

Informatica Magistrale (2021)

90720 - Usability & User Experience Design

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course the student is able to design, implement and evaluate software systems with respect to the dimensions of practicality, experience, affection, meaning and value that they may have on the target audience. Characteristics such as ease of use, usefulness and efficiency are fundamental for the positive evaluation of the user experience of the system. The student will be able to focus the functional analysis of the software on the characteristics and needs of the target audience, will be able to drive the development process so as to guarantee a constant connection between the technical and implementation features and the expectation of the audience, and will be able to evaluate whether and according to which metrics a software satisfies these expectations.

Course contents

Teaching will be mostly in English (some explanations will be repeated in Italian if needed and when asked). The exam will be allowed in both Italian and English. The course content is divided in distinct parts:

Background The evolution of the discipline from Human Computer Interaction to User Experience Design. A description of its scope: the human, the computer, and their interaction.

Usability analysis and design A systematic discussion of the techniques and standards for the management of the process of user experience design, with particular attention to the phases of usability analysis (with and without the participation of users) and the user- and goal-oriented usability design methodologies.

Guidelines, patterns and methods for usability design A discussion, with historical aspects, of the framework on which the concrete aspects of usability design is based. we will also give strong attention to the problem of usability for web applications and mobile apps.

81941 - Compilers and Interpreters

[PDF](#), [ADOC](#).

Learning outcomes

This course aims at teaching the techniques underlying the construction of compilers and interpreters. We will address the problems for designing high-level programming languages, as well as the tools used to perform syntax-directed translation and to implement execution environments of low-level codes. The techniques that will be described are nowadays used in several areas, whenever it is necessary a syntax-direct analysis of symbolic expressions, of (semi)

structured documents, of domain-specific languages, and their translation into more low-level descriptions. Possible applications range from person-computer interaction to advanced techniques of software engineering, including also the analysis and verification of programs. Furthermore, discussing the issues related to environments where high-level code is translated and executed, we will address specific aspects related to programming languages such as types and the object-oriented programming.

Course contents

Introduction to compilers and interpreters. The ANTLR framework and the corresponding Lexical and Syntactical Analysis. Semantic analysis: symbol table, type checking, static analysis of properties about resource and asset consumptions. Intermediate code generation for standard and advanced features of programming languages. Virtual Machines and Interpreters.

87469 - Decision Making with Constraint Programming

[PDF](#), [ADOC](#).

Learning outcomes

This course covers the fundamental methods in artificial intelligence to model and solve combinatorial problems requiring to take (optimal) decisions in the presence of many complex constraints. Such problems appear often in diverse domains of science, business and industry. The inherent difficulty in solving such practically crucial problems has led to the development of Constraint Programming (CP), an intelligent decision-support technology. A growing number of companies and research institutions worldwide successfully apply CP technology and contribute to its advancement. Skills in this area are therefore in high demand in the job market. The course combines theoretical foundations with practical modelling and solving of realistic problems. At the end of the course, the student has an understanding of the advanced modelling techniques and efficient solution methods, and possesses the necessary skills for modelling in a CP language and solving with a CP solver.

Course contents

Prerequisites: Basic computer science courses such as discrete mathematics, logic, algorithms and data structures, programming. Prior knowledge on artificial intelligence is not necessary.

Course topics

Overview and successful applications of CP

Modeling techniques

Local consistency notions and constraint propagation

Global constraints

Constructive tree search algorithms, search and propagation, branching heuristics, randomization and search restarts

Optimization problems

Constraint-based scheduling

Heuristic search methods

Hybrid CP and heuristic search methods

Advanced topics and hot research topics in CP

81676 - Digital Forensic

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course the students will know the main topics of digital forensics. Moreover, they have used several basic tools to manage some common scenarios: single device (computer, tablet, smartphone) and several kinds of file, networking (wireless and wired), e-mail and social media. The students will know the importance of the chain of custody and also the main procedures to acquire, conserve and analyze the data. The students will know both the importance of the final report and the conceptual instruments for its appropriate drafting

Course contents

Understanding the Digital Forensics Profession and Investigations

The Investigator's Office and Laboratory

Data Acquisition

Processing Crime and Incident Scenes

Working with Windows and CLI Systems

Current Digital Forensics Tools

Linux and Macintosh File Systems

Recovering Graphics Files

Digital Forensics Analysis and Validation

Virtual Machine Forensics, Live Acquisitions, and Network Forensics

E-mail and Social Media Investigations

Mobile Device Forensics

Cloud Forensics

Report Writing for High-Tech Investigations

Expert Testimony in Digital Investigations

Ethics for the Expert Witness

37760 - Systems Simulation

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course students will have acquired methods and tools to design, implement and validate simulation models for the performance analysis and assessment of computer and communication systems and for the analysis of social systems. Students will be able to design, implement and validate simulation models for the analysis and assessment of complex systems.

Course contents

1. classification of systems and models;
2. analytical models: queueing systems and queueing networks;
3. design of simulation experiments;
4. random number generation and random variate generation;
5. discrete events simulazione techniques;
6. design and implementation of simulators and simulation tools;
7. input and output data analysis;
8. verification, validation and testing of simulation model;
9. parallel and distributed simulation;
10. simulation and machine learning;
11. introduction to agent based simulation;
12. analysis and evaluation of complex systems.
13. Introduction to Virtual Reality.
14. VR experience with HTC technology

90749 - Teaching Tools for Informatics

[PDF](#), [ADOC](#).

