IMT SCHOOL FOR ADVANCED STUDIES LUCCA

IMT PhD Programs

Course List - A.Y. 2021/2022

PhD Program in "Cognitive and Cultural Systems"

Track in Analysis and Management of Cultural Heritage (AMCH)

Track in Cognitive, Computational and Social Neurosciences (CCSN)

PhD Program in "Systems Science"

Track in Computer Science and Systems Engineering (CSSE)

Track in Economics, Networks and Business Analytics (ENBA)

AMCH and **CCSN** PhD students are required to take all the **compulsory courses** scheduled for their tracks

CSSE PhD students are required to take courses for **at least 150 hours** (**at least 6 courses** must have the **final exam**)

ENBA PhD students are required to take all the **compulsory courses** and **at least 160 hours of specializing courses**

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Key:
C= Compulsory; S= Specializing; X= Elective; Free slots are "Also available"

Academic Year 2021/2022 - XXXVII cycle			CCS		SS	
Courses	**Hours**	**Lecturer**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
Advanced Concepts in Network Theory I	20	Tiziano Squartini				S
Advanced Concepts in Network Theory II	20	Tiziano Squartini				S
Advanced Methods for Complex Systems I	20	Diego Garlaschelli				S
Advanced Methods for Complex Systems II	20	Diego Garlaschelli				S
Advanced Neuroimaging	34	Giacomo Handjaras TBD TBD		X		
Advanced Numerical Analysis	20	Andrea Mola			X	
Advanced Seminars: Analysis and Management of Cultural Heritage	30	Maria Luisa Catoni	C			
Advanced Topics in Archaeology and Visual Studies	40	Alessandro Poggio Maria Luisa Catoni Linda Bertelli Riccardo Olivito	X			
Advanced Topics in Cultural Heritage Law	20	Andrea Magliari	C			
Advanced Topics in Econometrics	20	Francesco Serti				S
Advanced Topics in Machine Learning	10	Giorgio Gnecco			X	X
Advanced Topics in Museology	30	Emanuele Pellegrini Ruggero Longo	X			
Advanced Topics of	20	Marco Paggi			X	

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Academic Year 2021/2022 - XXXVII cycle			CCS		SS	
Courses	**Hours**	**Lecturer**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
Computational Mechanics		Pietro Lenarda				
Aesthetics and Visual Culture: Contextual Analysis and Individual Objects	30	Linda Bertelli	C			
Analytics in Economics and Management	20	Massimo Riccaboni				C
Applications of Stochastic Processes	20	Mirco Tribastone			X	S
Basic Elements of Cybersecurity	10	Paolo Prinetto			X	
Basic Linear Algebra and Statistics for Neuroscience	30	Giorgio Gnecco Francesco Serti		X		
Basic Principles and Applications of Brain Imaging Methodologies to Neuroscience	54	Emiliano Ricciardi Luca Cecchetti		C		
Basic principles and Applications of Electrophysiology and Stimulation Tecniques	52	Giulio Bernardi Monica Betta TBD TBD		C		
Basic Programming for Neuroscience	30	Monica Betta Giulio Bernardi		X		
Behavioral Economics	20	Ennio Bilancini				S
Brain Networks	10	Tommaso Gili				S
Business Cycle Theories c/o Scuola Sant'Anna	15	Andrea Roventini				X
Business model for emerging markets	20	Nicola Lattanzi				S
Clinical Psychopathology and Psychiatry	16	Pietro Pietrini		X		
Cognitive Economics	14	Luca Polonio		X		
Computational Contact and Fracture Mechanics	20	Marco Paggi			X	
Computer Programming and	30	Mirco Tribastone			X	

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Academic Year 2021/2022 - XXXVII cycle			CCS		SS	
Courses	**Hours**	**Lecturer**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
Methodology						
Critical Thinking	20	Gustavo Cevolani	X	X	X	X
Cultural Heritage and Law	30	Andrea Averardi	C			
Culture and Arts: Economic Analysis and Public Policy	25	Stefano Baia Curioni	C			
Data Analysis and Management for Cultural Heritage	20	Fabio Pinelli	C			
Decision-Making in Economics and Management	10	Massimo Riccaboni	C			
Dynamics on Complex Networks	10	Rossana Mastrandrea				S
East and West, Present and Past: The Cultural and Political Interplays between the Arabic World and Europe	30	Amos Bertolacci	C			
Econometrics I	20	Armando Rungi				C
Econometrics II	20	Armando Rungi				C
Evolutionary Game Theory	20	Ennio Bilancini				S
Experimental Economics	20	Chiara Nardi				X
Fast game prototyping with Godot	10	Gabriele Costa				
Firms, Business Analytics and Managerial Behavior	20	Nicola Lattanzi				C
Forensic and Legal Psychology	16	Pietro Pietrini		X		
Foundations of Probability and Statistical Inference	30	Irene Crimaldi				S
Funding and Management of Research and Intellectual Property	10	Marco Paggi	X	X	X	X
Game Theory	20	Ennio Bilancini				C
Geospatial Approaches to Cultural Heritage	25	Stuart Dunn	C			
Global Law	10	Andrea Averardi	X			X

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Academic Year 2021/2022 - XXXVII cycle			CCS		SS	
Courses	**Hours**	**Lecturer**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
History of Ancient Art and Archaeology	30	Maria Luisa Catoni	C			
History of Contemporary Art: Art History and Political History	20	Michele Dantini	C			
History of Early Modern and Modern Art	30	Chiara Franceschini	C			
Industrial Organization	20	Massimo Riccaboni				S
Information Economics	10	Federico Vaccari				
Introduction to Consciousness and Sleep	20	Giulio Bernardi		C		
Introduction to East and West: Languages, History, Challenges of Islam	30	Amos Bertolacci	X			
Introduction to Machine Learning	20	Alberto Bemporad			S	S
Introduction to Management of Complex Systems	10	Andrea Zocchi Simone Gerola	X			
Introduction to Network Science	20	Tiziano Squartini				C
Introduction to Neuropsychology	10	Francesca Garbarini		X		
Introduction to Project Management	5	Beatrice Manzoni	X			
Introduction to Psychophysics	12	Davide Bottari		X		
Introduction to sustainability and ecological economics	20	Angelo Facchini				X
Machine Learning in Brain Disorders: Methods and Applications	10	Andrea Mechelli		X		
Management and Models of Organization of Cultural Institutions	25	Paola Dubini	C			
Management of Complex Systems: Approaches to Problem Solving	30	Andrea Zocchi Simone Gerola	C			

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Academic Year 2021/2022 - XXXVII cycle			CCS		SS	
Courses	**Hours**	**Lecturer**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
Markov Processes (in collaboration with Scuola Sant'Anna)	12	Irene Crimaldi				X
MATLAB for Data Science	20	Giorgio Gnecco			X	X
Matrix Algebra	10	Giorgio Gnecco				X
Microeconomics	40	Kenan Huremovic Andrea Canidio				C
Model Predictive Control	20	Alberto Bemporad			X	
Museology and History of Collecting	30	Emanuele Pellegrini	C			
Neurobiology of Emotion and Behavior	12	Pietro Pietrini		C		
Neuroeconomics	12	Folco Panizza		X		
Neuroscience of Perception and Experience-Dependent Plasticity	48	Emiliano Ricciardi Davide Bottari		C		
Numerical Methods for Optimal Control	30	Mario Zanon			X	
Numerical Methods for the Solution of Partial Differential Equations	20	Marco Paggi			X	
Numerical Optimization	20	Alberto Bemporad			X	
Optimal Control	20	Giorgio Gnecco			X	
Philosophy and Neuroscience in Moral Reasoning	14	Gustavo Cevolani Camilla Francesca Colombo		X		
Philosophy of Science	20	Gustavo Cevolani	X	X	X	X
Principles of Brain Anatomy and Physiology	30	Luca Cecchetti		C		
Project Management	30	Beatrice Manzoni	C			
Python for Data Science	20	Fabio Pinelli			X	X
R and Stata for Data Science	20	Francesco Serti			X	X
Reinforcement Learning	30	Mario Zanon			S	X

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Academic Year 2021/2022 - XXXVII cycle			CCS		SS	
Courses	**Hours**	**Lecturer**	**AMCH**	**CCSN**	**CSSE**	**ENBA**
Research Seminars	24	Pietro Pietrini, Emiliano Ricciardi		X		
Research Topics in Computer Science	20	Rocco De Nicola			X	
Scientific Writing, Dissemination and Evaluation	8	TBD	X	X	X	X
Socio-Economic Networks	20	Massimo Riccaboni				S
Sources and methods of the History of Medieval Philosophy	10	Silvia Di Vincenzo	C			
Stochastic Processes and Stochastic Calculus	20	Irene Crimaldi				S
Behavioral Strategy and Business Behavior	20	Nicola Lattanzi				S
Theories of rationality	10	Gustavo Cevolani Camilla Francesca Colombo				
Temporary Organizing and Event Management in Cultural and Creative Industries	20	Yesim Tonga Uriarte	C			
Trends in Human Neuroscience	24	Antonio Bicchi Andrea Guzzetta Silvestro Micera Sara Palumbo Enzo Pasquale Scilingo		X		

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Concepts in Network Theory I
Tiziano Squartini

20 Hours

Learning Outcomes:

Students will learn how to extract properties from networks, design and simulate models to study them.

Abstract:

The first part of the course "Advanced Concepts in Network Theory" focuses on the topic of network reconstruction. Early attempts to infer missing information about networks will be reviewed, putting particular emphasis on the use of such techniques to reconstruct financial networks.

Lecture Contents:

Literature review about network reconstruction. Early attempts to infer a network structure from partial information (MaxEnt approach; the copula approach; MECAPM; Iterative Proportional Fitting algorithm; Minimum Density algorithm). Monopartite and bipartite financial networks reconstruction via the fitness model. Systemic risk estimation. Simulation of contagion processes on networks.

Teaching Method:

Combination of frontal lectures, blackboard discussions and students' presentations.

Bibliography:

References to relevant research papers will be provided during the lectures. Lecture slides will be regularly distributed to the students.

Final Exam:

Each student will discuss a research paper about a topic of his/her choosing among a basket of papers selected by the instructor.

Prerequisites:

Solid mathematical background, passion for theory, logical rigor, scientific curiosity, interest in multidisciplinarity. Successful completion of the course "Introduction to Network Science".

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Concepts in Network Theory II
Tiziano Squartini

20 Hours

Learning Outcomes:

Students will learn how to design complex models to study networked systems and simulate them numerically.

Abstract:

The second part of the course "Advanced Concepts in Network Theory" focuses heavily on deeper theoretical aspects and their consequences. Particular emphasis will be put on maximum-entropy models to study weighted complex networks.

Lecture Contents:

From null models to true models: weighted reciprocal configuration models and block-structured models. Bipartite formalism for Exponential Random Graph models. Continuous formalism for Exponential Random Graph models. Conditional framework for discrete and continuous Exponential Random Graph models. Information criteria for model selection (Likelihood Ratio Test, Akaike Information Criterion, Bayesian Information Criterion and extensions). Applications to economic and financial systems.

The course will include an overview of ongoing research carried out by Networks@IMT, thereby offering directions for possible PhD projects in this area.

Teaching Method:

Combination of frontal lectures, blackboard discussions and students' presentations.

Bibliography:

References to relevant research papers will be provided during the lectures. Lecture slides will be regularly distributed to the students.

Final Exam:

Each student will present and discuss a research project about a topic of his/her choosing among the ones covered during the course.

Prerequisites:

Solid mathematical background, passion for theory, logical rigor, scientific curiosity, interest in multidisciplinarity. Successful completion of the courses "Introduction to Network Science", "Advanced Concepts in Network Theory I", "Advanced Methods for Complex Systems I".

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Methods for Complex Systems I
Diego Garlaschelli

20 hours

Learning Outcomes:

Students will learn how to: identify the properties of real-world complex systems that defeat traditional tools of analysis across different disciplines and research fields; design advanced methods to empirically characterise, mathematically model and computationally simulate those properties.

Abstract:

This interdisciplinary course aims at introducing rigorous tools from statistical physics, information theory and probability theory for investigating real-world complex systems arising in different fields of research. First, some key aspects of complexity encountered in physical, biological, social, economic and technological systems will be reviewed. Then, emphasis will be put on the construction of theoretical models based on the concept of constrained randomness, i.e. the maximisation of the entropy subject to suitable constraints. This will lead to the introduction of maximum-entropy models that serve as mathematical benchmarks for the properties of highly heterogeneous systems. Special cases of interest for this first part of the course include statistical ensembles of time series and correlation matrices with given properties. Applications to pattern detection in econophysics and neuroscience will be discussed. Full mathematical derivations of the models, as well as methods of statistical inference and model selection for data analysis will be provided.

Lecture Contents:

- Introduction
- From Complexity to Thermodynamics
- From Thermodynamics to Statistical Physics
- Entropy in Probability Theory
- Entropy in Information Theory
- Empirical patterns in univariate time series
- Empirical patterns in multivariate time series- Community detection for correlation matrices

Teaching Method:

Combination of frontal lectures, blackboard discussions and students' presentations.

Bibliography:

References to relevant research papers are gradually provided during the lectures. Lecture slides and other course materials are regularly distributed to the students.

Final Exam:

Consists of students' presentations of research papers, around which the professor organises a critical discussion with the rest of the class, towards the end of the course. No additional time slot for the exam is therefore scheduled.

Prerequisites:

Solid mathematical background, scientific curiosity, logical rigor, interest in multidisciplinarity, passion for theory.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Methods for Complex Systems II
Diego Garlaschelli

20 hours

Learning Outcomes:

Students will learn how to: identify the properties of real-world complex systems that defeat traditional tools of analysis across different disciplines and research fields; design advanced methods to empirically characterise, mathematically model and computationally simulate those properties.

Abstract:

The second part of the course "Advanced Methods for Complex Systems" focuses on advanced practical applications of the concepts introduced in the first part. In particular, emphasis will be put on the successful areas of pattern detection and network modelling. Network pattern detection is the identification of robust empirical patterns (like scale-invariance, clustering, assortativity, reciprocity, motifs, etc.) that are widespread across real-world networks and that deviate systematically from some null hypothesis formalised in terms of a suitable random graph model. The models introduced in part 1 will then be used here for pattern detection purposes. Similarly, they will be used for modelling the properties of real networks in terms of explanatory factors.The course will include a combination of recent and ongoing research in the NETWORKS unit at IMT Lucca, thereby offering directions for possible PhD projects in this area.

Lecture Contents:

- Complex networks: robust empirical properties
- Maximum-entropy network ensembles
- Networks with given degree sequence
- Maximum likelihood parameter estimation in network ensembles
- Pattern detection in networks
- Reciprocity and the Reciprocal Configuration Model
- The International Trade Network (econometric vs network modelling)

Teaching Method: Combination of frontal lectures, blackboard discussions and students' presentations.

Bibliography:

References to relevant research papers are gradually provided during the lectures. Lecture slides and

other course materials are regularly distributed to the students.

Final Exam:

The final consists of students' presentations of research papers, around which the professor organises a critical discussion with the rest of the class, towards the end of the course. No additional time slot for the exam is therefore scheduled.

Prerequisites: Solid mathematical background, scientific curiosity, logical rigor, interest in multidisciplinarity, passion for theory. Successful completion of the course "Advanced Methods for Complex Systems I"

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Neuroimaging
Giacomo Handjaras, TBD, TBD

34 Hours

(Giacomo Handjaras - 20 Hours)

Learning Outcomes:

The course is aimed to introduce basic concepts and to provide the basis of practical applications on bivariate and multivariate analyses of neuroimaging data.

Abstract:

Early neuroimaging studies focused on univariate analyses in which the activity of each voxel (MRI) or channel (EEG/MEG) is processed independently from each other. Nowadays, multivariate machine learning techniques have been developed to model complex, sparse neuronal populations. This course will provide an introduction to new approaches to handle and model bivariate and multivariate interactions between voxels or channels. Specifically, the course focuses on functional connectivity and its derivatives, Representational Similarity Analysis and machine learning decoding and encoding perspectives. A comprehensive review of model validation and statistical inference is provided. The course also discusses the transdisciplinary approach combining different neuroimaging techniques and the advent of ultrahigh field neuroimaging.

Lecture Contents:

Part 1. Bivariate analyses: functional and effective connectivity and its derivatives (e.g., dynamic functional connectivity). Brief recap of graph measures used in neuroimaging. Part 2. Decoding approach.

Part 3. Encoding models.

Part 4. Representational Similarity Analysis.

Part 5. Computational modeling.

Part 6. Hands-on lesson using real data.

Teaching Method:

slides and working in groups on pc

Bibliography:

O'Reilly, J. X., Woolrich, M. W., Behrens, T. E., Smith, S. M., & Johansen-Berg, H. (2012). Tools of the

trade: psychophysiological interactions and functional connectivity. Social cognitive and affective neuroscience, 7(5), 604-609.

Bastos, A. M., & Schoffelen, J. M. (2016). A tutorial review of functional connectivity analysis methods and their interpretational pitfalls. Frontiers in systems neuroscience, 9, 175.

Hutchison, R. M., Womelsdorf, T., Allen, E. A., Bandettini, P. A., Calhoun, V. D., Corbetta, M., ... & Handwerker, D. A. (2013). Dynamic functional connectivity: promise, issues, and interpretations. Neuroimage, 80, 360-378

Haxby, J. V. (2012). Multivariate pattern analysis of fMRI: the early beginnings. Neuroimage, 62(2), 852-855.

Mitchell, T. M., Hutchinson, R., Niculescu, R. S., Pereira, F., Wang, X., Just, M., & Newman, S. (2004). Learning to decode cognitive states from brain images. Machine learning, 57(1-2), 145-175.

Haynes, J. D. (2015). A primer on pattern-based approaches to fMRI: principles, pitfalls, and perspectives. Neuron, 87(2), 257-270.

Pereira, F., Mitchell, T., & Botvinick, M. (2009). Machine learning classifiers and fMRI: a tutorial overview. Neuroimage, 45(1), S199-S209.

Naselaris, T., Kay, K. N., Nishimoto, S., & Gallant, J. L. (2011). Encoding and decoding in fMRI. Neuroimage, 56(2), 400-410.

Kriegeskorte, N., Mur, M., & Bandettini, P. A. (2008). Representational similarity analysis-connecting the branches of systems neuroscience. Frontiers in systems neuroscience, 2, 4.

Cichy, R. M., & Pantazis, D. (2017). Multivariate pattern analysis of MEG and EEG: A comparison of representational structure in time and space. NeuroImage, 158, 441-454.

Final Exam:

Knowledge is verified through oral presentation of selected papers on the theoretical and methodological aspects of neuroimaging.

Prerequisites:

None

(TBD - 8 Hours)

Course description will be available soon.

(TBD - 6 Hours)

Learning Outcomes:

At the conclusion of this course, participants should have a clear understanding of the principles at the basis of imaging techniques for mapping brain anatomy and function, in particular Magnetic Resonance Imaging. They will also be able to identify the scientific questions that can be addressed by different imaging techniques, acquire data and interpret results.

Abstract:

This course will provide an overview of technologies to depict brain anatomy and function, and then focus on Magnetic Resonance (MR) as a non-invasive, multi-contrast and multi-modal technique. The following principles will be explained: static magnetic field and net magnetization; radiofrequency pulses and the phenomenon of resonance; relaxation times T1, T2, T2*; how to set experimental parameters to obtain different image contrasts.

The MR scanner architecture will also be reviewed.

We will also explain the principles of two-dimensional MR imaging, including those of functional MR imaging (fMRI).

The importance of the strength of the static magnetic will be discussed, highlighting the pros and cons of MR at conventional (1.5T, 3T) and ultra-high field (7T and beyond). We will present advanced MR imaging topics, including parallel imaging, quantitative techniques, custom RF coils and x-nuclei data acquisition.

Lecture Contents:

This course will first provide an overview of technologies to depict brain anatomy (ultrasound/TCS, x-rays/CAT) and function (PET, EEG, MEG) and then focus on Magnetic Resonance (MR) as a non-invasive, multi-contrast and multi-modal technique. The following principles of MR will be explained:

- Static magnetic field and net magnetization;

- Radiofrequency (RF) pulses and the physical phenomenon of resonance;

- Relaxation times T1, T2, T2*;

- Time of Repetition (TR) and Time of Echo (TE);

- How to set experimental parameters to obtain image contrast weighted in proton density and different relaxation times.

The MR scanner architecture, including the main magnet, the transmit/receive RF coils, the gradient coils, etc., will also be reviewed.

In this course we will also explain the principles of two-dimensional MR imaging, including those of

functional MR imaging (fMRI):

- Slice selection, frequency encoding and phase encoding;

- The k-space;

- The Blood Oxygenation Level Dependent (BOLD) signal;

- The Echo-planar imaging (EPI) technique.

- The importance of the strength of the static magnetic will be discussed, highlighting the pros and cons of MR at conventional (1.5T, 3T) and at ultra-high field (7T and beyond).

We will introduce advanced MR imaging topics, including:

- Parallel imaging;

- Ultra high spatial resolution;

- Quantitative techniques;

- Motion correction;

- Custom RF coils and x-nuclei;

- Safety.

Teaching Method:

Lecturing and classroom discussion.

Bibliography:

R.H. Hashemi et al., "MRI The Basics", Lippincott Williams & Wilkins (2010)

C. Westbrook, "MRI at a glance", Blackwell Science (2003).

Final Exam:

Oral.

Prerequisites:

Basic physics

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Numerical Analysis
Andrea Mola

20 Hours

Learning Outcomes:

Develop awareness on the impossibility to find analytical and closed form solution for the vast majority of mathematical problems commonly encountered in physics, engineering and economy, and the consequent need for numerical solution. Ability to select the most convenient algorithm to obtain the numerical solution of the mathematical problems discussed. Implementing numerical algorithms in suitable computer programs, and learning how to use external libraries of numerical software.

Abstract:

The course introduces numerical algorithms that provide an approximation of the exact solution to several mathematical problems that are recurrent in physics, engineering and economy, such as of linear and nonlinear algebraic equations and systems, obtaining the numerical interpolant of a prescribed function, determining the numerical estimate of a function integral, as well as the matrices eigenvalues and eigenvectors. Along with providing motivation for the necessity of numerical solution schemes for each problem considered, the course also discusses the validity of each approach described both in terms of solution accuracy and computational cost, and describes the implementation of the numerical algorithms in suitable Python programs.

Lecture Contents:

- Motivation for numerical analysis and examples of relevant problems for which only numerical solution is accessible
- Fundamental definitions on general numerical algorithms and schemes
- Solution of linear algebraic systems by means of direct methods
- Solution of linear algebraic systems by means of iterative methods
- Solution of nonlinear algebraic equations and systems
- Numerical interpolation
- Numerical integration schemes
- Matrix Eigenvalue and Singular Value Decomposition algorithms

Teaching Method:

Blackboard, computer slides and Pyhton programming sessions. Due to the Covid-19 emergency, lectures will be provided online: (zoom link to be added)

Bibliography:

- A. Quarteroni, R. Sacco, and F. Saleri. Numerical mathematics, volume 37 of Texts in Applied Mathematics. Springer-Verlag, New York, 2000. [E-Book-ITA] [E-Book-ENG]
- D. Arnold. A concise introduction to numerical analysis. Institute for Mathematics and its Applications, Minneapolis, 2001. [E-Book-ENG]

Final Exam:

An application of the taught methodologies to one case study of relevance for the PhD student's research is recommended. Alternatively, a topic to investigate can be suggested by the lecturer.

Prerequisites:

The course is mostly self-contained. Fundamentals of algebra and calculus are required.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Seminars: Analysis and Management of Cultural Heritage
Maria Luisa Catoni

30 Hours

Learning Outcomes:

Critical Analysis; Research Methodology; Research planning and structuring; Research presentation; scientific argumentation.

Abstract:

Students present an agreed-upon research topic. The lecturer highlights the main critical issues, suggests methodological approaches, necessary additions, bibliography.

Professors and researchers of the Research Unit may participate in the class discussion.

Lecture Contents:

The content vary according to the topic selected in agreement with the student.

Teaching Method:

Discussion on a shared topic; inductive; learn by doing.

Bibliography:

Final Exam:

No final exam

Prerequisites:

None

Advanced Topics in Archaeology and Visual Studies
Maria Luisa Catoni, Linda Bertelli, Riccardo Olivito, Alessandro Poggio

40 Hours

Learning Outcomes:

Students will acquire a broad set of methodologies and critical skills to deal with detailed archaeology and visual studies topics.

Abstract:

The lecturers will stimulate class discussions on the methodologies of archaeology, history, art history and visual studies in order to develop critical skills for cultural heritage.

Therefore, students will be introduced to situations in which researchers deal with different methodological challenges such as visual testimonies and works of art, excavations, museums, exhibitions, archives.

