Corsi Offerti per l'anno 2023/2024

Curriculum in Matematica
Curriculum in Informatica
Curriculum in Statistica

(last update: February 01, 2024)

Curriculum in Matematica

Si ricorda che, ai sensi del regolamento, "i corsi e gli esami previsti nel piano di studi devono inserirsi in almeno due tematiche diverse"; per tematica si intende settore scientifico disciplinare (N.B. i Settori Scientifico Disciplinari della matematica sono i seguenti: MAT/01 Logica Matematica, MAT/02 Algebra, MAT/03 Geometria, MAT/04 Matematiche complementari, MAT/05 Analisi matematica, MAT/06 Probabilità e statistica matematica, MAT/07 Fisica Matematica, MAT/08 Analisi Numerica, MAT/09 Ricerca Operativa; quindi ad esempio Algebra e Geometria sono due diversi SSD.)

Title: *An Invitation to Nonlinear Regularity Theory: the stationary and diffusive p-Laplacean*
Lecturers: Simone Ciani (Università di Bologna - simone.ciani3@unibo.it), Vincenzo Vespri (Università di Firenze - vincenzo.vespri@unifi.it)
Hours/ECTS: 36 / 6
Period: January-February 2024
Course presentation:

Part I. We will start with the theory of regularity of Campanato and De Giorgi for harmonic functions

$$\Delta u = 0, \text{ weakly on } \Omega \subset\subset \mathbb{R}^N .$$

Part II. We will then introduce the theory of De Giorgi classes of growth p, exposed for the sake of simplicity only for the case of the p-Laplacean operator. Here we will study:
(1) Local boundedness of local weak solutions;
(2) The phaenomenon of Expansion of Positivity and its consequences:
(a) Harnack inequality and H¨older continuity;
(b) Rigidity properties (Liouville-type theorems).

Part III. Finally, we will talk about the state of the art of this theory in the context of parabolic equations: why the non-homogeneity between time and space requires a slightly different approach,
bearing the name of intrinsic scaling.

1. Prerequisites
We will give for granted the basics of weak differentiation, as Lebesgue and Sobolev function spaces,
recalling the basics for the nonlinear techniques to be introduced: embedding properties of Sobolev
functions and the inequalities of Young and H¨older. All the new techniques will be

constructive.

References

[1] S. Campanato, Propriet´a di h¨olderianit´a di alcune classi di funzioni. Annali della Scuola Normale Superiore di
Pisa-Classe di Scienze, 1963.
[2] E. De Giorgi, Sulla differenziabilit´a e l'analiticit´a delle estremali degli integrali multipli regolari. Mem. Acc. Sc.
Torino, 1957.
[3] E. DiBenedetto,Degenerate Parabolic Equations. Springer Science and Business Media, 1993.
[4] E. DiBenedetto, Partial differential equations. Springer Science and Business Media, 2009.
[5] L. C. Evans, Partial Differential Equations. Graduate Studies in Mathematics, AMS, 2010.
[6] E. Giusti,Direct Methods in the Calculus of Variations, Hong Kong, World Scientific, 2003.

University: Firenze
Webpage: https://www.unibo.it/sitoweb/simone.ciani3, https://web.math.unifi.it/users/vespri/

Title: *Calculus of Variations*
Lecturer: Elvira Mascolo (Università di Firenze - elvira.mascolo@unifi.it)
Hours/ECTS: 24 / 4
Period: second semester
Course presentation: Introduction to the calculus of variations. Euler-Lagrange equations. Direct methods in the calculus of variations. Applications of the direct methods: semicontinuity. Relaxation theory and non-convex problems, or Applications to non-linear elasticity.
University: Firenze
Webpage: http://web.math.unifi.it/users/mascolo/

Title: *Quantum transport in phase-space*
Lecturer: Luigi Barletti e Omar Morandi (Università di Firenze - luigi.barletti@unifi.it omar.morandi@unifi.it)
Hours/ECTS: 18/3 (possibly 24/4)
Period: second semester
Course presentation: Introduction to quantum statistical mechanics in phase-space (Wigner formalism). Transport of charge and spin. Asymptotic analysis: classical limit and fluid limit. Introduction to the control of Wigner equation. Introduction to local hidden-variable theory. Bell inequalities for continuous variables. Numerical algorithms for phase-space dynamics.
University: Firenze
Webpage: http://web.math.unifi.it/users/barletti/ http://web.math.unifi.it/users/morandi/

Title: *Simplicial Complexes in Finite Groups*
Lecturer: Francesco Fumagalli (Università di Firenze - francesco.fumagalli@unifi.it)
Hours/ECTS: 18 / 3
Period: march/april 2024
Course presentation: The course aims to give a rough overview of a modern research area in the field of finite group theory. Any finite group G contains plenty of partially ordered sets ("posets" for short), some basic examples are the lattice of all subgroups of G, the set of subgroups of G having prime power order (for a fixed prime), both these sets are ordered by natural inclusion, or the set of all subnormal subgroups of G ordered by subnormality. By passing to the order complex, any of these posets gets the structure of a simplicial complex and therefore of a topological space. We will trace the origin to Kenneth S. Brown's theorem that the Euler characteristic of the complex coming from nontrivial p-subgroups is congruent to 1 (mod p) and the following work of Daniel Quillen. In particular we will concentrate on a famous and still open conjecture of Quillen which says that: The order complex of nontrivial p-subgroup of a finite group G is contractible if and only if G has a nontrivial normal p-subgroup.
University: Firenze
Webpage: https://sites.google.com/unifi.it/fumagalli/

