UNIVERSITÀ DEGLI STUDI
DI MILANO
DIPARTIMENTO DI INFORMATICA
SEDE DI CREMA

STUDENT'S GUIDE
to the
MASTER DEGREE
in

INFORMATICS

at Crema (Italy)

Academic Year 2012/2013

DISCLAIMER: THE PRESENT STUDENT'S GUIDE IS AN INFORMATIVE SUPPORT THAT DOES NOT SUBSTITUTE THE OFFICIAL DOCUMENTS APPROVED BY THE ACADEMIC ORGANS AND AVAILABLE ON THE UNIVERSITY WEB SITES. THESE DOCUMENTS ARE EFFECTIVELY THE ONLY VALID REFERENCE.

CONTENTS

MASTER DEGREE IN INFORMATICS

STUDY ORGANISATION OF THE MASTER DEGREE IN INFORMATICS[1]

GENERALITIES

Belongs to master degree class: LM-18 Informatica (*Informatics*)

Granted qualification: Dottore Magistrale (Master Degree)

Active curricula: Single curriculum

Duration: 2 years

CFUs required to access the degree: 180

CFUs granted by the degree: 120

Degree years activated: 1st and 2nd year

Access limitations: No

Degree code: F94

GRANTED TITLE

Graduated students obtain the Italian **Laurea Magistrale in Informatica**, granted by the Università degli Studi di Milano.

At the Crema campus, starting from year 2011/2012, **all mandatory and some complementary courses are offered in English language**.

Also the final thesis dissertation can be prepared and discussed either in Italian or in English language.

REFERENCES

Course coordinator

Prof. Mario Ornaghi (Milano)

Reference person in Crema campus

Prof. Nello Scarabottolo

Tutors

Prof. Silvio Ghilardi, Prof. Federico Pedersini, Prof. Vincenzo Piuri (Crema), Prof. Marco Trubian

Web sites

http://www.ccdinf.unimi.it - http://www.ccdinfcr.unimi.it

Crema campus of the Dipartimento di Informatica

Via Bramante 65, Crema (CR), Phone +39 0373/898011-12,

http://www.ccdinfcr.unimi.it, segreteria.studenti.dti@unimi.it

Milan campus of the Dipartimento di Informatica

Via Comelico 39/41, Phone +39 02 503 16250 / 16326,

http://www.ccdinf.unimi.it, infostudenti@ccdi.unimi.it

Students office

http://www.unimi.it/studenti/segreterie

[1] Please note that this student guide is just an information support, not replacing in any case the official Italian documents of the master degree (ordinamento didattico, regolamento didattico, manifesto didattico) available on the UniMi web sites and constituting the only valid regulations.

MASTER DEGREE CHARACTERISTICS

INTRODUCTION

The Master Degree in Informatics has been activated by the Università degli Studi di Milano since 2009/10 and belongs to the master degree class in Informatics (LM-18).

GENERAL AND SPECIFIC GOALS

The Master Degree in Informatics aims at supplying advanced knowledge and at forming professional competences suitable for job positions in research, design and management of systems in the various application areas of computer science, with particular reference to commercial, industrial and scientific environments. Once graduated, the student will be employable in design, development, control and management of complex information systems. Her/his main goals will be the continuous improvement of information systems and the ability to foster innovation in her/his application fields. The Master Degree will thus prepare professionals characterized by high-level analytical and operating competences, but also by an open view of all problems connected with the adoption and usage of ICT.

The Master Degree ensures an advanced and complete knowledge of the main ICT sectors: networks and distributed systems, information management, theoretical informatics, computational intelligence.

The Master Degree also requires the development of a graduation thesis, to be carried on either inside the University or in another public or private Institution and to be discussed in the final graduation exam. The graduation thesis is a written report, structured as a scientific paper, to be prepared under the control of a supervisor and referring an original scientific experience related to ICT.

ACQUIRED COMPETENCES AND SKILLS

Following the European harmonization principles, the competences and skills granted by the Master Degree in Informatics are here summarized, according to the Dublin descriptors scheme.

Knowledge and understanding

Graduated students will possess advanced theoretical and operating competences in the following fields: information management, knowledge management, distributed systems, distributed algorithms, complex networks, mathematical logics, probability and statistics applied to information processes, automata theory, complexity theory, intelligent systems.

Applying knowledge and understanding

Graduated students will be able to apply acquired competences to analysis, design, implementation and evaluation of complex information systems in various application fields: commerce, industry, public administration, insurances, banks, hospitals, environment management, energy management, research.

They will also be able to evaluate the correctness and the sustainability of their own design choices, as well as the effects of their own decisions regarding information systems, when applied in their professional job positions in: industries, public and private research centers, government bodies, control authorities.

Making judgments

Graduated students will be able to formulate autonomous judgments regarding strategic decisions and design choices of companies and other institutions where they will be employed. They will also acquire the deontological professionalism principles driving the interpersonal relationships in their employment environments.

Communication skills

Graduated students will be able to argument their own opinions and to communicates results of their own analysis and evaluation in a clear, effective way, using the English language and exploiting the possibilities offered by up-to-date computer tools as well as mathematical, statistical, econometrics tools for the analysis and the presentation of data.

Learning skills

The Master Degree aims at gradually bring students to the frontiers of research in its reference disciplines. For this reason, the Degree will also develop student's ability of continuous learning and of undertaking autonomous research activities in line with international standards, in view of a possible prosecution of their studies in the frame of PhD programs in Informatics or similar fields.

PROFESSIONAL PROFILE AND POSSIBLE JOB POSITIONS

The acquired competences and skills will allow the graduated student in the Master Degree in Informatics to obtain high responsibility positions in projects requiring consultancy, analysis, design, management, maintenance, marketing of medium-to-large ICT systems.

She/he will be able to operate in a variety of application fields for the design and the management of ICT systems and for the study of new systems and applications.