The class will develop in a "workshop-like" modality through the discussion of a series of case studies that are part of ongoing projects at IMT and can be open to students' participation/collaboration.

Students from all cycles of AMCH are welcome.

Lecture Contents:

After a general introduction to the course, lectures will focus on selected case studies that are part of ongoing projects at IMT.

Teaching Method:

Lectures – In-class discussions – Assignments – Field trips.

Bibliography:

The bibliography will be provided by the lecturers. Students interested in specific issues are invited to request bibliographical references.

Final Exam:

None.

Prerequisites:

None.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics in Cultural Heritage Law
Andrea Magliari

20 Hours

Learning Outcomes:

Students will acquire a critical understanding of the European dimension of Cultural Heritage Law, including both EU Law and the European Convention on Human Rights law.

Abstract:

The aim of the course is to provide students with a critical understanding of the role of the EU and of the Council of Europe in the field of Culture and Cultural Heritage through the analysis of the case law of the European Court of Justice and of the European Court of Human rights dealing, inter alia, with the free circulation of goods and services, the right to property and the freedom of artistic expression. The course will also focus on the concept of "European common cultural identity" and on the role of the EU in the promotion of culture.

Lecture Contents:

- Basic notions of EU Law and of the European Convention on Human rights
- The impact of EU law on Cultural Heritage: the fundamental freedoms and the "cultural exception"
- The case law of the European Court of Justice (ECJ) regarding the free circulation of cultural goods and cultural services, and competition law
- Unlawful circulation of cultural properties within the EU
- The role of the EU in the promotion of culture: EU programmes and funds
- The impact of the European Convention on Human Rights on cultural rights
- The case law of the European Court of Human rights on the right to property and on the freedom of expression

Teaching Method:

Classes are based on lectures and on students' presentations followed by group discussion. The Course will adopt a case study approach.

Bibliography:

Course materials and other suggested readings will be provided during the lessons.

Final Exam:

The final evaluation takes into account students' presentations and active participation during the course.

Prerequisites:

None.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics in Econometrics
Francesco Serti

20 Hours

Learning Outcomes:

The module aims to bridge the step from a theoretical econometrics course to doing applied research. The emphasis is on the application of the methods rather than the technical details about them. The goal is to provide students with enough knowledge to understand when these techniques are helpful and how to implement each method in their empirical research.

Abstract:

This module covers some of the most important methodological issues arising in any field of applied economics when the main scope of the analysis is to estimate causal effects. A variety of methods are illustrated using theory and papers drawn from the recent applied literature.

Lecture Contents:

1 Causality, Randomized Experiments, and Directed Acyclic Graphs

a) Basic questions in empirical research

b) Rubin Causal model

c) Social Experiments

d) Directed Acyclic Graphs

e) Randomization Inference

2 Regression and Causality

a) Properties of the Conditional Expectation Function

b) Bad controls

c) Sources of bias

d) Conditional Independence Assumption

3 Instrumental variables

a) Basics/recap

b) IV and causality

c) IV with heterogeneous treatment effects – LATE

d) Weak instruments

e) The bias of 2SLS

f) Popular IV designs

4 Matching

a) Covariate Matching

b) Propensity Score Matching

c) Inverse Probability Weighting

d) Entropy balancing

e) Regression adjustment

5 Differences-in-Differences

a) Basics/recap

b) Regression Differences-in-Differences

c) Robustness checks and picking a suitable control group

d) DiD with heterogeneous treatment effects and heterogenous policy adoption.

6 Regression Discontinuity Design

a) Sharp RD

b) Fuzzy RD

c) Continuity-based and local-randomization approaches

d) Parametric vs. non-parametric approaches

7 The Synthetic Control Method

a) Basics

b) Extrapolation and interpolation biases

c) Multiple treated units

d) Placebos, robustness checks, and inference

8 Machine Learning (ML) tools for Econometrics

a) ML to build counterfactuals when no control group is available

b) ML to select control variables and/or instruments

c) ML to study heterogeneity of treatment effects

Teaching Method:

After reviewing the theory behind each empirical method, we will focus on their practical implementation in Stata and R and on some examples from the applied economic literature.

Bibliography:

References to relevant research papers and books will be provided during the lectures. Lecture slides and codes will be regularly distributed to the students.

Final Exam:

The assessment is based on producing a short empirical project using one of the methods studied in class.

Prerequisites:

Econometrics

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Sources and methods of the History of Medieval Philosophy
Silvia Di Vincenzo

10 Hours

Learning Outcomes:

Expected learning outcomes of the course are:

- Familiarization with the mechanisms of knowledge transmission from antiquity to the contemporaneity, with a special focus on handwritten traditions;
- The acquisition of a global vision of the spread of science and philosophy from the Middle Ages until the 20th century, from the Western to the Eastern borders of the Islamicate world;
- The acquisition of basic acquaintance with the manuscript as an object and with its components;
- The identification of ancient, medieval, and modern manuscripts as an important part of the cultural heritage in need of being studied and preserved.
- Awareness of the legal aspects of the trade and preservation of manuscripts.
- Awareness of the dynamics of the illegal trade of manuscripts.

Abstract:

Human beings have been spreading knowledge both in oral and written form since the earliest times. Before printing became the prevailing channel of written transmission, and in some areas of the world even afterwards, the production of handwritten documents largely dominated the history of culture. This course aims to introduce students to the study of Islamic cultural heritage, offering them a method of analysis of ancient, medieval and modern handwritten documents, i .e. manuscripts. A manuscript is an item whose textual, figurative, and material components provide a considerable amount of information useful to the reconstruction of intellectual and social history, and a specimen of cultural heritage worth reflection, analysis, and preservation. The manuscript tradition of Avicenna's (d. 1037) philosophical masterpiece, the Book of the Cure, transmitted in hundreds of codices along almost nine centuries all over the Islamicate world, will be taken as case-study.

Lecture Contents:

- Knowledge transmission East and West: History and mechanisms.
- Written transmission East and West: The different impacts of Gutenberg's invention of the printing press; the interactions and mutual influences of Eastern and Western traditions.
- Handwritten texts in the Islamicate world from Andalusia to India: The peculiarities of this manuscript culture.
- What are the manuscripts? What are their relevant parts? What is the use of studying them?

Methodologies for the analysis of manuscripts as sources of information.

- Where are manuscripts preserved and how do they circulate nowadays? The manuscript as part of our cultural heritage in need of preservation strategies.

Teaching Method:

Each lesson will alternate moments of direct instruction (supported by audio-visual equipment and PowerPoint presentations) and moments devoted to stimulating students' questions and discussions. Each student will also benefit from personalized learning, being guided and supported in the choice of a research subject related to the course that might be of his own interest and that will be the object of the final presentation.

Bibliography:

Bibliography:

Bertolacci, A., and Dadkhah, G. The Metaphysics of the Shifāʾ: Facsimile Edition of MS Malek Library (Tehran) 1085. Bibliotheca Iranica: Iranshahr Scientific and Philosophical Writings, no. 5. Costa Mesa, CA: Mazda Publishers, Inc, 2018.

Brodie, N., 'Consensual relations? Academic involvement in the illegal trade in ancient manuscripts', in P. Green and S. Mackenzie (eds), Criminology and Archaeology: Studies in Looted Antiquities (Oñati International Series in Law and Society), Oxford: Hart, 2009, pp. 41-58

Gacek, A. Arabic Manuscripts: A Vademecum for Readers. Leiden-Boston: Brill, 2009.

———. The Arabic Manuscript Tradition: A Glossary of Technical Terms and Bibliography - Supplement. Leiden: Brill, 2012.

Geoffrey, R. (ed.) Historical Aspects of Printing and Publishing in Languages of the Middle East: Papers From the Third Symposium on the History of Printing and Publishing in the Languages and Countries of the Middle East, University of Leipzig, September 2008. Leiden-Boston: Brill, 2014.

Gruber, Chr. J. The Islamic Manuscript Tradition: Ten Centuries of Book Arts in Indiana University Collections. Book Collections on Project MUSE. Bloomington: Indiana University Press, 2010.

Manacorda S., Chappell D. (eds.), Crime in the art and antiquities world: Illegal trafficking in cultural property, Springer, 2011.

Ulph, J., Smith, I. (eds.), The illicit trade in art and antiquities: International Recovery and Criminal and Civil Liability, Oxford: Hart, 2015.

Websites and links:

1. ERC Project: "PhiBor: Philosophy on the Border of Civilizations - Towards a Critical Edition of the Metaphysics of Avicenna", directed by Prof. A. Bertolacci:

http://project.avicennaproject.eu/

https://phibor.sns.it/

2. Culture under threat:

https://theantiquitiescoalition.org/understanding-the-problem/interactive-maps/

3. Printing History in the Arabic Speaking World:

http://exhibits.library.yale.edu/exhibits/show/arabicprinting/printing_history_arabic_world

4. A list of the main digitized collections of Arabic and Islamic manuscripts

https://aub.edu.lb.libguides.com/c.php?g=276485&p=1842810

Final Exam:

Presentation and discussion of a selected paper/essay related to the subject matter of the course.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics in Machine Learning
Giorgio Gnecco

10 Hours

Learning Outcomes:

At the end of the course, the student will have a basic knowledge of the theory behind some advanced machine learning techniques, including some topics of recent research.

Abstract:

The course provides an introduction to the theory behind some advanced machine learning techniques, including some topics of recent research. MATLAB implementations of most of the techniques examined in the course are described in the related course "MATLAB for Data Science".

Lecture Contents:

Lecture 1: Online learning: the perceptron learning algorithm and the LQG online learning framework.

Lecture 2: Convergence analysis of batch gradient descent and stochastic gradient descent. Backpropagation.

Lecture 3: Applications of linear and nonlinear approximation techniques to optimal control problems and reinforcement learning.

Lecture 4: Trade-off between sample size and precision of supervision.

Lecture 5: Matrix completion and its application to recommendation systems.

Teaching Method:

The teacher will project slides on the screen (a copy of the slides will be provided to the students).

Bibliography:

The following books are related to the course. They can be useful as a supplementary material.

D. P. Bertsekas and J. N. Tsitsiklis: "Neuro-Dynamic Programming," Athena Scientific, 1996

I. Goodfellow, Y. Bengio, and A. Courville, "Deep Learning," MIT Press, 2016

T. Hastie, R. Tibshirani, and M. Wainwright, "Statistical Learning with Sparsity: The Lasso and Generalizations," CRC Press, 2015

S. Shalev-Shwartz and S. Ben-David, "Understanding Machine Learning: From Theory to Algorithms," Cambridge University Press, New York, USA, 2014

C. Szepesvári: "Algorithms for Reinforcement Learning," Morgan & Claypool, 2010

The following are slides/lectures notes from related courses.

D. P. Bertsekas: slides for the course "Approximate Dynamic Programming," CEA, Cadarache, 2012, available online at http://www.athenasc.com/ADP_Short_Course_Complete.pdf

T. Jebara, Lecture notes for the course "Machine Learning 4771," Columbia University, 2015, http://www.cs.columbia.edu/~jebara/4771/handouts.html

A. Ng: lecture notes for the course "Machine Learning," Stanford, 2017, available online at http://cs229.stanford.edu/notes

Final Exam:

The student will prepare slides for a short seminar (20-30 minutes) on a topic related to advanced machine learning. The topic of the seminar will be either proposed by the teacher or chosen by the student. The date of the seminar will be agreed between the student and the teacher.

Prerequisites:

Calculus, Introduction to Machine Learning

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics in Museology
Emanuele Pellegrini, Ruggero Longo

30 Hours

Learning Outcomes:

The course aims at providing students with an advanced knowledge on museums organization and related forms of cultural promotion. Furthermore, it provides students with analytical tools to evaluate the role of museums and cultural promotion programs, including UNESCO, in present society.

Abstract:

The course offers concrete examples of museum curatorship and valorisation practices. The approach will have a dual-track: on the one hand, explanation of ongoing projects, such as museum display, cataloguing, disposal, storage management, contemporary exhibitions and curatorship; on the other hand, presentation of a general overview of issues related to worldwide cultural promotion, with a specific focus on UNESCO, conceived as a program aimed at the conservation, cultural promotion and transmission to the future of the natural and cultural heritage, monuments and sites, intangible heritage, cultural landscapes.

Lecture Contents:

General definitions and meanings of art, cultural assets, heritage, valorization, conservation, preservation, especially in relation to the UNESCO mission; UNESCO history overview;

Valorization and promotion of cultural heritage; National(istic) discourses;

Explanation of ongoing projects, museum display, cataloguing, disposal, storage management, contemporary exhibitions and curatorship.

Current case studies will be explored in order to get familiar with museum curatorship and with the processes of UNESCO nominations and inscriptions. Arabo-Norman Palermo and Early-Medieval Benedictine settlements in Italy are among the case studies.

Teaching Method:

Frontal classes and off-site lectures.

Bibliography:

A list of bibliographical references will be provided during the classes

Final Exam:

No exam

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Advanced Topics of Computational Mechanics
Marco Paggi (10h), Pietro Lenarda (10h)

20 Hours

Learning Outcomes:

Mathematical modelling and numerical methods for the simulation of coupled problems, with applications to renewable energy materials and biomechanics.

Abstract:

This course covers advanced topics of computational mechanics, with special emphasis on numerical methods to solve nonlinear coupled problems in solid mechanics (thermal, mechanical and electric fields, with applications to photovoltaics and thermo-piezo-electric materials) and in fluid dynamics (electro-physiology and mechanics of hearth tissue, advection-reaction-diffusion systems).

Lecture Contents:

The course content covers the following topics:

- Advanced numerical techniques for coupled nonlinear solid mechanics and fluid dynamics problems.
- Coupled problems in materials for renewable energy applications.
- Coupled problems in biomechanics

Teaching Method:

Powerpoint presentations. Due to the Covid-19 emergency, lectures will be provided online: https://zoom.us/j/93898866026?pwd=aXozRlFBMEFEVEdRb0d1eG9wSm9tZz09.

Bibliography:

M Paggi, S Kajari-Schröder, U Eitner (2011) Thermomechanical deformations in photovoltaic laminates, The Journal of Strain Analysis for Engineering Design 46 (8), 772-782.

M Paggi, M Corrado, MA Rodriguez (2013) A multi-physics and multi-scale numerical approach to microcracking and power-loss in photovoltaic modules, Composite Structures 95, 630-638.

A Sapora, M Paggi (2014) A coupled cohesive zone model for transient analysis of thermoelastic interface debonding, Computational Mechanics 53 (4), 845-857.

M Paggi, M Corrado, I Berardone (2016) A global/local approach for the prediction of the electric response of cracked solar cells in photovoltaic modules under the action of mechanical loads, Engineering

Fracture Mechanics 168, 40-57.

F Fantoni, A Bacigalupo, M Paggi (2017) Multi-field asymptotic homogenization of thermo-piezoelectric materials with periodic microstructure, International Journal of Solids and Structures 120, 31-56.

M Gagliardi, P Lenarda, M Paggi (2017) A reaction-diffusion formulation to simulate EVA polymer degradation in environmental and accelerated ageing conditions, Solar Energy Materials and Solar Cells 164, 93-106.

U Jahn, M Herz, M Köntges, D Parlevliet, M Paggi, I Tsanakas (2018) Review on infrared and electroluminescence imaging for PV field applications: International Energy Agency Photovoltaic Power Systems Programme: IEA PVPS Task 13, Subtask 3.3, International Energy Agency.

P Lenarda, M Paggi, RR Baier (2017) Partitioned coupling of advection–diffusion–reaction systems and Brinkman flows, Journal of Computational Physics 344, 281-302.

Final Exam:

An application of the taught methodologies to a problem relevant for the PhD research is welcome. Alternatively, the student is requested to deliver a short presentation/discussion on the content of an article based on methodologies related to those presented in the course.

Prerequisites:

Numerical Method for the Solution of Partial Differential Equations

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Analytics in Economics and Management
Massimo Riccaboni

20 Hours

Learning Outcomes:

The aim of this course is to teach students how to produce a research paper in economics and management using hands-on empirical tools for different data structures.

Abstract:

The aim of this course is to teach students how to produce a research paper in economics and management using hands-on empirical tools for different data structures. We will bridge the gap between applications of methods in published papers and practical lessons for producing your own research. After introductions to up-to-date illustrative contributions to literature, students will be asked to perform their own analyses and comment results after applications to microdata provided during the course.

How productive is a firm, an industry or a country? Why? Where is it more profitable to locate an economic activity? Who buys what products? How long can we expect a company to outlive its competitors? What is the relationship between economic welfare and size of a city? How do economic agents interact socially in a geographic space or in a workplace? The objective is to develop a critical understanding of the iterative research process leading from real economic data to the choice of the best tools available from the analyst kit. Students are expected to be familiar with microeconomics and econometrics from the first-year sequence.

Lecture Contents:

Class 1: Introduction

Class 2: Challenges of Big Data Analysis

Class 3: New Tricks for Econometrics and Artificial Intelligence

Class 4: Statistical Learning with Sparsity: The Lasso and Generalizations

Class 5: Classification and Regression Trees

Class 6: Bayesian statistical learning

Class 7: Using Big Data for Measurement and Research

Class 8: Matrix Completion and Networks

Class 9: Big Data, Big Cities, Global Studies

Class 10: Mining Text

Teaching Method:

Lecture-cum-Demonstration

Bibliography:

Main readings:

- Athey S. (2018) The Impact of Machine Learning on Economics, mimeo.
- Bajari P., Nekipelov D., Ryan S.P., Yang M. (2015) "Machine Learning Methods for Demand Estimation", American Economic Review, 105(5), 481-485.
- Bajari P., Nekipelov D., Ryan S.P., Yang M. (2015) Demand Estimation with Machine Learning and Model Combination, NBER 20955.
- Belenzon, S., Chatterji, A. K. and Daley, B. (2017), "Eponymous entrepreneurs", American Economic Review, 107(6), 1638-55.
- Belloni A., Chernozhukov V. and Hansen C. (2014) "High-Dimensional Methods and Inference on Structural and Treatment Effects", Journal of Economic Perspectives, 28(2), 29-50.
- Benson A.R., Gleich D.F., Leskovec J. (2016) "High-Order Organization of Complex Networks", Science, 353(6295), 163-166.
- Breiman L. (2001) "Statistical Modeling: The Two Cultures", Statistical Science, 16(3), 199-231.
- Cavallo A. and Rigobon R. (2016) "The Billion Prices Project: Using Online Prices for Measurement and Research", Journal of Economic Perspectives, 30(2), 151-178.
- Einav L. and Levin J. (2014) The Data Revolution and Economic Analysis, NBER, 19035.
- Einav L. and Levin, J. (2014) "Economics in the Age of Big Data", Science, 346(6210), 1243089.
- Engstrom R., Hersh J., Newhouse D. (2016) Poverty in HD: What Does High Resolution Satellite Imagery Reveal about Economic Welfare?, World Bank, working paper.
- Evans J.A. and Aceves Pedro (2016) "Machine Translation: Mining Text for Social Theory", Annual Review of Sociology, 42, 21-50.
- Fan J., Han F., Liu, H. (2014) "Challenges of Big Data Analysis", National Science Review, 1, 293-314.
- Gentzkow M., Kelly B.T., Taddy M. (2017) "Text as Data", NBER Working Paper 23276.
- Glaeser E.L., Kominers S.D., Luca M., Naik N. (2015) Big Data and Big Cities: The Promises and Limitations of Improved Measures of Urban Life, NBER 21778.
- Hassani H., Silva E.S. (2015) "Forecasting with Big Data: A Review", Annals of Data Science, 2(1), 5-19.
- Hastie T., Tibshirani R., Wainwright M. (2016) Statistical Learning with Sparsity: The Lasso and Generalizations, CRC Press, Chapters 2 and 11.

- Imbens G.W. and Wooldridge J.M. (2009) Recent Developments in the Econometrics of Program Evaluation, Journal of Economic Literature, 47(1), 5-86.
- James G., Witten D., Hastie T., and Tibshirani R. (2013) An Introduction to Statistical Learning with Applications in R. Vol. 6. New York: Springer, Chap. 8.
- Kleinberg J., Lakkaraju H., Leskovec J., Ludwig J. and Mullainathan S. (2017), Human decisions and machine predictions, The Quarterly Journal of Economics, 133(1), 237-293.
- Kleinberg J., Ludwig J., Mullainathan S. and Obermeyer, Z. (2015). "Prediction Policy Problems", American Economic Review, 105(5), 491-95.
- Madaleno M. and Waights S. (2015) Guide to Scoring Methods Using the Maryland Scientific Methods Scale, What Works Centre for Local Economic Growth.
- Manresa E. (2016), Estimating the Structure of Social Interactions Using Panel Data, mimeo.
- Mullainathan, S. and Spiess, J. (2017) "Machine learning: an applied econometric approach", Journal of Economic Perspectives, 31(2), 87-106.
- Ng S. (2015) Opportunities and Challenges: Lessons from Analyzing Terabytes of Scanner Data, mimeo
- Sutton C.D. (2004) "Classification and Regression Trees, Bagging and Boosting", Handbook of Statistics, 24, 303-329.
- Varian H.R. (2014) "Big Data: New Tricks for Econometrics", Journal of Economic Perspectives, 28(2), 3-28.
- Varian H.R. (2016) "Causal Inference in Economics and Marketing", Proceedings of the National Academy of Sciences, 113(27), 7310-7315.
- Varian H.R. (2018) Artificial Intelligence, Economics, and Industrial Organization, NBER working paper n. 24839, NBER, Cambridge, MA.
- White K.T., Reiner J.P., Petrin A. (2016) "Imputation in U.S. Manufacturing Data and Its Implications for Productivity Dispersion", NBER 22569.

Final Exam:

Final scores will be based 50% on individual presentations of a selected supplemental reading and 50% on an individual homework.

Prerequisites:

Microeconomics, Econometrics

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Applications of Stochastic Processes
Mirco Tribastone

20 Hours

Learning Outcomes:

To provide students with basic tools for the modeling and analysis of systems using stochastic processes.

Abstract:

This course offers an introduction to stochastic processes as a practical modelling tool for the quantitative analysis of systems. It covers the fundamentals of Markov chains, and presents algorithms and state-of-the-art software applications and libraries for their numerical solution and simulation. The class of Markov Population Processes is presented, with its most notable applications to as diverse disciplines as chemistry, ecology, systems biology, health care, computer networking, and electrical engineering. Finally, the course will examine the computational issues arising from the modelling of large- scale systems, reviewing effective approximation methods based ordinary differential equation (fluid) limits, moment-closure techniques, and hybrid models.

Lecture Contents:

Introductions to discrete- and continuous-Markov chains; examples (Page Rank, reaction networks, queuing networks); Markov population processes; stochastic simulation algorithms; fluid approximations of Markov population processes; software tools for analysing Markov chains.

Teaching Method:

Blackboard and slides.

Bibliography:

William Stewart. Probability, Markov Chains, Queues, and Simulation.

Final Exam:

Student may choose between the presentation of a research paper or the development of project

Prerequisites:

None

Basic Elements of Cybersecurity
Paolo Prinetto

10 Hours

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Basic Linear Algebra and Statistics for Neuroscience
Giorgio Gnecco, Francesco Serti

30 Hours

(Linear Algebra part - Giorgio Gnecco - 10 Hours)

Learning Outcomes:

The course is aimed to introduce basic notions of linear algebra and its applications to Neuroscience. It is focused more on applications than on theory.

Abstract:

This course provides a basic introduction to linear algebra to students with no (or minimal) background on it. The emphasis is on the description of some applications of linear algebra, including some of interest to students in neuroscience, such as basic image processing, principal component analysis, and spectral clustering. More advanced material will be provided upon request to students having already a solid bakground in linear algebra.

Lecture Contents:

- Historical introduction.
- Sum of two matrices, scalar multiplication, convex combination. Application to image processing.
- Vectors, vector norms, and transposition. Application to movie ratings and digit recognition.
- Product of a row vector and a column vector, cosine similarity. Application to movie ratings.
- Matrix product. Application to image processing.
- Linear systems, Gaussian elimination, Cramer's rule. Application to cryptography and to computed tomography.
- Least squares. Application to score prediction in races.
- Eigenvalues and eigenvectors. Application to graph centrality and spectral clustering.
- Matrix powers. Application to genetics.
- Principal component analysis, linear discriminant analysis, singular value decomposition. Application to image processing.
- Markov chains. Application to games and web surfing.
- Exercises on the blackboard on the following topics: sum of matrices, scalar multiplication, matrix product, Cramer’s rule, Gaussian elimination, eigenvectors and eigenvalues, determinants.

Teaching Method:

The teacher will project slides on the screen (a copy of the slides will be provided to the students). He will also solve some exercises on the blackboard.

Bibliography:

Tim Chartier, When life is linear: from computer graphics to bracketology, MAA Press, 2015.