Learning outcomes

The aim of the course is to provide the student with the knowledge of techniques and tools supporting the didactics of Computer Science. In particular, at the end of the course, the student will know how to organize and realize Computer Science courses, as well as the methodologies for generating didactic materials and for the verification of student learning.

Course contents

Learning objectives of this course include:

- knowledge of some historical, epistemological and ethical aspects of Computer Science as a scientific discipline and of the motivations underlying the necessity of its teaching;
- understanding of pedagogical aspects and learning theories in the context of computer science teaching;
- knowledge of multiple CS-specific teaching approaches;
- knowledge of the main cognitive difficulties in learning CS (with particular focus on programming), and knowledge of possible strategies to adopt to overcome them;
- ability to formulate and manage learning paths consistent with national standards and curricula related to Computer Science in schools of all levels;
- planning ability to organize laboratories, classroom equipment; ability to integrate students' devices as useful tools for learning.

Topics covered in the course include:

The scientific vision of Computer Science.

Computational Thinking.

Constructivism and constructionism applied to CS teaching.

Top-down and bottom-up approaches in CS teaching.

Teaching of Programming, Algorithms and Data Structures.

Pedagogical implications in the choice of programming languages.

Teaching of technological aspects: computer architecture, operating systems, networks.

CS teaching methods:

- unplugged
- dramatization/visualization
- code reading exercises
- debugging of others's code
- program execution visualization
- making/tinkering
- repositories as software museums

Difficulties and misconceptions in learning to program.

Creation of learning paths

- in primary schools
- in lower secondary schools
- in scientific lyceums - applied sciences
- in specific courses of technical institutes
- in other upper secondary schools

Assessment methodologies of computer programs.

Importance, planning, and management of computer laboratories.

- Use of BYOD in lessons.

Software licenses: libre (free and open source) and proprietary software: implications in education

Affective and motivational aspects in computer science learning.

77803 - Service - Oriented Software Engineering

[PDF](#), [ADOC](#).

Learning outcomes

The aim of the course is to provide insight into analysis, design and implementation of complex software systems using an approach based on process and service abstractions. The course will tackle, from both a design and a technical point of view, enterprise architectures based on services (SOA) and resources (REST API), and it will describe how they can support business processes.

Course contents

Service-oriented architectures (SOAs) are used to build large software systems that operate across multiple organizations (as is the case in the enterprise environment) but also as a basic structure to

build flexible and extremely scalable applications (as in the case of microservices).

Designing this class of systems and reasoning about their properties requires the use of appropriate abstractions and modeling techniques.

In this course we will see how service and process abstractions can interoperate to describe complex distributed systems and we will see modeling techniques based on these abstractions that help design them.

We will learn how to model processes (using BPMN), services (using UML) and how to model the interaction between processes and services and between different services through choreographies.

We will see how to exploit these techniques to design applications adhering to the service-oriented architectural style both across-enterprises and through microservices (also by adopting specific patterns).

We will also see in practice the protocols and the technologies that can be used for their implementation; in particular for the technologies to support web services we will see SOAP / WSDL and the RESTful style; for microservices we will see the use of containers (eg Docker), microservice orchestrators (eg Kubernetes), service meshes (eg Linkerd) and serialization technologies (eg Protobuf). As far as microservices are concerned, we will try in particular to understand the strengths and weaknesses of this class of applications and we will understand how to build systems that are both scalable and reliable.

To facilitate the prompt realization of examples of some of the technologies related to web services as they are introduced, we will use the Jolie language which allows rapid prototyping of SOA solutions.

Below is a list of the main topics of the course:

Enterprise software systems

Enterprise architecture and modeling

Business Process Management and BPMN

SOA / Choreography Web services (SOAP / WSLD / RESTful)

Microservices properties, design, patterns and implementation

Jolie

66870 - Concurrent Models and Systems

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course, the student will learn the basic ingredients of concurrency theory, their

models and verification systems on such models. (S)He will be able to analyze simple concurrent programs with automatic or semi-automatic tools.

Course contents

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Introduction to concurrency and to the problem of the correctness of reactive systems design.

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Labeled transition systems

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Behavioral equivalences: traces, simulation, bisimulation (strong and weak), properties.

- The language CCS: syntax and SOS semantics.

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Subclasses of CCS: finite processes, finite-state processes, regular processes, BPP, finite-net processes, finitary CCS.

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Turing completeness of finitary CCS; undecidability of behavioral equivalences of finitary CCS.

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Value-passing CCS.

- Algebraic properties, behavioral congruences and axiomatizations.

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Expressiveness of CCS: encodability of additional operators (internal choice, hiding, sequential composition)

- The problem of multi-way synchronization: Multi-CCS; case study: dining philosophers.

- Petri nets: definition, equivalences, decidable properties, expressiveness.

- Languages for representing Petri nets. Distributed computability.
- Fixpoint theory, least and greatest fixpoints, strong bisimilarity

as a greatest fixpoint.

- Hennessy-Milner Logic (HML), extension with recursively defined

formulae, modal mu-calculus.

- Analysis and verification tools for CCS and HML:

Concurrency Workbench (CWB).

- Modeling, analysis and verification of some mutual

exclusion algorithms with CWB.