These activities will take place in all areas of public and private institutions using ICT: banks, insurances, logistics and transportations, health, public administrations, telecommunications and media, service providers, industry. More specifically, roles and positions of graduated students according to the Italian ISTAT coding are listed below.

2114 Informatics and telematics

21141 Specialists in basic informatics research

21142 Analysts and designers of system and application software

21143 System analysts

21144 Information security specialists

21145 Networks and computer communications specialists

26200 Researchers and graduated technicians in mathematical and information sciences

Access requirements

To register for the Master Degree in Informatics, candidates must have obtained in their previous studies at least:

- 66 CFUs (University Formative Credits) belonging to sectors INF/01, ING-INF/05
- 36 CFUs belonging to sectors MAT/01-09
- 6 CFUs belonging to sectors FIS/01-03

Access of students not complying with the above requirements will be possible only after decision of the Didactics Council.

Other curricular integrations necessary to fulfill the above requirements should be acquired before accessing the Master Degree, by passing exams of the courses of the Bachelor Degree in Informatics (Laurea in Informatica) indicated by the Didactics Council.

Access of a student who obtained her/his Bachelor degree in a country not adopting the ECTS credit scheme will be granted after the verification of her/his personal qualification (see below).

On the basis of the Bachelor degree declared by a foreign applying student, a *letter of conditional acceptance* will be issued, stating that the application itself needs to be clarified by the Italian embassy of the country the student belongs to.

To profitably follow the lessons, students should have at least a B1 knowledge of the English language, as defined by the CEFR (Common European Framework of Reference for Languages). B1 corresponds to the following levels in the most widely adopted verification schemes:

- TOEFL 57-86 (on the 0-120 TOEFL scale)
- IELTS $\geq$4
- PET

- BEC Preliminary
- Trinity College ISE 1 GESE5 GESE6

DEGREE STRUCTURE

Single curriculum.

DEGREE CURRICULUM ORGANIZATION

The standard duration of the Master Degree in Informatics is two years. To graduate, the students should acquire 120 CFUs. The acquisition of competences and skills by students is quantified in terms of CFUs according to the didactical regulations of the Università degli Studi di Milano.

The CFU is a measurement unit of the amount of learning work required to each student, corresponding to 25 hours of activities, which can include either:

- 8 hours of lectures and 17 hours of individual study;
- 12 hours of exercising and 13 hours of individual study;
- 16 hours of labs and 9 hours of individual study;
- 25 hours of activities related to the preparation of the final graduation exam.

Teaching activities are organized for each course year in two coordinated cycles, conventionally called semesters, having a minimum duration of 12 weeks each, were lectures, exercises and labs take place. It is also planned a stage activity, to be done possibly outside the university, in public or private institutions.

NOTES

Student should verify each year the activation of the courses inserted in her/his study plan.

COURSES LOCATIONS

Informatics courses in English language are held at the Crema campus of the Dipartimento di Informatica, via Bramante 65, Crema (CR).

Other courses in Italian language are held at the Milan campus of the Dipartimento di Informatica, via Comelico n. 39/41 – Milano, and the Settore Didattico, via Celoria – Milano.

LANGUAGE TESTS

To be admitted to the final graduation exam, the student must demonstrate her/his ability to fluently use the written and oral English language in the technical environment through a pass/fail verification test granting 3 CFUs. Usually, this verification can be done either:

- by presenting a B2-level internationally recognized certification (list of recognized certifications is available at http://www.ccdbiol.unimi.it/it/informazioni/linguaInglese.html);
- by passing a B2-level test (*placement test*) organized during exam sessions;
- by frequenting a specific course provided by the Faculty and by passing the level-B2 test.

For students of the English edition of the Master Degree in Informatics, such a verification test is substituted by the first passed exam of one of the courses of the Degree.

ATTENDANCE OBLIGATION

The attendance is not compulsory, but strongly recommended.

PROFICIENCY ASSESSMENT METHODS

The proficiency is assessed through written and oral exams, with results expressed in thirtieths. Some teachers organize *in itinere* exams, on a voluntary basis.

GENERAL RULES FOR ENROLMENT AND ADMISSION TO THE EXAMS

It is mandatory the enrolment to the exams using the SIFA kiosks or the SIFA on-line service at http://www.unimi.it/studenti/servizi_online.htm

GENERAL RULES FOR ENROLMENT TO THE EDUCATIONAL ACTIVITIES AND LABORATORIES

None.

FULFILLMENT OF STUDIES/INTERNSHIP ABROAD

The procedure and forms for applying for internships (same for internship in Italy or abroad) can be downloaded from www.dti.unimi.it. For periods of study abroad, the subscription to the Erasmus project is necessary, according to the timing and the procedures established by UniMi and published on www.unimi.it.

FORMULATION AND PRESENTATION OF THE STUDY PROGRAMME

Students must submit their Study Programme, in compliance with the Academic Regulations of the Faculty of Sciences, choosing complementary courses among those listed in the course programs. The choice can be made from the 1st year and may be modified during the following year. The Study Programme should also indicate how the student intends to obtain the free choice CFUs that can be chosen from courses offered by UniMi, or selected from among those proposed by the Didactics Coordination Council.

The Study Programme must be submitted using the service provided at http://www.unimi.it/studenti/servizi_online.htm, during the periods stated by the Students Offices.

FINAL EXAM ADMISSION CRITERIA

In order to be admitted to the final exam (laurea) the student must have at least 81 CFUs, as stated by the composition rules of the present course program. The final exams agenda, the deadlines for the submission of the graduation application and the required documentation are published on www.dti.unimi.it.