Timothy Hagle, Basic math for social scientists: concepts, SAGE Publications, 1995.

Timothy Hagle, Basic math for social scientists: problems and solutions, SAGE Publications, 1996.

Final Exam:

Final written examination (2 hours).

Prerequisites:

None

(Statistics Part - Francesco Serti - 20 Hours)

Learning Outcomes:

To provide students with an introduction to probability and statistics.

Abstract:

This part of the course will provide students with an introduction to probability and statistics and it will be focused on topics that are particularly relevant to neuroscience. The lessons will be designed for students with a minimum knowledge of the subject.

Lecture Contents:

The topics covered will be:

- Introduction to probability: random variables, discrete and continuous distributions
- Introduction to statistics: definition of statistical model, estimate and estimator, point estimation and
- interval estimation
- Statistical tests: parametric and non parametric tests
- Analysis of Variance: one-way and two-way ANOVA

- Relation between variables: linear model, multiple regression

Teaching Method:

Each class will consist of a first introductory part with basic notions of statistics and of a second part in which those notions are applied to examples by using the software R.

Bibliography:

Wilcox, Rand R - Understanding and applying basic statistical methods using R - John Wiley & Sons (2016).

Wilcox, Rand R. - Modern statistics for the social and behavioral sciences _ a practical introduction - CRC Press (2017).

Russell Poldrack - Statistical Thinking for the 21st Century An open source textbook for statistics, with companions for R and Python - Stanford University (2020).

Final Exam:

The final exam will consist in a short applied essay in which students will elaborate and try to answer a simple research question, such as investigating the effect of some treatments in a clinical trial/(social)experiment, or using observational data (surveys or administrative data) to study the effect of some individual characteristics/behaviors on some individual outcome.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Basic Principles and Applications of Brain Imaging Methodologies to Neuroscience
Emiliano Ricciardi, Luca Cecchetti

54 Hours

Learning Outcomes:

At the end of the course, students are expected to have a general background knowledge of the basic principles, methodologies and applications of the most important brain functional techniques and to be prepared to evaluate the applicability of, and the results provided by these methodologies for different problems in cognitive and clinical neuroscience.

Abstract:

The course aims at introducing the fundamentals of brain metabolism and brain imaging methodologies. Neuroimaging techniques provided cognitive and social neuroscience with an unprecedented tool to investigate the neural correlates of behavior and mental functions. Here we will specifically review the basic principles, research and clinical applications of positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). Solid background in the concepts common to many types of neuroimaging, ranging from study design to data processing and interpretation, will be discussed to address neuroscientific questions. In particular, we will first review the basics of neurophysiology to understand the principles of brain imaging. Then, methodologies of data processing for the main brain imaging tools will be provided to the students with hands-on sessions: students will become familiar with the main pipelines for PET and fMRI data reconstruction, realignment, spatio- temporal normalization, first and second-level analyses.

Lecture Contents:

- Introduction to behavioral and cognitive neurosciences: definition and overview of main applications. The contribution of neuroimaging to cognitive neuroscience
- Principles of in vivo brain metabolic and functional exploration. Basics of brain metabolism: the concepts of neurovascular unit, neurovascular coupling, glucose and oxygen metabolism, synapses.
- Introduction to Positron Emission Tomography, basics of PET functioning and application. PET applications for clinical and research purposes. Examples of neurological cases of PET imaging. Indications for running a PET experimental protocol.
- Introduction to functional magnetic resonance imaging. Introduction to nuclear magnetic resonance imaging and its application in brain functional imaging
- Introduction to functional magnetic resonance imaging: definition of T2* and origin of the BOLD signal. Experimental design for fMRI protocols. Introduction to fMRI data preprocessing (image registration, realignment, smoothing, motion correction, etc.). Statistical approaches for group analysis in fMRI.

- Resting state protocols and the default mode network

Teaching Method:

The course includes theoretical and methodological face-to-face lessons with the help of slides. E-learning platform are used to share learning materials (slides, data, etc.). Hands-on lessons will be promoted.

Bibliography:

Slides of the course

Poldrack, R. A., Mumford, J. A., & Nichols, T. E. (2011). Handbook of functional MRI data analysis. Cambridge University Press.

Final Exam:

Knowledge is verified through oral presentation of selected papers on the theoretical and methodological aspects of neuroimaging, and through the completion of an analytical pipeline relative to an assigned fMRI dataset.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Basic principles and Applications of Electrophysiology and Stimulation Tecniques
Giulio Bernardi, Monica Betta, TBD, TBD

52 Hours

(Giulio Bernardi - 30 Hours)

Learning Outcomes:

Knowledge of procedures for the acquisition of electroencephalographic activity in humans. Knowledge of common procedures for the preprocessing and analysis of electroencephalographic recordings.

Abstract:

The course will provide an introduction to the use of standard and high-density electroencephalography (EEG) for the study of brain activity in humans. In particular, the course deals with the following topics:

a) Principles of electroencephalography;

b) Preprocessing of EEG recordings;

c) Basic approaches for the analysis of EEG data.

Lecture Contents:

Part 1. Principles of electroencephalography. Standard and high-density EEG systems. Introduction to the preparation of an EEG recording in humans (Lectures).

Part 2. Preprocessing of EEG recordings. Identification of the most common artifacts. Procedures for the exclusion or reduction of common artifacts. Basic principles of source modeling (Lectures).

Part 3. Step-by-step preparation of high-density EEG recordings (Lab practical lesson or video tutorial).

Part 4. Procedures for the visualization and inspection of EEG recordings in MATLAB. Use of the EEGLAB toolbox for data visualization and analysis (Practical lesson).

Part 5. Procedures for basic data preprocessing, including data filtering and data inspection for the identification and rejection of electrodes and epochs containing physiological or non-physiological artifacts (Practical lesson).

Par 6. Use of independent component analysis (ICA) for the reduction of ocular, muscular, and electrocardiographic artifacts in EEG signals (Practical lesson).

Part 7. Analysis of EEG data: power spectral density, power in conventional frequency bands, time-frequency representation. Principles of connectivity analysis.

Teaching Method:

Lectures, Practical lessons, Practical lesson in the EEG laboratory (or video tutorial)

Bibliography:

Riitta Hari, Aina Puce. MEG-EEG Primer. 2017
Mike X Cohen. Analyzing Neural Time Series Data. 2014

Final Exam:

Yes (practical and oral exam)

Prerequisites:

None

(Monica Betta - 6 Hours)

Course description will be available soon.

(TBD - 8 Hours)

Course description will be available soon.

(TBD -8 Hours)

Learning Outcomes:

Basic knowledge of non invasive brain stimulation techniques for research and treatment uses

Abstract:

The course will provide the neurophysiological basis of how non invasive brain stimulation techniques may interact with cortical neurons and networks. The following topics will be covered: Examples of how the different techniques can be used to get causal evidences on the role of different brain regions in cognitive tasks (memory, intelligence); Examples on how corticospinal motor synergies can be studied; A

survey on the safety of non invasive brain stimulation techniques; uses of these techniques with therapeutic purposes.

Lecture Contents:

TMS, TMS-EEG coregistration, tDCS, tACS, tRNS, EEG, Combination of techniques

Teaching Method:

Frontal lessons with video support; Interaction with students

Bibliography:

https://scholar.google.it/citations?user=1YEh9q4AAAAJ&hl=it

Final Exam:

No

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Basic Programming for Neuroscience
Monica Betta, Giulio Bernardi

30 Hours

Learning Outcomes:

You will learn how to plan and script by yourself the simple and complex functionalities that will be fundamental for your research activity, and to understand the code before running it

Abstract:

The course is aimed at students who have little or no experience with programming and will provide a general introduction to the Matlab software package.

Basic concepts and description of elementary functions will be illustrated.

Practical applications, in particular in the framework of neuro-signal analysis, will be carried out during hands-on sessions.

Lecture Contents:

Basic concepts of programming (defining the problem, planning the solution, coding the program, testing the program, documenting the program) and a preliminary description of Matlab environment

Teaching Method:

Frontal lessons followed by hands-on sessions

Bibliography:

I am a biomedical engineer. During my PhD in "automation, robotics and bioengineering" I intensely worked on the development of validated and automated functionalities for sleep research, in collaboration with the Institute of Clinical Physiology (CNR, Pisa) and the Lausanne University Hospital (switzerland). I am a member of the MoMiLab since 2016.

Final Exam:

Oral examination. At the end of the course you will be asked to write by yourself some parts of a code

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Behavioral Economics
Ennio Bilancini

20 Hours

Learning Outcomes:

The goal of the course is to provide an all-purpose introduction to behavioral economics as well as to offer hooks and suggestions for cutting-edge research projects concerning bounded rationality and prosocial behavior.

Abstract:

The course is a self-contained presentation and discussion of state-of-the-art research in behavioral economics, an area merging economics and psychology for the purpose of modelling and predicting human decision-making and behavior.

Lecture Contents:

1. What is Behavioral Economics? An economist's take on surprising human behaviors, with a reference to why psychologists and neuroscientists are hardly surprised
2. Rationality with cognitive bounds: Searching for predictable mistakes
3. Beyond homo economicus: Searching for predictable other-regarding preferences
4. A case study in behavioral game theory: Cognitive foundations of human prosociality
5. A discussion on methods: Experiments by economists in the lab and in the field, with a reference to how psychologists and neuroscientists would disagree

Teaching Method:

Frontal lectures

Bibliography:

Dhami, Sanjit. The foundations of behavioral economic analysis. Oxford University Press, 2016.

Final Exam:

A 10-page essay applying behavioral economics to a phenomenon decided by the student

Prerequisites:

The course is self-contained, but basic knowledge of microeconomics and choice theory are welcome.

Trends in Human Neuroscience
Antonio Bicchi, Andrea Guzzetta, Silvestro Micera, Sara Palumbo, Enzo Pasquale Scilingo

28 Hours

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Brain Networks
Tommaso Gili

10 Hours

Learning Outcomes:

knowledge of the basis of Brain Networks

Abstract:

we shall provide the tools to measure and analyze the different kinds of networks that can be defined when studying the human brain (e.g. the functional and the structural one).

Lecture Contents:

Physics of Brain measurements. Networks from Functional Magnetic Resonance Imaging, applications to cohorts of patients

Teaching Method:

Powerpoint slides

Bibliography:

Scale-Free Networks G. Caldarelli

Final Exam:

the candidate will work in the classroom and we shall assign a "pass" or "retake" vote at the end of course.

Prerequisites:

None

Business Cycle Theories
c/o Scuola Sant'Anna
Andrea Roventini

10 Hours

Syllabus is included in "Macroeconomics" (Sant'Anna School for Advanced Studies - Pisa)

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Business model for emerging markets
Nicola Lattanzi

20 hours

Learning Outcomes:

The course will provide students key business concepts to understand and evaluate business models in competitive and emerging markets. The course will describe the decision-making in competitive and in emerging markets at the business unit level, in which many key strategic choices and actions are formulated and undertaken. The course provides the essential "tool-kit" that combines a broad understanding of strategies, businesses and market dynamics, together with businesses' new challenges in today's world.

Abstract:

With globalization widening firms' competition at the world level, firms must be able to leverage their distinctive features. Thus, the course will first discuss the drivers of firms' competitive advantage in the globalized world, including the role of intangibles and the "local made in". Then, it will focus on the new role of China in the geo-economic scenarios, also including the new challenges and opportunities that Western firms will face when the Belt and Road initiative will be concluded, connecting Europe and China. The course will then discuss the emerging possibilities that the digital transformation and neuroscience are opening for firms to change their business models and strategies, concluding with some remarks on the emerging research lines for management and strategy research.

Lecture Contents:

- Fundamentals of business and strategy
- Tangible and intangible economy and business performance
- What makes the economy emerging and the market new?
- Family business and Italian SMSB: "Made in a recognizable place"
- Digital economy: effects and implications on business modeling, business plan and business reporting
- The new Silk Road - Belt and Road: avoiding errors, discovering opportunities
- Zombie economy and zombie firms: the emerging phenomena
- Network approach for business modeling and decision-making process
- Fintech challenge: centralized economy versus decentralized economy? Decentralized organizations and business models? DAO, DAC and others
- Creation of needs, emerging behaviors and business dynamics: the interaction of neuroscience and technology for business and strategy
- The role and function of studies in management science and business strategy. The emerging scenario.

Teaching Method:

The lectures slides, along with a list of selected suggested readings, will be provided at the end of each lecture.

Bibliography:

Suggested readings will be provided for each topic.

Final Exam:

Critical paper presentations in groups.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Clinical Psychopathology and Psychiatry
Pietro Pietrini

16 Hours

Learning Outcomes:

By attending this Course, students will learn the fundamental psychopathological and clinical aspects of the main psychiatric disorders, including affective disorders, psychosis and personality disorders. Students will learn the most recent acquisitions from genetic and cognitive neuroscience to the understanding of the etiopathogenesis and clinical course of mental disorders. Implications for mental insanity evaluation will also be discussed.

Abstract:

Mental disorders remain to-date still undiagnosed or misdiagnosed in many cases, with deleterious effects on the individual patient's life, including extreme acts that could be prevented by early and prompt diagnosis. Because most mental disorders appear during adolescence, their effects may be even more disruptive and dramatic. Furthermore, mental disorders may favor alcohol and drug abuse as well as promote abnormal behaviors that may pose serious risks for the patients and their family members. At the same time, mental disorders may affect, even severely, the ability of the patient to control their acts. This, in turn, may become relevant for assessing their responsibility in situations that fail to respect the law. Implications for the forensic and legal setting, including the role of personality disorders in imputability (see the Raso Sentence by the Italian Supreme Court in 2005) will be discussed.

Lecture Contents:

* The issue of the diagnostic process in Psychiatry. Differences as compared to the other medical branches
* Affective disorders. Mood depression. Psychopathological factors in mood depression. The neurobiology of depression

* Bipolar disorder. The psychopathological condition of mania. Lack of critical abilities in mania. Clinical course of bipolar disorders. Predicting switch from one polarity to the other

* Anxiety disorders. General anxiety, panic attacks. Obsessive-compulsive disorders

* Psychoses. Schizophrenia and schizophreniform disorders. Delusional thinking. Hallucinations

* Personality disorders. Definition and classification. The three clusters of personality disorders. Psychopathological and clinical aspects of the individual personality disorders.

* Mental disorders and implications for imputability: the assessment of insanity and implications for the forensic and legal settings

Teaching Method:

The course includes theoretical and methodological face-to-face lessons, with the help of slides and publications. E-learning platform are used to share learning materials (slides, data, publications, text chapters, etc.).

Bibliography:

Lesson slides; selected papers and text chapters discussed in class

Final Exam:

Knowledge will be verified throughout the course by student's engagement into discussion in class; a written examination with open questions and multiple choice questions will be administered at the end of the course

Prerequisites:

It is strongly suggested, though not mandatory, that students have taken the following courses prior to enrolling in this one: Introduction to Cognitive and Social Psychology; Neurobiology of Emotion and Behavior.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Cognitive Economics
Luca Polonio

14 Hours

Learning Outcomes:

At the end of the course, the student should have a clear understanding of different methods in the field of cognitive economics. The student should be able to design an experiment to investigate simple economic decision making processes. The student should be able to recognize the weaknesses and strengths of published articles, starting from the research question, through the method used, to the reporting of the project's outcome. me.

Abstract:

Cognitive economics studies patterns of (strategic) behavior and decision-making starting from the analysis of the actual beliefs, preferences, and cognitive abilities of real people. It thus relies on an interdisciplinary approach merging economics, psychology and cognitive science in general, and it emphasizes the relevance of individual differences and heterogeneity for the study of human reasoning and cognition. The goal of the course is to provide an introduction to cognitive economics and a balanced view of the main approaches in this field. Moreover, the course aims to provide a practical understanding of different methods from psychophysics, including the analysis of mouse-tracking and eye-tracking, enabling students to design their own experiments.

Lecture Contents:

1) What is Cognitive Economics
2) Methods from psychophysics for the investigation of decision making (mouse- and eye-tracking)
3) Process data applied to the study of strategic thinking, bounded rationality, and social preferences
4) Belief formation process and learning in games
5) Role of emotions and cognitive skills in strategic decision making
6) Estimating cognitive load and arousal in games using pupil dilation
7) Computational models of decision making (drift-diffusion models)

Teaching Method:

Lectures/Oral presentations

Bibliography:

Brocas, I., & Carrillo, J. D. (2003). The Psychology of Economic Decisions: Volume Two: Reasons and Choices.

Rachel Croson & Monica Capra & Mary I. Rigdon & Tanya Rosenblat (ed.), 0. "Handbook of Experimental Game Theory," Books, Edward Elgar Publishing.

Final Exam:

Writing of a research project proposal

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Computational Contact and Fracture Mechanics
Marco Paggi

20 Hours

Learning Outcomes:

The course provides a comprehensive overview of theory and numerics for the understanding and simulation of frontier research topics relevant for the design of innovative materials and structures subject to surface interactions, fracture and damage.

Abstract:

This course provides an overview on the theories of contact and fracture mechanics relevant for a wide range of disciplines ranging from materials science to engineering. Introducing their theoretical foundations, the physical aspects of the resulting nonlinearities induced by such phenomena are emphasized. Numerical methods (FEM, BEM) for their approximate solution are also presented together with a series of applications to real case studies.

Lecture Contents:

- The course covers the following topics:
- Hertzian contact between smooth spheres;
- the Cattaneo-Mindlin theory for frictional contact;
- numerical methods for the treatment of the unilateral contact constraints;
- contact between rough surfaces;
- fundamentals of linear elastic fracture mechanics;
- the finite element method for crack propagation;
- nonlinear fracture mechanics and the cohesive zone model;
- interface finite elements;
- phase field modelling of fracture;
- applications to materials science, retrofitting of civil/architectonic structures, composite materials.

Teaching Method:

Powerpoint presentations. Due to the Covid-19 emergency, lectures will be provided online: https://zoom.us/j/93898866026?pwd=aXozRlFBMEFEVEdRb0d1eG9wSm9tZz09.

Bibliography:

Contact Mechanics

M Paggi DA Hills (2020) Modeling and Simulation of Tribological Problems in Technology, Springer, https://link.springer.com/book/10.1007/978-3-030-20377-1

J Bonari, M Paggi, J Reinoso (2021) A framework for the analysis of fully coupled normal and tangential contact problems with complex interfaces, Finite Elements in Analysis and Design 196, 103605.

A Bemporad, M Paggi (2015) Optimization algorithms for the solution of the frictionless normal contact between rough surfaces, International Journal of Solids and Structures 69, 94-105.

M Ciavarella, JA Greenwood, M Paggi (2008) Inclusion of "interaction" in the Greenwood and Williamson contact theory, Wear 265 (5-6), 729-734.

M Paggi, M Ciavarella (2010) The coefficient of proportionality κ between real contact area and load, with new asperity models, Wear 268 (7-8), 1020-1029.

G Zavarise, M Borri-Brunetto, M Paggi (2007) On the resolution dependence of micromechanical contact models, Wear 262 (1-2), 42-54.

M Paggi, R Pohrt, VL Popov (2014) Partial-slip frictional response of rough surfaces, Scientific reports 4 (1), 1-6.

Fracture Mechanics

M Paggi, J Reinoso (2017) Revisiting the problem of a crack impinging on an interface: a modeling framework for the interaction between the phase field approach for brittle fracture and the interface cohesive zone model, Computer Methods in Applied Mechanics and Engineering 321, 145-172.

J Reinoso, M Paggi, C Linder (2017) Phase field modeling of brittle fracture for enhanced assumed strain shells at large deformations: formulation and finite element implementation, Computational Mechanics 59 (6), 981-1001.

M Paggi, P Wriggers (2016) Node-to-segment and node-to-surface interface finite elements for fracture mechanics, Computer Methods in Applied Mechanics and Engineering 300, 540-560.

J Reinoso, M Paggi (2014) A consistent interface element formulation for geometrical and material nonlinearities, Computational Mechanics 54 (6), 1569-1581.

M Paggi, P Wriggers (2012) Stiffness and strength of hierarchical polycrystalline materials with imperfect interfaces, Journal of the Mechanics and Physics of Solids 60 (4), 557-572.

M Paggi, JR Barber (2011) Contact conductance of rough surfaces composed of modified RMD patches, International Journal of Heat and Mass Transfer 54 (21-22), 4664-4672.

M Paggi, P Wriggers (2011) A nonlocal cohesive zone model for finite thickness interfaces–Part I: mathematical formulation and validation with molecular dynamics, Computational Materials Science 50 (5), 1625-1633.

M Paggi, P Wriggers (2011) A nonlocal cohesive zone model for finite thickness interfaces–Part II: FE implementation and application to polycrystalline materials, Computational Materials Science 50 (5),

1634-1643.

Final Exam:

An application of the taught methodologies to a problem of interest for the PhD student's research is recommended. Alternatively, a topic for the exam can be suggested by the lecturer.

Prerequisites:

Numerical Methods for the Solution of Partial Differential Equations

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Computer Programming and Methodology
Mirco Tribastone

30 Hours

Learning Outcomes:

This course aims to provide students with basic principles and methodologies of computer programming using Python. It is aimed particularly to students without a computer science background. The main objective is to develop the necessary skills to effectively read, write, and maintain computer programs. It provides background for facilitating the understanding of advanced programming classes as well as the proficiency with domain-specific software libraries and tools.

Abstract:

The course will cover the basic principles of programming, starting from the interaction between programs and the environment (memory, input/output) in which they execute. It will discuss: fundamental programming constructs (conditional statements, l oops); how to effectively structure code using functions; recursion; object-oriented programming; basics of functional programming; memory management for programs (garbage collection). The Python programming language will be used to demonstrate these concepts and to develop simple illustrative programs that will be presented throughout the course.

Lecture Contents:

Introduction to computer architectures; programming; variables; data structures and Python sequences; memory management; conditional statements; for and while l oops; functions; basics of object-oriented programming; basics of functional programming.

Teaching Method:

Blackboard; slides; programming tutorials

Bibliography:

M. Lutz. Learning Python, O'Reilly.

Final Exam:

Group project

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Aesthetics and Visual Culture: Contextual Analysis and Individual Objects
Linda Bertelli

30 Hours

Learning Outcomes:

By the end of this course, Ph.D. Students will be able to:

- describe and interpret the main contents and methodologies in visual culture studies and visual studies of science;
- perform close readings of key texts in visual culture studies and media theory of the 20th Century;
- analyze critically key essays regarding the topics covered in class (presentation);
- understand and evaluate the main features of scientific photography (case studies from the end of the 19th Century).

By the end of the assessment, Ph.D. Students will be able to:

- Critically evaluate a specific topic at the juncture of the topics discussed in class and their own research projects;
- Produce an original paper

Abstract:

The course will be divided into two, closely interrelated parts. The first part will be dedicated to a clarification of contents and methodologies of the research field visual studies of sciences, mostly conducted through a genealogical approach. Mentioning and analyzing a vast array of texts and authors, the course will offer an in-depth study of visual culture studies, Bildwissenschaft and theories of media from the 20s and 30s (L. Moholy-Nagy and W. Benjamin in particular).

In order to put the methodological framework outlined in the first part to work, the second part of the course will be dedicated to specific case studies, starting from the photographic work of the French physiologist Etienne-Jules Marey (1830-1904).

The understanding of the course material will be assessed through a (1) mid-term examination given in class through the course and (2) a final paper. The paper will be based on material from any topic discussed in class, in engagement with Students' research projects. The aim is to publish the best papers, and/or use your essay in order to prepare a joint publication together with me and/or your classmates.

A more detailed course description with additional information (required readings, grading scale, class policies, etc.) will be sent to all the Students at least 2 weeks before the beginning of the course.

Lecture Contents:

(I) Course Presentation. Introduction and Key Concepts: visual studies of science and visual cultures studies (1st part).

(II) Introduction and Key Concepts: visual cultures studies (2nd part).

Methodological conclusion and brief description of the impacts of visual studies of science.

(III) Midterm Presentation#1: Key texts on visual cultures studies.

(IV) Media theories and the cultural meanings of images: Laszlo Moholy-Nagy, Walter Benjamin and Siegfried Kracauer (1st part).

(V) Media theories and the cultural meanings of images: Laszlo Moholy-Nagy, Walter Benjamin and Siegfried Kracauer (2nd part).

(VI) Midterm Presentation#2: Key texts on media theory.

(VII) Analysis of the first case study.

(VIII) Analysis of the second case study.

(IX) Midterm Presentation#3: Key texts on case studies.

(X) Conclusions and general discussion about the final paper.

Teaching Method:

The course combines various teaching approaches, both student-centered and teacher-centered methods, such as:

(1) Inquiry-based learning.

(2) Direct Instruction.

