Corsi Offerti per l’anno 2021/2022

Curriculum in Matematica
Curriculum in Informatica
Curriculum in Statistica

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: Fluid Mechanics and Human Circulation

Lecturer: Angiolo Farina (Università di Firenze)

Hours/ECTS: 20/4

Period: second semester

Course presentation: in the proposed course we focus our attention on one of the most intriguing branches of medicine: hematology. Many experimental studies over the years have shown that blood flow exhibits extremely complex characteristics. In this framework mathematics can play an important role, setting up reliable and, at the same time, "simple" models. Indeed, the more difficult are the phenomena to be studied, the more necessary is to simplify equations, and simplifications always need to be justified and kept within a tolerance degree guaranteeing that the model is still meaningful, at least for some specific target.
Blood-related topics are so numerous and each subject has been so widely studied that it is unthinkable to treat all of them in a short course. We just deal with some aspects, showing old and new approaches. Indeed, the main objective is to focus on some blood fluid dynamics problems and to illustrate the relative mathematical models, trying to emphasize both the physical aspects and the mathematical techniques. In summary, we analyze some blood flow in specific body vessels. However, as preliminary discussion, we recall some issues concerning the constitutive models that can be used to describe the peculiar blood rheology.

Course plan:

1. The Human Circulatory System
2. Hemorheology and Hemodynamics
   Blood Rheology
   Constitutive Models for Blood
   Microcirculation, vasomotion, Fåhræus–Lindqvist effect
3. Blood Filtration in Kidneys
   General Structure of Kidneys
   Modelling of the filtration process
   The Steady Flow and the Glomerular Filtration Rate
4. Extracorporeal Blood Ultrafiltration
   The hollow fibers dialyzers
   Osmotic pressure

Modeling the devices

Bibliography:
Fasano A., Sequeira A.: Hemomath. The Mathematics of Blood. Springer (2017).

University: Firenze

Webpage: https://www.unifi.it/p-doc2-0-0-A-3f2b3a2e3a2d2f.html

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Title: Inverse and ill-posed problems

Lecturer: Elisa Francini, Sergio Vessella (Università di Firenze)

Hours/ECTS: between 20 and 30 hours / between 4 and 6 ECTS

Period: January-May 2022

Course presentation: TBA

University: Firenze

Webpage: http://web.math.unifi.it/users/francini/,
https://www.unifi.it/p-doc2-2017-200052-V-3f2a3d2d382729-0.html

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Title: Variational Methods for Imaging

Lecturer: Simone Rebegoldi (Università di Firenze)

Hours/ECTS: 10/2

Period: February 2022

Course presentation: TBA

University: Firenze

Webpage: https://www.unifi.it/p-doc2-2019-0-A-2d2b3832352c-0.html

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Title: Spline models for data analysis

Lecturer: Costanza Conti (Università di Firenze)

Hours/ECTS: 10/2

Period: December 2021

Course presentation: spline models have attracted a great deal of attention in recent years and have been widely used in many areas of science and engineering, such as signal and image processing, computer graphics, and, more recently, deep learning and neural networks, or Isogeometric Analysis (see the course "Isogeometric Boundary Element Methods" for the latter application of splines). In particular, splines are an important tool in the regression model framework to model and predict data trends.

The course aims at providing an introduction to basic spline models (smoothing, regression, and penalized splines) based on polynomial splines, exponential-polynomial splines, thin-plate splines, L-splines. It also aims at giving a general overview of more advanced models, including nonparametric and nonlinear regression splines. Two models will be described in detail: smoothing splines and penalized least squares splines (PSplines and HPSplines, in more detail). Methods for parameter selection of PSplines and HPSplines will also be discussed.