Title: Modular representation theory of finite groups
Lecturer: Josep Miquel Martínez Marín (Università di Firenze - josep.m.martinez@uv.es)
Hours/ECTS: 18/3
Period: February/April 2024
Course presentation: The aim of the course will be to introduce the audience to the modular representation theory of finite groups. We will start by developing the basic properties of Brauer characters, blocks and defect groups and then we will prove Brauer's first and third main theorems. If time permits, we will explore the interaction between the modular representation theory of a finite group and its normal subgroups and prove Brauer's height zero conjecture for blocks with normal defect groups.
University: Firenze
Webpage: www.uv.es/jomimar8

Title: *Character theory of finite groups*
Lecturer: Silvio Dolfi and Emanuele Pacifici (Università di Firenze - silvio.dolfi@unifi.it, emanuele.pacifici@unifi.it)
Hours/ECTS: 18 / 3

Period: April/May

Course presentation: The course topic will be the character theory of finite groups. Depending on the background and interests of the audience, the course can be either an introduction to the subject, aimed at laying the foundations of the theory and getting to the first fundamental applications, e.g. the theorems by Burnside and Frobenius, or a 'second level' course on more specific arguments, like character correspondences and the theory of character triples.

University: Firenze

Webpage: http://web.math.unifi.it/users/dolfi/, https://sites.google.com/unifi.it/pacifici/

Title: *Geometric structures and their automorphisms*

Lecturer: Daniele Angella, Fabio Podestà, Luigi Verdiani (Università di Firenze - daniele.angella@unifi.it, fabio.podesta@unifi.it, luigi.verdiani@unifi.it)

Hours/ECTS: 30 / 5

Period: second semester

Course presentation: TBA

University: Firenze

Webpage: https://www.unifi.it/p-doc2-0-0-A-3f2b3c2e39282e.html, https://www.unifi.it/p-doc2-2009-0-A-2b3335303428.html, https://www.unifi.it/p-doc2-0-0-A-3f2a3d31352f2a.html

---

Title: *An introduction to geometric control theory*

Lecturer: Francesca Carlotta Chittaro (Université de Toulon - francesca.chittaro@univ-tln.fr)

Hours/ECTS: 24 / 4

Period: may 2024

Course presentation:

This course deals with the control theory of ODEs; even if we consider dynamical systems on R^n, we will adopt an intrinsic description that makes all results true on smooth manifolds also.

We will start by stating existence and uniqueness results for ODEs with discontinuous right-hand side (with respect to time).

We will then state the problem of attainability and controllability; to inspect it, we will do a digression on the properties of flows of vectors fields (Orbit Theorem, Rashevski-Chow Theorem, Frobenius' Theorem, Krener's Theorem, Hormander condition). Finally, we will consider the problem of stability of equilibria of control systems, and state Lyapunov's criteria for stability

University: Firenze

Webpage: https://pageperso.lis-lab.fr/francesca-carlotta.chittaro/

Title: *Control theory for systems governed by Partial Differential Equations: an introduction*

Lecturer: Francesca Bucci (Università degli Studi di Firenze - francesca.bucci(at)unifi.it), Sergio Vessella (Università degli Studi di Firenze - sergio.vessella(at)unifi.it)
Hours/ECTS: 24 / 4
Period: First semester: mid-November 2023 to Christmas (or at most mid-January 2024)
Course presentation:
The course aims at providing an initial overview on the fundamental concepts of mathematical control theory such as controllability, (stability and) stabilization, optimal control, feedback control. While these core topics will be introduced from a broader functional analytic /system theoretic perspective (within infinite dimensional spaces), the discussion will be accompanied by the analysis of problems associated with actual partial differential equations (PDE) models, along with the targeted PDE methods involved. The crucial role of direct and inverse (observability) inequalities will be highlighted. Finally, the topics of Carleman estimates and unique continuation properties will be outlined.
University: Firenze
Webpage: https://www.unifi.it/p-doc2-0-0-A-3f2a3d2f322d2f.html, https://www.unifi.it/p-doc2-0-0-A-3f2a3d2d382729.html

---

Title: Metodi di Approssimazione in Spazi Funzionali (Approximation methods in Functional Spaces)
Lecturer: Laura Angeloni and Luca Zampogni (Università di Perugia)
Hours/ECTS: 24/4
Period: March-May 2024
Course presentation:

The course aims to introduce the student to some issues of Approximation Theory, a branch of mathematics that mainly involves, but is not limited to, Mathematical Analysis and Numerical Analysis. The course will have an analytical approach and, starting from the classical approximation results about the convolution operators, it will arrive to introduce and study discrete sampling operators. These operators, whose applicative effects in the fields of Signal, Image Processing, Transmission, Medical Sciences, Engineering etc., have a considerable scope, will be studied in terms of their approximation properties in various functional spaces, such as, in addition to those ones of continuous and uniformly continuous functions, in L^p spaces, in Orlicz and modular spaces and in spaces of functions of bounded variation (BV-spaces). Moreover, we will introduce more general operators, both of discrete and integral type, and we will take full advantage by studying their approximation properties for functions defined in locally compact topological groups.

A possible plan for the course is the following:

· Convolution and singular integrals: definitions, properties and approximation results in spaces of continuous functions

· Convergence and order of approximation in BV spaces

· Discrete sampling type operators: historical introduction (Shannon sampling theorem), generalized sampling operators and Kantorovich sampling operators

· Approximation results for sampling type operators in spaces of continuous functions, in Orlicz and modular spaces and in BV spaces

· Family of operators acting on functions defined in locally compact topological groups: introduction, review on basic facts concerning topological groups, definition and properties of the operators, approximation in Orlicz and modular spaces. Brief introduction to rate of convergence: a qualitative estimate.