(3) Eventual off-site lectures

Bibliography:

- Albera, F., and M. Tortajada (eds.), Cinema Beyond Film: Media Epistemology in the Modern Era. Amsterdam: Amsterdam University Press, 2010.
- Benjamin, W. One-way street and other writings. London: Penguin, 2009.
- Benjamin, W., The Work of Art in the Age of Its Technological Reproducibility and Other Writings on Media, Harvard University Press, 2008, pp. 158-165.
- Braun, M., Picturing Time. The Work of Etienne-Jules Marey (1830-1904). Chicago: University of Chicago Press, 1992.
- Bredekamp, H., "A Neglected Tradition? Art History as Bildwissenschaft", Critical Inquiry, 29, 3, 2003: 418-428

- Charney, L., and V. R. Schwartz. Cinema and the Invention of Modern Life. Berkeley, Calif: University of California Press, 1995.
- Crary, J., Techniques of the Observer. On Vision and Modernity in the Nineteenth Century. Cambridge [Massachusetts]: MIT Press, 1990.
- Daston, L., and P. Galison, Objectivity, Zone Books, 2007, pp. 115-190.
- Didi-Huberman, G., Images in spite of all: four photographs from Auschwitz. Chicago: University of Chicago Press, 2008.
- Gordon, R.B., Why the French Love Jerry Lewis: From Cabaret to Early Cinema. Stanford, Calif: Stanford University Press, 2001.
- Edwards, E., Anthropology and photography 1860-1920. New Haven: Yale University Press, 1992.
- Elkins, J., "Art History and Images that are not art", The Art Bulletin, 77, 4, 1995: 553-571.
- Ginzburg, C., "Minutiae, Close-up, Microanalysis", Critical Inquiry, 34, 1: 174-189.
- Hansen, M., Cinema and Experience. Siegfried Kracauer, Walter Benjamin, and Theodor W. Adorno. Berkeley, Calif: University of California Press, 2011.
- Jones, Caroline A., and Peter Galison. Picturing Science, Producing Art. New York: Routledge, 1998.
- Mitchell, W.J.T., Picture Theory. Essays on Verbal and Visual Representation, Chicago/London: The University of Chicago Press, pp. 1-34 (Introduction and Chapter I).
- Mitchell, W.J.T., What do pictures want? The lives and loves of images, Chicago/London: The University of Chicago Press, pp. 28-56.
- Moholy-Nagy, L., Painting Photography Film. Cambridge, Mass: MIT Press, 1987.
- Pauwels, L., Visual cultures of science: Rethinking representational practices in knowledge building and science communication. Hanover, New Hampshire: Dartmouth College Press, 2006.
- Rabinbach, A., The Human Motor: Energy, Fatigue, and the Origins of Modernity. New York: BasicBooks, 1990.
- Valihao, P., Mapping the Moving Image: Gesture, Thought and Cinema Circa 1900. Amsterdam: Amsterdam Univ. Press, 2009.
- Véray, L., Les images d'archives face à l'histoire: de la conservation à la création. Futuroscope: Scéren, 2011.

Final Exam:

In order to delve deeper into critical issues at the juncture of the topics discussed in class and students' research projects, each student will be responsible for submitting one essay assignment on a topic of her/his choice which must be established in agreement with me. Each student can decide on the topic of the final paper at any point during the course. Essays should be 8-10 pages in length.

Deadline for the submission will be scheduled during the course.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Critical Thinking
Gustavo Cevolani

20 Hours

Learning Outcomes:

The course aims at improving the students' skills in understanding, presenting and evaluating problem statements and arguments. After following the course, students will be able to rigorously distinguish between "strong" and "weak" arguments; they can formulate and analyze theses and hypotheses and evaluate the impact that evidence and information has on them; and they can better draw logical and effective conclusions from both hypotheses or evidence.

Abstract:

Constructing and evaluating arguments is fundamental in all branches of science, as well as in everyday life. The course provides the basic tools to recognize and analyze correct forms of inference and reasoning, detect the unsound or fallacious ones, and assess the strength of various kinds of argument. The toolbox includes elementary deductive logic, naïve set theory, patterns of inductive and abductive inference, and the elements of statistical and probabilistic reasoning. By engaging in real-world exercises of correct and incorrect reasoning, students will familiarize with basic epistemological notions (truth vs. certainty, knowledge vs. belief, theory vs. evidence, etc.), with the analysis of relevant informal concepts (like truth, falsity, truthlikeness, lies, misinformation, disinformation,

post-truth, fake news, etc.) and with common reasoning pitfalls, heuristics and biases as investigated in cognitive psychology and behavioral economics.

Lecture Contents:

Lecture Topics

1 Presentation of the course. Discussion and choice of specific topics. Introduction: reasoning, rationality, and science.

2 Evaluating statements: Truth, certainty, informativeness, truthlikeness, etc. Relativism and post-truth.

3 Evaluating arguments: Deductive reasoning and valid arguments. Fallacies and invalid arguments.

4 Evaluating arguments: Non-deductive and uncertain reasoning. Inductive and abductive reasoning.

5 Reasoning under uncertainty: Probabilistic reasoning and confirmation. Stastical thinking.

6 Reasoning and decision-making: Dualprocess theories. Heuristics and biases. Ecological rationality.

7 Reasoning, science, and society: Understanding and communicating risk.

8 Reasoning, science, and society: Consensus and dissensus in science.

9 General discussion.

Teaching Method:

Mixture of lectures and discussion seminar.

Bibliography:

We are not going to use a textbook or have a proper reading list.

W. C. Salmon (1963) is an old but still useful booklet on logic (it is also on Google Drive). In the IMT library you find some textbooks on critical reasoning, including Giere, Bickle, and Mauldin (2005) and M. H. Salmon (2013). Nisbett

(2015) is very readable.

Kahneman (2011) is a must-read for anyone interested in reasoning and cognition; the same is true for the books by Gigerenzer (2003a,b, 2007, 2008, 2015);

Thaler (2016) completes the trio. Taleb (2012) and his other books are also interesting

(and often amusing).

Huff (1993) is a classic on the use and misuse of statistics.

You can find in the Google Drive folder a number of other papers and books containing different material I'm going to cover in the seminar.

General information

Socrative.com Familiarize yourself with the Socrative website and install the Socrative Student app on you device. Google Drive I'll send you an invitation to join a shared Google Drive folder containing relevant course materials. From time to time, check the folder for newly uploaded material.

REFERENCES

Giere, Ronald N., John Bickle, and Robert Mauldin (July 1, 2005). Understanding

Scientific Reasoning.Wadsworth Inc Fulfillment. 320 pp.

Gigerenzer, Gerd (2003a). Calculated Risks: Howto KnowWhenNumbers Deceive

You. 1 edition. New York: Simon & Schuster.

— (2003b). Reckoning with Risk: Learning to Live with Uncertainty. New Ed edition. London: Penguin Books Ltd.

— (2007). Gut Feelings the Intelligence of the Unconscious. New York: Viking.

— (2008). Rationality for Mortals: How People Cope with Uncertainty. Oxford ; New York: Oxford University Press.

— (2015). Imparare a rischiare: come prendere decisioni giuste. Milano: Cortina.

Huff, Darrell (1993). How to lie with statistics. New York: Norton.
Kahneman, Daniel (2011). Thinking, Fast and Slow. 1st edition. New York: Farrar, Straus and Giroux.
Nisbett, Richard E. (2015). Mindware: Tools for Smart Thinking. First edition. New York: Farrar, Straus and Giroux.
Salmon, Merrilee H. (2013). Introduction to Logic and Critical Thinking. 6th ed.
Salmon,Wesley C. (1963). Logic. Englewood Cliffs, N.J., Prentice-Hall.
Sunstein, Cass R (2009). On Rumors: How Falsehoods Spread, Why We Believe
Them, What Can Be Done. OCLC: 900282701. New York: Farrar, Straus and Giroux.
Taleb, Nassim Nicholas (2012). Antifragile: Things That Gain from Disorder. 1st ed. New York: Random House.
Thaler, RichardH(2016). Misbehaving: The Making of Behavioral Economics.OCLC:
921868932.

Final Exam:

Active contribution from the participants is a prerequisite for passing the course.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Cultural Heritage and Law
Andrea Averardi

30 Hours

Learning Outcomes:

By the end of the course students will be able to identify the most relevant legal features of cultural heritage and they will acquire the ability to analyze, in a critical manner, the interplay of public and private interests underlying cultural heritage.

Abstract:

The course will examine the main elements of International Law, EU law and Domestic Law on Cultural Heritage. More in detail, during the course students will be provided with: the definition of Cultural Heritage; the fundamental legal principles and the main public interests underlying Cultural Heritage (protection, circulation, access). Moreover, the course will also focus on: the European Landscape Convention and Domestic Law on Landscape; the fundamental principles and main issues underlying Landscape Law (definition of landscape; levels of governance; public law instruments).

Lecture Contents:

Cultural Heritage; Administrative Law; European Administrative Law, Global Administrative Law; International Law; Public Law; Comparative Law.

Teaching Method:

Integrated Method: Frontal Lectures and Case Law Teaching.

Bibliography:

Course readings and materials will be provided at the beginning of the course

Final Exam:

Individual discussions/presentations will be arranged. Evaluations will also take into account student's participation during the classes.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Culture and Arts: Economic Analysis and Public Policy
Stefano Baia Curioni

25 Hours

Learning Outcomes:

The aim of the course is to provide a theoretical and evidence based introduction on some of the main issues and controversies that characterize the contemporary arts and cultural production scene at national and international level.

Abstract:

During the XX century arts and culture have undergone a process of deep transformation which has placed them inside the capitalistic mode of exchange. In particular, since the 60s, artistic and cultural production has drawn the attention of economists and policy makers who tried to define borders and rules of these industries and the extend to which economic theory could apply to such systems. The research that will be presented will try to interrogate this scene as a community of practices, in which actions, thoughts, behaviors, social rules constantly share a representational and symbolic dimension, and cultural statements. Even when it appears to be just gaming pure financial interests.

This interrogation lasted for more than ten years now, with different focuses: on the practices of galleries and museum, on the collector practices, on art prices, on the problematic issue raised by the idea of "aura" in the contemporary cultural environment.

The evidences piled up as the result of a multiplicity of methodologies and research practices, within and outside the academic environment: statistical analysis: qualitative analysis, historical analysis, dialogues with artists, galleries and curators, and also through the experience of a direct involvement in curatorial, managerial, and institutional tasks.

Lecture Contents:

The course will articulate two main sessions:

- Practices and Challenges of the contemporary art system
- In this session the lectures will address the issue of understand art as a "practice", the artworks as "agents" and the so called art system as a mediation/ relational system. The session will provide:
- The basic theoretical frameworks, based on the works of Pierre Bourdieu, Bruno Latour, Arthur Danto, George Dickie and Howard Becker;
- An historical overview of the evolution of the "contemporary" art system from its late XIX century premises;
- An empirical and critical assessment of the recent evolution of the contemporary art system and

market

- Cultural policies, cultural institutions and art cities

This session will concentrate on the issue of cultural, arts, heritage policies, and their relationship with the overall process of modernization and development. The session will be dedicated in particular at the issue of understanding the process of transformation of a museum and cultural institution in the context of the development of an art city. The case of Mantua and Palazzo Te will be the central argument of the session. This session will take place in Mantua.

Teaching Method:

Lecture, on site visits, participation to projects

Bibliography:

a. Sociology - Foundational studies on the art system and markets

Becker H. (1988) Arts Worlds, Berkeley UP

Moulin R. (1992) L'Artiste et le marché, Flammarion, Paris

Bourdieu P. (1996) The Rules of Art. Genesis and Structure of the Literary Field, Stanford University Press

Luhmann N. (2000) Art as a Social System, Stanford University Press, (originally published in German in 1995, Frankfurt: Suhrkamp Verlag). Chapter 4: 'The Function of Art and the Differentiation of the Art System', pp 133-184.

Karpik L. (2010) Valuing the Unique. The Economics of Singularities, Princeton University Press, Princeton and Oxford, 2010

b. History

Lippard L. R. (1973) Six Years; the Dematerialization of the Art Object from 1966 to 1972, University of California Press, Berkeley, Los Angeles

Hobbs S.D. (1997) The end of the American Avant Garde, New York University Press, New York

Alberro A. (2003) Conceptual Art and the Politics of Publicity, Massachusetts Institute of Technology

De Marchi N. & Van Miegroet H.J. (2006) "The History of Art Markets" - in Victor A. Ginsburgh and David Throsby (eds): in Handbook of the economics of art and culture, Amsterdam: Elsevier/North Holland, 2006 - pp. 69-116

Richard S. (2009) Unconcealed: The International Network of Conceptual Artists 1967-1977, Ridinghouse, London

c. Philosophy

Harris R. (2010) The Great Debate About Art, Prickly Paradigm Press, Chicago

Danto A. C. (1964) The Artworld, Journal of Philosophy, 61, pp. 571-584

Danto A. C. (1997), After the End of Art. Contemporary Art and the Pale of History, Princeton University Press, Princeton

Dickie G. (1974), Art and the Aesthetics. An Institutional Analysis, Cornell University press, Ithaca

Dickie G. (2000) «The Institutional Theory of Art» in Noel Carrol (ed.) Theories of Art Today

d. Economics /management

Goodwin C. (2006) Art and Cuture in the History of Economic Thought, in D. Thorsby and V. Ginsburgh (eds): Handbook of the economics of art and culture, Amsterdam: Elsevier/North Holland, 2006, pp 3-24

Ginsburgh V, Mei J. and Moses M, The computation of Prices indices - in D. Thorsby and V. Ginsburgh (eds): Handbook of the economics of art and culture, Amsterdam: Elsevier/North Holland, 2006, pp 947-974

Wilde C. The intrinsic value of a Work of Art: Masaccio and the Chapmans in M. Hutter and D. Throsby (eds) Beyond Price - Value in Culture, Economics, and the Arts, pp. 220 -236

Adler M. (1985) Stardom and talent, American Economic Review, 75, 208-212

Rosen S. (1981) The economics of superstar, American Economic Review, 71, pp.845-848

e. Contemporary studies on art system, art markets, art value

General and Globalization

Velthuis O. (2005) Talking prices, Princeton Un. Press

Quemin A. (2006) Globalization and mixing in the visual arts: An empirical survey of 'high culture' and globalization. International Sociology, 21 (4), pp. 522- 550

Groys B. (2008) Art Power, MIT, Boston

Graw I. (2009) High prices. Art between the market and the celebrity culture, Sternberg, Berlin

Horowitz N. (2011) Art of the Deal, Princeton University, Princeton

Mc Andrew C. (2012) The International Art Market in 2011. Observations on the Art Trade over 25 years. The European Fine Art Foundation, Tefaf, Helvoirt

Lind M., Velthuis O. (2012) Contemporary art and its commercial market. A report on current condition and future scenario. Sternberg, Berlin

Velthuis O., Baia Curioni S (2015), Global Canvases, Oxford University Press

Public Art

Sharp J., V. Pollock and Paddison, R. (2005) Just art for a just city: Public art and social inclusion in urban regeneration, Urban Studies, 42(5), pp. 1001-1023

Pollock, V. and R. Paddison (2010) Embedding Public Art: Practice, Policy and Problems, Journal of Urban Design, 15 (3), pp. 335 – 356

f. Critical and Curatorial studies

Burn I. (1975), The Art Market: Affluence and Degradation, Artforum, April 1975, pp. 34-37 (also in Charles Harrison & Paul Wood, Art in Theory, Blackwell 1992, pp. 908-909)

AAVV (2007) Curating Subjects, Open Editions, London

Altshuler B. (2009), From Salon to Biennial, Phaidon, London

Sholette G. (2011) Dark Matter: Art and Politics in the Age of Enterprise Culture, Pluto Press, New York

g. Actors

Ashenfelter O. and Graddy K. (2006) "Art Auctions" in V. A. Ginsburgh and D. Thorsby (eds), Handbook of the economics of art and culture, Amsterdam: Elsevier/North Holland, 2006 pp 909-942

Lindemann A. (2011) Collecting Contemporary Art, Taschen, Munich (Several editions)

Cohen Solal A. (2010) Leo and His Circle: The Life of Leo Castelli, Alfred Knopf, New York

Saatchi C. (2009) My Name is Charles Saatchi and I Am an Artoholic, Phaidon, London

Bowness A. (1989) The Conditions of Success, How the Modern Artist Rises a Fame, Thames&Hudson, Wisbech, Balding and Mansell Ldt

Baia Curioni S. (2012) A fairy tale. The art system globalization and the fairs movement, in M. Lind and O. Velthuis (eds) Contemporary art an its commercial markets, Sternberg Press, Berlin

Adams G. (2012), Fair or foul: more art fairs and bigger brand galleries, but is the model sustainable?, The Art Newspaper, London, 20 June 2012

Baia Curioni (2014), Which fair, which art: exchange rituals and impossible markets, in Garutti F, (ed.)Fairland, Explorations, insights, and outlooks in the future of Art Fairs, Mousse Publishing, Milan, 2014.

Final Exam:

Personal dissertations agreed with the lecturer

Prerequisites:

None

Data Analysis and Management for Cultural Heritage
Fabio Pinelli

20 Hours

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Decision-Making in Economics and Management
Massimo Riccaboni

10 Hours

Learning Outcomes:

The main goals of the course are: (1) to take marketing theories and methodologies out into the world, applying them to interesting questions of individual behavior and societal outcomes; (2) to develop a basic understanding of human psychology and social dynamics as they apply to marketing contexts; (3) to become familiar with the major theory and research methods for analyzing consumer behavior; (4) to develop market analytics insight into consumer actions.

Abstract:

This class is structured into two parts: 1) general knowledge relating to basic conceptual notions of marketing and consumer behavior; and 2) heritage marketing. Most of time will be devoted to close reading of textbook and research papers, including discussion of the relative merits of particular methodologies. Students will participate actively in class discussion, engage with cutting-edge research, evaluate empirical data, and write an analytical paper. The course aims at enabling students to develop and enhance their own skills and research interests.

Lecture Contents:

1. Course overview, consumer behavior; Chapters 1-4, Principles of Marketing
2. Marketing to create value, theory and practice; Chapters 5-9, Principles of Marketing
3. The Marketing Plan; Chapters 14-16, Principles of Marketing
4. Heritage marketing
5. Behavioral economics insights, guidelines for final paper

Teaching Method:

Lecturing

Bibliography:

The main textbook for this course is entitled "Principles of Marketing" and is freely available online https://open.lib.umn.edu/principlesmarketing/.

See also: Kotler (2019), Principles of Marketing, Peason (17th Edition), available at the library and Misiura

(2006), Heritage Marketing, Elsevier.

Additional readings will be provided by the instructor based on students' research interests (see Google Drive)

Final Exam:

50% Participation. Attendance is required and will be recorded. The teaching format is interactive, i.e. active discussion is expected between students and instructor and will be part of the student evaluation. Abstract concepts will be understood through real life examples and observations. 50% Final Paper. You will select a topic related to marketing and consumer decision making and write a paper.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Dynamics on Complex Networks
Rossana Mastrandrea

10 Hours

Learning Outcomes:

students will become familiar with the main growth models for networks. They will learn how spreading processes on network work (epidemics, information) and how it is possible to further generalise them introducing the Agent Based Modelling (ABM). Finally, they will see some recent results about game theory on networks.

Abstract:

The course is highly interdisciplinary focusing both on theory and applications. It aims to carefully describe the main growth models for networks: starting from stylised facts observed in real networks different growth models with increasing complexity will be introduced. Then, the course will focus on spreading models on networks: compartmental models to study epidemics diffusion and extension to information/innovation diffusion. The possibility to generalise compartments introducing individual (or groups) behaviours will bring to Agent Based Models and application. Finally, some recent results about game theory on networks will be discussed..

Lecture Contents:

Empirical evidence and introduction of growth models (3h)

Epidemic spreading on networks (3h)

Agent Based Models (2h)

Game theory on networks (2h)

Teaching Method:

Lectures with slides/blackboard.

Bibliography:

Barrat A., Barthelemy M., and Vespignani A., "Dynamical processes on complex networks. " Cambridge university press, 2008.

Newman MEJ., : ”Networks. An Introduction" Oxford University Press, 2010

Barabasi A., ”Network Science” University Cambridge Press, 2016 http://networksciencebook.com/

de Arruda, Guilherme Ferraz, Francisco A. Rodrigues, and Yamir Moreno.

"Fundamentals of spreading processes in single and multilayer complex networks."

Physics Reports 756 (2018): 1-59.

Other references to relevant research papers are gradually provided during the lectures. Lecture slides and other course materials are regularly distributed to the students

Final Exam:

No final exam or group discussion of some selected papers.

Prerequisites:

Solid mathematical background, scientific curiosity, logical rigor, interest in multidisciplinarity, passion for theory. Successful completion of the course “Introduction to Network Science”.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

East and West, Present and Past: The Cultural and Political Interplays between the Arabic World and Europe
Amos Bertolacci

30 Hours

Learning Outcomes:

The intent is to defend a historical period, like the so-called Middle Ages, affected by negative prejudices, and to vindicate its importance in order to get inspiration and orientation for contemporary concerns and issues.

Abstract:

On closer inspection, the Middle Ages turn out to be a lively, bright, and instructive historical period, contrary to how they are frequently presented. At the time, the fiercest religious confrontation between Europe and Islam ever seen in history, and ambivalent political dynamics inspired by Realpolitik, coexisted with a very intense cultural interaction: in a religious situation of mutual accusations, and in a political scenario made of both clashes and negotiations, European culture regained acquaintance with his Greek past through the mediation of the Arabic-Muslim "other". In this way, a primeval cultural "globalization" took shape, the first European system of education was built, and a strong rationalistic continuum – from Aristotle, through the Arabic philosophers, until the main universities in Europe – created a non-dogmatic and trans-national "illuminism" ante litteram. If cultural "bridges", side by side with religious "walls" and political "shaky grounds", existed at that time, analogous forms of dialogue and positive interaction can for sure be explored also nowadays.

Lecture Contents:

The course will consist of three main sections, historical, aesthetic, and political, respectively. 1) Historical Analysis: A "terra franca" of philosophical culture spread in the Abrahamitic monotheisms (Christianity, Islam, Judaism) around the Mediterranean Sea in the Middle Ages, gathering in a trans-national scientific community intellectuals belonging to each of these three religions (on the footsteps of Aristotle: al-Kindi, Avicenna, Averroes, Moses Maimonides, Albert the Great, Thomas Aquinas, Dante Alighieri), whose works underwent, or benefited from, the Greek-into-Arabic and the Arabic-into-Latin translations. This process shaped a well-defined paradigm of intercultural synergy in the Middle Ages for the first time in history: Greek philosophy, shared through translations, provided a common rational basis to distinct cultures, each one of which affirmed its own language, religion, and political status, but was nonetheless able to interact with the others at a high cultural level, despite religious and political antagonisms, thanks to the universalizing force of the shared philosophical tradition. The peak of Medieval rationalism was reached in Arabic-Islamic philosophy, which pursued the goal of a totally rational – and, by the same token, moderate and tolerant – version of the Muslim religion, in replacement of the more literalist and radical interpretation by theologians.

2) Aesthetic Reflexes: This paradigm was mirrored in Medieval and Renaissance art and iconography. On the one hand, the Arabic script, often deprived of any conceptual meaning, detached from religious connotations, and taken simply as an image (the so-called "pseudo-Koufic" or "pseudo-Arabic"), appears frequently as a decorative element in Western art (paintings, sculptures, buildings) through channels to be precisely assessed. This can be taken as a sign of the bridging force of Arabic culture. On the other hand, when the relationship affects the religious level, the confrontation of different creeds – Christian

and Muslim, respectively, in the case at stake – emerges in all clarity in iconographic motifs like the "triumph of Thomas Aquinas over Averroes".

3) Political Perspective: The Medieval pattern of intercultural synergy holds significant actuality and can be variously applied to the contemporary scenario: it affects the role of education in multi-ethnic communities; the emergence of new international and a-confessional issues and concerns; and the re-assessment of the "de-radicalizing" role of philosophy in contemporary culture. Discussion of stereotypes such as the "clash of civilizations" and the "wars of religion", and of the debate on the "cultural roots of Europe".

Teaching Method:

Frontal lessons with discussion

Bibliography:

F. Starr, Lost Englightenment. Central Asia's Golden Age from the Arab Conquest to Tamerlane, Princeton University Press, Princeton 2013.

Further bibliography will be communicated in class.

Final Exam:

Oral presentation of a topic related to the course content

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Econometrics I
Armando Rungi

20 Hours

Learning Outcomes:

The objective is to develop a critical understanding of the iterative research process leading from real economic issues to the choice of the best tools available from the analyst kit.

Abstract:

The course covers the most important topics of modern econometrics. A variety of methods are illustrated with a hands-on-tool approach, combining theory and practice.