FINAL EXAM PECULIARITIES

Once the required CFUs have been acquired, in accordance with the present regulations, the student is admitted to the final exam for graduation, in compliance with the general principles expressed in the Rules of the Faculty, to which reference is made for any other provision on the subject. The final exam for obtaining the Master Degree in Informatics consists in the presentation and discussion of a master thesis (in English or Italian) in the form of an original work made by the student under the guidance of a supervisor, which involves an organic and complete job, that can demonstrate abilities of researching, processing and synthesis.

LESSONS SCHEDULE

The class schedule for the Crema's edition is available at: http://www.ccdinfcr.unimi.it/.

The class schedule for the Milano's edition is available at: http://www.ccdinf.unimi.it/.

ADMISSION CONDITIONS: 1ST YEAR OPEN

INFORMATION AND ORGANIZATIONAL ARRANGEMENTS FOR THE REGISTRATION

For information contact the students office at phone number +39 0373/898011-12 or by e-mail at segreteria.studenti.dti@unimi.it.

USEFUL LINK FOR THE REGISTRATION

www.unimi.it

APPLICATION REQUEST

The application request, mandatory for both graduate and final year students, must be electronically submitted:

- from July 16th 2012 to September 7th 2012 for students graduated in Italian universities;
- from April 2nd 2012 to September 7th 2012 for students **graduated in foreign universities**.

Only graduate and final year students from UniMi or other Universities can submit the application request.

Students graduated in foreign universities must enclose with their application request the following documents:

- certification of the university where the bachelor title has been obtained, with list of passed exams (or diploma supplement where available);
- detailed syllabus of each exam passed during the Bachelor studies;
- curriculum vitae in European format;
- copy of the applicant's passport.

PERSONAL QUALIFICATION VERIFICATION

The personal qualification of the applicants will be verified, for the admission at the Master Degree, through an interview on topics related to the fundamental subjects studied in the Bachelor courses. The interview will be conducted by a committee of teachers designated by the Didactics Coordination Council.

The interview can be made even before the achievement of the Bachelor Degree (which must still be obtained on or before February 28th 2013), withstanding the curricular requirements.

Compliance with the requirements will be verified by the Didactics Coordination Council.

The negative results obtained in the interview, for all graduate students and undergraduates, involves the foreclosure to the admission to the Master of Science for the current year.

If successful, the student must indicate the site chosen (Milano or Crema).

The interview for students graduated in foreign universities will be carried on online.

REGISTRATION

Students who have successfully passed the interview will be able to enroll after 5 working days from the date of the interview/documentation exam, if already graduated, but no later than February 28th 2013, if not yet graduated at the time of the interview/documentation exam. To enroll in the Master Degree, students must acquire the Bachelor Degree no later than February 28th 2013.

The University students who graduate between October 2012 and February 2013 will attend the courses and laboratories planned for the Master Degree course and take the exams gaining their CFUs. These CFUs, in

excess with respect to the 180 needed for Bachelor Degree, will be validated in order to attain the 120 credits required for the Master of Science, provided that they are achieved before January 31st 2013.

DEGREE COURSE STRUCTURE

1st YEAR Mandatory educational activities				
Delivering	**Training activity**	**CFU**	**Field**	**Teaching Format**
1st semester	Logica matematica *Mathematical Logic* (*)	6	MAT/01	48 hours Lessons
1st semester	Sistemi intelligenti *Intelligent Systems* (*)	6	INF/01	48 hours Lessons
2nd semester	Informatica teorica *Theory of Computation* (*)	6	INF/01	48 hours Lessons
2nd semester	Reti wireless e mobili *Wireless and Mobile Networks* (*)	6	INF/01	48 hours Lessons
2nd semester	Sistemi distribuiti *Distributed Systems* (*)	6	INF/01	48 hours Lessons
	Total mandatory CFUs	**30**		

2nd YEAR Mandatory educational activities				
Delivering	**Training activity**	**CFU**	**Field**	**Teaching Format**
1st semester	Gestione dell'informazione *Information Management* (*)	6	INF/01	48 hours Lessons
2nd semester	Conoscenza della lingua inglese 2 *English Language 2* (*)	3	L-LIN/12	24 hours Lessons
	Total mandatory CFUs	**9**		

Optional educational activities				
Delivering	**Training activity**	**CFU**	**Field**	**Teaching Format**
THE STUDENT WILL HAVE TO GAIN 18 CFUs BY CHOOSING FROM THE FOLLOWING COURSES (TABLE 1):				
1st semester	Algoritmi e complessità	6	INF/01	48 hours Lessons
2nd semester	Algoritmi per reti di calcolatori	6	INF/01	48 hours Lessons
1st semester	Architetture digitali	6	INF/01	48 hours Lessons
1st semester	Architetture e programmazione DSP	6	INF/01	48 hours Lessons
1st semester	Architetture software orientate ai servizi (***)	6	INF/01	48 hours Lessons
1st semester	Bioinformatica	6	INF/01	48 hours Lessons
1st semester	Crittografia II	6	INF/01	48 hours Lessons
2nd semester	Elaborazione delle immagini I	6	INF/01	48 hours Lessons
2nd semester	Elaborazione delle immagini II	6	INF/01	48 hours Lessons
1st semester	Elaborazione di immagini *Image Processing* (**)	6	INF/01	48 hours Lessons
1st semester	Elaborazione di segnali *Digital Signal Processing* (**)	6	INF/01	16 hours Lab, 40 hours Lessons
1st semester	Elaborazione numerica dei segnali II	6	INF/01	48 hours Lessons
1st semester	Estrazione e gestione della conoscenza *Knowledge extraction and management* (**)	6	INF/01	48 hours Lessons