References

1. L. Angeloni, D. Costarelli, G. Vinti, *A characterization of the convergence in variation for the generalized sampling series*, Annales Academiae Scientiarum Fennicae Mathematica, 43 (2018) 755-767.

2. J. Appell, J. Banas, N. Merentes, *Bounded variation and around*, De Gruyter Series in Nonlinear Analysis and Applications, De Gruyter, Berlin, 17, 2014.

3. P.L. Butzer, R.J. Nessel, *Fourier Analysis and Approximation I*, Academic Press, New York-London, 1971.

4. C. Bardaro, P.L. Butzer, R.L. Stens, G. Vinti, *Kantorovich-type generalized sampling series in the setting of Orlicz spaces*, Sampl. Theory Signal Image Process, 6 (1) (2007) 29-52.

5. C. Bardaro, J. Musielak, G. Vinti, *Nonlinear Integral Operators and Applications*, in: de Gruyter Series in Nonlinear Analysis and Applications, vol. 9, Walter de Gruyter & Co., Berlin, 2003.

6. R.A. DeVore, G.G. Lorentz, *Constructive approximation*, Springer Berlin Heidelberg, 1993.

7. J. Musielak, *Orlicz Spaces and Modular Spaces*, in: Lecture Notes in Mathematics, 1034, Springer-Verlag, Berlin, 1983.

8. M.M. Rao, Z.D. Ren, *Theory of Orlicz Spaces*, Monograph Textbooks Pure Appl. Math., Marcel Dekker Inc., New York, 1991.

9. G. Vinti, L. Zampogni, *A General Approximation Approach for the Simultaneous Treatment of Integral and Discrete Operators,* Advanced Nonlinear Studies 18 (2018), 705-724.

More detailed references will be provided during the course.

University: Perugia

Webpage: https://angeloni.sites.dmi.unipg.it/ (Laura Angeloni)
https://www.unipg.it/personale/luca.zampogni (Luca Zampogni)

Title: Analyzing Semilinear Differential Equations through Fixed Point Theorems

Lecturer: Irene Benedetti (Università di Perugia - irene.benedetti@unipg.it)

Hours/ECTS: 18 / 3

Period: second semester

Course presentation:

In this course, we will focus on semilinear differential equations, characterized by a combination of a linear component that generates a semigroup of linear operators and a nonlinearity exhibiting specific regularity properties. The course will cover a wide range of existence techniques to establish results for different types of problems, relying on fixed point
theory. Specifically, we will analyze different boundary conditions and perturbations, including nonlocal or periodic initial conditions. To facilitate this, we will provide an introduction to semigroup theory. Additionally

University: Perugia or Firenze

Webpage: https://www.unipg.it/personale/irene.benedetti

Title: An invitation to Analytic Number Theory

Lecturer: Marco Cantarini (marco.cantarini@unipg.it)

Hours/ECTS: 24 / 4

Period: November 2023 to mid-December 2023, at most mid-January 2024

Course presentation:

The course aims to provide an introduction to some basic notions of Analytic Number Theory, such as the properties of arithmetical functions, the distribution of prime numbers, primes in arithmetical progressions, the theory of Riemann Zeta functions, and their connections to the distribution of prime numbers. It also includes an overview of the well-known Riemann's Conjecture. Finally, the course covers the behavior and error control of averages of arithmetical functions.

University: Perugia

Webpage: https://www.unipg.it/personale/marco.cantarini

Title: Galois theory and applications

Lecturer: Marco Timpanella (Università di Perugia)

Hours/ECTS: 24 hours / 4 ECTS

Period: December 2023/January 2024

Course presentation:

Galois theory and function field theory are two of the most established topics in mathematics, with historical roots that led to the development of many central concepts in modern mathematics. In recent years, these topics have found surprising applications in other branches of mathematics such as Finite Geometry, Coding Theory, and Cryptography.

The main objective of this course is to provide an in-depth knowledge of Galois theory, and to show how these techniques can be applied to the study of other relevant mathematical objects.

The course is divided into two parts. The first one presents the foundations of field extensions and the interplay between group theory and field theory, formulated via Galois theory.

In the second part, we will focus on Galois extensions of function fields, and their applications to Finite Geometry and Coding Theory.

References:
- J. W. P. Hirschfeld, G. Korchmáros, F. Torres, Algebraic Curves over a Finite Field, Princeton University Press (2008).
- D. A. Cox, Galois Theory, John Wiley & Sons Inc (2012).
- H. Stichtenoth, Algebraic Function Fields and Codes, Springer (2009).
More detailed references will be provided during the course.
University: Perugia
Webpage:

Title: Algebraic curves and applications to cryptography and coding theory
Lecturer: Daniele Bartoli (Università di Perugia)
Hours/ECTS: 30 hours / 5 ECTS
Period: March-May 2024
Course presentation:
An introduction to algebraic curves over finite fields and related function fields is provided in the first part. Applications to relevant classes of polynomials over finite fields will be given in the second part.
University: Perugia/Firenze
Webpage: https://www.unipg.it/personale/daniele.bartoli

Title: Neural network-type approximation methods: classical and recent results **Lecturer**: Danilo Costarelli (Università degli Studi di Perugia – danilo.costarelli@unipg.it)
Hours/ECTS: 30 / 5
Period: march-april 2024
Course presentation:
The aim of the present course is to retrace the main theoretical results concerning neural network-type approximation methods obtained in the last forty years. Particular emphasis will be given to the classical results established from 1989 to now. A large part of the courses will deal with the theory of neural network (NN) operators, and finally a brief overview concerning the recent development of the above mentioned theories will be given. During the course, in order to better understand the proposed results, some fundamental tools of the Approximation Theory will be recalled, together with some notions of Real and Functional Analysis.