Lecture Contents:

1) Introduction to Econometrics

Review of concepts from probability and statistics; Data Structures; Populations and samples; Identification and causality

2) The Linear Regression Model

The algebra of least squares; Large and small sample properties; Heteroskedasticity; Hypothesis tests and model selection

3) Endogeneity and Instrumental Variables

Taxonomy of endogeneity problems; Triangular models: IV and 2SLS estimation; Hypothesis tests and model selection

4) Introduction to M-Estimation

General framework and identification; Consistency and asymptotic normality; Hypothesis tests and model selection

5) Maximum Likelihood Estimation

Properties of maximum likelihood; Probit, Logit, and Linear Probability Models; Hypothesis tests and model selection

6) Generalized Method of Moments

Definition, estimation of the variance; Linear and non-linear models; Testing overidentification

7) The Evaluation Problem

Randomization; Experiments and quasi-experiments; Potential Outcome Model; Difference-in-difference estimators

8) Introduction to Time Series

Stationary and non-stationary variables; Unit root tests; Cointegration; Vector autoregressive models; GARCH models.

Teaching Method:

Frontal lectures with a hands-on tool approach combining theory and practice.

Bibliography:

• Suggested Textbooks:

Greene, Econometric Analysis, 2017, Pearson

• Secondary Suggested Textbooks:

Wooldridge, Econometric Analysis of Cross-Section and Panel Data, 2010 MIT Press

Carter Hill, Griffiths and Lim, Principles of Econometrics, Wiley

Final Exam:

The assessment is based on a written exam (50%) and the production of a short empirical project (50%).

Prerequisites:

Foundations of Probability and Statistical Inference

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Econometrics II
Armando Rungi

20 Hours

Learning Outcomes:

The objective is to develop a critical understanding of the iterative research process leading from real economic issues to the choice of the best tools available from the analyst kit.

Abstract:

The course covers the most important topics of modern microeconometrics. A variety of methods are illustrated with a hands-on-tool approach, combining theory and practice.

Lecture Contents:

1) Introduction to Microeconometrics

Heterogeneity and microdata; structural approach; endogeneity and identification; parametric, semiparametric and non-parametric estimators

2) Linear Panel Models

Pooled models; Within-group estimator; Random effects estimator; mixed models; GMM estimators for panel data. Application: Firms, Productivity and Technical Change (Industrial Organization)

3) The Evaluation Problem

Brush-up of the Potential Outcome Model; Introduction to matching models, regression discontinuity design, and models with control functions. Application: Trade Wars (International Economics)

4) Simulated Models

Brief overview of dynamic programming; maximum simulated likelihood (SMM) models; moment-based simulated models. Application: Consumption and preferences (Microeconomics)

5) Multinomial Models

The multinomial logit model; The conditional logit model; The nested logit model; The ordered probit model. Application: Location Choices (Economic Geography)

6) Models for Count Data

Poisson regression model; Negative binomial regression model; Zero-inflated models; hurdle models. Application: Mergers & Acquisitions (Corporate Finance)

7) Survival/Duration Models

On Censoring and Truncation; The Kaplan-Meier curve; The Cox regression model; The Weibull model Application: Firms' Failures (Organizational Economics)

8) Special seminar: Econometrics and Statistical Learning (Prediction vs. Causality)

Teaching Method:

Frontal lectures with a hands-on tool approach combining theory and practice.

Bibliography:

Cameron and Trivedi (2005), Microeconometrics: Methods and Applications, Cambridge University Press.

Cameron and Trivedi (2010), Microeconometrics using Stata, Stata Press.

Angrist and Pischke (2009), Mostly Harmless Econometrics, Princeton University Press.

Angrist and Pischke (2015), Mastering Metrics, Princeton University Press.

Other notes and scientific articles will be distributed in class

Final Exam:

The assessment is based on the production of a short empirical project (50%), a written exam (30%) and the presentation/replication of a published scientific article (20%).

Prerequisites:

Foundations of Probability and Statistical Inference, Econometrics I

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Evolutionary Game Theory
Ennio Bilancini

20 Hours

Learning Outcomes:

To provide students with a state of the art overview of evolutionary game theory which can be useful to the potential researcher in the area as well as the interested scholar who works in a related field (behavioral sciences, social sciences, complexity studies).

Abstract:

Evolutionary methods allow to study how behaviors and traits evolve in a population of interacting agents. The object of evolution can be a biological or cultural trait or a profile of strategies in a game. The process by which it changes can depend on fitness, imitation or optimization, possibly as the outcome of a deliberative process.

Lecture Contents:

1. Overview of Evolutionary Game Theory

   Basic concepts, techniques and findings, from ESS strategies to evolutionary stability.

2. Deterministic evolutionary dynamics

   Models of deterministic evolution, mostly based on replicator dynamics and imitation.

3. Stochastic evolutionary models

   Models of stochastic evolution, mostly based on markov chains. Equilibrium selection based on stochastic stability techniques.

Teaching Method:

Frontal lectures

Bibliography:

Sandholm, William H. Population games and evolutionary dynamics. MIT press, (2010).

Newton, Jonathan. "Evolutionary game theory: A renaissance." Games 9.2 (2018): 31.

Young, H. Peyton. Individual strategy and social structure: An evolutionary theory of institutions. Princeton University Press, (2001)

Final Exam:

A 10-page essay applying evolutionary game theory to a phenomenon decided by the student

Prerequisites:

The course is self-contained, but basic knowledge of game theory and markov chains is welcome.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Experimental Economics
Chiara Nardi

20 Hours

Learning Outcomes:

The main goal of the course is to provide an introduction to the theory and practice of experimental economics. At the end of the course, students should have acquired the set of basic tools which are necessary to independently conduct an experiment (online, in the lab or in the field), to understand the existing experimental literature, and to assess the strengths and weaknesses of an experimental paper.

Abstract:

The course will provide an overview of the methods used in experimental economics to study people's behavior. It will explain i) why there is the need for controlled experiments in empirical economics, ii) how to design and implement controlled experiments, and iii) what sort of knowledge experiments can produce about economic matters.

Lecture Contents:

1) What is experimental economics? And why do we need experiments?

2) Methods and techniques for conducting economic experiments: rules for control, matching, incentives, instructions, deceptive practices, subjects, sample size

3) Applications: public goods games, prisoners' dilemma games, ultimatum/dictator/yes-no games, trust games (other topics/games may be discussed, depending on students' research interests)

4) Experimetrics: the econometric analysis of experimental data

Teaching Method:

Frontal lectures

Bibliography:

Jacquemet, N., and L'Haridon, O. (2018). *Experimental economics: Method and applications*. Cambridge University Press.

Moffat, P. (2015). *Experimetrics: Econometrics for experimental economics*. Palgrave Macmillan.

Further references will be indicated during the course.

Final Exam:

A research project that involves finding a topic, developing testable research question(s), designing an experiment to answer the question(s), and proposing a data analysis.

Prerequisites:

The course is self-contained, but basic knowledge of microeconomics, game theory and statistics are welcome.

Fast game prototyping with Godot
Gabriele Costa

10 Hours

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Firms, Business Analytics and Managerial Behavior
Nicola Lattanzi

20 Hours

Learning Outcomes:

Students will learn the key business concepts to understand and evaluate business behaviors, firms' strategies and financial results. The goal of this course is to give a solid understanding of the opportunities, techniques, and challenges in analyzing firms, business analytics and managerial behavior.

Lectures will include the fundamental concepts of management science, ranging from the theory of the firm to business performances, financial statements, strategy and entrepreneurship.

Abstract:

The course will start introducing the theory of the firm, to provide an understanding of what a business is and under which conditions it exists and is sustainable over time. Then, the course will offer an in-depth view of businesses, providing students with the key tools to understand businesses' status and future performances from reading their financial statements. Following the "new economic humanism" perspective, which considers the human being as a fundamental part of the firm, the course will focus on the human side of businesses. Thus, it will explore the role that soft skills, neuroscience and dynamic capabilities can provide for management and strategy, to conclude with insights of how to govern a business in today's uncertain and complex world.

Lecture Contents:

• The contemporary scenarios. The firm as a system of choices and decisions in progress: theory.

• The system of forces in a business organization: efficiency in production and effectiveness in results

• Business performance, quantitative and qualitative measures. The financial conditions and the profit and loss prospect. A view on decoupling in economy.

• The statement of financial situation. How to read and comprehend performances and results in a business organization: methodology and tools.

• How to read and comprehend performances and results: cost accounting and break-even-point.

• Future jobs for society and business corporations

• Occupations and soft skills in a business combination: the analysis

• Dynamic capabilities and strategy: forecast simulation versus predictive simulation. Business and data analytics

• Business model innovation, managerial neuroscience and business behavior

• Entrepreneurship and management in a complex scenario

Teaching Method:

Lectures, discussions, business cases, presentations. The teaching format is interactive: active discussion of the lectures' topics is expected from students.

Bibliography:

The lectures slides, along with a list of selected suggested readings, will be provided at the end of each lecture.

Final Exam:

Critical paper presentations in groups.

Prerequisites:

None.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Forensic and Legal Psychology
Pietro Pietrini

16 Hours

Learning Outcomes:

By attending the course, students will learn the fundamentals of psychology and psychiatry as well as the most innovative applications of cognitive and experimental neuroscience to the forensic field. Students will have a first-hand presentation of ground-breaking cases, including the expert report in the 2009 Trieste Court of Appeal case, the 2011 Como's Court case and others, in which neuroscientific data have been used to corroborate the expert report conclusions. Students will learn the critical aspects and the pitfalls of psychiatric forensic examinations and of expert cross-examination.

Abstract:

Contrary to all the other branches of medicine, diagnostic process in psychiatry still suffers from the (almost) complete absence of objective laboratory tests. which results in a poor diagnostic concordance. Even worse is the case in forensic psychiatry, where matters are more complex as compared to the clinical setting. Faced with the classical forensic question, whether or not the defendant is capable to understand and to will, consultants appointed by the different parts (i.e., the judge, the prosecutor, the defendant, the victim) most of the times reach opposite conclusions - based on their role - which are highly speculative and lack of any objective support . Over the last decade, progressive effort has been put to minimize subjective speculations in forensic psychiatric assessment. Applications of neuroscience methodologies, including structural and functional brain imaging and molecular genetics, have proven to increase objectivity.

Lecture Contents:

* The concept of Free Will in the forensic context. The psychological determinants of behavior. How we make decisions

* Structural and functional brain correlates in decision making processes. How we control (aggressive) behavior. Behavioral abnormalities associated with brain lesions or neurodegenerative disorders. Fronto-temporal dementia.

* Psychopathy and behavior. Psychopathy from a psychiatric perspective. Is there a moral blindness?

* Psychopathy and anti-social behavior. Psychopathy as a predictor of criminal behavior. Inside the brain of psychopathics: structural brain differences between psychopathic individuals and healthy controls.

* The functional neuroanatomy of aggressive behavior in humans. Relevance to the understanding of anti-social behavior

* Genetic bases of personality and behavior. Principles of genetics

* Gene and environment in the modulation of social and anti-social behavior.

* Structural and functional brain imaging examinations in the forensic domain: what can these methods tell us about imputability?

* Behavioral genetic examinations in the forensic domain

* Applications of behavioral genetics and brain imaging examinations in the individual assessment in the forensic domain: the 2009 Trieste Court of Appeal case (the first case in Europe); the 2011 Como Court case

* Acquired paedophilia as a results of brain tumor. Literature review and discussion of a recent Italian case.

* Working research hypothesis: is there a Functional Frontal Fragility Syndrome?

Teaching Method:

The course includes theoretical and methodological face-to-face lessons, with the help of slides and case-report publications. E-learning platform are used to share learning materials (slides, data, publications, etc.). Hands-on lessons will be promoted.

Bibliography:

Lesson slides; selected papers of studies and case reports discussed in class

Final Exam:

Knowledge will be verified throughout the course by student's engagement into discussion in class; a written examination with open questions and multiple choice questions will be administered at the end of the course

Prerequisites:

Basic knowledge of brain imaging methodologies; strongly suggested, though not mandatory, that students have followed the following courses prior to enrolling in this one: Introduction to Cognitive and Social Psychology ; Neurobiology of Emotion and Behavior: Clinical Psychopathology and Psychiatry

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Foundations of Probability and Statistical Inference
Irene Crimaldi

30 Hours

Learning Outcomes:

- By the end of this course, students will:
- have the ability to employ the fundamental tools of Probability Theory in order to solve different kinds of problems,
- have the fundamental concepts of Statistical Inference in order to perform various kinds of statistical analysis,
- appreciate the importance of mathematical formalization in solving probabilistic problems and in performing statistical analysis,
- be able to independently read mathematical and statistical literature of various types and be life-long learners who are able to independently expand their probabilistic and statistical expertise when needed.

Abstract:

This course covers the fundamental concepts of probability theory and statistical inference. Some proofs are sketched or omitted in order to have more time for examples, applications and exercises.

Lecture Contents:

- This course deals with the following topics:
- probability space, random variable, expectation, variance, cumulative distribution function, discrete and absolutely continuous distributions,
- random vector, joint and marginal distributions, joint cumulative distribution function, covariance,
- conditional probability, independent events, independent random variables, conditional probability density function, order statistics,
- multivariate Gaussian distribution, copula functions,
- probability-generating function, Fourier transform/characteristic
- function,
- types of convergence and some related important results,
- Mathematical Statistics (point estimation, interval estimation,
- hypothesis testing, linear regression, introduction to Bayesian

- statistics).

Teaching Method:

Frontal teaching

Bibliography:

- Slides and other material provided by the lecturer
- R. Durrett, Elementary Probability for Applications, Cambridge Univ. press (2009)
- S. M. Ross, Introduction to Probability Models, Academic press (2003)
- M. Mitzenmacher, E. Upfal, Probability and Computing, Cambridge Univ. press (2005)
- O. Kallenberg, Foundations of Modern Probability, Springer (1997)
- S. M. Ross, Introductory Statistics, Elsevier (2010)
- K. V. Mardia, J. T. Kent, J. M. Bibby, Multivariate analysis. Academic press (1979)
- R. B. Nelsen, An Introduction to Copulas, Springer Series in Statistics (2006)
- P. K. Trivedi, D. M. Zimmer, Copula modeling: an introduction for practitioners (2005)

Final Exam:

Written test

Prerequisites:

Mathematical analysis and linear algebra (sequences and limits, series, vectors and matrices, vector-valued function of one or more variables, differentiation, integration, complex numbers)

Funding and Management of Research and Intellectual Property
Marco Paggi

10 Hours

Learning Outcomes:

How to write a research/mobility project proposal; fundamentals on the management of intellectual property rights.

Abstract:

The long seminar aims at providing an overview of funding opportunities for PhD

students' mobility, post-docs, and researchers (Erasmus+ scheme; scholarships by the Alexander von Humboldt Foundation; initiatives by the Deutscher Akademischer Austausch Dienst; scholarships offered by the Royal Society in UK; bilateral Italy-France exchange programmes; Fulbright scholarships; Marie Curie actions; grants for researchers provided by the European Research Council). For each funding scheme, specific hints on how to write a proposal are given. In the second part of the long seminar, fundamentals on the management of intellectual property rights (copyright transfer agreements, open access, patents, etc.) are provided.

Lecture Contents:

- Overview of funding schemes to support research mobility;
- Fundamentals of Intellectual Property Rights (patents, copyrights, etc.);
- Fundamentals of academic entrepreneurship.

Teaching Method:

Powerpoint presentations. Due to the Covid-19 emergency, lectures will be provided online: https://zoom.us/j/93898866026?pwd=aXozRlFBMEFEVEdRb0d1eG9wSm9tZz09

Bibliography:

Handouts are provided to the participants.

Final Exam:

This long seminar has no final exam.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Game Theory
Ennio Bilancini

20 Hours

Learning Outcomes:

The goal is to equip students with an in-depth understanding of the main concepts and tools of game theory in order to enable them to successfully pursue research related to the analysis of strategic behavior and interactive decision-making.

Abstract:

The course provides a detailed discussion of state of the art in the modeling of interactive decision-making as games. Special attention will be given to the prediction of outcomes in strategic situations. For this purpose, prominent solution concepts of games are reviewed and discussed, together with their main refinements based on rationality and information requirements.

Lecture Contents:

Game concepts covered: normal form game, extensive form game, strategy, mixed strategy, Dominance and iterative dominance, rationalizability, Nash equilibrium, subgame perfect Nash equilibrium, trembling hand perfect Nash equilibrium, weak perfect Bayes-Nash equilibrium, sequential equilibrium, perfect Bayes-Nash equilibrium, out-of-equilibrium beliefs refinements.

The discussion of all theoretical concepts will be accompanied by representative applications from biological, economic, information and social sciences.

Teaching Method:

Frontal lectures

Bibliography:

Mas-Colell A, Whinston MD, Green JR. Microeconomic theory. New York: Oxford university press (chapters 7,8,9)

Final Exam:

Either assignments during course or final essay.

Binary evaluation: pass/don't pass

Prerequisites:

The course is self-contained, but being familiar with basic concepts from calculus, linear algebra, and probability theory may be helpful.

Geospatial Approaches to Cultural Heritage
(Stuart Dunn)

25 Hours

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Global Law
Andrea Averardi

10 Hours

Learning Outcomes:

By the end of the course students will be able to identify the most relevant legal features of the globalization.

Abstract:

The course illustrates how globalization affects the international legal context and how global regulatory regime emerge and develop. With the examples taken from several different sectors (such as world trade, Internet, sports, finance, environment, publish health, cultural heritage) the course will focus on the regulatory, institutional and procedural dimensions of international organizations and on the relationships between these latter and domestic legal orders. Specific attention will be devoted to the consequences of the pandemic crisis on legal globalization features.

Lecture Contents:

Administrative Law; European Administrative Law, Global Administrative Law; European Law; International Law; Public Law; Comparative Law.

Teaching Method:

Case Law Teaching Method. The use of the Case Law Teaching Method requires classes of four hours in order to give the students the opportunity to analyze readings and materials and then to discuss it.

Bibliography:

Course readings and materials will be provided at the beginning of the course.

Final Exam:

Evaluations will be based on student's participation during the classes.

Prerequisites:

None.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

History of Ancient Art and Archaeology
Maria Luisa Catoni

30 Hours

Learning Outcomes:

The course aims at providing students with:

1. methodological tools to perform visual analyses
2. critical tools to perform contextual analyses of visual productions.
3. basic knowledge of a number of ancient classical monuments, contexts and/or productions
4. methodological and critical tools to analyse the "Classical Tradition", visual in particular, focussing on contemporary and modern uses of Classical Antiquity and in particular to analyse:
   - the interplay between contemporary contexts and ancient Greek and Roman objects, images, texts, data, contexts, ideals, notions, stories;
   - the historical approach to image and art perception;
   - the notions of media, techniques and mediality;
   - the role of specific spaces and contexts of fruition in defining the status of an object, the status of Art, the notion of Artist, etc.;
   - the role of specific cultural traditions in defining the status of an object, the status of Art, the notion of Artist, etc.;
   - the interplay between present and past in archaeology, archaeological sites, monuments and museums.

The use of different analytical tools is learned inferentially through case studies, discussions of papers and analyses of visual and textual documents performed i n class by the students. The course includes off-site lectures at close contact with the objects, sites, cultural institution.

Abstract:

The course is shaped according to the characteristics, backgrounds and needs of the class. It consists of four main threads strictly and dynamically intertwining:

1. The nature and types of questions asked about Classical Antiquity (approached and analysed mainly through the case studies of Impressionism, Cubism, Video art, Design, Advertisement)

2. The applicability of those questions to the Ancient World (through the cases of the Ara Pacis, the Parthenon and Ancient Portraiture)

3. Contemporary and modern uses, manipulations, mediation and fruition of ancient monuments, arts, ideals; the role of museums.

4. Modern and contemporary scientific practices related to Antiquity.

Lecture Contents:

The content of the individual lectures will be adapted to the needs of the class. The course consists of four main blocks of lectures

1. The questions asked (through the cases of Impressionism, Cubism, Video Art, Design, Advertisement: visual, textual, contextual analysis)
2. The Ancient World: the status of objects, the notion of techne and medium, history of perception and musealization of ancient art: visual, textual, contextual analysis;
   - 2.1 The Ara Pacis: past and present (the Augustan Era, the XVIth century, the fascist excavation, the present museum and uses); visual, textual, contextual analysis; style and iconography in the ancient political propaganda;
   - 2.2 The Parthenon: ancient uses and modern debates; visual, textual, contextual analysis;
   - 2.3 Ancient portraiture: ancient status and modern misunderstandings;visual, textual, contextual analysis

3. Contemporary and modern uses, manipulations, mediation and fruition of ancient monuments, sites, objects, images, arts, ideals; the role of museums; scientific practices related to Antiquity;

4. Conclusions

Teaching Method:

The course requires an active participation of the students in performing both case or paper discussions, visual analyses, argument analysis as well as preparing site visits.

Bibliography:

Bibliography will be provided by the lecturer.

Final Exam:

The evaluation is based on the actual participation in the class training activities (paper discussions, visual analyses, case analyses as well as on seminars held by each student on a subject chosen with the lecturer. The scope of the seminar is to verify the actual acquisition of the capacities and tools to perform visual, textual and contextual analysis.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

History of Contemporary Art: Art History and Political History
Michele Dantini

20 Hours

Learning Outcomes:

The antithesis fascism/anti-fascism will prove inadequate to describe the multiplicity of Italian artistic addresses between the two wars - this is the main thesis of the course; and unexpected continuities between the first and second half of the century will emerge on pre-political or anthropological-cultural levels rather than on merely stylistic ones.

Abstract:

The course is aimed at students of various backgrounds and does not require particular historical-artistic skills. It is proposed to consider the Italian art of the period between the two wars - "second" Futurism, Strapaese, Novecento, etc. - in its relationship with the politics of image promoted by the fascist regime and the different "ideas of nation" debated at public level.

Lecture Contents:

We will try to recognize and delineate the specificity of the Italian nationalism between the two wars, selected in its difference from the French and German nationalism of the same period, in the light of historical events of primary importance, such as the post-war period, the D'Annunzio occupation of Fiume, the squads, the March on Rome and finally the political history of the Twenties and Thirties.

Continuous references to literature and politics will be proposed, through essays, official speeches and newspaper or magazine articles, in an attempt to connect as accurately as possible the figurative conversation promoted by this or that artist to current ideologies; and to reconstruct the relationships between art history and political history on the one hand; history of art and ecclesiastical and religious history on the other.

Teaching Method:

Frontal lessons

Bibliography:

Michele Dantini, Art and politics in Italy between fascism and the Republic, Donzelli, Rome 2018

Laura Malvano, Fascism and politics of the image, Bollati Boringhieri, Turin 1988

Gioacchino Volpe, Italy on the move, Donzelli, Rome 2010 (1928)

Emilio Gentile, Fascismo di pietra, Laterza, Roma 2007

Final Exam:

No Exam

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

History of Early Modern and Modern Art
Chiara Franceschini

30 Hours

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Industrial Organization
Massimo Riccaboni

20 Hours

Learning Outcomes:

To master the concepts developed in the course material in such a way that independent research can be carried out. Demonstrate knowledge and understanding that provide a basis for originality in developing ideas, often related to a research context. Students should possess the learning outcomes that enable them to continue studying in a way that will be largely self-directed or autonomous.

Abstract:

This course will survey recent developments in theory and empirics of firm dynamics and its importance for aggregate outcomes such as innovation, growth and international trade. In particular, this class will center around the following questions: a) what are the key empirical regularities on firm dynamics and what are the principal measurement issues? b) what drives firms' size and growth dynamics? c) what determines the dynamics of entrepreneurial growth and innovation by firms? d) how do different sources of firm-level heterogeneity influence aggregate outcomes? e) what drives the rise and fall of inter-firm collaboration and trade networks?

Students are expected to be familiar with microeconomics and econometrics from the first-year sequence.