not delivered	Gestione dell'informazione nei sistemi mobili e pervasivi	6	INF/01	48 hours Lessons
2nd semester	Gestione e organizzazione di progetti (***)	6	INF/01	48 hours Lessons
2nd semester	Ingegneria dei processi aziendali *Business Process Engineering* (**)	6	INF/01	48 hours Lessons
not delivered	Intelligenza artificiale e laboratorio	6	INF/01	48 hours Lessons
not delivered	Laboratorio di segnali	6	INF/01	48 hours Lessons
2nd semester	Linguaggi e traduttori	6	INF/01	48 hours Lessons
not delivered	Metodi formali dell'informatica	6	INF/01	48 hours Lessons
not delivered	Metodi per il ragionamento automatico	6	INF/01	48 hours Lessons
1st semester	Modelli dei dati e DBMS di nuova generazione	6	INF/01	48 hours Lessons
2nd semester	Ontologie e web semantico	6	INF/01	48 hours Lessons
2nd semester	Progettazione e sviluppo software per sistemi mobili e pervasivi	6	INF/01	48 hours Lessons
1st semester	Progetto e ottimizzazione di reti *Network Design and Optimization* (**)	6	INF/01	48 hours Lessons
2nd semester	Sicurezza informatica	6	INF/01	48 hours Lessons
not delivered	Simulazione	6	INF/01	48 hours Lessons
2nd semester	Sistemi informativi geografici	6	INF/01	48 hours Lessons
2nd semester	Sistemi informativi II	6	INF/01	48 hours Lessons
1st semester	Sistemi intelligenti per il monitoraggio e il controllo *Intelligent Systems for Monitoring and Control* (**)	6	INF/01	48 hours Lessons
2nd semester	Soft computing	12	INF/01	96 hours Lessons
1st semester	Tecniche speciali di programmazione	6	INF/01	48 hours Lessons
2nd semester	Verifica e convalida del software	6	INF/01	48 hours Lessons
THE STUDENT WILL HAVE TO GAIN 6 CFUs BY CHOOSING ONE OF THE FOLLOWING COURSES:				
2nd semester	Metodi probabilistici *Probabilistic Methods* (*)	6	MAT/06	48 hours Lessons
2nd semester	Metodi statistici per l'apprendimento	6	MAT/06	48 hours Lessons
2nd semester	Processi stocastici	6	MAT/06	48 hours Lessons
THE STUDENT WILL HAVE TO GAIN 6 CFUs BY CHOOSING FROM THE FOLLOWING COURSES (TABLE 2):				
not delivered	Algebra computazionale	6	MAT/02	48 hours Lessons
2nd semester	Calcolo numerico	6	MAT/08	48 hours Lessons
1st semester	Complementi di ricerca operativa *Operations research complements* (*)	6	MAT/09	48 hours Lessons
1st semester	Elettronica digitale	6	ING-INF/01	48 hours Lessons
1st semester	Fisica II	6	FIS/01,02,03	48 hours Lessons
1st semester	Geometria computazionale	6	MAT/03	48 hours Lessons
1st semester	Logica II	6	MAT/01	48 hours Lessons
2nd semester	Logistica *Logistics* (**)	6	MAT/09	48 hours Lessons
not delivered	Metodi e modelli per le decisioni	6	MAT/09	48 hours Lessons
2nd semester	Organizzazione aziendale (***)	6	SECS-P/10	48 hours Lessons
1st semester	Tecnologie informatiche per la qualità *Information Technology for Quality Control* (**)	6	ING-INF/07	48 hours Lessons

(*) Course held in English language at the Crema campus, and in Italian language at the Milan campus.

(**) Course held in English language only at the Crema campus.

(***) Course held in Italian language only at the Crema campus.

Final activities	
Final exam	39
Total mandatory CFUs	**39**

Optional Activities

The student have to gain **12 freely chosen CFUs** from among:

- courses freely chosen by the student from among those provided by UniMi;
- other certified and CFU-quantified academic activities carried out also in other places, provided the Didactics Coordination Council approval;
- additional internships, which can also supplement the final stage, carried out after the Didactics Coordination Council approval.

The EUCIP certification can grant 3 CFUs.

The CISCO certification can grant 5 CFUs.

COURSE SYLLABI

SYLLABI OF THE ENGLISH LANGUAGE COURSES - A.A. 2012/2013

Complementi di ricerca operativa

Operations research complements

Professor: Righini Giovanni

Goals
The course aims at presenting some of the classical algorithmic techniques in Operations Research, both for solving problems of polynomial complexity and for NP-hard problems.

Syllabus
EFFICIENT ALGORITMS FOR GRAPH OPTIMIZATION PROBLEMS:

- Graphs, definitions and properties.
- Problems of minimum cost connectivity. Minimum cost spanning tree: Kruskal, Prim, Boruvka algorithms. Minimum cost spanning arborescence: Edmonds algorithm.
- Shortest path problems. Unweighted graphs: BFS algorithm. Weighted acyclic graphs: Critical Path Method. Graphs without negative cost cycles: Bellman-Ford algorithm. Graphs without negative cost arcs: Dijkstra algorithm. Floyd-Warshall algorithm for the computation of the all-pairs shortest paths matrix on a weighted digraph.
- Optimal flow problems. Ford-Fulkerson algorithm for the maximum flow problem and its implementations. Algorithms for the maximum flow minimum cost problem. Duality: max flow - min cut theorem. Gomory and Hu algorithm for the minimum cut in a weighted graph.
- Matching problems. Transformation of matching problems into flow problems. Hungarian algorithm.
- Minimum cost transportation problems. Transformation into minimum cost flow problems. Dantzig algorithm.

OPTIMIZATION ALGORITHMS FOR NP-HARD PROBLEMS:

- Branch-and-bound. Techniques for dual bounds computation: linear relaxation, Lagrangean relaxation, surrogate relaxation, combinatorial relaxations. Heuristics for the computation of primal bounds. Tree search policies. Branching methods. Implementation of branch-and-bound algorithms.
- Dynamic programming. Illustration and examples. Data-structures and space an dtime complexity of dynamic programming algorithms. State space relaxation. Implementation of dynamic programming algorithms.