84401 - Context-Aware Systems

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course, the student is able to design, deploy and evaluate ubiquitous systems and mobile applications able to adapt their behaviors to the context characteristics and to the current location/activity of the user. At the end of the course, the student: -knows the fundamental concepts of context-aware computing, and the main techniques for the localization of users/devices and the human activity recognition; -knows the fundamental models of context-data representation and managing; - knows the main middleware and software architectures in order to deploy adaptive and ubiquitous applications and services

Course contents

The course addresses the design and deployment of ubiquitous and context-aware services and applications, made possible by the pervasive diffusion on the market of devices able to sense the environment and to analyze the sensed data. The course program is structured in two main parts. The first part illustrates the definition of "context" and context-aware systems, focusing on the design and implementation of location-aware, activity-aware, emotion-aware and social-aware systems. Special focus will be given to the spatial data management, by illustrating the main technologies for indoor/outdoor positioning, mapping APIs, geo-data storage and location intelligence. The second part will present the lifecycle of context-aware systems, focusing on methods and technologies for context acquisition, context modeling and context reasoning. Business seminars will be scheduled during the last week of the course. In the following, we provide a brief summary of the course program:

Introduction and definition of context and context-awareness

Use case of context-aware systems

Location-aware systems

Location-based services

Positioning technologies

Mapping APIs

Spatial database

Location intelligence

Activity-aware systems

Emotion-aware systems and affective computing

Context-aware networking and SDN

Context-aware application components

Context acquisition via primary and secondary sensors

Context modeling (context graphs, context languages, web semantic approaches)

Context reasoning via learning-based or inference-based approaches

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23762 - Physics of Complex Systems

[PDF](#), [ADOC](#).

Learning outcomes

Basic knowledge of physical and mathematical methods to develop dynamic and statistical model for the study of complex systems. Basic knowledge of graphical methods 2D and 3D used to illustrate the results.

Course contents

Complex system definition. Role of non-linear interactions.

Simple theoretical and numerical models for complex systems.

Examples from Physics, economy and biology.

Data distribution: comparison between exponential and power laws.

Agent, neural network and cellular automata models.

Numerical solution of ordinary differential equations (ODE) with errors evaluation. Numerical

solution of partial differential equations (PDE) with errors evaluation. Consistency, stability and convergence. Second order linear PDE: wave, heat and Laplace equation.

Solution visualization and animation. Introduction to OpenGL.

Final C++ project with OpenGL graphics.

30214 - Logical basis of Computer Science

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course, the student knows the logical and formal basics of computer science. More specifically, the lambda-calculus and its theory, the correspondence between programs and proofs, the typed lambda-calculus, system T and system F. He or she can write simple numerical functions in the lambda-calculus, and derive their types.

Course contents

First module:

1. Propositional and First-Order Logic (recall)

Syntax, Semantics, Soundness and Completeness, Undecidability of First Order Logic

1. Untyped Lambda Calculus

Syntax and operational semantics. The lambda-calculus as a programming language: evaluation strategies and encodings of data types; Turing completeness

1. Meta-theory of untyped lambda calculus

Confluence; Bohm's separation theorem

1. Simply typed lambda-calculus and Curry-Howard isomorphism

Curry's style and Church's style syntaxes. Isomorphism with propositional minimal logic. Type checking and type inference algorithms.

1. Meta-theory of simply typed lambda-calculus

Weak and strong normalization theorems

1. Curry-Howard isomorphism and extensions to the typing system

Products and coproducts, empty and singleton types. Parametric polymorphisms (System-F). Dependent types and Hindley-Milner polymorphisms.

Second module:

1. Logic and Databases

Relational algebra, FO as Query Language, Cylindrical Algebras, Implementation aspects

1. Logic and Computational Complexity

Finite structures and decision problems. NP and PSPACE characterization via first order logics. SAT Solving.

1. Logic and Artificial Intelligence

Epistemic logic: syntax, semantics, applications

1. Logic and Formal Methods

LTL and CTL: syntax and semantics. Reactive systems and their verifications. Model Checking.

30216 - Probability Models

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course the student knows some advanced probability theories with application to computer science, such as Markov chains with discrete and continuous time. He is able to analyze some simple stochastic systems such some with application to biology.

Course contents

Prerequisites: course of calculus, linear algebra, initial course of probability-

Denumerable additivity. One-dimensional random walk. Generating

function. Gamblers' ruin problem. Galton Watson processes. Markov

chains. Recurrent and transient states. Stationary distributions. Reversible Markov chains. Gibbs sampler. Metropolis algorithm. Markov chains with continuous time. Poisson process. Pure birth

processes. Semi-Markov processes. Queueing processes. Queueing

Markov processes.. Open and closed systems of queues. Jackson's

property.

70090 - Computer Graphics

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course, students know fundamentals of 3D computer graphics (polygonal modeling and real-time rendering).

In particular, they are able to model and render scenes making use of suitable open source softwares and libraries.

Course contents

Raster-scan systems, I/O devices, graphics libraries, event-driven programming. 3D mesh and graphics representation. 2D/3D geometric transformations, viewing transformations, perspective and parallel projections, window-viewport transformations. Graphics pipeline. Real-time rendering, algorithms with hidden parts removal (hidden lines and hidden surfaces), illumination models and shading algorithms (Z-buffer), texture mapping. 3D polygonal models, curves and surfaces in parametric form, geometric modeling with spline and rational spline (NURBS) curves and surfaces, geometric modeling tools. The course provides a practical part where JavaScript programming language and WebGL/GLSL (C/C++ programming language and OpenGL/GLSL) graphics libraries will be used.