University: Firenze

Webpage: https://www.unifi.it/p-doc2-2013-200006-C-3f2a3d3034292c-0.html

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Title: Isogeometric Boundary Element Methods

Lecturers: Alessandra Sestini and Maria Lucia Sampoli

Hours/ECTS: 20/4

Period: January-February 2022

Course presentation: the course focuses on Boundary Element Methods (BEMs) for the numerical solution of differential problems, even on unbounded domains. In particular it aims to present their recent formulation within the Isogeometric Analysis paradigm (IgA-BEMs), where splines are used for both geometric and analytical purposes, see the course "Spline models for data analysis" for a different application of splines. After necessary prerequisites about Sobolev and spline spaces, the IgA numerical discretization of Boundary Integral Equations will be considered, dealing in particular with 2D and 3D Laplace and Helmholtz problems with Dirichlet/Neumann boundary conditions. The course will be concluded by presenting a quadrature rule specific for IgA-BEMs recently developed and introducing the IgA-BEMs formulation which is the object of current research.

University: Firenze

Webpage: http://web.math.unifi.it/users/sestini/, https://docenti.unisi.it/it/sampoli-0

Title: Einstein equations in Riemannian and Kähler Geometry

Lecturers:
- Daniele Angella (Università di Firenze),
- Alexandra Otiman (Università di Firenze),
- Francesco Pediconi (Università di Firenze)

Hours/ECTS: 40 hours / 8 ECTS

Period: January-June 2022

Course presentation: inspired by General Relativity, the Einstein equations are a fundamental topic at the intersection between topology, analysis and differential geometry.

We will introduce the main problems and results concerning Einstein metrics. In the second part of the course, we will examine in depth some advanced topics. A possible plan for the course is the following:
- Preliminary notions in Riemannian geometry.
- Introduction to Einstein metrics.
- Variational approach to Einstein metrics.
- Topology of Einstein manifolds.
- Preliminary notions in complex and Kähler geometry.
- Kähler-Einstein metrics.
- Calabi-Yau theorem.
- Further topics, according to the attendee's interests.

Main reference:
- A. L. Besse, Einstein Manifolds.

Additional references:
- P. Gauduchon, Calabi's extremal Kähler metrics: An elementary introduction.
- G. Székelyhidi, An introduction to extremal Kähler metrics, Graduate Studies in Mathematics, 152, American Mathematical Society, Providence, RI, 2014.

University: Firenze

Webpage:
(DA) https://sites.google.com/site/danieleangella/
(AO) https://sites.google.com/site/alexandraotiman/
(FP) https://sites.google.com/view/francescopediconi/

Title: Mathematics, Deep Learning and Deep Reinforcement Learning

Lecturer: Maurizio Parton (Università di Chieti-Pescara)

Hours/ECTS: 30/6

Period: Summer 2022

Course presentation: The last few years have seen impressive accomplishments of artificial intelligence. Without a doubt, Deep Learning DL and Deep Reinforcement Learning DRL are the techniques that contributed most to these successes. Despite the extremely diverse areas involved (image recognition, games, biology, natural language processing, to name a few), we are still a long way from truly understanding the mathematics behind DL and DRL. Along with its theoretical interest, this would further increase their performance and fields of application.

This course is addressed to mathematicians who aim to understand the relationship between DL/DRL and mathematics, in both directions. How can mathematicians contribute to the mathematical foundations of DL/DRL? How can DL/DRL be used by mathematicians in their everyday research field?

We will provide (partial) answers to the above questions by introducing Geometric Deep Learning, a theory at the same time recent and fascinating, and by illustrating recent results obtained in the realm of Algebraic Geometry with complete intersection Calabi-Yau manifolds.

I will do my best to make this course accessible to the average mathematician. In particular, no prior knowledge of DL or DRL is required. A basic knowledge in probability, algebraic geometry and/or differential geometry could provide helpful, but not essential.