APPROXIMATION ALGORITHMS FOR NP-HARD PROBLEMS:

- Definitions. Approximation error, approximation schemes.
- Algorithms with constant approximation error.
- Algorithms with approximation error depending on the size of the instance.
- Algorithms with data-dependent approximation error.
- Combination of approximation algorithms.
- Polynomial approximation schemes. The knapsack problem.

Recommended preparatory courses
-

Course materials
F. S. Hillier, G. J. Lieberman: “Introduction to operations research”, McGraw-Hill, 1995.
R. K. Ahuja, T. L. Magnanti, J. B. Orlin: “Network flows”, Prentice Hall, 1993.
Slides available on the course website.

Prerequisites
Operations Research, Computer programming, Algorithms and Data-structures, English.

Course assessments
Written and oral exams

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-28/

Other information
Under the supervision of the teacher the students will implement some of the algorithms learned during the course.

Elaborazione di immagini

Image Processing

Professor: Ferrari Stefano

Goals
The aim of this course is to provide the general principles on the acquisition, the representation, and the improvement of digital images and the processing techniques for extracting information from images of real scenes.

Syllabus
The course concerns the funding concepts of the digital image processing. The lectures will introduce the principles of the processing of digital signals, the sampling, and encoding, the techniques generally used in image processing: geometrical operations, features extraction, equalization, filtering, transforms, image encoding and compression. Laboratory sessions will also take place in which numeric simulation software will be used.

- **Introduction**: introduction to the image processing, image basic concepts.
- **Digital images fundamentals**: light, vision and perception; acquisition and digitalization of images.
- **Image representation**: formats for the representation of digital images, pixel relations, basic mathematical operations.
- **Intensity transforms and spatial filtering**: intensity transforms, histograms, equalization, spatial domain filtering, equalization, image improvement in spatial domain.
- **Filtering in the frequency domain**: Discrete Fourier Transform, extension to 2D functions, filtering and improvement of images in the frequency domain.
- **Morphological image processing**: dilation, erosion, opening, closing, extraction of connected components, convex hull, thinning, thickening, contour extraction.
- **Image segmentation**: edge detection and linking, region based processing.
- **Image compression**: redundancy, image encoding.

Recommended preparatory courses
Fundamentals of probability and statistics, signal processing, and programming.

Course materials
R.C. Gonzalez and R.E. Woods, Digital Image Processing, (3 ed.), Prentice Hall, 2008. ISBN 9780131687288.

Prerequisites
-

Course assessments
Written and oral exams

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-45/

Elaborazione di segnali

Digital signal processing

Professor: Sassi Roberto

Goals
The course will cover the basis for digital signal processing at an advance undergraduate / graduate level. While rigorously covering the theoretical foundations of the discipline, the course will also include several laboratory sessions where the students will practice writing their own codes (MATLAB).

Syllabus
- **Introduction**. Continuous-time and discrete-time signals. Sequences. Analysis of continuous-time signals in the frequency domain: the Fourier transform. Convolution and correlation.
- **Digital signals: sampling and quantization**. Sampling of continuous-time signals and the sampling theorem. Sampling of periodical signals. Aliasing. Reconstruction of continuous-time signals from samples and interpolation. Quantization.
- **Analysis of discrete-time signals in the frequency domain**. Discrete-time Fourier Transform (DTFT), Discrete Fourier Transform (DFT) and FFT algorithm. Spectral characterization of sampled signals.
- **Linear time**-invariant systems (LTI). Impulse response. Stability and causality. Systems interconnection (series, parallel, feedback). Finite-difference equations as representation of LTI systems.
- **Zeta transform**. Definition and principal properties. Region of convergence. Analysis of LTI systems via Zeta transform. Transfer functions, poles and zeros. Frequency response. Stability condition in the Zeta domain
- **FIR filters**. Linear phase and LTI filter with symmetrical impulse response. FIR filters design with the window method.
- **IIR filters**. Design of digital IIR filters starting from their analog counterparts. Sensitivity to quantization of the filter coefficients.
- **Wavelet transform**. Definition and main properties of the wavelet transform.

Recommended preparatory courses
Courses of "matematica del continuo" (continuous mathematics and "calcolo delle probabilità e statistica matematica" (probability and mathematical statistics)

Course materials
Material freely available from the course's web page.
A. V. Oppenheim & R. W. Schafer, "Discrete-Time Signal Processing" (3rd ed.), Prentice Hall, 2009. (Main textbook in English).
Massimiliano Laddomada e Marina Mondin, "Elaborazione Numerica dei Segnali", Pearson Education Italia, 2007. (Main textbook in Italian).
John G. Proakis, Dimitris G. Manolakis, "Digital signal processing" (4th ed.), Pearson Prentice Hall, 2007. (Reading material).

Prerequisites
-

Course assessments
Written and oral exams

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-44/

Other information
Course breakdown: 20 lectures (40 hours, 5 CFU) and 8 laboratory sessions (16 hours, 1CFU).

Estrazione e gestione della conoscenza

Knowledge extraction and management

Professor: Tettamanzi Andrea Giovanni Battista

Goals
This class is a continuation of the teaching on Information Management.

Syllabus
There is no detailed program. The class is structured around individual student projects under the supervision of the teacher.

Recommended preparatory courses
Information Management

Course materials
Jiawei Han, Micheline Kamber. Data Mining: Concepts and techniques (2nd ed.). Morgan Kauffman, 2006.

Prerequisites
English proficiency, knowledge of discrete mathematics, calculus, probability and statistics, and data bases.

Course assessments
Oral exam

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-50/

Gestione dell'informazione

Information management

Professor: Tettamanzi Andrea Giovanni Battista

Goals
The aim of this class is to illustrate several advanced information management techniques that are collectively known as data mining. These techniques are oriented toward the automatic or semi-automatic extraction of knowledge from huge volumes of data.