12569 - Computational Mathematics

[PDF](#), [ADOC](#).

Learning outcomes

At the end of this course, the student is aware of techniques for the solution of scientific calculus problems. She/He can face and solve such problems within a uniform, integrated computer algebra environment.

Course contents

Introduction to the Mathematica environment. Kernel, FrontEnd, and Notebook.

Introduction to programming within Mathematica.

Graphics and visualization tools.

Employing the system capabilities to analyze and solve a

particular applied problem, of didactical interest to the student, via a

package development.

90748 - Blockchain and Cryptocurrencies

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course, the student knows the relevant themes related to blockchain technologies, cryptocurrencies, smart contracts and novel applications that can be built over the blockchain. The student is able to develop simple smart contracts that can be deployed on a blockchain.

Course contents

Bitcoin and novel cryptocurrencies gathered momentum in the last months. More and more investors look with interest at these technologies, while others label them as a dangerous speculative bubble. The truth is that the blockchain, and the alternative implementations of a distributed ledger, represent very interesting technologies, that can be exploited to build novel distributed applications. The underlying building blocks are related to many concepts and research areas of computer science in general. This course will illustrate the main principles and conceptual foundations of the blockchain and the Bitcoin network.

Program

Introduction to peer-to-peer systems

Overlay topologies and decentralization

Introduction to Crypto and Cryptocurrencies

The blockchain: how to achieve decentralization

Transactions and transaction scripting languages

Mining

Attacks to the blockchain

Anonymity

Smart contracts

81943 - Complex Systems & Network Science

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course, the student will have acquired the basic notions of complexity as it arises through interactions among simple agents in nature and in modern computing systems. The student will be able to identify, formulate, model and analyze new problems using the mathematical framework of dynamical systems and network science.

Course contents

Description: Modern information systems and services often rely on large numbers of independent

interacting components to provide their functions. Under certain conditions, the behavior that results from these interactions can be unexpected and surprising. Complexity Science is an interdisciplinary field for studying global behaviors resulting from many simple local interactions in an effort to characterize and control them. Networks allow us to formalize the structure of interactions. They play a central role in the transmission of information, transportation of goods, spread of diseases, diffusion of innovation, formation of opinions and adoption of new technologies. Network Science is an interdisciplinary field for studying the interconnectedness of modern life by exploring fundamental properties that govern the structure and dynamic evolution of networks.

Contents: Complex systems: definitions, methodologies; Dynamical systems, Nonlinear dynamics; Chaos, Bifurcations and Feigenbaum constant, Predictability, Randomness and Chaos; Models of complex systems, Cellular automata, Wolfram's classification, Game of life; Autonomous agents, Flocking, Schooling, Synchronization, Formation creation; Cooperation and Competition, Game theory basics, Nash equilibrium; Game theory: Prisoner's Dilemma, Coordination games, Mixed strategy games; Adaptation, Evolution, Genetic algorithms, Evolutionary games; Network Science: Definitions and examples; Graph theory, Basic concepts and definitions; Diameter, Path length, Clustering, Centrality metrics; Structure of real networks, Degree distribution, Power-laws, Popularity; Models of network formation; The Erdos-Renyi random model; Clustered models; Models of network growth, Preferential attachment; Small-world networks, Network navigation; Peer-to-peer systems and overlay networks; Structured overlays, DHTs, Key-based routing, Chord; Distributed network formation: Newscast, Cyclon, T-Man; Processes on networks: Aggregation; Rational dynamics: Cooperation in selfish environments, Homophily, Segregation; Diffusion, Percolation, Tipping points, Peer-effects, Cascades.

Prerequisites: Basic notions of computer system architecture, computer networks, operating systems, and probability theory.

90733 - Data Analytics

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course, the student: (i) is aware of different types of data-analytics (diagnostic, predictive, prescription, etc) and of the main enabling techniques; (ii) is able to design and implement a full data-pipeline process, from the data acquisition until the data analysis and valorization; (ii) knows the main applications of data analytics, with a special emphasis on industrial and business applications.

Course contents

The course introduces concepts, techniques and tools for the design and implementation of data valorization and analytics processes. To this purpose, the course aims at providing an exhaustive illustration of all the stages of a digital data pipeline, from the data acquisition, pre-processing and knowledge extraction through statistical and Machine Learning techniques, to the data visualization and performance evaluation. In addition, it discusses state-of-the-art applications of the data-analytics on business use-cases and on technological scenarios characterized by high

industrial impact, and enabled by the availability of big-data (e.g. IoT and Industry 4.0). After a brief recap of Python programming concepts (including the libraries for the data processing), the course illustrates -in sequence- each stage of the data-pipeline. More in detail, we review the essential techniques of data acquisition (data querying, APIs, Web scraping, etc) and the main architectures of data streaming and pipelining (e.g. AWS DP). At the next stage, we illustrate the pre-processing techniques for data filtering/cleaning, feature selection/transformation, dimensionality reduction. We then present the most common techniques of data visualization, aimed at showing the outcomes but also at supporting the design choices of the analytics process, as well as their relative implementations through Python library. A key component of the data pipeline, and hence of the course, is constituted by the illustration of techniques for automatic knowledge extraction from the datasets; to this purpose, we present in detail the most used techniques of Data Mining/Machine Learning, based on Supervised/Unsupervised approaches, and their implementations through Python frameworks (e.g. Scikit Learn, PyTorch). Finally, we address metrics and methodologies for the performance assessment of the data analytics process. We conclude the course with seminars on relevant applications of the data-analytics in business/industrial use-cases, by envisaging the participation of external companies working on the field. In the following, we list the course contents discussed so far:

Recap of Python programming and Python libraries for data science (Pandas, Numpy, etc)

Stages of the data-pipeline:

Data acquisition: techniques and architectures

Data pre-processing: cleaning, transformation, dimensionality reduction, feature extraction, etc

Data visualization: markers and channels, separability, graph types

Modeling

Base concepts (classification vs regression, overfitting vs underfitting, generalization, regularization, etc)

Supervised approaches (e.g. KNN, SVM, introduction to neural networks)

Unsupervised approaches (e.g. k-Means, Gaussian Mixture model)

Performance analysis: metrics, evaluation methods, hyperparameters optimization

Data analytics applications in business/industrial use-cases

90747 - Corporate Social Responsibility and Business Ethics

[PDF](#), [ADOC](#).

Learning outcomes

The aim of the course is to present the fundamental theories that deal with (i) the role of companies in society and the meaning to be assigned to profits and to share value, (ii) with the relationships with stakeholders and (iii) with the business ethics. Specifically, the objective of the course is to achieve a level of knowledge that allows students to interpret the transformations taking place in the relationship between business and society as the consequence of the evolution of information technology. The course is articulated in two sections. A first section introduces the theoretical background while, in a second section, the economic and socio-political role played by companies such as Google, Facebook e Amazon will be analysed.

Course contents

Introduction to business ethics

Corporate Social Responsibility

Stakeholder theory

Normative ethical theory

Descriptive ethical theory

Tools and techniques of business ethics management

91721 - Laboratory of Virtual Reality and Advanced Reality

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course, the student knows the fundamental theoretical principles, the hardware and the main software platforms required to design and create virtual and augmented reality environments. Furthermore, the student acquires the skills necessary to design, create, modify and interact with such environments

Course contents

Introduction to Augmented and Virtual Reality (AR/VR)

Principles: Computer Graphics in AR/VR

Principles: Perception and Human Factors (Designing and developing 3D UI: strategies and evaluation)

Principles: Interaction in AR/VR (Selection and manipulation, Travel, Navigation, Way finding, System control, Symbolic input)

Hardware: Output (Visual, Auditory, Haptic, Vestibular, and Olfactory Channels)

Hardware: Input (Tracking Systems, Input Devices)

VR contents (Standards and Designing)

Software: Platforms (Introduction, VR runtime systems, Real Time Physics Engines, Distributed Virtual Environments, Collaborative Virtual Environments, Game Engines)

Mixed Reality (Mixed Reality Continuum - AR to VR, Mixed Reality Technologies)

Applications of AR/VR

Future of AR/VR

Exercises/Demonstrations

91258 - Natural Language Processing

[PDF](#), [ADOC](#).

Learning outcomes

At the end of this course, the student acquires foundational notions about Natural Language Processing with particular attention at the statistical/algorithmic techniques. The methods and instruments from Natural Language Processing will be then applied at each level of linguistic analysis.

Course contents

Part I: Foundations

Introduction

Natural Language Processing - Problems and perspectives

Introduction/Recall to/of probability calculus

N-grams and Language Models

Markov Models

Recurrent Neural Network Language Models

The evaluation of NLP applications

Corpora

Corpora and their construction: representativeness

Concordances, collocations and measures of words association

Methods for Text Retrieval

Part II: Natural Language Processing

Computational Phonetics

Speech samples: properties and acoustic measures

Analysis in the frequency domain, Spectrograms

Applications in the acoustic phonetic field.

Speech recognition with HMM and Deep Neural Networks

Computational Morphology

Morphological operations

Static lexica, Two-level morphology

Computational Syntax

Part-of-speech tagging

Grammars for natural language

Natural language Parsing

Supplementary worksheet: formal grammars for NL

Formal languages and Natural languages. Natural language complexity

Phrase structure grammars, Dependency Grammars

Treebanks

Modern formalisms for parsing natural languages

Computational Semantics

Lexical semantics: WordNet and FrameNet

Word Sense Disambiguation

Word-Space models

Logical approaches to sentence semantics

Part III: Applications and Case studies:

Emotions and Sentiment in Speech and language

Topic modelling

(Automatic detection of Prosodic Prominence)

(Stylometry and Dialectometrics)

90730 - Social Network Analysis

[PDF](#), [ADOC](#).

Learning outcomes

The course is meant to examine the essential models, methods and topics of social network analysis, while also comprehending information networks, where more generally nodes and links represent respectively data and relations between data. The first half is devoted to those analytical methods based on the comparison between real-world networks and random graphs, with emphasis on the configuration model and modularity clustering. The second half is devoted to objective function-based methods and to fuzzy models for community/module detection, with focus on the cluster score of vertex subsets quantified by pseudo-Boolean functions.

Course contents

The programme is the same for both attending and non-attending students:

Introduction to Network Analysis, gentle introduction to the field of network analysis and its usages in other fields of research (e.g., computer science, forensics, archeology, literature, history, science of religion, etc.).