Lecture Contents:

Class 1: Gibrat Legacy

Class 2: Size distribution of business firms, theory

Class 3: Size distribution of business firms, empirics

Class 4: Growth-of-firm, theory

Class 5: Growth-of-firm, empirics 1 (econometrics)

Class 6: Size-Growth Relationship, theory

Class 7: Market Structure: The Bounds Approach

Class 8: Industry Dynamics

Class 9: Machine Learning Firm Dynamics

Class 10: Microfoundations of Aggregate Fluctuations

Teaching Method:

Lecture-cum-Demonstration

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Bibliography:

Main reference:

- Buldyrev S., Pammolli F., Riccaboni M., H.E. Stanley (2019) The Rise and Fall of Business Firms, Cambridge University Press, Cambridge (MA); ISBN: 1107175488, in press.
- Other references:
- Acemoglu D., Carvalho V.M., Ozdaglar A., Tahbaz-Salehi A. (2012). "The network origins of aggregate fluctuations", Econometrica, 80(5), 1977-2016
- Axtell R.L. (2001), "Zipf Distribution of U.S. Firm Sizes", Science, 293: 1818-20
- Bee M., Schiavo S. and Riccaboni M. (2013) "The Size Distribution of US Cities: Not Pareto, Even in the Tail", Economics Letters, 120(2), 232-237
- Bottazzi G., Secchi A. (2006) "Explaining the Distribution of Firm Growth Rates", RAND Journal of Economics, 37(2), 235-256
- Cabral, L., and J. Mata (2003), "On the Evolution of the Firm Size Distribution: Facts and Theory",.American Economic Review, 93(4), 1075-1090
- Dunne T., Roberts M.J., and Samuelson L. (1988), "Patterns of Firm Entry and Exit in U.S. Manufacturing Industries", Rand Journal of Economics, 19(4), 495–515
- Easley D. and Kleinberg J. (2010) Networks, Crowds, and Markets: Reasoning about a Highly Connected World, Cambridge University Press, 2010. Chapter 18. Power Laws and Rich-Get-Richer Phenomena, https://www.cs.cornell.edu/home/kleinber/networks-book/networks-book-ch18.pdf
- Evans D.S. (1987) "The Relationship between Firm Growth, Size, and Age: Estimates for 100 Manufacturing Industries", Journal of Industrial Economics, 35(4), 567–581
- Fu D., Pammolli F., Buldyrev S.V., Riccaboni M., Matia K., Yamasaki K., Stanley H.E. (2005), "The Growth of Business Firms: Theoretical Framework and Empirical Evidence", Proceedings of the National
- Academy of Sciences, 102(52): 18801-6
- Gabaix X. (1999), "Zipf's Law for Cities: An Explanation", Quarterly Journal of Economics, 114(3): 739-67
- Gabaix X. (2009), "Power Laws in Economics and Finance", Annual Review of Economics, 1: 255-93
- Gabaix X. (2011) "The Granular Origins of Aggregate Fluctuations", Econometrica, 79, 733-772
- Hall, Bronwyn (1987) "The Relationship between Firm Size and Firm Growth in the U.S. Manufacturing Sector", Journal of Industrial Economics, 35(4), pp. 583–606
- Klette T.J., Kortum S. (2004), "Innovating Firms and Aggregate Innovation", Journal of Political Economy, 112(5): 986-1018
- Luttmer E. (2010) "Models of Growth and Firm Heterogeneity", Annual Reviews of Economics, 2,

547-576

- Mansfield E. (1962), "Entry, Gibrat's Law, Innovation, and the Growth of Firms", American Economic Review, 52(5): 1023-51
- Mitzenmacher M. (2004), "A Brief History of Generative Models for Power Law and Lognormal Distributions", Internet Mathematics, 1(2): 226-51
- Rossi-Hansberg E. and Wright M.L.J. (2007), "Establishment Size Dynamics in the Aggregate Economy",
- American Economic Review, 97(5): 1639-66
- Stanley M.H.R., Amaral L.A.N, Buldyrev S.V., Havlin S., Leschhorn H., Maass P., Salinger M.A., Stanley H.E. (1996), "Scaling Behaviour in the Growth of Companies", Nature, 379: 804-6
- Sutton J. (1997), "Gibrat's Legacy", Journal of Economic Literature, 35:40-59
- Sutton J. (2002), "The Variance of Firm Growth Rates: the `Scaling' Puzzle", Physica A, 312: 577-90
- Sutton J. (2006), "Market Structure: Theory and Evidence", Handbook of industrial organization,3, 2301-2368, http://personal.lse.ac.uk/sutton/market_structure_theory_evidence.pdf
- Sutton J. (2007), "Market Share Dynamics and the ' Persistence of Leadership' Debate", American Economic Review, 97: 222-41
- Virkar Y. and Clauset A. (2012) "Power-law Distributions i n Binned Empirical Data", The Annals of Applied Statistics, 8(1), 89-119, http://arxiv.org/pdf/1208.3524v1.pdf

Final Exam:

• Final presentation of student research proposal: 70%

• Class participation and constructive discussion of other students' research ideas: 30%

Prerequisites:

Microeconomics, Econometrics I & II

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Information Economics
Federico Vaccari

10 Hours

Learning Outcomes:

The main goal of this course is to give students an understanding of the role of information asymmetries in economics and more broadly in settings that are relevant in social sciences. Eventually, students taking this course should be able to conduct research in the field of information economics.

Abstract:

The course starts by introducing asymmetric information into a simple model of competitive markets to show that in these cases market equilibria often fail to have desirable properties. Several situations in which informational asymmetries exist between individuals at the time of contracting are considered. The course proceeds by studying situations where individuals anticipate the development of such asymmetries and thus seek to mitigate the inefficiencies they cause.

Lecture Contents:

This course covers the basics of information economics. The topics covered are asymmetric information, adverse selection, signaling, screening, and principal-agent problems such as moral hazard. The course also discusses a wide range of settings and fields within economics and other social sciences in which the problems and solutions hereby studied apply.

Teaching Method:

Frontal lectures.

Bibliography:

Mas-Colell A, Whinston MD, Green JR. Microeconomic theory. New York: Oxford university press.

Final Exam:

There is no examination for this course.

Prerequisites:

There is no examination for this course.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Consciousness and Sleep
Giulio Bernardi

20 Hours

Learning Outcomes:

Knowledge of the main approaches for the study of consciousness in humans. Identification of main states of vigilance based on electroencephalographic activity. Knowledge of the impact of homeostatic and circadian factors on brain structure and function.

Abstract:

The course will provide an introduction to fundamental concepts and current experimental approaches related to the study of the functional and anatomical basis of consciousness. In particular, the course deals with the following topics:

a) Definition of consciousness and identification of its fundamental properties;
b) The neuroanatomical bases of consciousness;
c) Main experimental paradigms and methodological approaches to the study of consciousness;
d) Altered states of consciousness: sleep, anesthesia, seizures, coma and related conditions;
e) Sleep as a model for the study of consciousness: local aspects of sleep and wakefulness.

Lecture Contents:

Part 1. Definition of consciousness and identification of its fundamental properties. The neuroanatomical basis of consciousness.

Part 2. Conscious access and experimental approaches for the study of visual consciousness. Electrophysiological and functional signatures of distinct states of vigilance. Impact of changes in vigilance state on neuroimaging investigations.

Part 3. Behavioral and functional differences between sleep and wakefulness. Sleep scoring and analysis of sleep structure. Sleep as a model for the study of consciousness. Local aspects of sleep and wakefulness. The neural correlates of dreaming.

Part 4. Altered states of consciousness: sleep, anesthesia, coma, unresponsive wakefulness syndrome (or vegetative state), minimally conscious state, seizures. Measures of the level of consciousness in

physiological and pathological conditions.

Teaching Method:

Lectures

Bibliography:

Steven Laureys Olivia Gosseries Giulio Tonon. The Neurology of Consciousness (2nd Edition) - Cognitive Neuroscience and Neuropathology. 2015

Stanislas Dehaene. Consciousness and the brain: Deciphering how the brain codes our thoughts. 2014

Hans Dringenberg. Handbook of sleep research (1st Edition). 2019

Final Exam:

Yes (short seminars)

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to East and West: Languages, History, Challenges of Islam
Amos Bertolacci

30 Hours

Learning Outcomes:

The aim of the course is to grant students a basic familiarity with the fundamental elements of Arabic-Islamic civilization, taking the language (Arabic), on the one hand, and the religion (Islam), on the other, as pivotal axes of a survey of the development of Islamic culture, with a final analysis of the challenges that the dogmatic, historico-geographical, and socio-political specificities of Islam pose to contemporary concerns.

Abstract:

A bedouin and peripheral semitic language like pre-Islamic Arabic became, with the rise of Islam, not only the holy language of God's revelation in the Qur'an, but also an instrument of cultural communication soon shared by Muslims, Christians, and Jews, both within and outside the Muslim empire. The first part of the course will be devoted to providing some hints at the basic features of Arabic as a language, its way of writing, alphabet, pronunciation, and linguistic profile. The second part will focus on the historical setting of the emergence of Islam as a religion, its dogmatic development, and its rapid fragmentation into a series of distinct Islamic confessions. From a contemporary point of view, the course will end with a brief consideration of the compatibility of Islam with Christianity and Judaism in so far as it purports to be the last revelation of the God of Abraham, a "territorial" religion, and a system of thought in which the boundaries between religion and politics remain fluid.

Lecture Contents:

1) Language: Arabic, its main features, and the first globalization of culture
2) Religion, the founder: the prophet Muhammad
3) Religion, main principles: the Five Pillars
4) Religion, particular branches: Sunnis, Shi'is, and other religious groups
5) Challenges, religious: "There is no God but God": the last and definitive Monotheism?
6) Challenges, geographical: a religion of the earth (Mecca and Medina; Jerusalem; the "House of Islam")
7) Challenges, political: secularism and theocracy, Islam and Islamism

Teaching Method:

Frontal lessons with discussion

Bibliography:

Gerhard Endress, Islam. An Historical Introduction, Edinburgh University Press, Edinburgh 1988, 2nd edition 2002.

Further bibliography will be communicated in class.

Final Exam:

Oral presentation of a topic related to the course content

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Machine Learning
Alberto Bemporad

20 Hours

Learning Outcomes:

The goal of the course is to provide a concise introduction to the most popular and practical techniques for learning mathematical models from data.

Abstract:

Different methods for solving function regression, classification, and clustering problems will be illustrated, understanding their mathematical foundations, the underlying learning algorithms, and how to validate their prediction performance. Examples from different application domains and how to solve them in Python will be shown during the course to illustrate the concepts.

Lecture Contents:

Introduction to machine learning: supervised/unsupervised learning, classification/regression, overfitting, bias/variance tradeoff, cross-validation, examples. Linear regression and least squares: loss functions and regularization, basis functions and Kernel least squares, support vector regression, recursive least squares. Linear and Bayesian classification: ridge classifier, logistic regression, support vector classification, naive Bayes classifier. Non-parametric regression and classification: nearest neighbors, decision trees, Gaussian process regression, ensemble methods (bagging, bootstrap, random forests and feature importance, boosting methods). Neural networks: feedforward networks, backpropagation and automatic differentiation, learning algorithms (stochastic gradient descent, nonlinear least squares), AutoML; temporal convolutional networks, recurrent neural networks. Unsupervised learning: clustering methods (K-means clustering, density-based spatial clustering), dimensionality reduction (principal component analysis, nonlinear PCA), autoencoders.

Teaching Method:

Frontal lessons with discussion

Bibliography:

References:

[1] T. Hastie, R. Tibshirani, J. Friedman, "The elements of statistical learning: data mining, inference, and prediction" (2009)

[2] K.P. Murphy, "Probabilistic Machine Learning: An Introduction" (2021)

[3] S.P. Boyd, L. Vandenberghe, "Convex optimization" (2004)

[4] J. Nocedal, S. Wright, "Numerical optimization", (2006)

[5] G.H. Golub, C.F. Van Loan, "Matrix computations", 4th Ed. (2013)

[6] "Scikit-learn - User's guide", https://scikit-learn.org/stable/user_guide.html

[7] A.C. Müller, S. Guido, "Introduction to machine learning with Python: a guide for data scientists" (2016)

Relevant speaker's references:

[1] A. Bemporad and D. Piga, "Active preference learning based on radial basis functions," Machine Learning, vol. 110, no. 2, pp.417-448, 2021. Code available at http://cse.lab.imtlucca.it/~bemporad/glis

[2] A. Bemporad, "Global optimization via inverse distance weighting and radial basis functions," Computational Optimization and Applications, vol. 77, pp. 571–595, 2020.

[3] V. Breschi, D. Piga, and A. Bemporad, "Piecewise affine regression via recursive multiple least squares and multicategory discrimination," Automatica, vol. 73, pp. 155–162, Nov. 2016.

[4] A. Bemporad, "Piecewise linear regression and classification," arXiv eprint 2103.06189, 2021. Code available at http://cse.lab.imtlucca.it/~bemporad/parc

[5] D. Masti and A. Bemporad, "Learning nonlinear state-space models using deep autoencoders," in Proc. 57th IEEE Conf. on Decision and Control, pp. 3862–3867. Miami Beach, FL, USA, 2018.

[6] A. Bemporad, V. Breschi, D. Piga, and S. Boyd, "Fitting jump models," Automatica, vol. 96, pp. 11–21, Oct. 2018, Code available at http://cse.lab.imtlucca.it/~bemporad/jump_models/..

Final Exam:

Typically a small research project, or discussion about a paper on a subject related to the course, or oral exam

Prerequisites:

Basics of calculus, linear algebra, numerical optimization, probability theory, computer programming.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Management of Complex Systems
Andrea Zocchi, Simone Gerola

5 Hours

Learning Outcomes:

Understanding of how a structured approach can lead to a "high quality and high impact problem solving"

Abstract:

Problem solving of complex situations and systems requires a structured approach. This course, which is based on the training adopted by some top management consulting Firms, provides a methodology which is applicable to a broad variety of industries and issues.

Lecture Contents:

1) Introduction to "high impact and high quality" problem solving;

2) 7 steps problem solving approach;

3) Intro to a grocery retail case; 4) problem definition and logic trees

Teaching Method:

Theory applied to specific business cases. In class group exercises and discussions

Bibliography:

Lecture notes and exercises handed out during each lesson

Prerequisites:

Participation to all lessons and in class exercises

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Network Science
Tiziano Squartini

20 Hours

Learning Outcomes:

Students will learn how to dive into the literature of the field, identify the basic properties of networks, design simple models to study them.

Abstract:

The course offers a panoramic view of network science. Following its historical development, we will review the main concepts and methods of this discipline. Moving from the basic stylized facts characterizing real-world networks we will describe the most popular techniques to extract information from them.

Lecture Contents:

Introduction to graph theory. Empirical properties of complex networks (scale invariance of the degree, small-world phenomenon, modularity). Network representations (monopartite, bipartite and multilayer; binary and weighted; undirected and directed networks; hypergraphs; simplicial complexes). Centrality. Mesoscale structures (communities, core-periphery and bow-tie structures). Ranking and reputation algorithms. A primer on dynamical models: Watts-Strogatz, Barabasi-Albert. A primer on static models: Erdos-Renyi model, Chung-Lu model and fitness model.

Teaching Method:

Combination of frontal lectures and blackboard discussions.

Bibliography:

References to relevant research papers will be provided during the lectures. Lecture slides will be regularly distributed to the students.

Final Exam:

Each student will present and discuss a brief literature review about a topic of his/her choosing.

Prerequisites:

Solid mathematical background, passion for theory, logical rigor, scientific curiosity, interest in multidisciplinarity

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Neuropsychology
Francesca Garbarini

10 Hours

Learning Outcomes:

The course is aimed at providing the students with advanced theoretical and methodological knowledge to promote critical thinking about the neuropsychological approach, with a specific focus on motor and bodily awareness disorders after brain damaged. During the course, students a) will familiarize with the neuropsychological method using the pathological models to make inferences about the normal functioning of the human brain and b) will acquire in depth theoretical and methodological knowledge about the topic of motor and bodily awareness in cognitive neuropsychology.

Abstract:

The course will be focused on both theoretical and methodological aspects of the neuropsychological research. Neuropsychology can be defined as the discipline that studies the relationship between brain damages and higher cognitive functions. While its clinical goal is the description, diagnosis and treatment of the disorders consequent upon the brain damage, in our lessons we will be focused on its experimental aims: to draw inferences from the pathological conditions to normal functions. We will see in details three neuropsychological deficits after brain damage: anosognosia for hemiplegia, somatoparaphrenia and pathological embodiment. Anosognosic patients claim to be able to move their paralyzed limb, thus showing an altered motor awareness. When affected by somatoparaphrenia, patients report a sense of disownership over their contralesional limb (disembodiment). When affected by the pathological embodiment, patients report an abnormal sense of body ownership over someone else's limb (embodiment). The concepts of embodiment and disembodiment will be discussed even in the context of the rubber hand illusion that allows us to manipulate the body awareness in healthy subjects. During the lessons, we will focus on experimental aspects of the neuropsychological literature about anosognosia for hemiplegia, somatoparaphrenia and pathological embodiment to discuss the potentialities and limits of the neuropsychological experimental paradigms applied to brain-damaged patients.

Lecture Contents:

Lesson 1 (3 hours):

Introduction to neuropsychology

Anosognosia for hemiplegia

Written test + correction

Small group activities

Lesson 2 (3 hours):

Small group presentations

Pathological Embodiment and Somatoparaphrenia

Written test + correction

Small group activities

Lesson 3 (4 hours):

Small group presentations

Rubber Hand Illusion

Written test + correction

Teaching Method:

Academic teaching, focused on specific arguments of the course, will be combined with an interactive teaching modality leading to an active learning, by means of supervised small group activities. During small group activities, students will design an experimental paradigm to investigate some relevant aspects of anosognosia for hemiplegia, somatoparaphrenia, pathological embodiment, and rubber hand ilusion. At the end of the activity, each group will present its project to the other groups.

Bibliography:

Suggested papers can be found at the following link

https://drive.google.com/drive/folders/13GOAzyaRZaiwIz01JUyIF1wMYDInlvMq?usp=sharing

Final Exam:

There is no a final formal exam (no marks but Pass/No pass). After the discussion of each theoretical content of the course (Introduction to neuropsychology, Anosognosia for hemiplegia, Somatoparaphrenia, Pathological Embodiment, Rubber Hand Illusion), the students will have to answer some questions in a short written test. The teacher's evaluation will be based on the students' participation during lessons and during the small group activities and presentations.

Prerequisites:

No specific prerequisites are required

Introduction to Project Management
Beatrice Manzoni

5 Hours

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to Psychophysics
Davide Bottari

12 Hours

Learning Outcomes:

At the end of the course, students are expected to have specific knowledge of the basis of the psychophysical approach and how to analyse behavioural data sets.

Abstract:

The course will review how to implement a behavioural experimental designs, how to calculate thresholds, what are the Bayesian framework and the Optimal integration. The course will detail practical examples with hands-on sessions based on real and simulated data. Practical examples will be performed by learning Matlab based toolboxes.

Lecture Contents:

- Introduction to Introduce basic concepts and terminology.
- Experimental designs
- Available psychophysical procedures. Palamedes
- Psychometric PF functions. Fitting a psychometric function (single subj level)
- Adaptive methods, e.g. Pest, Quest
- Bayesian framework; Optimal cue integration
- MLE; toolbox from Hills et al. Optimal cue integration toolbox

Teaching Method:

The course includes theoretical and hands-on sessions. E-learning platform are used to share learning materials (slides, data, etc.).

Bibliography:

Slides of the course

Final Exam:

Knowledge is verified through hands-on sessions

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Machine Learning in Brain Disorders: Methods and Applications
Andrea Mechelli

10 Hours

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Management of Complex Systems: Approaches to Problem Solving
Andrea Zocchi, Simone Gerola

30 Hours

Learning Outcomes:

A structured approach to problem solving with related tools for each step

Abstract:

Problem solving of complex situations and systems requires a structured approach. This course, which is based on the training adopted by some top management consulting Firms, provides a methodology which is applicable to a broad variety of industries and issues.

Lecture Contents:

1) 7 steps problem solving approach and related tools;
2) Grocery retail case;
3) Relaunch of museum case;
4) Company X relaunch case in group exercise

Teaching Method:

Theory applied to specific business cases. In class group exercises and discussions

Bibliography:

Lecture notes and exercises handed out during each lesson

Final Exam:

Written test and oral exam

Prerequisites:

Participation to all lessons and in class exercises

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Markov Processes
(in collaboration with Scuola Sant'Anna)
Irene Crimaldi

12 Hours

Learning Outcomes:

- By the end of this course, students will:
- be familiar with Markov processes with discrete state space and discrete or continuous time,
- be able to employ the fundamental tools of Markov processes theory in order to solve different kinds of problems,
- appreciate the importance of mathematical formalization in solving probabilistic problems,
- be able to independently read mathematical and statistical literature on Markov processes.

Abstract:

This course covers the fundamental results regarding Markov processes with discrete state space and discrete or continuous time. Some proofs are sketched or omitted in order to have more time for examples, applications and exercises.

Lecture Contents:

- This course deals with the following topics:
- Markov chains (definitions and basic properties, classification of
- states, invariant measure, stationary distribution, ergodic limit theorem, cyclic classes, passage problems);
- Markov processes with discrete state space and continuous time (definitions, Markov's property, transition intensities, generator, forward Kolmogorov equations, stationary probability distribution);
- Birth-Death processes and queues.

Teaching Method:

Frontal teaching (mixed mode)

Bibliography:

- Slides and other material provided by the lecturer

- S. M. Ross, Introduction to Probability Models, Academic press (2003)
- G. Grimmett, D. Stirzaker, Probability and Random Processes, Oxford Univ. Press, third ed. (2001)
- W. Woess, Denumerable Markov chains, EMS textbooks in Mathematics (2009).
- N. Lanchier, Stochastic Modeling, Springer (2017)
- O. Kallenberg, Foundations of Modern Probability, Springer (1997)

Final Exam:

Assignment (exercise + written report on a topic of student's choice)

Prerequisites:

Mathematical analysis and linear algebra, basics of probability theory

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

MATLAB for Data Science
Giorgio Gnecco

20 Hours

Learning Outcomes:

At the end of the course, the student will be able to implement in MATLAB some common and more advanced machine learning techniques.

Abstract:

The course provides MATLAB implementations of several machine learning techniques.

Lecture Contents:

MATLAB code for:

- principal component analysis;

- spectral clustering;

- linear and polynomial regression;

- bias/variance trade-off;

- resampling methods;

- bounding box identification via the quasi-Monte Carlo method;

- logistic regression;

- batch gradient descent and stochastic gradient descent for training perceptrons/multilayer neural networks;

- perceptrons/multilayer neural networks applied to the XOR problem;

- digit recognition via neural networks;

- backpropagation with momentum;

- backpropagation applied to the minimization of the cross-entropy function;

- comparison of backpropagation applied to the minimization of the cross-entropy function and of the sum of squares error function;

- spam recognition via support vector machines;

- symmetry and antisymmetry in support vector machine training problems;

- trade-off between number of examples and precision of supervision in ordinary least squares, weighted least squares, and fixed effects panel data models;

- learning with boundary conditions;

- learning with mixed hard/soft constraints;

- LQG online learning;

- RBF interpolation;

- surrogate optimization for optimal material design;

- curve identification in the presence of curve intersections;

- matrix completion.

Depending on the students' background, additional slides will be presented/provided to them, illustrating a summary of the theory behind some of the techniques considered in the course.

Teaching Method:

The teacher will present to the students and discuss with them the MATLAB code developed for the applications above. Students will have the possibility to run the code and modify it..

Bibliography:

The next references report commented MATLAB code for some of the machine-learning techniques presented in the course (some of which are described in the related course "Advanced Topics in Machine Learning"):

Books

P. Kim, "MATLAB Deep Learning With Machine Learning, Neural Networks and Artificial Intelligence," Apress, 2017.

K. Kay, MATLAB code from the course "Statistics and Data Science in MATLAB", https://www.cmrr.umn.edu/~kendrick/statsmatlab/

Papers:

The MATLAB code for most of the other applications is related to the following articles:

A. Bacigalupo, G. Gnecco, "Metamaterial filter design via surrogate optimization," in Proceedings of the International Conference on Metamaterials and Nanophotonics (METANANO 2018), Sochi, Russia, September 17th-21st, 2018 (published in Journal of Physics: Conference Series, vol. 1092, article ID, 012043, 4 pages, 2018).

G. Gnecco, "An algorithm for curve identification in the presence of curve intersections," Mathematical Problems in Engineering, vol. 2018, article ID, 7243691, 7 pages, 2018.

G. Gnecco, "Symmetric and antisymmetric properties of solutions to kernel-based machine learning problems," Neurocomputing, vol. 306, pp. 141-159, 2018.

G. Gnecco, A. Bemporad, M. Gori, M. Sanguineti, "LQG online learning," Neural Computation, vol. 29, pp. 2203-2291, 2017.

G. Gnecco, M. Gori, M. Sanguineti, "Learning with boundary condition," Neural Computation, vol. 25, pp. 1029-1106, 2013.

G. Gnecco, M. Gori, S. Melacci, M. Sanguineti, "Learning with mixed hard/soft pointwise constraints," IEEE Transactions on Neural Networks and Learning Systems, vol. 26, pp. 2019-2032, 2015.

G. Gnecco, F. Nutarelli, "On the trade-off between number of examples and precision of supervision in machine learning problems," Optimization Letters, 2019, DOI: 10.1007/s11590-019-01486-x.

G. Gnecco, F. Nutarelli, D. Selvi, "Optimal trade-off between sample size and precision for the fixed effects generalized least squares panel data model," Machine Learning, 2021, DOI: 10.1007/s10994-021-05976-x.