Syllabus
INTRODUCTION
- Motivations and definitions: purposes, tools, applications.

DATA PREPARATION
- Description: statistical tools, visualization.
- Data cleaning: missing values, noise, cleaning as a process.
- Transformation and Reduction: integration, transformation, attribute selection, dimensionality reduction, discretization and conceptual hierarchy generation.
- Data warehouses and OLAP: differences with databases, purposes and function, multidimensional model, architectures.

CLASSIFICATION AND PREDICTION
- Main models: fuzzy logic, decision trees, Bayesian classification, rules, neural networks, SVM, k-nearest neighbor.
- Model induction techniques: linear regression, quadratic optimization, evolutionary algorithms.
- Model evaluation: error and accuracy, information-theoretic measures, validation, bootstrap, confidence interval estimation, ROC curve.
- Cluster analysis: partitioning, hierarchic methods, density-based methods, model-based methods.

TIME SERIES ANALYSIS
- Specificities: sequence analysis, pattern extraction, clustering, phase space.
- Financial time series: markets and financial instruments, technical analysis, modeling, prediction.

Recommended preparatory courses
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Course materials
Jiawei Han, Micheline Kamber. Data Mining: Concepts and techniques (2nd ed.). Morgan Kauffman, 2006.

Prerequisites
English proficiency, knowledge of discrete mathematics, calculus, probability and statistics, and data bases.

Course assessments
Oral exam

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-9/

Informatica teorica

Theory of computation

Professor: Trucco Gabriella

Goals
This course is about the part of theoretical computer science that studies the limits of what can be done with computing machines.
The course introduces the basics of the theory of computability and complexity. We deal with the concepts of problem algorithmically solvable and problems that do not allow algorithmic resolution. Then we analyze the classification of problems in complexity classes, defined in terms of limits on the amount of available resources.

Syllabus
- Automata and languages: deterministic and non-deterministic finite automata, regular languages, context-free languages, pushdown automata.
- Theory of computability: Turing machine, decidability, reducibility.
- Complexity theory: time and space complexity.

Recommended preparatory courses
-

Course materials
- Lectures slides
- M. Sipser, Introduction to the theory of computation

Prerequisites
-

Course assessments
Written exam

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-8/

Ingegneria dei processi aziendali

Business process engineering

Professor: Damiani Ernesto

Goals
The goal of the course is the study and design of Business Processes and of the role of information systems and technologies that support them. The course will focus on the analysis, design, and implementation of Business Processes, also discussing the issues of workflow management. A number of real case studies will be presented to students during the lectures to get students used to main organizational processes, fostering an applied knowledge on Business Process modeling.

Syllabus
The program of the course is focused on the following main points:

- Learn how to analyze, model, and design a process.
- Understand the role of workflow and process analysis in the context of Business Process Management (BPM).
- Learn the basic principles of process and workflow analysis and management.
- Study in deep the techniques and tools for process modeling and learn how to exploit them in the workflow management.

The subjects treated during the course include:

- Course Introduction
  - Introduction to Business Process
  - Introduction to process analysis and modeling
  - Introduction to BPMN
  - Use of BPMN for process modeling
- Process Modeling
  - Diagrams and swimlanes
  - Event-Driven Process Chain (EPC)
- Workflow Implementation Technologies
  - Technologies for process automation
  - Collaborative organization
  - Workflow base concepts
- Business Process Automation – Workflow Interoperability and Integration
  - Creation of Tasks, Cycles, and logic operator
  - Process and contract interoperability
  - Business workflow – deadlines, reports, tests, and process logs
- Business Process Management from an integration viewpoint
  - Migration of process model towards the implementation platform
  - Analysis of Enterprise and Business Management Tools

Recommended preparatory courses
Course of "Architetture orientate ai servizi" (Service-oriented architectures)

Course materials
Slide and notes of the course.
Reference: A. Grosskopf, G. Decker, and M. Weske, "The process: Business Process Modeling using BPMN," Meghan-Kiffer Press, 2009. ISBN-13: 978-0929652269.

Prerequisites
Web technologies, XML, and main application protocols.

Course assessments
Exercises during the course + final project

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-49/

Other information
COURSE EVALUATION

- Written examination: 30.00%
- Team Design Project and presentation: 70.00%
- Extra points will be given during lessons with specific homeworks.
- Assignments: Readings and Research Papers – Besides the reading list given below, each student will be encouraged to search the web and find current journal articles related to the course.

Logica matematica

Mathematical Logic

Professor: Ciriani Valentina

Goals
The content objectives of the course are threefold:

- Developing the attitude for formalizing problems in propositional and first order logic. The source problems will be taken from puzzles, games, verification of programs and protocols, and knowledge engineering.
- Understanding logic computations performed in appropriate state-of-the-art tools, such as for instance SAT-solvers, SMT-solvers, OBDD libraries, model checkers, provers based on resolution and rewriting or tableaus, and logic programming tools.
- Acquisition of fundamental mathematical concepts related to logic, including the formal semantics of propositional and first order logic.

Syllabus

- Propositional and predicate logic.
- Resolution and logic programming.
- Fuzzy logic.
- Binary decision diagrams and logic synthesis.
- Program and system verification.
- Modal logic.
- Logic for security.

Recommended preparatory courses
None.

Course materials

- Michael Huth , Mark Ryan. Logic in Computer Science: modelling and reasoning about systems (2nd edition), Cambridge University Press, 2004.
- Mordechai Ben-Ari. Mathematical Logic for Computer Science (2nd edition), Springer, 2001.
- Papers in English, distributed by the lecturer and made available through the course's web page.

Prerequisites
Concepts of computing foundations, computer programming, and English reading.

Course assessments
Oral exam and project

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F2Y/curriculum/F2Y-35/

Logistica

Logistics

Professor: Righini Giovanni

Goals
The course describes the supply chains operations and functions and the problems related to planning and management of logistic systems, with particular emphasis on optimization problems and on computational techniques to solve them.