Research Design and How to Read a (Network Analysis) Research Paper: introduction to the scientific publication process, elements of research papers (on network analysis), research design, analysis of research papers.

Mathematics of Networks: networks and their representation, types of networks, graph representations, paths and components, adjacency matrices and matrix representations, ways and modes, operations on Matrices.

Data Collection and Data

Management: network questions, data collection and reliability, data formats and transformation, algorithms and software for network analysis and visualisation.

Measures and Metrics, Nodes: kinds of measures, multi-category nominal scales, ordinal and scalar measures, centrality, degree and other kinds of centrality (e.g. Google's PageRank), hubs and authorities, closeness and betweenness centrality, groups of nodes (cliques, cores, components and k-components), clustering and clustering coefficients, reciprocity and similarity, structural and other types of equivalence, homophily and types of assortative mixing.

Testing Hypotheses: the role of hypotheses in the scientific method, testing hypotheses in network analysis, permutation tests, dyadic hypotheses.

Ego Networks: ego networks, obtaining and analysing ego-network data, tie analysis, structural-shape measures.

Measures and Metrics, Networks: small-world effects, degree distribution, power laws and scale-free networks, visualisation and properties of power-law distributions, local-clustering coefficient, cohesion, reciprocity, transitivity and the clustering coefficient, triad census, centralisation and core-periphery indices, centrality, random graphs, means on edges and degree, degree distribution, giant and small component(s), locally tree-like networks.

**Dividing Networks into Groups:
dividing networks into groups,
modularity maximisation, methods
based on information theory,
methods based on statistical
inference, betweenness-based
methods (dendrograms),
hierarchical clustering, overlapping
communities, hierarchical
communities, latent spaces,
stratified networks, and rank
structure, percolation and network
resilience, uniform and non-
uniform (random) node removal.**

Network Visualisation: the importance of network visualisation, graph-layout algorithms, embedding node attributes, node filtering, visualising ego networks, embedding tie characteristics, tie strengths, visualising network change.

Handling Large Networks: reducing the size of the problem, eliminating edges, pruning nodes, divide and conquer, aggregation, sampling, small-world and scale-free networks.

93478 - COMPUTER VISION

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course the students will be able to implement algorithms addressing relevant computer vision tasks, such as: object detection, semantic segmentation, image and video captioning. During the course they will learn the basics of image, video analysis and computer vision. They will gain knowledge about the design and implementation of convolutional neural

networks, recurrent neural networks and how to combine them. During the course they will also acquire familiarity with the relevant frameworks used to design modern deep architecture.

Course contents

The course introduces concepts, and tools for the design and implementation of image/video acquisition, processing, and analysis techniques.

The first part of the course will focus on the fundamental concepts related to the image formation and acquisition process, such as: geometry of image formation, pinhole camera model, perspective projection, projective coordinates and perspective projection matrix, camera calibration, image rectification.

Then it will focus on the extraction of hand-crafted features and their matching: edges and corners, detectors and descriptors, scale invariant features, SIFT features, efficient feature matching, image stitching, bag of visual words.

The second part of the course will focus on modern deep learning architectures proposed for:

- object detection (two-stages, one-stage, and anchor-free detectors, RoI pooling operator, feature pyramid networks)
- semantic segmentation (fully convolutional networks, transposed and dilated convolutions, RoI Align operator, architectures for semantic, instance, and panoptic segmentation)
- self-attention (transformer architecture, vision transformer, data-efficient image transformer)
- metric learning (deep metric learning, contrastive and triplet losses, multi-task learning, application to different recognition/identification tasks)

81678 - Laboratory of Making

[PDF](#), [ADOC](#).

Learning outcomes

At the end of this course students will be able to design and create digitally enabled "things" consisting of single board computers, sensors and actuators. They will be also able to study and implements all the software components needed by their "things" to interface peripherals, to process data and to communicate/interoperate.

Tools to create physical objects will be studied in this course as well, both additive and subtractive manufacturing methods. The students will learn how to implement innovative software for CNC-like machines (3D printers, CNC mills, laser cutters, etc).

In this way a student can design physical and digitally enabled objects and tools from blueprint to prototype. Such "digital craft working" professionals can provide original solutions for both practical and artistic challenges.

Subjects of the course will also be the design and development of teaching methods for computer

Science based on Making, and Making as a problem solving paradigm.

Course contents

Makers and Making.

Digital Revolution, Internet, Second Renaissance and Third Industrial Revolution.

Basic knowledge of digital electronics and concepts of analogic electronics.

Microcontrollers, microprocessors, SoC and single-board systems.

Concepts of Hardware description languages (for FPGA and ASIC).

Development Systems.

Sensors, actuators and bus standards to interface them.

Protocols and Data formats for CNC.

Internet of things and internet of threads

Wireless Systems for makers

Applications: Home automation, education, music, drones, meteorology, automotive, ham radio, fun.

91269 - Multimedia Data Management

[PDF](#), [ADOC](#).

Learning outcomes

The course aims to provide the knowledge and skills necessary for the effective and efficient management of multimedia (MM) data, with particular attention to the problems of MM data representation, MM data retrieval models, and interaction paradigms between the user and the MM system (both for purposes of data presentation and exploration). We first consider architectures of traditional ("standalone") MM systems; then, we concentrate on more complex MM services, by primarily focusing on search engines, social networks and recommendation systems.