It is well-known that, artificial neural networks (ANNs) have been introduced around 1947 with the main purpose to implement a very simple model for the human brain, which is able to reproduce all its main activities.

Among the main activities of the brain, we can find the capability to learn from the experience; this task can be viewed, from the discrete point of view, as the ability to reproduce values taken from datasets by means of the application of suitable algorithms. From the mathematical point of view, this can be translated as an interpolation process, or more in general, as an approximation process.

The first author that considered the problem of approximating function by neural networks was Cybenko in 1989 ([2]). The main peculiarity of Cybenko's approximation theorem was

that it can be proved by resorting to non-constructive methods. In practice, Cybenko proved that for any continuous function on a compact domain, there exists a NN that approximates f with any given degree of accuracy. However, from the theory developed in [2] the problem of concretely finding such a NN was not faced. It is clear that, in order to study applications by means of NNs it is important to have at disposal constructive approximation processes. The latter consideration has motivated several studies in this direction, i.e., the study of constructive approximation results (which we will deal with during the present course).

In recent years, particular emphasis has been given to the so-called theory of neural network (NN) operators. Such a theory started with the paper of French mathematicians Cardaliaguet and Euvrard ([1]), and in 2013-2014, it has been extended to a more general framework (see, e.g., [3,4]).

References:

[1] P. Cardaliaguet, G. Euvrard, Approximation of a function and its derivative with a neural network, Neural Netw. 5 (2) (1992) 207-220.

[2] G. Cybenko, Approximation by superpositions of a sigmoidal function, Math. Control Signals Systems 2, (1989), 303-314.

[3] D. Costarelli, R. Spigler, Approximation results for neural network operators activated by sigmoidal functions, Neural Netw., 44 (2013) 101-106.

[4] D. Costarelli, R. Spigler, Convergence of a family of neural network operators of the Kantorovich type, J. Approx. Theory, 185 (2014) 80-90.

University: Perugia
Webpage: https://www.unipg.it/personale/danilo.costarelli

Title: Spectral methods in applied mathematics
Lecturer: Lorenzo Fusi (Università di Firenze)
Hours/ECTS: 24 / 4
Period: march 2024
Course Presentation: Spectral collocation methods consist in a class of numerical methods used to solve ordinary differential differential equations (ODEs) and partial differential equations (PDEs). These methods are particularly efficient when one considers simple domains (they can achieve a level of accuracy five times bigger than the alternatives), demanding less computer memory than other methods. In spectral methods solutions are sought by means of high order polynomial expansions (notably, trigonometric polynomials for periodic solutions and orthogonal polynomials for non-periodic solutions). In applied mathematics they are often used to solve boundary and initial value problems occurring in various fields of application (geomechanics, biology, chemistry, physics, fluid dynamics ecc). We shall present the essentials of spectral collocation methods (Differentiation matrices, Fast Fourier Transform, Clustered Grids, Chebyshev Series, ecc) and see how the can easily be implemented on Matlab to solve some classical problems arising

in fluid mechanics, quantum mechanics, linear and nonlinear elasticity.
Bibliography:
[1] Trefethen L.N., Spectral Methods in Matlab, SIAM 2000.
[2] Canuto C., Hussaini M.Y., Quarteroni A., Zang T.A., Spectral methods in fluid dynamics, Springer 1988.

Title: Algorithmic challanges on discrete tomography, graph theory and combinatorics on words
Lecturer: Andrea Frosini
Hours/ECTS: 4 CFU (24 ore)
Period: inizio 4 marzo
Course presentation: I define the main problems in discrete tomography and I pointed out the most interesting algorithmic results in literature.
Then, I show how these same problems fit in the framework of graph and hypergraph theory with some complexity results about their reconstruction from degree sequences. Finally, I set a bridge between discrete tomography and combinatorics on words and provide some algorithmic results. In the last part of the course, I show some open problems in the three fields and I give hints to challenge them.
University: Firenze
Webpage:

Title: Turbomachinery Aeroacoustics: mathematical models and applications
Lecturer: Benedetta Calusi and Lorenzo Pinelli (Università degli Studi di Firenze – benedetta.calusi@unifi.it, lorenzo.pinelli@unifi.it)
Hours/ECTS: 24/4
Period: second semester
Course presentation: FIRST PART: MATHEMATICAL MODELS AND METHODS

1. Gas dynamics background
2. A first approach to the acoustic approximation: flow in a thin cylindrical and rectangular ducts
3. Acoustic perturbations in cylindrical duct
4. Application to turbines: Tyler-Sofrin rotor stator interaction rule

In the first part we briefly recall the basic concepts of the fluid dynamics providing a general formulation of the mathematical problem. We indeed introduce the general equations for the pressure field and the flow and specialize them assuming that the fluid behaves as a perfect gas.

In the second part we further specialize even the model, considering the evolution of “small perturbations” (usually referred to as

acoustic perturbations) of a uniform flow on a cylindrical surface. The purpose of this part, given the particular "simplicity" of the domain, is to introduce the mathematical concepts of acoustic perturbations modal decomposition and propagation.

The third part is devoted to the mathematical methods used to solve the problem in a cylindrical duct. The approach, while making use of the same mathematical concepts, will be different and the comparison with what has been analyzed previously will be highlighted.