Syllabus
THE SUPPLY CHAIN:
- Terminology and definitions. Description of the supply chain and its main components.

FORECASTING:
- The problem of demand foreccatsing. Models and algorithms for demand forecasting. Least squares and simple linear regression.

INVENTORY MANAGEMENT:
- Models of inventory systems. Inventory systems with continuous and discrete replenishment. Single-product and multi-product systems. Single-depot and multi-depot systems. Economic order quantity. Scale economies and discount policies.

PRODUCTION LOGISTICS:
- Lot sizing problems. Mathematical models and algorithms.
- Scheduling problems. Mathematical models and algorithms.

DISTRIBUTION LOGISTICS:
- Packing problems. Mathematical models and approximation algorithms: first-fit and best-fit.
- Exact solution via spreadsheet.
- Routing problems. Vehicle routing with additional constraints and heuristic algorithms.

QUEUING THEORY:
- Definitions and properties of queuing systems. Modeling, analysis and synthesis of queuing systems. Use of software for queuing systems optimization.

Recommended preparatory courses
Operations Research

Course materials
Ghiani, Gianpaolo, Gilbert Laporte, Roberto Musmanno. 2004. Introduction to Logistics Systems Planning and Control. John Wiley and Sons, New York.

Prerequisites
-

Course assessments
Written exam

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-42/

Metodi probabilistici

Probabilistic Methods

Professor: Pizzi Rita Maria Rosa

Goals
The course aims to complete and integrate the mathematical skills of the student using as a reference frame the classical probability theory and its main application methods.

Syllabus
Introduction to the probability calculus
Theory of random variables
Models of discrete and continuous random variables
Estimation theory
Statistical hypothesis tests
Random processes and Markov chains
Autoregressive methods

Recommended preparatory courses
Mathematics: at least 12 credits
Probability Calculus and Statistics

Course materials
Course website documentation
Introduction to the theory of statistics. Mood, Alexander McFarlane
New York, NY, US: McGraw-Hill. (1950). xiii, 433 pp.

Prerequisites
Mathematics: foundations
Probability calculus and Statistics

Course assessments
Written and oral exams

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-4/

Progetto e ottimizzazione di reti

Network design and optimization

Professor: Ceselli Alberto

Goals
The course aims at giving both theoretical and practical tools for solving complex decision problems, arising in the design and optimization of telecommunication network infrastructures and services.
Issues related to the design of infrastructures and services offering robustness and efficiency guarantees will be analyzed in depth during the course, together with the problem of protection against failures.
The course is aimed at students in both Computer Science and Information Security.

Syllabus
Part I: overview on main graph optimization problems; models and algorithms for flow problems, min cost flow and multicommodity flow; models and algorithms for network routing.
Part II: design and optimal dimensioning of network infrastructures.
Part III: models and algorithms for the protection and the design of networks with robustness guarantees.

Recommended preparatory courses
Computer programming, algorithms and data structures (suggested: operations research).

Course materials
M. Pioro, D. Medhi "Routing, Flow, and Capacity Design in Communication and Computer Networks", Morgan Kauffman, 2004
R.K. Ahuja, T.L. Magnanti, J.B. Orlin "Network Flows: Theory, Algorithms, and Applications", Prentice Hall, 1993

Prerequisites
Good coding skills, good attitude to mathematical modeling, and design and analysis of algorithms.

Course assessments
Oral exam + Exam project

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-59/

Reti wireless e mobili

Wireless and mobile networks

Professor: Agazzi Simone

Goals
The Course deals with mobile and wireless networks by a technological and architectural point of view. The main current technologies for communication on radio channel will be analyzed, with particular reference to cellular network and to technologies for wireless networks ad hoc, as Bluetooth, IEEE 802.11, ZigBee. We will identify for each solution the architecture of protocols and services and we will point out the most relevant algorithmic aspects. An important course part will be kept for routing protocols on wireless networks, with a hint also to the case of mobile knots, and for the impact on TCP protocol generated by radio channels.

Syllabus
- Introducing Personal and Local Wireless Networks
- Bluetooth
    - Configuration and architecture
    - Protocol and service in basic band
    - Protocol and L2CAP service
    - SDP protocol
- IEEE 802.11
    - Configuration and architecture
    - Protocol and under-level MAC service
- Introducing sensor networks
    - MAC energy-aware protocol (S-MAC)
    - ZigBee
- Cellular Networks
    - WCDMA politics
    - UMTS
    - High Speed Downlink Packet Access (HSDPA)
- Routing on wireless networks
    - Mobile IP and WAP
    - Networks ad hoc (AODV, geographic routing, epidemic routing)
- TCP on wireless channel
    - TCP Reno e TCP New Reno
    - End-to-end approaches
    - Link Layer approaches
- Conclusions and exercises

Recommended preparatory courses
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Course materials
- UMTS. Tecniche e architetture per le reti di comunicazioni mobili multimediali
    - Author: Columpsi Gennaro ; Leonardi Marco; Ricci Alessio
    - Editor: Hoepli
- Wi-Fi, Bluetooth, Zigbee and WiMAX
    - Author: Di Houda Labiod,Afifi Hossam,Costantino De Santis
    - Editor: Springer
- Slides given by the teacher.

Prerequisites
Theoretical knowledge about networks

Course assessments
Oral exam

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-7/

Sistemi distribuiti

Distributed systems

Professor: Foresti Sara

Goals
The aim of this class is to present the basic distributed system technologies. The class discusses the main issues and design choices of a distributed system, the architectural principles, with a particular focus on interconnection networks, communication among processes, remote method invocation and remote procedure call mechanisms. In addition, basic methods and algorithms for controlling concurrency are introduced.