R. Morisi, G. Gnecco, A. Bemporad, "A hierarchical consensus method for the approximation of the consensus state, based on clustering and spectral graph theory," Engineering Applications of Artificial Intelligence, vol. 56, pp. 157-174, 2016.

Final Exam:

There is no final exam

Prerequisites:

Machine learning, basic programming.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Matrix Algebra
Giorgio Gnecco

10 Hours

Learning Outcomes:

The course is aimed to review basic concepts of matrix algebra at an intermediate/advanced level.

Abstract:

The course is aimed to review the following basic concepts of linear algebra:

- systems of linear equations: solution by Gaussian elimination, PA=LU factorization, Gauss-Jordan method;
- vector spaces and subspaces, the four fundamental subspaces, and the fundamental theorem of linear algebra;
- determinants and eigenvalues, symmetric matrices, spectral theorem, quadratic forms;
- Cayley-Hamilton theorem, functions of matrices, and application of linear algebra to dynamical linear systems;
- iterative methods for systems of linear equations;
- ordinary least squares problem, normal equations, A=QR factorization, condition number, Tikhonov regularization;
- singular-value decomposition, Moore-Penrose pseudoinverse;

The course also shows how to apply the methods above using MATLAB. Finally, an economic application of matrix algebra (the Leontief input-output model) is also detailed.

Lecture Contents:

- Systems of linear equations;
- Properties of systems of linear equations;
- Determinant and eigenvalues;
- Applications of eigenvalues;
- QR factorization, ordinary least squares problem, and variations;
- An economic application of linear algebra: the Leontief input-output model.

Teaching Method:

The teacher will project slides on the screen (a copy of the slides and of the MATLAB code will be provided to the students). He will also solve some exercises on the blackboard.

Bibliography:

Gilbert Strang, Introduction to linear algebra. Wellesley, Cambridge Press, Fourth Edition, 2009

Gilbert Strang, Linear algebra and its applications. Thomson, Brooks/Cole, Fourth Edition, 2006

MATLAB teaching codes based on Prof. Strang's books:

http://web.mit.edu/18.06/www/Course-Info/Tcodes.html

Students having already a good background in matrix algebra are encouraged to read the following more advanced topics from the second book by Prof. Strang:

- application of linear algebra to graphs (Section 2.5),
- application of Gram-Schmidt orthogonalization process to function spaces (Section 3.4),
- Fast Fourier transform (Section 3.5),
- complex matrices (Section 5.5),
- minimum principles (Section 6.4),
- finite element method (Section 6.5),
- linear programming, the simplex method, and duality (Sections 8-1-8.4),
- Jordan’s canonical decomposition (Appendix B).

Final Exam:

Final written examination (optional, 2 hours)

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Microeconomics
Andrea Canidio, Kenan Huremovic

Hours: 40

(part 1 - Andrea Canidio – 20 Hours)

Learning Outcomes:

Acquire a solid understanding of classical microeconomic theory; learn how to read and write mathematical proofs; learn to apply the concepts discussed in class to solve specific exercises

Abstract:

The course aims at introducing students to graduate-level microeconomic theory. The course will give emphasis to problem solving. For this reason problem sets will be assigned during the course at dates to be communicated in class. Students will then rotate on the board in the following lecture to discuss the problems.

Lecture Contents:

Consumer Theory; Producer Theory; Choice under uncertainty; Partial equilibrium and market structure;

General Equilibrium; Externalities and Public Goods; Elements of Social Choice Theory (time permitting)

Teaching Method:

Lectures

Bibliography:

There is no required textbook for the course. However, the material presented in class will be taken from Mas-Colell, Whinston, and Green "Microeconomic Theory", which you are encouraged to consult

Final Exam:

Yes.

Prerequisites:

Knowledge of intermediate-level microeconomics is helpful but not necessary.

(part 2 – Kenan Huremovic – 20 Hours)

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Model Predictive Control
Alberto Bemporad

20 Hours

Learning Outcomes:

Knowledge of the theory and practice of Model Predictive Control (MPC) of constrained linear, linear time-varying, nonlinear, stochastic, and hybrid dynamical systems, and of the numerical optimization methods required for the implementation of MPC.

Abstract:

Model Predictive Control (MPC) is a well-established technique for controlling multivariable systems subject to constraints on manipulated variables and outputs in an optimized way. Following a long history of success in the process industries, in recent years MPC is rapidly expanding in several other domains, such as in the automotive and aerospace industries, smart energy grids, and financial engineering. The course is intended for students who want to learn the theory and practice of Model Predictive Control (MPC) of constrained linear, linear time-varying, nonlinear, stochastic, and hybrid dynamical systems, and numerical optimization methods for the implementation of MPC. The course will make use of the MPC Toolbox for MATLAB developed by the teacher and co-workers (distributed by The MathWorks, Inc.) for basic linear MPC, and of the Hybrid Toolbox for explicit and hybrid MPC.

Lecture Contents:

General concepts of Model Predictive Control (MPC). MPC based on quadratic programming. General stability properties. MPC based on linear programming. Models of hybrid systems: discrete hybrid automata, mixed logical dynamical systems, piecewise affine systems. MPC for hybrid systems based on on-line mixed-integer optimization. Multiparametric programming and explicit linear MPC, explicit solutions of hybrid MPC. Stochastic MPC: basic concepts, approaches based on scenario enumeration. Linear parameter- and time-varying MPC and applications to nonlinear dynamical systems. Selected applications of MPC in various domains, with practical demonstration of the MATLAB toolboxes.

Teaching Method:

Lecture slides and blackboard

Bibliography:

Lecture slides available on http://cse.lab.imtlucca.it/~bemporad/mpc_course.html

A. Bemporad, M. Morari, V. Dua, and E.N. Pistikopoulos, The explicit linear quadratic regulator for constrained systems, Automatica, vol. 38, no. 1, pp. 3–20, 2002

A. Bemporad, A multiparametric quadratic programming algorithm with polyhedral computations based on nonnegative least squares, IEEE Trans. Automatic Control, vol. 60, no. 11, pp. 2892–2903, 2015.

A. Bemporad and M. Morari, Control of systems integrating logic, dynamics, and constraints, Automatica, vol. 35, no. 3, pp. 407–427, 1999

F.D. Torrisi and A. Bemporad, HYSDEL — A tool for generating computational hybrid models, IEEE Trans. Contr. Systems Technology, vol. 12, no. 2, pp. 235–249, Mar. 2004

D. Bernardini and A. Bemporad, Stabilizing model predictive control of stochastic constrained linear systems, IEEE Trans. Automatic Control, vol. 57, no. 6, pp. 1468–1480, 2012

Final Exam:

Typically a small research project, or discussion about a paper on a subject related to the course, or oral exam.

Prerequisites:

Linear algebra and matrix computation, linear control systems, numerical optimization.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Management and Models of Organization of Cultural Institutions
Paola Dubini

25 Hours

Learning Outcomes:

To frame the issue of governance from an institutional and managerial perspective; to clarify the meaning of some widely used terms associate with governance of cultural organizations; to provide a conceptual basis to incorporate managerial logic in non managerial streams of research

Abstract:

The course will discuss different governance configuration (mechanisms and structures to guarantee continuity) through the lens of four broad dichotomies: private vs public; short vs long term; economic vs non economic value creation; local vs global

Lecture Contents:

the course is logically organized into the following modules:

1. management what? what is management all about in (cultural) organizations
2. the intrinsic fragility of cultural organizations
3. governance and long term sustainability
4. archetypes of cultural organizations: public no profit private
5. cultural organizations at play: the geographical perspective
6. performance of cultural organizations and its assessment

Teaching Method:

Face to face lectures - discussion of cases and incidents - exercises

Bibliography:

Will be provided in class

Final Exam:

Will be discussed with participants on the first day of class

Prerequisites:

I am starting from the assumption that participants will have no prior knowledge of governance issues. I suggest an introductory reading at your convenience Dubini Montanari Cirrincione Management of cultural organizations Egea 2017

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Museology and History of Collecting
Emanuele Pellegrini

30 Hours

Learning Outcomes:

The course aims at providing students with an advanced knowledge on museum as a cultural, social and historical problem. Furthermore, it provides students with analytical tools to evaluate the role of museums and their mission in present society.

Abstract:

The course aims at discussing topics in museology and history of collecting. Based both on theoretical reflections on art collecting as a social phenomenon, and practical case taken from present debate on museums and museum studies, the course provides students with critical tools for the analysis of emerging themes i n early collections, private and public goods, ownership of the collection/fruition of the collection. Organization of museums i n Italy, France, UK and the USA should be considered also course key issues.

Basically the course i s structured i n two parts. The first one (30 hours) is dedicated to general issue in museology and history and collecting. Lessons try to answer to five main questions on museum and its nature: definition (what), history and present development (when), relationship between collections and territories (where), reasons for collecting (why), the relationship between public and museum staff (who). The second part (30 hours) is dedicated to case studies on key topic on collecting issues such as provenance, curatorship, museum organization. Off site lectures are included in the course.

Lecture Contents:

1: Introduction. Method matters

2: Defining a museum: past and present

3-4: A museum birth?

5-6: (off site Lucca Villa Guinigi and Palazzo Mansi);

7: Museum and its territory

8: Museum and its public

9-10: (off site, tbd);

11-Beyond borders: museums in the future

12: The role of provenance

13: Musealizing a private collection

14: Dispossession and musealization

15: Original and fake

16: New perspectives, old technologies

17: (off site tbd);

18: Final Seminar

Teaching Method:

Class and offsite lectures

Bibliography:

Bibliography will be provided in class

Final Exam:

Research seminar

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Neurobiology of Emotion and Behavior
Pietro Pietrini

12 Hours

Learning Outcomes:

By attending this Course, students will learn the fundamentals of the neurobiological correlates of emotion and behavior and their evolutionary meaning under physiological conditions. Neurobiological correlates and effects of altered mental conditions on emotion and behavior also will be discussed.

Abstract:

The body of knowledge gained in the field of neuroscience in the last quarter of century have changed the way we conceptualize mind, behavior and even human nature. Since the 19th century it has been known that lesions to the cerebral cortex may lead to impairments in specific cognitive functions and in the ability to modulate behavior. The recent development of modern methodologies for investigating brain functions, including positron emission tomography and functional magnetic resonance imaging has made it possible to investigate the neural circuits implicated not only in cognitive processes such as perception, attention, memory and language, but also in more elusive mental functions, including emotion and behavior. In addition, molecular biology and genetics have led to the decoding of the human genome and are now investigating the role that the genetic endowment plays in shaping not only physical, but also personality features, behavior and vulnerability to mental disorders.

Lecture Contents:

* Brain structures involved in emotion and behavior in humans, non humans primates and other vertebrates. Why it is important to study the neurobiological correlates of emotion and behavior in the human brain

* Brain functional and structural correlates of emotion and behavior in humans. How structural and functional brain imaging methodologies can be applied to the in vivo study of human emotion and behavior

* Brain response to fearful stimuli. The role of amygdala. Emotions as a way to enhance signal-to-noise ratio in information processing. Evolutionary meaning of emotional processing

* Mood influence on emotional brain response. Effects of priming on amygdala response to neutral and sad stimuli. Implications for the understanding of the effects of environmental factors on mood balance

* Effects of negative life events on brain structures. Implications for the neurobiology of depression. Effects of meditation on brain structure and function

* Cognitive and emotional determinants in behavioral modulation. From instinct to decision making. The neural correlates of aggressive control in the healthy human brain. Altered structural and functional

cortical and subcortical factors in behavioral dysfunctions: implications for mental insanity in the forensic context

* The human genome. Genetic alleles involved in emotional processing and behavior. Genetic vulnerability to mood disorders

* Moral behavior. Cognitive and emotional aspects. The genetic factors that may influence human moral decisions

* Genes and environmental factors in shaping individual social behavior and vulnerability to psychological distress and depression

* Implications of recent neuroscience acquisitions about human emotion and behavior for the social sciences and the law

Teaching Method:

The course includes theoretical and methodological face-to-face lessons, with the help of slides and experimental research publications. E-learning platform are used to share learning materials (slides, data, publications, etc.)

Bibliography:

Lesson slides; selected papers of studies and case reports discussed in class

Final Exam:

Knowledge will be verified throughout the course by student's engagement into discussion in class; a written examination with open questions and multiple choice questions will be administered at the end of the course

Prerequisites:

Basic knowledge of brain imaging methodologies.It is strongly suggested, though not mandatory, that students have followed the following courses prior to enrolling in this one: Introduction to Cognitive and Social Psychology; Basic Principles and Applications of Brain Imaging Methodologies to Neuroscience.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Neuroeconomics
Luca Polonio

12 Hours

Learning Outcomes:

At the end of the course, the student should have a clear understanding of the strengths and limitations of the different techniques used in Neuroeconomics. The student should be able to integrate approaches coming from different disciplines such as computational neuroscience, psychology of judgment and decision, microeconomics, and anthropology. Moreover, the student should have a general understanding of how human and animal preferences are represented in the mammalian nervous systems. A general understanding of the main reinforcement learning, value learning, and value representation models. The ability to recognize the weaknesses and strengths of published articles, starting from the research question, through the method used, to the reporting of the project's outcome.

Abstract:

The course will provide an overview of the field and an exhaustive description of the most important discoveries in the major research areas of Neuroeconomics such as decision making under risk, loss aversion, inter-temporal choice and social decision making. We will discuss the need for Neuroeconomics and the limitations of the traditional fields of Economics, Psychology and Neuroscience. The course will provide an overview of how human and animal preferences are represented in the mammalian nervous systems and particular emphasis will be given to the neural mechanisms for choice. The course will include an introduction to the most influential reinforcement learning, value learning and value representation models and will describe the brain circuits involved in social decision making.

Lecture Contents:

Introduction and scope of Neuroeconomics; The neural mechanisms for choice; How human and animal preferences are represented in the mammalian nervous systems; Risk, time preferences, social preferences, and emotion; Social decision-making in humans and animals.

Teaching Method:

Lectures/oral presentations

Bibliography:

Glimcher, P. W., & Fehr, E. (Eds.). (2013). Neuroeconomics: Decision making and the brain. Academic Press.

Final Exam:

Critical analysis essay on an article.

Prerequisites:

While a general understanding of brain systems is welcome, no prerequisite is strictly necessary.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Neuroscience of Perception and Experience-Dependent Plasticity
Emiliano Ricciardi, Davide Bottari

48 Hours

Learning Outcomes:

At the end of the course, students are expected to have specific knowledge of the neurophysiology of perception and of the applications of the most important brain functional techniques toward the investigation of the neuronal basis of perception across different sensory modalities. Students will be also introduced to the topic of sensory deprivation and to the comprehension of how (the lack of) visual experience shapes brain development and function. Moreover, students will learn how neural plasticity and its dependence from environmental input changes along the development.

Abstract:

The course will review the neurophysiological bases of perception in humans. In particular, for each sensory modality, the basic neurophysiology of perception will be described and evaluated with an experimental perspective. The course will consequently detail the neural bases of unimodal, multisensory and supramodal perception. The course will review the literature concerning early and late sensory-deprived individuals to understand how the lack of sensory experience affects brain functional and structural development. Moreover, the course will review the specificity of neural plasticity in early phases of the development, describing sensitive and critical periods from a functional and structural perspectives. Finally the course will review studies showing the differences between the neural plasticity occurring during childhood and in adulthood.

Lecture Contents:

- Introduction to perception and sensory experience; definition perception vs. sensation and sensory modalities; common features across sensory modality; perception and imagery.
- Perception: methodological approaches, advantages and pitfalls.
- The bodily senses: definition, subtypes, the skin and mechanoreceptors, physiology of bodily senses, central pathways, neural correlates of active and passive touch, brain imaging approaches applied to touch-based experimental design.
- Pain and nociception, physiology and central processing of pain ('pain matrix'). Brain imaging of pain perception, pain anticipation and pain modulation.
- The Auditory system: anatomy, auditory perception, functional organization (anterior/posterior), computational neuroscience of auditory perception.
- Chemical senses. Physiology of olfaction and taste. Brain imaging applied to the assessment of the neural correlates of chemical senses.
- The visual system. Physiology of vision, the eye and the central visual pathways. Brain imaging

approaches to the investigation of the visual system. The functional organization of the ventral and dorsal extrastriate patterns. Maps and modules in the ventral stream. Neural basis of face perception.

- Multisensory I and II. What is multisensory processing, behavioral and neural correlates.
- Cross-modality I and II. Heteromodal responses in sensory deprived models (animal and human) and in typical development.
- Supramodality, definition and indications from the research in blind individuals. Functional features of supramodality and discussion on the open questions on the topic.
- Functional and Structural Development I and II. Definition and examples of sensitive and critical periods. Physiological basis. Review of sensitive periods in vision. Perceptual narrowing. Unisensory and multisensory functional development.
- Experience dependent plasticity I and II. Developmental and adulthood experience dependent plasticity. Probabilistic learning and perceptual training in animal and human models.

Teaching Method:

The course includes theoretical and methodological face-to-face lessons with the help of slides. E-learning platform are used to share learning materials (slides, data, etc.).

Bibliography:

Slides of the course and scientific papers that are relevant to the presented topics.

Suggested readings:

Cognitive Neuroscience: The Biology of the Mind - Michael S. Gazzaniga, Richard B. Ivry, George R. Mangun

Principles of neural science - Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, Steven A. Siegelbaum, A.J. Hudspeth

Final Exam:

Learning outcomes are verified through oral presentations on selected topics.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Numerical Methods for Optimal Control
Mario Zanon

30 Hours

Learning Outcomes:

The students will learn how to properly formulate and solve an optimal control problem using state-of-the-art techniques.

Abstract:

Many control and estimation tasks seek at minimizing a given cost while respecting a set of constraints, which belongs to the class of problems denoted as Optimal Control (OC). The most practical approach to solve OC problems is via direct methods, which consists in discretizing the problem to obtain a Nonlinear Program (NLP) which is then solved using one of the many available approaches. The course will be introduced by an overview of the available classes of algorithms for OC and place direct methods in this context. The core of the course is structured around the following two main parts.

NLP solvers:

This part of the course first establishes a sound theoretical background on the characterization of local minima (maxima) by introducing geometric optimality concepts and relating them to the first- and second-order conditions for optimality, i.e. the Karush-Kuhn-Tucker conditions, constraint qualifications and curvature conditions.

Second, the theoretical concepts will be used to analyze the most successful algorithms for derivative-based nonconvex optimization, i.e. Sequential Quadratic Programming and Interior Point Methods, both based on Newton's method. Since there does not exist a plug-and-play NLP solver, attention will be devoted to giving the students a solid understanding of the mechanisms underlying the algorithms so as to endow them with the ability to formulate the problem appropriately and choose the adequate algorithm for each situation.

Discretization techniques:

This second part of the course covers the most successful discretization approaches, i.e. single-shooting, multiple-shooting and collocation. All mentioned approaches rely on the simulation of dynamical systems, for which a plethora of algorithms have been developed. The students will be explained the features of the different classes of algorithms, with particular attention on the numerical efficiency, simulation accuracy and sensitivity computation. Finally, the structure underlying the NLP obtained via direct methods for OC will be analyzed in order to understand the immense benefits derived from developing dedicated structure-exploiting OC solvers.

Advanced Topics:

The course will be concluded by two lectures on parametric sensitivities, path-following methods and Nonlinear Model Predictive Control (NMPC) with considerations on stability, tuning and real-time solvers.

Lecture Contents:

The following lectures are divided by topic in the order in which they will be presented. Some lecture requires more than 2 hours and some other requires less. Altogether, the 9 lectures require 20 hours of teaching, which will be supported by 10 hours of supervision for the solution of the assignments.

1. Introduction to optimal control
2. Nonlinear Programming: optimality characterization
3. Newton's method and algorithms for nonconvex optimization
4. Shooting methods
5. Numerical integration with sensitivities
6. Collocation methods
7. Structure of discretized optimal control problems
8. Parametric sensitivity and path-following
9. Nonlinear Model Predictive Control

Teaching Method:

Lectures and exercise sessions

Bibliography:

L. Betts. Practical Methods for Optimal Control Using Nonlinear Programming, Advances in Design and Control 2010

L. Biegler. Nonlinear Programming, MOS-SIAM Series on Optimization 2010

J. Nocedal and S. Wright. Numerical Optimization, Springer 2006

S. Boyd and L. Vandenberghe. Convex Optimization, University Press 2004

M. Bierlaire. Optimization: principles and algorithms, EPFL Press 2015

J. Guddat, F. Guerra Vazquez, H. Th. Jongen. Parametric Optimization: Singularities, Pathfollowing and Jumps, Springer 1990

J. C. Butcher Numerical Methods for Ordinary Differential Equations, Wiley 2016

E. Hairer, S. P. Nørsett, and G. Wanner. Solving Ordinary Differential Equations I, Springer 1993

E. Hairer ,and G. Wanner. Solving Ordinary Differential Equations II, Springer 1996

Final Exam:

Solution of all the assignments

Prerequisites:

Basic knowledge in dynamical systems and linear algebra. Some knowledge on numerical optimization and simulation can be helpful but is not required.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Numerical Methods for the Solution of Partial Differential Equations
Marco Paggi

20 Hours

Learning Outcomes:

Ability to solve numerically a problem related to a physical system and predict its response. The physical system can be embedded within an optimization problem, for instance, or it can be part of a complex system (biological, mechanical, thermo-mechanical, chemical, or even financial) you are interested in predicting its behavior and evolution over time.

Abstract:

The course introduces numerical methods for the approximate solution of initial and boundary value problems governed by linear and nonlinear partial differential equations (PDEs) used to describe physical systems. The fundamentals of the finite difference method and of the finite element method are introduced step-by-step in reference to exemplary model problems taken from heat conduction, linear elasticity, and pricing of stock options in finance. Notions on numerical differentiation, numerical integration, interpolation, and time integration schemes are provided. Special attention is given to the implementation of the numerical schemes in finite element analysis programs for fast intensive computations.

Lecture Contents:

- Numerical differentiation schemes
- Numerical interpolation schemes
- Numerical integration schemes
- Time integration algorithms
- Newton-Raphson incremental-iterative schemes for nonlinear problems
- Finite difference method
- Finite element method

Teaching Method:

Blackboard. Due to the Covid-19 emergency, lectures will be provided online: https://zoom.us/j/93898866026?pwd=aXozRlFBMEFEVEdRb0d1eG9wSm9tZz09 .

Bibliography:

- A Quarteroni, Numerical Models for Differential Problems, Second Ed. Springer, 2013.
- K-J Bathe, Finite Element Procedures, Pearson College Div, 2005.
- N Hilber, O Reichmann, C Schwab, C Winter, Computational Methods for Quantitative Finance, Springer, 2013.

Final Exam:

An application of the taught methodologies to one case study of relevance for the PhD student's research is recommended. Alternatively, a topic to investigate can be suggested by the lecturer.

Prerequisites:

The course is self-contained. Fundamentals of algebra are required.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Numerical Optimization
Alberto Bemporad

20 Hours

Learning Outcomes:

Learn how to model optimal decision problems as optimization problems and how to solve them using numerical optimization packages. By learning the basic theory behind the most used numerical optimization methods (optimality conditions, sensitivity, duality) and understanding how the algorithms work, the student will be able to formulate real-life optimization problems and to choose the most appropriate algorithms to solve them, or to develop new optimization algorithms or adapt existing ones to solve them.

Abstract:

Optimization plays a key role in solving a large variety of decision problems that arise in engineering (design, process operations, embedded systems), data science, machine learning, business analytics, finance, economics, and many others. This course focuses on formulating optimization models and on the most popular numerical methods to solve them, including active-set methods for linear and quadratic programming, proximal methods and ADMM, stochastic gradient, interior-point methods, line-search methods for unconstrained nonlinear programming.

Lecture Contents:

Course introduction. Basic definitions in optimization (function, constraints, minima, convexity). Linear programming (LP), quadratic programming (QP), mixed-integer programming (MIP), optimization taxonomy. LP models. Convex functions and sets, convexity recognition. Constrained least squares, QP, LASSO. Second-order cone programming, semidefinite programming, geometric programming. First order necessary conditions. Optimality conditions. Sensitivity. Duality. Dual functions for LP and QP. Example from machine learning: support vector regression. Proximal operator, proximal point and proximal gradient methods, gradient projection methods for quadratic programming. Proximal operator calculus. Convex conjugate function. Alternating direction method of multipliers (ADMM), ADMM for quadratic programs, ADMM for LASSO problems, consensus ADMM for separable functions. Stochastic gradient descent methods. Unconstrained nonlinear optimization: gradient descent methods, line search, Gauss-Newton method for unconstrained nonlinear optimization. Interior-point methods.

Teaching Method:

Lecture slides and blackboard.