Course contents

Basics on Multimedia Data Management

Multimedia data and content representations

MM data and applications

MM data coding

MM data content representation

How to find MM data of interest

Description models for complex MM objects

Similarity measures for MM data content

MM Data Base Management Systems

Efficient algorithms for MM data retrieval

MM query formulation paradigms

Sequential retrieval of MM data

Index-based retrieval of MM data

Automatic techniques for MM data semantic annotations

Browsing MM data collections

MM data presentation

User interfaces

Visualization paradigms

Dimensionality reduction techniques

Result accuracy, use cases and real applications

Quality of the results and relevance feedback techniques

Use cases and demos of some applications

Multimedia Data on the Web

Web search engines

Graph-based data: semantic Web and social networks

Web recommender systems

N.B. For students of the second cycle degree programmes (LM) in Artificial intelligence and Computer Science, the "Efficient algorithms for MM data retrieval" part of the program is not required.

81613 - Business Intelligence

[PDF](#), [ADOC](#).

Learning outcomes

The students is expert in the design, implementation and information systems management for intelligence of decisions that melt on the management knowledge of analytical nature. The second part (30 hours) of the course is developed in the computing laboratory using the system language of SAS System and SAS Enterprise Miner. At the end of the course, the student knows: - Customer relationship management (CRM) and Customer Intelligence; - Problems of evaluation of the advertising impact; - Oriented information system implementation for the analytical approach to the Business Intelligence; - Software realization for Analytical Business Intelligence projects and statistical data mining.

Course contents

Supervised and unsupervised classification Multivariate analysis:

principal component analysis, correspondence analysis, discriminant analysis

86658 - Soft Skills to be Effective at Work - Bologna 1

[PDF](#), [ADOC](#).

Learning outcomes

The course aims to develop students' awareness concerning the importance of soft skills in work contexts and the most suitable strategies for their enhancement and/or consolidation among university students. These skills, in fact, represent essential means, combined with the knowledge and specific skills of the scientific fields chosen by the participants, to tackle efficiently the challenges involved in their future career path, as well as the steps essential when entering the labour market (for instance, during the recruitment procedure).

Specific aims: The aims of this course already described correspond to the following specific purposes:

Becoming aware of the role played by soft skills when entering the labour market;

Recognizing one's soft skills and their suitability to different contexts and situations;

Developing the ability to assessment one's soft skills;

Promoting the development and/or enhancement of one's soft skills;

Developing the ability to define a specific plan aimed at fostering those skills that seem to be weaker on inadequate.

Course contents

The course consists of three lessons (4 hours each).

Through the implementation of an active teaching method, based on team works requiring the translation of soft skills in order to face concrete situations similar to typical job search activity (for example, tackling job interviews and in-basket exercises).

Specifically, these exercises will be focused on three areas of expertise:

To read/understand each situation, which includes the ability to gather information/data that allow to analyse and interpret circumstances and relationships, to process this information/data in order to identify a proper solution;

To address/solve the situations, including the ability to plan, manage and implement a targeted action plan, the ability to make consistent decisions and to effectively manage changes. This area of expertise is further developed through the MOOC named "Change management";

To collaborate, which includes the ability to present oneself, to work within teams, to interact effectively with others, being aware of inter-individual dynamics and conflict management. This area of expertise will be strengthened also with the MOOC named "Conflict management".

The activities in class (integrated by MOOCs) address specific areas of expertise. Moreover, students will attend a e-learning platform (this activities will take above 6 hours) aimed at encouraging involvement, active participation, awareness of the importance of soft skills for work placement and the ability to self-evaluate one's own skills.

This e-learning activity will be defined in the following specific contents:

Presentation and description of the role of soft skills through the interviews with different figures pertaining to the labour market (e.g., HR Directors of large companies);

Self-assessment of one's soft skills;

Integration of this self-assessment activity with classroom activities, participation in MOOCs and the outputs of online questionnaires;

Summary of one's soft skills. This profile will allow photographing the skills already developed, those that should be enhanced, and a detailed description of a plan aimed at strengthening those skills emerged as critical for job placement activities and/or accessing advanced training courses.

The topics will be analyzed/presented in terms of inclusive industrialization, multiculturalism, innovation and diversity management too, as indicated by the UN Sustainable Development Goals.

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73387 - Creativity and Innovation M

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course the student will gain knowledge of the following topics. Learnings from the history of science. Theoretical foundations of creative thinking. Cognitive modelling. The DIMAI model. Strategies and processes for specific thinking stages. Innovation: hurdles and strategies for success. Application to study cases.

Course contents

- 1) The necessity for creativity and its definition
- 2) Creativity in the history of art and science.
- 3) Theoretical foundations of creative thinking. Cognitive modelling.
- 4) The Da Vinci thinking model. Strategies and processes for specific thinking stages.
- 5) Application of creative thinking to study cases.

86716 - Entrepreneurship - Bologna

[PDF](#), [ADOC](#).

Learning outcomes

The main aim of the course is to give a practical orientation to entrepreneurship through the development of the personal capabilities, leadership and the supply of operational and conceptual tools for the launching of an entrepreneurial innovative venture.

Course contents

Entrepreneurship and leadership

Business Model Canvas: how to develop your business idea

Principles of Marketing and Brand Management

Public Speaking and pitch: how to present a project

Project Management: basic principles

Corporate and social: B corp and benefit companies.

