of multiple agent systems as a unifying model of many distributed AI systems regularly used today. In particular, *swarm* and *evolutionary intelligence* are two paradigms based on multi-agent systems, which have proved to be very effective in solving applications that require a distributed approach. The final part of the course is devoted to advanced topics in artificial intelligence, such as: how to speed up deep neuro-fuzzy networks (using novel representations for real numbers and implementing the associated hardware accelerators), design and validation of one-class classifiers, the design of neural networks with infinitesimal or infinite weights, etc.
Language: English

Statistica (6 ECTS)

Learning objectives:

- Learn mathematical foundations of statistics
- Learn and practice the concepts of covariation and correlation
- Develop regression models (linear and logistic) and be able to interpret appropriately the estimates
- Acquire and practice the main multivariate models (factor analysis, principal component analysis, clustering)
- Build and interpret data time series
- Practice R software tools and facilities in order to build up datasets, run appropriate models and analyze data

Language: Italian

Free Activity (9 ECTS)

Learning objectives: Free choice course, to be submitted for approval by the Degree Program Board.