In the last part we analyze, from a theoretical point of view, the application of the model to the interaction between blade rows in rotating pressure patterns as the ones usually occurring in turbines.

SECOND PART: APPLICATION AND NUMERICAL METHODS

1. Turbomachinery noise: tonal and broadband component
2. Noise generation and propagation in turbomachinery
3. Acoustic perturbation in annular duct with shear and swirl: numerical approach based on eigenvector problem
4. Numerical methods for tone and core noise evaluation and their application (analytical, time-linearized, harmonic balance, non-linear)
5. High fidelity numerical methods for broadband noise and their application (DDES, LES)

The second part of the course will be dedicated to the application of acoustic models for the prediction of turbomachinery noise by means of CFD (Computational Fluid Dynamics).

First, the turbomachinery noise will be described with a special focus on aeronautical applications that require strict regulation related to noise emitted by aircrafts. Tonal and broadband contribution will be explained, describing in detail the aeroacustic phenomena that generate such noise components.

The formulation of acoustic perturbation in annular duct will be extended to real environment where shear and swirling flows are present. This leads to an eigenvector problem that can be solved numerically to define convective and acoustic perturbations.

In the last part, numerical methods based on analytical and CFD URANS (Unsteady Reynolds Averaged Navier-Stokes) approaches will be presented for the prediction of tonal component generated by rotor/stator interaction and by combustor/turbine interaction (core noise). Finally, some application of high-fidelity approaches (DES, Detached Eddy Simulation - and LES, Large Eddy Simulation) will be

described to predict the broadband components of aeroengine noise and to assess the efficiency of passive noise adsorbers (acoustic liners).

University: Firenze (CDM - Centro Didattico Morgagni)

Webpage: https://sites.google.com/view/benedetta-calusi, http://arnone.de.unifi.it/tgroup/pinelli

---

- *list being update..*

Title:
Lecturer:
Hours/ECTS:
Period:
Course presentation:
University: Firenze
Webpage:

Title:
Lecturer:
Hours/ECTS:
Period:
Course presentation:
University: Firenze
Webpage:

==========

Curriculum in Informatica

Elenco Corsi Dottorato Curriculum in Informatica
AA 2023-2024

Title: Safe Machine Learning: Are we there yet?
Lecturer: Zoppi Tommaso, Bondavalli Andrea
Hours/ECTS: 3 CFU (@UNIFI, 18hrs + project discussion and presentation (final exam)) **Period**: Dicembre 2023 - Gennaio 2024

Prerequisites: Basics of Machine Learning, Basics of Python Programming

Course presentation:

With the growing processing power of computing systems and the increasing availability of massive datasets, Machine Learning (ML) algorithms have led to major breakthroughs in many different areas. This applies also to safety-critical systems, ICT systems whose failure may have catastrophic consequences for the health of citizens, environment, and infrastructures. However, components and software that use ML algorithms may fail: this failure may propagate to the incorporating critical systems and may create severe hazards that need to be avoided. As such, companies, researchers and practitioners are investing in methodologies, architectures and algorithms that are suitable to be safely used in critical systems, albeit no general and reliable solution has been yet found. This course overviews the problem of incorporating ML algorithms into critical systems and the (few) standards that regulate their inclusion. Then, we go through design patterns that are typically used to build safety-critical systems, and apply them to ML algorithms, aiming at designing safe ML components.

University: Firenze

Webpage:

Title: Artificial Intelligence for Affective Computing

Lecturer: Valentina Franzoni, Alfredo Milani

Hours/ECTS: 6 CFU

Period: secondo semestre A.A:2023/2024

Course presentation:

Introduction to AI approach to Emotion Recognition (ER) and Affective Computing. Neurophysiological aspects, emotional models (Plutchik), applications.

Image based ER, CNN and knowledge transfer techniques. Sound baser ER, spectrogramization. ER in text, PoS, word-to-vec, semantic similarity.

Sensors-based and PoB based ER. Insights on emotional intelligence, Mirror Neurons, Social Emotions, Errors, biases and overconfidence.

University: Perugia

Webpage:

Title: An introduction to Quantum Computing

Lecturer: Marco Baioletti

Hours/ECTS: 3 CFU (18 ore)

Period: probabilmente gennaio-febbraio 2024

Course presentation:

1. Basic concepts of quantum computing (qubit, measurement, gate, circuit,...)
2. Oracle-based quantum algorithms (Deutsch, Deutsch-Josza, Grover, ...) 3. Shor's algorithm and its applications (factoring, discrete logarithm, QFT, ...) 4. QC for optimization and machine learning (Quantum annealers, QAOA, QML, ...) 5.

Advanced aspects of QC (teleportation, cryptography, error correction, error mitigation, ...)

6. Quantum Computer Science (computational complexity, programming, compilation, ...)

University: Firenze

Webpage:

Title: An algorithmic perspective in innovative and emerging research areas

Lecturer: Betti Sorbelli, Navarra, Pinotti

Hours/ECTS: 6 CFU (36 hours)

Period: January-March 2024

Course presentation:

In this course, the GEAR Lab of UNIPG will present its recent research activities which are characterized by the study of algorithmic problems raised using drones for localizing sensors, for package delivery, for agriculture of precision, and for emergency activities. We will also investigate algorithms for communications using multi-interfaces and for pattern formation that can rise when swarms of drones fly together in the air.