Syllabus
PRINCIPLES
- Architectures.
- Communication.
- Processes.
- Naming.
- Synchronization.
- Consistency and Replication.
- Fault Tolerance.
- Security.

PARADIGMS
- Object-based Systems.
- Distributed File Systems.
- Document-based Systems.
- Coordination-based Systems.

Recommended preparatory courses
-

Course materials
A. S. Tannenbaum, M. van Steen. Distributed Systems. Pearson Education 2006.

Prerequisites
-

Course assessments
Project

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-11/

Sistemi intelligenti

Intelligent systems

Professor: Sassi Roberto

Goals
The course presents methodologies and techniques to implement intelligent systems for processing information and knowledge, i.e., systems which behaves like the human brain by employing computational intelligence approaches. In particular, the following main approaches will be studied: neural networks, fuzzy systems, and evolutionary computing.

Syllabus
- **Neural networks**: Definitions. Neurons: structures, perceptrons, RBF. Neural topologies: feed-forward, feedback, SOM. Learning: supervised, unsupervised. Performance. Optimization. Classification and clustering. Associative memories. Prediction. Function approximation. Applications.
- **Fuzzy logic and systems:** Fuzzy sets. Membership functions. Fuzzy rules. Defuzzification. Fuzzy reasoning. Fuzzy systems. Rough sets. Performance. Applications.
- **Evolutionary computing:** Genomic representation. Fitness functions. Selection. Genetic algorithms. Genetic programming. Evolutionary programming. Evolutionary strategies. Differential evolution. Swarm intelligence. Artificial immune systems.
- **Hybrid systems**

Recommended preparatory courses
Concepts of computing foundations, computer programming, calculus, and English reading.

Course materials
Simon Haykin, Neural Networks: A Comprehensive Foundation, Prentice Hall
Timothy Ross, Fuzzy Logic with Engineering Applications, Wiley
A.E. Eiben, J.E. Smith, Introduction to Evolutionary Computing, Sprinter
Course slides published in the course's website

Prerequisites
Concepts of computing foundations, computer programming, calculus, and English reading.

Course assessments
Oral exam and project

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-10/

Sistemi intelligenti per il monitoraggio e il controllo

Intelligent Systems for Monitoring and Control

Professor: Piuri Vincenzo

Goals
The course presents methodologies and techniques to implement intelligent systems for monitoring and control in industrial and environmental applications, typically based on computational computational intelligence approaches.

Syllabus
- **Intelligent sensors:** Heterogeneous multi-sensor systems. Sensor data analysis. Diagnosys. Fault tolerance. Self-calibration. Adaptivity. Management.
- **Sensor networks:** Structure. Functions. Adaptivity. Management. Distributed data analysis. Fault tolerance. Diagnosys.
- **Measurements:** Acquisition and processing of sensor measurement in advanced adaptive infrastructures.
- **Sensor signal and image processing:** Feature extraction. Multi-sensorial data fusion. Adaptivity of measurement representation, operations and functions to the application needs. Virtual sensors. Information compression.
- **Classification and clustering:** Classification and clustering of sensor signals. Sensitività analysis. Class robustness.
- **Data mining and knowledge extraction:** Adaptive knowledge extraction from sensor data and system information. Knowledge representation.
- **Monitoring:** Applications of intelligent system sto complex system monitoring. Applications to industrial process monitoring. Qualità monitoring. Applications to environmental monitoring.
- **Prediction:** Applications of intelligent system sto prediction in the industry and the environment. Quality prediction.
- **Control:** Applications of intelligent system sto control of industrial processes, industrial automation, robotic systems, complex products, power distribution grids, automotive and transport systems.

Recommended preparatory courses
Concepts of computing foundations, computer programming, calculus, intelligent systems, industrial automation and measurements, and English reading.

Course materials
Papers in English, distributed by the lecturer and made available through the course's web page.

Prerequisites
Concepts of computing foundations, computer programming, calculus, intelligent systems, industrial automation and measurements, and English reading.

Course assessments
Oral exam and project

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-43/

Tecnologie informatiche per la qualità

Information technology for quality control

Professor: Lazzaroni Massimo

Goals
The aim of the course is the study of the Quality Control with particular attention on methodologies based on Statistical Process Control (SPC).

Syllabus
INTRODUCTION
Introduction to Quality. Historical evolution. Software for Quality Control. Quality assurance.
Quality characteristic, traceability, conformity, nonconformity, defect, requirement, grade, Upper Specification Limits, Lower Specification Limits.
STATISTICAL PROCESS CONTROL
Introduction to Statistical Process Control. Data representation. Observing processes over time. Charts. Dot diagram. Time plot. Stem and Leaf diagrams. Frequency distribution and histograms. Cumulative distribution plot. Box Plots. Pareto chart. Control charts. Mean. Standard Deviation, Variance, Range. Ishikawa chart. Electronic sheets.
QUALITY SYSTEMS
Quality systems and certification. UNI EN ISO 9000 (Quality management systems - Fundamentals and vocabulary), UNI EN ISO 9001 (Quality management systems - Requirements standard), UNI EN ISO 9004 (Quality management systems - Guidelines for performance improvements). Total Quality. Software for Quality management.
MEASUREMENTS VS QUALITY SYSTEMS
Metrology. Measurement unceratinty. Uncertainty evaluation and propagation. Uncertainty due to hardware and software.
QUALITY AND IT
Software for Quality Control and Assurance. Information system in laboratory. Test management. Documentation.

Recommended preparatory courses
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Course materials
MONTGOMERY DOUGLAS C., STATISTICAL QUALITY CONTROL, ISBN-13: 9780470233979, Ed. 6, 2009.

Prerequisites
-

Course assessments
Written and oral exams

Lecture attendance
Recommended

Teaching format
In presence learning

Language
English

Course web page
http://www.ccdinfcr.unimi.it/it/corsiDiStudio/2012/F94/default/F94-46/