Women's businesses

How to be supported and what are the initiatives they support and the UNIBO ecosystem.

86212 - Italian language Lab L1 - E-learning

[PDF](#), [ADOC](#).

Learning outcomes

At the end of the course students: recognize constitutive elements of a «text» (coherence, cohesion, etc.); summarize and rewrite an argumentative text; organize ideas and informations with a concept map; use dictionaries (monolingual, synonyms); use readability testing tools.

Course contents

The text;

writing as a process;

punctuation;

dictionaries;

readability testing tools.

86673 - Soft Skills to be Effective at Work - Bologna 3

[PDF](#), [ADOC](#).

Learning outcomes

The training course on soft skills aims to create awareness of the importance of soft skills in working contexts and the most appropriate strategies for their development and/or consolidation in university students. These skills are actually essential means, in combination with the specific knowledge and skills of the disciplines in which participants have chosen to specialize, to deal as effectively as possible with the challenges of their future profession and, even before, the steps functional to the entry into the world of work (for example, selection procedures).

Specific Objectives:

The objectives of the course already described are declined in the following specific objectives:

Acquire awareness of the value of soft skills for job placement

Recognize soft skills and their applicability to different contexts and circumstances

Develop the ability to self-assess their soft skills

Encourage the acquisition and/or enhancement of soft skills

Acquire the ability to accurately define an action plan aimed at developing the weakest skills

Course contents

The five classes (18 hours) will be focused on the following three areas:

Analysing/understanding the situation, which includes the ability to gather information/data, to analyse and interpret circumstances and relationships, and to process this information/data in order to identify a proper solution;

Addressing/solving the problems, which is the ability to plan, manage and implement a targeted action plan, to make consistent decisions and to effectively manage changes. This area is further developed through the attendance of the MOOC named "Change management";

Collaborating/interacting with others, which includes the ability of self-presentation, working within teams, interacting effectively with others, being aware of inter-individual dynamics and conflict management.

Moreover, students will be involved in e-learning activities (duration: 6 hours) aimed at encouraging active participation, self-awareness and self-assessment of the soft skills and their importance for job placement.

This e-learning activity will include:

Videos of some interviews with different figures (e.g., HR Directors of large companies) of the importance of soft skills to achieve in the laboru market;

Questionnaires for soft skills self-assessment;

Exercise for reflecting on classroom activities, participation in MOOCs and output of online questionnaires;

A development plan to fill for describing the soft skills ownened, discussing personal career goals and action plans for strengthening the soft skills emerged as crucial for job placement and/or accessing advanced training courses.

The topics will be analyzed/presented in terms of inclusive industrialization, multiculturality, innovation and diversity management too, as indicated by the UN Sustainable Development Goals.

86675 - Soft Skills to be Effective at Work - Bologna 4

[PDF](#), [ADOC](#).

Learning outcomes

The course aims to develop students' awareness concerning the importance of soft skills in work contexts and the most suitable strategies for their enhancement and/or consolidation among university students. These skills, in fact, represent essential means, combined with the knowledge

and specific skills of the scientific fields chosen by the participants, to tackle efficiently the challenges involved in their future career path, as well as the steps essential when entering the labour market (for instance, during the recruitment procedure).

Specific aims: The aims of this course already described correspond to the following specific purposes:

Becoming aware of the role played by soft skills when entering the labour market;

Recognizing one's soft skills and their suitability to different contexts and situations;

Developing the ability to assess one's soft skills;

Promoting the development and/or enhancement of one's soft skills;

Developing the ability to define a specific plan aimed at fostering those skills that seem to be weaker or inadequate.

Course contents

Through the implementation of an active teaching method, based on team works requiring the translation of soft skills in order to face concrete situations similar to typical job search activity (for example, tackling job interviews and in-basket exercises).

Specifically, these exercises will be focused on three areas of expertise:

To read/understand each situation, which includes the ability to gather information/data that allow to analyse and interpret circumstances and relationships, to process this information/data in order to identify a proper solution;

To address/solve the situations, including the ability to plan, manage and implement a targeted action plan, the ability to make consistent decisions and to effectively manage changes. This area of expertise is further developed through the MOOC named "Change management";

To collaborate, which includes the ability to present oneself, to work within teams, to interact effectively with others, being aware of inter-individual dynamics and conflict management. The activities in class (integrated by MOOCs) address specific areas of expertise. Moreover, students will attend a e-learning platform (these activities will take above 6 hours) aimed at encouraging involvement, active participation, awareness of the importance of soft skills for work placement and the ability to self-evaluate one's own skills.

This e-learning activity will be defined in the following specific contents:

Presentation and description of the role of soft skills through the interviews with different figures pertaining to the labour market (e.g., HR Directors of large companies);

Self-assessment of one's soft skills;

Integration of this self-assessment activity with classroom activities, participation in MOOCs and the outputs of online questionnaires;

Summary of one's soft skills. This profile will allow photographing the skills already developed,

those that should be enhanced, and a detailed description of a plan aimed at strengthening those skills emerged as critical for job placement activities and/or accessing advanced training courses.

The topics will be analyzed/presented in terms of inclusive industrialization, multiculturalism, innovation and diversity management too, as indicated by the UN Sustainable Development Goals.

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81799 - Project Management and Soft Skills

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[PDF](#), [ADOC](#).