Program content:

Sensor Localization with Drones [6 hours]

1) Range-based algorithms
2) Range-free algorithms
3) Test-beds

Package Delivery with Drones [6 hours]

1) With Interval Conflicts
2) With Wind
3) By considering EM-grids

Other Drone-based Applications [4 hours]

1) Monitoring
2) Disaster Recovery
3) Sea emergency activities

Drones and Robot in Smart Agriculture [6 hours]

1) Irrigation
2) Data Collection
3) Bug Detection
4) With Machine Learning

Multi-Interface communications [8 hours]:

1) Coverage in the bounded and unbounded case
2) Connectivity and Shortest paths
3) Maximum matching
4) Variants and multi objectives

Pattern Formation [6 hours]:
1) Pattern Formation with minimal assumptions
2) Arbitrary Pattern Formation
3) Embedded Pattern Formation
University: Firenze
Webpage:

Title: Algorithmic challanges on discrete tomography, graph theory and combinatorics on words
Lecturer: Andrea Frosini
Hours/ECTS: 4 CFU (24 ore)
Period: inizio 4 marzo
Course presentation: I define the main problems in discrete tomography and I pointed out the most interesting algorithmic results in literature.
Then, I show how these same problems fit in the framework of graph and hypergraph theory with some complexity results about their reconstruction from degree sequences. Finally, I set a bridge between discrete tomography and combinatorics on words and provide some algorithmic results. In the last part of the course, I show some open problems in the three fields and I give hints to challenge them.
University: Firenze
Webpage:

---

list being update..

Title:
Lecturer:
Hours/ECTS:
Period:
Course presentation:
University: Firenze
Webpage:

Title:
Lecturer:
Hours/ECTS:
Period:

Course presentation:
University: Firenze
Webpage:

Title:
Lecturer:
Hours/ECTS:
Period:
Course presentation:
University: Firenze
Webpage:

==========

Curriculum in Statistica

Corso di Statistica (metodi e modelli)

Moduli:

Title: Elements of statistical inference
Lecturer: Alessandra Mattei, Agnese Panzera, Anna Gottard
Hours/ECTS: 12/2
Period: Nov 23/Jan 24
Course presentation: *Mandatory course for the curriculum in Statistics. The course will be held as a flipped class.*
University: Firenze

Title: Gaussian Mixture Models for Model-Based Clustering, Classification and Density Estimation
Lecturer: Luca Scrucca
Hours/ECTS: 12 Hours / 2 ECTS
Period: March-April 2024
Course presentation: The course introduces Gaussian mixture models, a widely-used family of models that have proved to be an effective and computationally

convenient way to perform model-based clustering, classification, and density estimation.
Topics presented during this course are maximum likelihood estimation via the EM algorithm, resampling-based inference, model selection, data simulation, Bayesian regularization, presence of noise and outliers, variable selection for model-based clustering. All the methods are illustrated using the mclust package for the software R.
University: Perugia

Title: Finite population inference using modern regression techniques
Lecturer: Maria Giovanna Ranalli
Hours/ECTS: 12 Hours / 2 ECTS
Period: March-April 2024
Course presentation: The course introduces descriptive inference for finite populations under the classical design-based approach and then moves to more recent approaches based on or assisted by statistical models. In particular, we will focus on the use of nonparametric regression models, machine learning methods, random effect and latent variable models also for small area estimation.
University: Perugia

Title: Regression Chain Graph Models
Lecturer: Giovanni Maria MarchettiandMonia Lupparelli
Hours/ECTS: 12/2
Period:April 2024
Course presentation: The theory of Graphical Markov Models defines a common framework to model, analyze and interpret data for several partially ordered sets of joint responses. The analysis consists of a sequence of multivariate regressions where the responses may be continuous or discrete. The structure of dependence is summarized by a generalization of directed acyclic graphs (DAG) with three types of edge: arrows, lines and bi-directed arcs. We will discuss the models and their interpretation with special emphasis on categorical data, showing examples with data and computations. The models will be fitted by likelihood or Bayesian methods.
University: Firenze

Title: Introduction to composite likelihood
Lecturer: Monia Lupparelli
Hours/ECTS: 12 hours/2CFU
Period: March 2024
Course presentation: The course provides an introduction to composite likelihood theory, both marginal and conditional approaches are discussed, with possible applications. The focus is mainly on inference and model selection. The course includes a reading group activity based on a selection of published papers.
University: Firenze

Title: Bayesian methods for high-dimensional data
Lecturer: Francesco Stingo, Alberto Cassese
Hours/ECTS: 18/3
Period: May
Course presentation: Bayesian approaches for model selection in the context of Linear regression, GLM and Graphical models; Hidden Markov models; introduction to Bayesian nonparametrics. All the topics will be integrated with applications in bio-medicine, with a particular focus on genomics.
University: Firenze

Title: Approximate Bayesian Computation (ABC)
Lecturer: Fabio Corradi; Cecilia Viscardi
Hours/ECTS: 12 /2
Period: June - July 2024
Course presentation: The course introduces Approximate Bayesian Computation (ABC) - a class of likelihood-free methods for Bayesian inference.
Topics presented during this course: ABC as an explanation of how Bayes rule works; Generative models; ABC with no approximation; Sources of approximation in ABC; Rejection ABC and its convergence to exact Bayesian computation; Limits in the use of Rejection ABC by examples; Examples from network analysis and Population genetics; Trade-off between level of approximation and computational efficiency; Importance Sampling ABC; Markov Chain Monte Carlo ABC. Sequential methods: Population MC and Sequential MC.
At the end of the course, we provide an introduction to some more advanced topics, possibly related to student research interests, to be further developed in a presentation given by the students during the last lecture.
University: Firenze