University: Firenze

Webpage: https://www.unich.it/ugov/person/1741

Title: Topological methods for differential equations [Metodi topologici nello studio delle equazioni differenziali]

Lecturers: Irene Benedetti and Paola Rubbioni (Università degli Studi di Perugia)

Hours/ECTS: 30/6

Period: second semester

Course presentation: TBA

University: Perugia

Webpage: https://www.unipg.it/personale/irene.benedetti,
https://www.unipg.it/personale/paola.rubbioni

Title: Symmetry results for elliptic PDE's and analytic/geometric inequalities.
Lecturer: Alberto Roncoroni (Università di Firenze & INdAM)
Hours/ECTS: 10-15/2-3
Period: November-December 2021
Course presentation: the course will focus on the study of qualitative properties of solutions to elliptic PDE's and to analytic/geometric inequalities (such as the isoperimetric inequality, the Sobolev inequality and the Brunn-Minkowski inequality). In particular, in the first part of the course symmetry results for elliptic PDE's will be presented, while in the second part of the course some results related to classical analytic and geometric inequalities will be discussed. All the classical results will be accompanied by recent generalizations and further results (e.g. in the anisotropic setting and in the context of convex cones).
A possible plan for the course is the following:

- Preliminaries from the classical theory of elliptic PDE's.
- Symmetry results for overdetermined problems: the method of moving planes, P-functions, the duality theorem and integral identities.
- A jump in differential geometry: Alexandrov soap bubbles theorem.
- A symmetry result in the ball: a further application of the method of moving planes.
- The critical p-Laplace equation: the sharp Sobolev inequality via optimal transport and classification results.
- The optimal transport and geometric inequalities: the isoperimetric inequality and the Brunn-Minkowski inequality.

References:

1. L. Ambrosio, N. Gigli. A user's guide to optimal transport. In: Modelling and Optimisation of Flows on Networks. Lecture Notes in Mathematics, vol. 2062, pp. 1-155 Springer-Verlag (2013).
2. X. Cabré. Elliptic PDE's in probability and geometry: symmetry and regularity of solutions. Discrete Contin. Dyn. Syst. 20, no. 3 (2008), 425-457.
3. G. Ciraolo, A. Roncoroni. The method of moving planes: a quantitative approach. Bruno Pini Mathematical Analysis Seminar. 9 (2018), 41-77.
4. S. Dipierro, E. Valdinoci. Elliptic partial differential equations from an elementary viewpoint. Lecture notes (2021) arXiv:2101.07941
5. D. Gilbarg, N. S. Trudinger. Elliptic Partial Differential Equations of Second Order. Springer, Berlin (1977).
6. Q. Han, F.H. Lin. Elliptic Partial Differential Equations. Courant Lect. Notes Math., vol. 1, Amer. Math. Soc., Providence, RI, 1997.
7. R. Magnanini. Alexandrov, Serrin, Weinberger, Reilly: symmetry and stability by integral identities. Bruno Pini Mathematical Seminar. 8 (2017), 121-141.
8. C. Nitsch, C. Trombetti. The classical overdetermined Serrin problem. Complex Variables and Elliptic Equations. 63, no.7-8 (2018), 665-676.
9. M. H. Protter, H. F. Weinberger. Maximum Principles in Differential Equations. New Jersey: Prentice-Hall 1967.

10. P. Quittner, P. Souplet. Superlinear parabolic problems. Blow-up, global existence and steady states. Birkhäuser, Basel, 2007; xii+584 p.

More detailed references will be provided during the course.

University: Firenze
Webpage: https://sites.google.com/view/albertoroncoroni/home

Title: Spectral methods in applied mathematics

Lecturers: Lorenzo Fusi (Università di Firenze)

Hours/ECTS: 20/4

Period: March 2022

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.