Title: Statistical analysis of spatial data
Lecturer: Chiara Bocci
Hours/ECTS: 12/2
Period: a.a. 2024/25 - il corso è offerto ad anni alterni.
Course presentation: The aim of the course is to introduce students to statistical techniques for the analysis of spatial data, that is data that exhibit a spatial dependence. After the presentation of stochastic spatial processes and their properties, we present methods for the analysis of Point Process data, Geostatistical (random surface) data, and Lattice (areal) data. A brief discussion on spatial datasets and GIS will be given.
University: Firenze

Corso di Statistica medica e biostatistica

Moduli:

Title: Compartmental models for the analysis of contagion dynamics: inference and GSA
Lecturer: Michela Baccini, Giulia Cereda
Hours/ECTS: 12 hours/2CFU
Period: January 2024
Course presentation:
The course will provide an introduction to compartmental models for epidemic dynamics and their use for prediction and inference.We will illustrate frequentist calibration techniques for parameters estimation and parametric bootstrap procedures for confidence intervals construction. Special focus will be given to global sensitivity analysis (GSA) and Sobol's indexes calculation as tools to assess and characterize model uncertainties both in the phase of model construction and in the inference one. The course will include practicals on Covid19 data. University: Firenze

---

Title: Advanced statistical methods for the analysis of the short-term effect of environmental exposures on population health
Lecturers: Michela Baccini, Francesco Sera
Hours/ECTS: 12/2
Period: June 2024
Course presentation: This course will offer a thorough overview of established approaches and recent advancements in methods for the analysis of the short-term effects of environmental exposures (e.g. air pollution, extreme temperatures) on human health. We will address the following topics:
1) Generalized Linear Models for the analysis of mortality and morbidity time series, in the presence of delayed and non-linear effects (use of Distributed Lag Non Linear models in frequentist and Bayesian frameworks).
2) Potential outcome approach to causal inference to estimate counterfactual exposure-response functions representing the short-term effect of environmental exposures, with investigation of effect modification and interaction effects.
3) Methods for assessing the impact of actual, hypothetical and future exposures on health, with focus on projections under alternative climate change and air pollution scenarios.

Title: Machine Learning and Omics in Epidemiology
Lecturer: Gianluca Severi and Chiara Marzi
Hours/ECTS: 6/1
Period: febbraio-luglio 2024
Course presentation: This course aims at introducing Ph.D. students to statistical

and machine learning methods for the analysis of high-dimensional data in epidemiology - the so-called “omics”. Particular emphasis will be placed on the different types of omics data (e.g., molecular data, metabolomics, genomics, proteomics, radiomics, etc.), as well as on the fundamental steps performed within a Machine Learning analysis to extract useful insights from these data (e.g., data harmonisation, features selection, validation scheme, etc.).
University: Firenze

Title: From literature search to data synthesis: Classic and advanced systematic reviews with meta-analysis
Lecturers: Ersilia Lucenteforte, Francesco Sera, and Michela Baccini
Hours/ECTS: 12/2
Period: April-May 2024
Course presentation: This course introduces Ph.D. students to the concept of systematic reviews and explains their use and interpretation. It provides an overview of the systematic review process, including data analysis. The course encompasses the analysis of various types of meta-analyses, such as traditional meta-analysis (for dichotomous and continuous outcomes), diagnostic test accuracy meta-analysis (both bivariate and hierarchical models), extended meta-analysis (covering longitudinal, dose-response, and multilevel analyses), and network meta-analysis (within both the frequentist and the Bayesian frameworks).
University: Firenze

Corso di Informatica e statistica computazionale

Moduli

Title: Simulation experiments in Econometrics
Lecturer: Giorgio Calzolari
Hours/ECTS: 12/2
Period: Nov. 2023
Course presentation: Intensive Monte Carlo simulation experiments are applied to some well known estimation methods (like Ordinary least squares, Instrumental variables, Maximum likelihood, Quasi maximum likelihood, Indirect inference), to verify their statistical properties (whose “theory” is usually studied in the undergraduate and graduate courses: unbiasedness, consistency, efficiency, asymptotic normality, computational efficiency).
University: Firenze

Title: Fundamentals of computer science for the data scientist
Lecturer: Andrea Marino, Donatella Merlini, Cecilia Verri
Hours/ECTS: 24 hours/4
Period: Spring 2025

Course presentation:
Programming in Python: fundamental structures, python modules,
functions, recursion, strings, lists, dictionaries, analysis of algorithms,
search, and sorting. Algorithmic techniques: greedy, divide et impera, dynamic programming. Graphs and algorithms on graphs. Relational algebra and normalization.
Preprocessing of relational data for data mining applications using the SQL language.
University: Firenze

Corso di Statistica economica e ricerca sperimentale

Moduli:

Title: Experimental design and statistical models for engineering and quantitative marketing: theory and case studies
Lecturer: Rossella Berni (Part#1: 2CFUs 12h- April); Nedka D. Nikiforova (Part#2: 1CFU 6h-May)
Hours/ECTS: 18h+2h (for the exams) /3
Period: April-May 2024
Course presentation:
This teaching course focused on the design of experiments in the technological field and for studying the consumers' behavior. More precisely, the main aim is the illustration of features and steps for planning an experimental design according to design properties and statistical modeling issues. Last developments will be shown theoretically as well as through case studies.
Contents:
Part#1
- Fundamental principles of experimental design
- The experimental design in the technological field: planning and modeling
- Split-plot design and modeling
- Optimal designs: introduction and general features
- Case-studies and last developments in the literature.

Part#2
- Optimal designs for choice experiments
- Choice experiments and modeling: main Random Utility Models (RUMs)
- Respondents' heterogeneity and heteroscedasticity of the alternatives;
- Complex modeling by RUMs;
- Computer experiments and Kriging modeling
- Case-studies and last developments in the literature.