University: Firenze

Webpage: http://web.math.unifi.it/users/fusi/

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Curriculum in Informatica

Methods for Parallel Programming

Docente: Gervasi Osvaldo

Periodo: Secondo Semestre Febbraio-Maggio 2021 (18 ore di lezione frontale + approfondimento personale)

Modalità: On line

CFU: 6

Metaheuristics and Evolutionary Computation

Docenti: Marco Baioletti, Valentino Santucci

Periodo: Secondo Semestre Febbraio-Giugno 2021 (18 ore di lezione frontale + approfondimento personale)

Modalità: In presenza e/o online

CFU: 6

Quantum Computing

Docenti: Marco Baioletti

Periodo: Secondo Semestre Febbraio-Giugno 2021 (18 ore di lezione frontale + approfondimento personale)

Modalità: In presenza e/o online

CFU: 6

Affective Computing and Emotion Recognition

Docenti: Alfredo Milani, Valentina Franzoni

Periodo: Secondo Semestre Febbraio-Giugno 2021 (18 ore di lezione frontale + approfondimento personale)

Modalità: In presenza e/o online

CFU: 6

Blockchain technology

Docente: Stefano Bistarelli,

Periodo: Secondo Semestre Febbraio-Maggio 2021 (18 ore di lezione frontale + approfondimento personale)

Modalità: On line

CFU: 6

Advanced Algorithms
Docente: Pinotti Cristina M.
Periodo: Secondo Semestre Febbraio-Maggio 2021 (18 ore di lezione frontale + approfondimento personale)
Modalità: On line
CFU: 6

Advanced Neural Networks

Docente: Valentina Poggioni

Periodo: Secondo Semestre Gennaio-Febbraio 2021 (18 ore di lezione frontale + approfondimento personale)

Modalità: In presenza e/o online

CFU: 6

Unsupervised Anomaly-Based Intrusion Detection

Docenti: Bondavalli Andrea, Zoppi Tommaso

Periodo: Secondo Semestre Febbraio-Maggio 2021 (18 ore di lezione frontale + approfondimento personale)

Modalità: In presenza (On line se non possibile in presenza)

CFU: 6

Abstract:

Anomaly detection aims at identifying patterns in data that do not conform to the expected behaviour, relying on machine-learning algorithms that are suited for binary classification. It has been arising as one of the most promising techniques to suspect attacks or failures, as it has the potential to identify errors due to unknown faults as well as intrusions and zero-day attacks. Different studies have been devised Unsupervised Machine Learning (ML) algorithms belonging to different families as clustering, neural networks, density-based, neighbor-based, statistical, and classification. Those algorithms have the potential to detect even unknown threats thanks to a training phase that does not rely on labels in data. The talk shows how different algorithms are better suited for the detection of specific anomalies of system indicators, which manifest when attacks are conducted against a system. However, building, configuring, exercising, and evaluating anomaly detection algorithms is not trivial, as it may generate misleading results. Moreover, recent Meta-Learning techniques show promising results even with unsupervised algorithms, but are difficult to understand

and implement, stacking up even more complexity. In any case, the quality of the best solution that can be devised depends strongly on the problem at hand and demands for high cost for selecting and finding the optimal set up of unsupervised algorithms. To this end, we conclude the course by proposing a cheap method to quantitatively understand the achievable results without exercising the full optimization activities.

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Curriculum in Statistica

Elements of statistical inference
Prof. Alessandra Mattei, Agnese Panzera, Anna Gottard (UNIFI)
Hours/CFU: 10/2
When: Gennaio/Febbraio
Mandatory course for the curriculum in Statistics

Social demography: models and applications
Prof. B. Arpino, R. Guetto, E. Pirani, V. Tocchioni, D. Vignoli (UNIFI)
Hours/CFU: 15/3
When: Gennaio/Febbraio
Course description: The seminars will give an overview on current topics in the field of populations 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:
We Found Causality in a Hopeless Place. Challenges of Causality in Demographic Observational Studies (BA)
The growth of mixed unions in Italy: a marker of immigrant integration and societal openness? (RG)
Social determinants of health (EP)
Pathways into childlessness. A holistic approach (VT)
Fertility in the Era of Uncertainty (DV)

Random effects models for multilevel and longitudinal data
Prof. Leonardo Grilli, C. Rampichini (UNIFI)
Hours/CFU: 15/3
When: gennaio-febbraio
Abstract: 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.