MAIN REFERENCES:

1. Cox D.R, Reid (2000), The theory of the design of experiments, Chapman & Hall.
2. Khuri, A.I. and Cornell, J.A., 1996, Response Surfaces: design and analysis. 2nd Ed. Marcel Dekker, New York.
3. Montgomery DC 2001, Design and analysis of Experiments, 5th Ed. Wiley
4. Searle, S.R., Casella, G., McCulloch, C.E., 1992, Variance components, New

Jersey: John Wiley & Sons.
5. Atkinson, A.C. & Donev, A.N., 1992, Optimum Experimental Designs. Oxford Statistical Science
6. Train K. Discrete Choice Simulation, Cambridge University Press, 2002

NOTE: In addition to the books cited in references, a scientific paper will be given to each PhD student for a deep discussion, as *reading group*. The PhD student should give a seminar (exam) in order to promote the discussion, among all the attendants, on the paper.

University: Università di Firenze

Title: Efficiency frontiers and composite indicators: Foundations and Spatial applications
Lecturer: Elisa Fusco
Hours/ECTS: 12/2
Period: March/May 2024
Course presentation:
The efficient use of physical (e.g., labor, energy, capital, etc.) and monetary resources, or an efficient production process, are the two main objectives of any production unit (firms, banks, local authorities, etc.) to be competitive in the market and to maximize profits. Since 1950, starting with Koopmans (1951), Debreu (1951) and Shephard (1953), a wide literature has developed in the fields of econometrics, management sciences, operations research and mathematical statistics, with the aim of implementing new tools for the analysis of productivity and efficiency of decision-making units. Therefore, the objective of this course is to introduce the fundamentals and state-of-the-art methods, both parametric and non-parametric, for production and cost efficiency analysis, with particular emphasis on recent advances in temporal and spatial effects. In addition, frontier models have recently been used to construct composite indicators. Interest in composite indicators as a useful tool to assist decision makers in policy analysis and communication is growing rapidly due to their ability to summarize multidimensional issues, to rank countries in benchmarking analysis, and their ease of interpretation.
The course consists of theory and practical applications in R.
University: Firenze

Corso di Statistica e modelli per la demografia e la statistica sociale

Moduli:

Title: Exploring socio-demographic research: methods and applications
Lecturers: G. Alderotti, M. Cozzani, V. Dorgali, G. Lombardi, V. Tocchioni
Hours/ECTS: 15/2.5
Period: 1-15 February 2024
Course presentation: The seminars will give an overview on current topics in the

field of population studies in contemporary societies. We will propose a critical and in-depth discussion on major social and demographic issues that contemporary societies are facing and on future challenges, also offering new and fresh insights on methodological approaches useful in these domains.
List of proposed seminars:

- Employment uncertainty and family formation in high-income countries (GA)
- Natural experiments in demographic research (MC)
- Exploring health decision-making: vaccination, hesitancy, psychology and health behaviour (VD)
- Should I stay or Should I go? Internal student migration in the Italian Tertiary Education system (GL)
- Pathways into life-course trajectories (VT)

University: Firenze

Title: Random effects models for multilevel and longitudinal data
Lecturer: Leonardo Grilli, Carla Rampichini
Hours/ECTS: 12/2
Period: 22, 23, 24, 25 January 2024
Course presentation: The course introduces the theory and practice of random effects (mixed effects) models for the analysis of multilevel data in both cross-sectional and longitudinal settings. Emphasis is placed on model specification and interpretation. The course covers random effects models for continuous responses and for categorical responses. University: Firenze

---

Title: Methods and tools for longitudinal data analysis
Lecturer: Maria Francesca Marino
Hours/ECTS: 12/2
Period: 10-11-12 gennaio 2024
Course presentation: The course aims at introducing students to methods and models for the analysis of longitudinal data. These are characterized by a complex dependence structure that, if not properly taken into consideration in the analysis, may lead to biased inferential conclusions. Particular emphasis will be placed on the description of the main features of longitudinal data, as well as on the methodological aspects behind the main modeling alternatives available in the literature. The treatment of missing data in longitudinal data modeling will be also discussed.
University: Firenze

Title: Latent Variable Models for cross-section and longitudinal data
Lecturer: Silvia Pandolfi
Hours/ECTS: 12 Hours / 2 ECTS
Period: March-April 2024
Course presentation: The aim of the course is to introduce the fundamental concepts and state-of-art about latent variable models. Specific discrete latent

variable models, including both discrete and continuous latent variables will be introduced, such as finite mixture, latent class, latent regression, item response theory, hidden Markov models, and stochastic block models. Algorithms for maximum likelihood estimation of these models are reviewed, focusing in particular on the Expectation-Maximization algorithm. Model selection, clustering, and computation of standard errors will be discussed. All approaches will be illustrated by means of real data applications implemented through the software R.
University: Perugia

- *list being update..*

Title:
Lecturer:
Hours/ECTS:
Period:
Course presentation:
University: Firenze
Webpage:

Title:
Lecturer:
Hours/ECTS:
Period:
Course presentation:
University: Firenze
Webpage:

Title:
Lecturer:
Hours/ECTS:
Period:
Course presentation:
University: Firenze
Webpage:

Title:
Lecturer:
Hours/ECTS:
Period:
Course presentation:
University: Firenze
Webpage:

Title:
Lecturer:
Hours/ECTS:
Period:

Course presentation:
University: Firenze
Webpage:

Title:
Lecturer:
Hours/ECTS:
Period:
Course presentation:
University: Firenze
Webpage:
==========