Gaussian Mixture Models for Model-Based Clustering, Classification and Density Estimation
Prof. Luca Scrucca (UNIPG)
Hours/CFU: 10/2
When: February
Course description: Finite mixture models, Gaussian Mixture Models, Model-based clustering based on multivariate Gaussian distribution, EM algorithm, Model selection,

Density estimation via finite mixture modeling, Classification using Gaussian mixture models, Variable selection, The R package mclust

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Latent variable models for cross-section and longitudinal data
Prof. Silvia Pandolfi (UNIPG)
Hours/CFU: 10/2
When: February
Course description: The course aims at introducing the basic concepts of latent variable models for cross-section and longitudinal data. Different specifications of this class of models, according to the nature of the response variables, of the latent variables and the inclusion or not of individual covariates, will be outilined. Maximum likelihood estimation of these models, based on the Expectation-Maximization algorithm, will be presented using the R language. Prior knowledge of the fundamental concepts of statistics and probability will be assumed. In addition, a basic knowledge of the R software is required for laboratory activities.

Experimental design and statistical models: main principles for the experimental planning; theory and case studies
Prof Rossella Berni - email: rossella.berni@unifi.it - (University of Florence)
Hours/CFU: 15/3
When: March-April 2022
Course description:
- Fundamental principles of experimental design
- The experimental design in the technological field: planning and modelling
- Split-plot design and modelling
- optimal designs
- Computer experiments

Reading list:
. Cox D.R, Reid (2000), The theory of the design of experiments, Chapman & Hall.
. Khuri, A.I. and Cornell, J.A., 1996, Response Surfaces: design and analysis. 2nd Ed. Marcel Dekker, New York.
. Searle, S.R., Casella, G., McCulloch, C.E., 1992, Variance components, New Jersey: John Wiley & Sons.
. Atkinson, A.C. & Donev, A.N., 1992, Optimum Experimental Designs. Oxford Statistical Science
NOTE:
1-Oltre ai testi di base, durante il corso le tematiche verranno approfondite tramite articoli scientifici che saranno proposti ai Dottorandi e sui quali si svilupperà una discussione tipo “reading group”, come per il corso precedente, sarà fatto a distanza in live streaming (ovviamente se non sarà possibile svolgerlo in presenza).

Introduction to Statistical Decision Theory
Prof Silvia Bacci (University of Florence)
Hours/CFU: 10 / 2

When: April-May 2022
Course description: Starting from the origins of modern Statistics, the course frames classical and Bayesian approaches to statistical inference in a decisional perspective. Links among sample data, prior information and decisional processes are outlined, illustrating the basic concepts that characterize the Classical statistical decision theory and the Bayesian statistical decision theory. A special focus is devoted to illustrating the axiomatic basis of expected utility theory and its main empirical violations.
Program: Statistics and Decisions. Utility theory. Elicitation of the utility function. Classical statistical decision theory and Bayesian statistical decision theory. Statistics, causality, and decisions.
Webpage: Silvia Bacci: https://www.unifi.it/p-doc2-2007-0-A-2c2a382b3228.html

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Bayesian methods for high-dimensional data
Prof. Francesco Stingo (UNIFI)
Hours/CFU: 10/2
When: May 2022
Breve descrizione:
Bayesian approaches for model selection and inference in the context of: Linear regression, GLM, Semi-parametric regression and other topics (e.g., mixtures, graphical models), time permitting
With applications in bio-medicine, with a particular focus on genomics.

Kernel smoothing
Prof. Agnese Panzera
Hours/CFU: 10/2
When: May-June
Abstract: Kernel smoothing refers to a general class of techniques for non-parametric estimation of functions. The course offers an overview of the applications of kernel smoothing idea to density estimation and regression problems, along with some related issues.

Introduction to causal inference
Prof. Fabrizia Mealli, Alessandra Mattei
Hours/CFU: 10/2
When: June
Course description: The potential outcome approach. The assignment mechanism. Design and analysis of randomized experiments. Design and analysis of observational studies with regular assignment mechanisms. Causal inference in irregular designs: Causal studies with intermediate variables, Regression discontinuity designs, Causal studies where units are clustered or organized in networks. Miscellanea: Machine Learning and Causal inference; Difference-in-differences; synthetic controls; causal inference in time series setting.
Mandatory course for the curriculum in Statistics

Short course of Bayesian Causal Inference
Prof. Fan Li (Department of Statistical Science, Duke University, Durham, NC, USA)
Hours/CFU: 5 days/6CFU
When: 6-10 June 2022
Course description: The aim of this course is to introduce the fundamental concepts and state-of-art methods for causal inference under the potential outcome framework. The lectures will be organized by the treatment assignment mechanisms. Topics will cover randomized experiments, observational studies with ignorable assignment mechanisms, natural experiments, sequential ignorable longitudinal treatments.
Recent advances related to machine learning and more complex situations such as spatial-temporal treatments and interference will also be discussed. All methods will be illustrated via real case studies in health studies, economics and biology. Though the causal framework and most of the methods are independent of the inferential paradigm, an emphasis will be put on the Bayesian paradigm for inference.

Approximate Bayesian Computation (ABC)
Prof. Fabio Corradi, Cecilia Viscardi (UNIFI)
Hours/CFU: 15/3
When: June -July 2022
Course description: ABC as an explanation of how Bayes rule works. Generative models. ABC with no approximation. Examples from network analysis and Population genetics. Statistics and approximations in ABC. Rejection ABC and its convergence to exact Bayesian computation. Some limits in the use of Rejection ABC by examples. Further topics: Trade-off between degree of approximation and computational efficiency. Relevance of the prior distribution for mixing. 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 like Random Forest ABC, Selection of Statistics and Regression adjustment to be further developed by a presentation given by the students in the last lecture.

Statistical learning based on trees
Prof. Anna Gottard (UNIFI)
Hours/CFU: 15/3
When: June-July 2022
Course description: Regression and classification trees based on CART and its extensions. Bagging, Random Forest, Boosting. BART.

Geo-spatial methods for global health applications with focus on Disease Clustering
Prof. Annibale Biggeri
Hours/CFU: 10/3
When: September/October 2022

Course description: The ultimate goal of global health science is to improve health conditions for all people worldwide. In an increasingly interconnected world, tackling the emergence of disease outbreaks requires solutions that transcend national borders. To this end, understanding the spatial variation in disease risk and the exposure to environmental hazards has become increasingly important.

In this course, we introduce state-of-the-art methods in disease clustering and disease mapping, a sub-branch of spatial statistics whose focus is on hot spots identification and on the prediction of health outcomes and exposures within a geographical area of interest. These methods have found application in public health problems both in developing and developed countries.

Scanning for hot spots of disease cases in time and/or in space is essential part of epidemiological surveillance. In the last two days of the course we shall focus our attention on case studies of disease clustering. We will review relevant literature, highlight potentially misleading approaches and introduce update methodologies.In the first part of the course we will introduce geostatistical methods and we will review popular methods for disease mapping. In low-resource settings, household surveys are a fundamental tool to quantify the disease burden, while In developed countries, disease registries provide detailed information on individuals with a specific disease or condition. Bayesian modeling will be introduced and justified.

Specific extensions to active surveillance and high risk area profiling will be discussed. This section of the course will show the connections between the two approaches and present the course topics in a unique frame.

Fundamentals of computer science for the data scientist

Prof. M. Boreale, A. Marino, D. Merlini, M. C. Verri
Hours/CFU: 40/8
When: Spring 2023
Course description: 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. Introduction to Shared Key Encryption (Feistel ciphers) and Public Key Encryption (RSA). Digital signature. Data privacy: k-anonymity and differential privacy.