Bibliography:

Lecture slides available on http://cse.lab.imtlucca.it/~bemporad/optimization_course.html

J. Nocedal and S.J. Wright. NumericalOptimization. Springer, 2nd edition,2006.

M.S. Bazaraa, H.D. Sherali,and C.M. Shetty. NonlinearProgramming-Theory and Algorithms.

John Wiley & Sons, Inc., NewYork, 3rd edition, 2006.

S. Boyd and L. Vandenberghe. Convex Optimization. Cambridge University Press, New York, NY, USA, 2004. http://www.stanford.edu/~boyd/cvxbook.html.

H.P. Williams. Model Building in Mathematical Programming. John Wiley & Sons, 5th edition, 2013."

Final Exam:

Typically a small research project, or discussion about a paper on a subject related to the course, or oral exam.

Prerequisites:

Linear algebra and matrix computation, calculus and mathematical analysis.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Optimal Control
Giorgio Gnecco

20 Hours

Learning Outcomes:

At the end of the course, the student will be able to formulate optimal control problems and will know a wide range of techniques that can be applied for solving such problems. By attending the course, the student will learn mathematical methods useful for applications of optimal control in differential game theory, machine learning, and macroeconomics.

Abstract:

The course provides an overview of optimal control theory for the deterministic and stochastic cases. Both discrete-time and continuous-time problems are considered, together with some applications to economics.

Lecture Contents:

- An overview of optimal control problems.
- An economic example of an optimal control problem: the cake-eating problem.
- Dynamic programming and Bellman's equations for the deterministic discrete-time case.
- Reachability/controllability and observability/reconstructability for time-invariant linear dynamical systems.
- The Hamilton-Jacobi-Bellman equation for continuous-time deterministic optimal control problems.
- Pontryagin's principle for continuous-time deterministic optimal control problems.
- LQ optimal control in discrete time for deterministic problems.
- Application of dynamic programming to stochastic and infinite-horizon optimal control problems in discrete time.
- LQ optimal control in discrete time for stochastic problems and Kalman filter.
- Introduction to approximate dynamic programming and reinforcement learning.
- An economic application of optimal control: a dynamic limit pricing model of the firm.

Teaching Method:

The teacher will project slides on the screen (a copy of the slides will be provided to the students).

Bibliography:

The following books are related to the course. They can be useful as an optional supplementary material.

D. Acemoglu: Introduction to modern economic growth, Princeton University Press, 2009.

J. Adda and L. W. Cooper: Dynamic economics: quantitative methods and applications, MIT Press**,** 2003.

P. J. Antsaklis and A. N. Michel: A linear systems primer, Birkhäuser, 2007.

M. Athans and P. L. Falb: Optimal control, Dover, 2007.

M. Bardi and I. Capuzzo-Dolcetta: Optimal control and viscosity solutions of Hamilton-Jacobi-Bellman equations, Birkhäuser, 2008.

D. P. Bertsekas: Dynamic programming and optimal control, vols. 1 and 2, Athena Scientific, 1995.

D. P. Bertsekas and S. E. Shrieve: Stochastic optimal control: the discrete-time case, Academic Press, 1978.

M. R. Caputo: Foundations of dynamic economic analysis: optimal control theory and applications, Cambridge University Press, 2005.

F. Cugno and L. Montrucchio: Scelte intertemporali: teoria e modelli (in Italian), Carocci Editore, 1998.

A. de la Fuente: Mathematical methods and models for economists, Cambridge University Press, 2000.

H. P. Geering: Optimal control with engineering applications, Springer-Verlag, 2007.

M. Gopal: Modern control system theory, New Age International Publishers, 2005.

S. Ross: Applied probability models with optimization applications, Dover, 1970.

S. Ross: Introduction to stochastic dynamic programming, Academic Press, 1983.

J. Rust: Numerical Dynamic Programming in Economics, in Handbook of Computational Economics, H. M. Amman, D. A. Kendrick, and J. Rust (ed.), 1996.

E. D. Sontag: Mathematical control theory: deterministic finite dimensional systems, Springer, 1998.

N. L. Stokey, R. E. Lucas, and E. C. Prescott: Recursive methods in economic dynamics, Harvard University Press, 1989.

C. Szepesvári: Algorithms for reinforcement learning, Morgan & Claypool, 2010.

The following are slides/lectures notes from related courses.

D. P. Bertsekas: slides for the course "Approximate dynamic programming", CEA, Cadarache, 2012, available online at http://www.athenasc.com/ADP_Short_Course_Complete.pdf.

J. Cho: lecture notes for the course "Linear systems and control", Michigan State University, Michigan, US, 2010, available online at http://www.egr.msu.edu/classes/me851/jchoi/.

J. Le Ny: lecture notes for the course "Dynamic programming and stochastic control", University of Pennsylvania, 2009, available online at http://www.professeurs.polymtl.ca/jerome.le-ny/teaching/

DP_fall09/notes/.

A. Ng: lecture notes for the course "Machine Learning", Stanford, 2017, available online at http://cs229.stanford.edu/notes/cs229-notes12.pdf.

J. R. Norris: lecture notes for the course "Optimization and Control", Cambridge, UK, 2007, available online

at http://www.statslab.cam.ac.uk/~james/Lectures/.

B. Van Roy: lecture notes for the course "Reinforcement Learning", Stanford, 2013, available online at http://www.stanford.edu/class/msande338/ScribeLec3.pdf.

R.Weber :lecture notes for the course "Optimization and Control", Cambridge, UK, 2013, available online at www.statslab.cam.ac.uk/~rrw1/oc/.

Final Exam:

The student will prepare slides for a short seminar (20-30 minutes) on a topic related to optimal control. The topic of theseminar will be either proposed by the teacher or chosen by the student. The date of the seminar will be agreed between the student and the teacher. The seminar will take place either in the teacher's office or in the classroom (in case several students will decide to have their seminars in the same day).

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Philosophy and Neuroscience in Moral Reasoning
Gustavo Cevolani, Camilla Francesca Colombo

14 Hours

Learning Outcomes:

On completing the course, the students will be able to appreciate the main issues surrounding the cognitive, behavioral and neural foundations of morality, and to rigorously analyze and discuss them. They can also assess the relevance of empirical findings for current debates on ethics and for sensitive social issues more generally.

Abstract:

The analysis of moral reasoning and surrounding topics { how to assess \good" and \bad" actions, how to choose between different moral principles, how to justify these choices {is a classical problem of moral philosophy. More recently, moral psychologists started tackling those problems using a descriptive, empirically based approach. Even more recently, neuroethicists" began investigating the neural correlates of moral judgment and the implications of neuroscientific results for moral philosophy. In the meantime, behavioral economists started addressing issues like fairness, altruism, reciprocity and social preferences, documenting the influence of (broadly construed) moral considerations on human decision-making. The course is an introduction to the analysis of moral reasoning at the interface between neuroscience, moral psychology, moral philosophy, and economics. We shall explore problems concerning the biological and neural bases of moral thinking, the role of emotions in moral reasoning, the economic way of interpreting moral behavior, the significance of empirical results for normative theories of morality, and some methodological issues arising within neuroethics.

Lecture Contents:

The topic of each lesson will be decided at the beginning of the course on the basis of student's feedback; the following is a tentative list subject to change. Please refer to your IMT Google Calendar for the updated schedule.

Lecture Topics

1 Presentation, introduction, choice of topics.

2 Moral philosophy

3 Moral psychology and neuroethics

4 Behavioral economics and human sociality

5 Coordination and the evolution of morality

6 Objectivity, reason, and facts in moral reasoning

7 Recap, verification and general discussion.

Teaching Method:

Mixture of lectures and discussion seminar (online).

Bibliography:

We won't have a textbook; the reading list will be shared later. The following are suggestions for background readings:

{David Edmonds (2013). Would You Kill the Fat Man? Princeton University Press

{Antonio R. Damasio (2004). Descartes' Error: Emotion, Reason and the Human Brain. New York: Quill

{Jonathan Haidt (2013). The Righteous Mind: Why Good People Are Divided by Politics and Religion. Vintage

{Joshua Greene (2013). Moral Tribes: Emotion, Reason, and the Gap Between Us and Them. Penguin

{Ken Binmore (2005). Natural Justice. Oxford University Press

{Michael Tomasello (2009). Why we cooperate. A Boston review book. MIT Pr

{Cristina Bicchieri (2006). The Grammar of Society the Nature and Dynamics of Social Norms. Cambridge University Pressess

Final Exam:

Active contribution from the participants is a prerequisite for passing the course.

Each student will select a paper or topic related to the fields of neuroethics, moral psychology, moral philosophy, behavioral economics, or the philosophy of neuroscience and give a 20{30 minutes presentation during one of the classes. The talk should present, clearly and concisely, a topic/problem/thesis, relevant arguments/results supporting or undermining it, and a final assessment.

Students can choose among the suggested readings or propose a topic of their choice..

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Philosophy of Science
Gustavo Cevolani

20 Hours

Learning Outcomes:

On completing the course, the students will have an enhanced capacity of understanding and evaluating past and current debates about the reliability, the rationality and the limits of science. They can assess the scope and limits of scientific knowledge and appreciate the differences and relations between science and other scientific endeavours. They understand why and to which extent science is rational and often successful, and what is its role in guiding decision-making in modern societies.

Abstract:

The course provides an introduction to the basic concepts and problems in the philosophical analysis of scientific reasoning and inquiry. We will focus on some central patterns of reasoning and argumentation in science and critically discuss their features and limitations. Topics covered include the nature of theory and evidence, the logic of theory testing, and the debate about the aims of science and the trustworthiness of scientific results. We shall discuss classical examples and case studies from the history and practice of science to illustrate the relevant problems and theoretical positions. Students will freely engage in brainstorming on these topics and are welcome to propose examples, problems, and methods from their own disciplines..

Lecture Contents:

The topic of each lesson will be decided at the beginning of the course on the basis of student's feedback; the following is a tentative list subject to change. All lessons, except for the starred ones which are online, are in mixed modality.

Lecture Topics

1 Introduction, discussion and choice of specific topics. What is science?

2 How many sciences? The method(s) of science. Exact and inexact sciences.

3 Theories, models, data. Experiments and observations.

4 Inferences in science. Falsification, confirmation, disconfirmation.

5 Bayesian rationality and scientific reasoning.

6 Science, pseudoscience, junk science.

7 History of science and scientific progress. The aim(s) of science.

8 Trust and objectivity in science. The role of experts.

9 Social and human sciences.

10 Science, truth, and reality.Lecture 10. Science, truth, and reality.

Teaching Method:

Mixture of lectures and discussion seminar.

Bibliography:

We won't have a textbook or a proper reading list. Relevant readings will be shared on Google Drive. The following are suggestions for background readings and possible topics of discussion (many of them are also available in Italian).

Two readable textbook on contemporary philosophy of science are Okasha (2016) and Godfrey-Smith (2003). Losee (1972) and Oldroyd (1986) are general introductions more oriented toward the historical and philosophical roots of the discipline. Salmon (2017) is a classic text and Sprenger and Hartmann (2020) a recent treatment from a formal (Bayesian) perspective.
Classical discussions of methodological and philosophical problems in science are:
– Duhem (1906, ch. 6) on how scientific theories can be tested against empirical evidence;
– Popper (1963, ch. 1) on the method of science and how it differs from pseudoscience;
– Hempel (2002) on scientific explanation;
– Popper (1963, ch. 3) on how theories relate to reality;
Other classical contributions are collected in Curd and Cover (1998).
Philosophers of science initially focused on the "hard" (mathematical, exact, natural, . . .) sciences only; today, there is much ongoing work also on the "soft" (social, human, behavioral, inexact, . . .) sciences, but no comprehensive overview is available. For some more or less classical readings on foundational and methodological issues see, e.g., Elster (1989) and Guala (2016); for the philosophy of historical research see also Mises (1957) and Ginzburg (1979).
Anyone interested in science as part of human culture should read physicist and historian of science Lucio Russo (YouTube has many interesting lectures, mostly in Italian). Russo (2004) is a revolutionary treatment of the scientific revolution; it is the translation of Russo (2013b), but the English and Italian versions contain partially different materials. Russo (2013a) is a surprising reconstruction of ancient scientific geography; the main argument is summarized in Russo (2016). On more specific subjects see: Bonelli and Russo (1996) for the theory of the tides (for a more complete and updated treatment, also Russo 2003), Russo (1994) for Hellenistic astronomy, and the chapters of Russo (2015) for a selection of different themes.
Discussions of some interesting cases and examples from the (ancient and recent) history of science are:
– Kuhn (1957) on geocentric and heliocentric astronomy;
– Carlo Rovelli (2011) on Eratosthenes' measure of the circumference of science;
– C. Rovelli (2015) on Aristotelian physics from a modern viewpoint;
– Hempel (1966, ch. 2) on Semmelweis' work on puerperal fever and on Torricelli's discussion of atmospheric pressure;
– Gawande (2004) on why it's still so difficult for doctors to wash their hands;

– Bellarmino (1615) on the proper method of astronomy;
– Guala (2016, ch. 3) on the theory of money as a social institution;
– Guala (2005) on various issues in the methodology of experimental economics (external validity, monetary incentives, etc.)
– Little (1995) on objectivity in social science and methodological dualism;
– Mises (1957) on methodological dualism and the epistemology of history;
– Ginzburg (1979) on the method of historical research;
– Diamond (1999, Epilogue) and Diamond andRobinson (2010, Prologue, pp. 1–5) on history as a science;
– Mesoudi (2011, chs. 1 and 5) on Darwinian models of cultural evolution;
– Gardner (1957) on a number of pseudoscientific disciplines and how to recognize them;
– Gardner (2000) on memetics as pseudoscience;
– Benton (2008, ch. 3) on "catastrophism" in paleontology;
– Skrabanek and McCormick (1998, ch. 4) on the problems of prevention in medicine;
– Frances (2013) on psychiatric diagnosis;
– Poldrack (2006) on "reverse inference" in neuroscience;
– Uttal (2001, Preface, Appendix A and B) on the status of scientific psychology and cognitive neuroscience;
– Núñez, Allen, Gao, Rigoli, Relaford-Doyle, and Semenuks (2019) on the future of cognitive science as a discipline;
– Newell and Simon (1975) on the methodological status of computer science;
– Galton (1872) and Leibovici (2001) on the healing efficacy of prayers.

REFERENCES

Bellarmino, Roberto (1615). Letter to Foscarini.
Benton, M. J. (2008). When Life Nearly Died: The Greatest Mass Extinction of All Time. OCLC: 845287156. London: Thames & Hudson.
Bonelli, Federico and L. Russo (1996). "The Origin of Modern Astronomical Theories ofTides: Chrisogono, de Dominis and Their Sources". In: The British Journal for the History of Science 29.4, pp. 385–401.
Curd, Martin and J. A. Cover, eds. (1998). Philosophy of science: the central issues.
1st ed. New York:W.W. Norton. ISBN: 978-0-393-97175-0.
Diamond, Jared M. (1999). Guns, Germs and Steel.W.W. Norton & Company.
Diamond, Jared M. and James A. Robinson, eds. (2010). Natural Experiments of History. Cambridge, Mass: Belknap Press of Harvard University Press.
Duhem, Pierre (1906). La Théorie Physique: Son Objet, Sa Structure. Vrin.
Elster, Jon (1989). Nuts and bolts for the social sciences. Cambridge New York:
Cambridge University Press.
Frances, Allen (2013). "TheNew Crisis of Confidence in Psychiatric Diagnosis".
In: Annals of Internal Medicine 159.3, pp. 221–222.

Galton, Francis (1872). "Statistical Inquiries into the Efficacy of Prayer". In.
Gardner, Martin (1957). Fads and Fallacies in the Name of Science. Dover Publications. ISBN: 0486203948.
— (2000). "KilroyWas Here". In: Los Angeles Times.
Gawande, Atul (Mar. 2004). "On Washing Hands". In: New England Journal of Medicine 350.13, pp. 1283–1286. DOI: 10.1056/nejmp048025.
Ginzburg, Carlo (1979). "Clues". In: Theory and Society 7.3. DOI: 10.1007/bf00207323.
Godfrey-Smith, Peter (2003). Theory and Reality: An Introduction to the Philosophy of Science. University of Chicago Press.
Guala, F. (2005). The Methodology of Experimental Economics. Cambridge University Press.
— (2016). Understanding Institutions: The Science and Philosophy of Living Together. Princeton, NJ: Princeton University Press.
Hempel, C. G. (1966). Philosophy of Natural Science. Prentice Hall.
— (2002). "Two Models of Scientific Explanation". In: Philosophy of Science: Contemporary Readings. Ed. by Yuri Balashov and Alexander Rosenberg. Routledge, pp. 45–55.
Kuhn, Thomas S. (1957). The Copernican revolution: planetary astronomy in the development of western thought. eng. 8. print.OCLC: 255797153. Cambridge, Mass.: Harvard Univ. Pr. ISBN: 978-0-674-17103-9.
Leibovici, Leonard (2001). "Effects of Remote, Retroactive Intercessory Prayer on Outcomes in Patients with Bloodstream Infection:Randomised Controlled Trial". In: BMJ 323.7327, pp. 1450–1451.
Little, Daniel (1995). "Objectivity, Truth and Method: A Philosopher's Perspective on the Social Sciences". In: Anthropology News 36.8, pp. 42–43.
Losee, John (1972). A Historical Introduction to the Philosophy of Science. Oxford University Press.
Mesoudi, Alex (2011). Cultural Evolution: How Darwinian Theory Can Explain Human Culture and Synthesize the Social Sciences. Chicago ; London: University of Chicago Press.
Mises, Ludwig von (1957). Theory and History. An Interpretation of Social and Economic Evolution. Liberty Fund.
Newell, Allen and Herbert A. Simon (1975). "Computer science as empirical inquiry: symbols and search". In: ACM Turing Award Lectures. Association of Computing Machinery. DOI: 10.1145/1283920.1283930.
Núñez, Rafael, Michael Allen, Richard Gao, Carson Miller Rigoli, Josephine Relaford-Doyle, and Arturs Semenuks (June 2019). "What happened to cognitive science?" In: Nature Human Behaviour 3.8, pp. 782–791. DOI: 10.1038/s41562-019-0626-2.
Okasha, Samir (2016). Philosophy of Science: A Very Short Introduction. Oxford University Press.
Oldroyd, D. R. (1986). The Arch of Knowledge: An Introductory Study of the History of the Philosophy and Methodology of Science. Methuen.
Pigliucci, M. (2010). Nonsense on Stilts. The University of Chicago Press.
Poldrack, R (2006). "Can Cognitive Processes Be Inferred from Neuroimaging Data?" In: Trends in Cognitive Sciences 10.2, pp. 59–63.
Popper, Karl (1963). Conjectures and Refutations: The Growth of Scientific Knowledge. Routledge.
Rovelli, C. (2015). "Aristotle's Physics: A Physicist's Look". In: Journal of the American Philosophical Association 1.1, pp. 23–40.
Rovelli, Carlo (2011). The First Scientist: Anaximander and His Legacy. OCLC: ocn694832795. Yardley:Westholme.

Russo, L. (1994). "The Astronomy of Hipparchus and His Time: A Study Based on Pre-Ptolemaic Sources". In: Vistas in Astronomy 38, pp. 207–248.
— (2003). Flussi e Riflussi: Indagine Sull'origine Di Una Teoria Scientifica. Feltrinelli Editore.
— (2004). The Forgotten Revolution. Springer Science & Business Media.
— (2013a). L'America Dimenticata. 2nd ed. Milano: Mondadori.
— (2013b). La rivoluzione dimenticata. Il pensiero scientifico greco e la scienza moderna. 7 edizione. Milano: Feltrinelli.
— (2015). Stelle, Atomi e Velieri: Percorsi Di Storia Della Scienza. Prima edizione Mondadori università. Milano: Mondadori università.
— (2016). "Far-Reaching Hellenistic Geographical Knowledge Hidden in Ptolemy's Data". URL: https://hal.archives-ouvertes.fr/hal-01275282.
Salmon,Wesley C. (2017). The Foundations of Scientific Inference. Pittsburgh, Pa: University of Pittsburgh Press.
Skrabanek, P and James McCormick (1998). Follies and Fallacies in Medicine. OCLC: 963704597. Whithorn: Tarragon Press.
Sprenger, Jan and S. Hartmann (2020). Bayesian philosophy of science. Oxford: Oxford University Press. ISBN: 9780199672110.
Uttal, William (2001). The new phrenology : the limits of localizing cognitive processes in the brain. Cambridge, Mass: MIT Press.

Final Exam:

Active contribution from the participants is a prerequisite for passing the course.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Principles of Brain Anatomy and Physiology
Luca Cecchetti

30 Hours

Learning Outcomes:

At the end of the course, students will be able to recognize major anatomical landmarks of the human brain, both in volume and surface space. They will also be able to analyze structural brain data using several neuroimaging tools (e.g., FSL, Freesurfer, TrackVis).

Abstract:

The course aims at introducing the fundamentals of brain anatomy and physiology. In the first part of the course we will revise cell types and cytoarchitectonic of the cortical mantle, with particular regards to visual, auditory, somatosensory and motor systems. We will then focus on gross neuroanatomy: gyri and sulci of the cortex, subcortical structures, brainstem nuclei and major white matter fasciculi. The second part of the course will be devoted to the study of functional neuroanatomy, with insights on the relationship between specific brain structures and human cognition, collected using functional and lesion studies. In the last part of the course we will review structural brain imaging methods: voxel-based and surface-based (e.g., thickness, folding) morphology, diffusion weighted imaging and tractography. Students will be also involved in the analysis of structural imaging datasets.

Lecture Contents:

- Useful terms to "navigate" the brain (e.g., dorsal, caudal, rostral) and how they relate to viewing planes (axial, coronal, sagittal); overall description of grey and white matter, as well as of the ventricular system. General description of brain development.
- Examples coming from comparative neuroanatomy on brain volume and cortical folding. General organization of white matter (associative, commissural and projection fibers). Brain morphology: to what extent is inherited and how it relates to gender and ethnicity. Changes in brain volume related to development, ageing and to circadian rhythms.
- Brainstem structure and function (pons, midbrain and medulla oblongata). Description of major pathways (e.g., corticopontocerebellar fibers, cerebral and cerebellar peduncles) and nuclei (inferior and superior olive, red nucleus, substantia nigra).
- Cerebral hemispheres and lobes. Identification of major sulci and gyri of the frontal lobe using Surfice and FSL. Frontal lobes functions with examples coming from lesion studies (e.g., impulse control, speech production, motor planning). Identification of white matter tracts connecting distinct regions of the frontal lobes using Trackvis.
- Identification of major sulci and gyri of the parietal lobe. Parietal lobes functions with examples coming from lesion studies (e.g., spatial and somatosensory processing). Dissection of white matter tracts connecting distinct regions of the parietal lobes. Temporal lobes functions with examples

coming from lesion studies (e.g., speech comprehension, auditory processing). Dissection of white matter tracts connecting distinct regions of the temporal lobes.

- Identification of major sulci and gyri of the occipital lobe. Occipital lobes functions with examples coming from lesion studies (e.g., visual processing and multisensory integration). Dissection of white matter tracts connecting distinct regions of the occipital lobes using. Limbic lobe functions with examples coming from lesion studies (e.g., emotional and salience processing). Dissection of white matter tracts connecting distinct regions of the limbic lobe.
- Identification of subcortical structures. Basal ganglia, thalamus, hippocampus and amygdala functions with examples coming from lesion studies (e.g., memory, motor control). Dissection of white matter cortico-subcortical tracts.
- Spatial normalization, AC-PC alignment, Talairach and MNI152 templates. Linear and Nonlinear spatial registration techniques: algorithms, cost functions (e.g., mutual information), degrees of freedom (e.g., affine vs rigid body) and interpolation (e.g., trilinear, spline, nearest neighbour). How to implement spatial transformations in FSL and how to deal with abnormal brains (e.g., lesions, atrophy).
- How to measure structural properties of the white matter: the diffusion weighted imaging. How does DWI works and which type of measures we can obtain (e.g., fractional anisotropy, mean diffusivity).
- Use of Freesurfer for cortical morphology and FSL for voxel-based morphology. Examples of structural covariance.

Teaching Method:

The course includes theoretical lectures with the help of slides. Practical lectures will cover the application of analysis tools to structural imaging data.

Bibliography:

Slides of the course

Final Exam:

Knowledge is verified through an interview on functional neuroanatomy and gross brain morphology (using both volumetric and surface-based representations).

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Project Management
Beatrice Manzoni

30 Hours

Learning Outcomes:

At the end of the course participants will be able to:

- Understand the project management process and the main phases of a project with a specific focus on the cultural heritage sector.
- Use the main project management tools (project charter, stakeholder map, WBS, responsibility matrix, Gantt chart, RBS).
- Discuss the challenges of building a project team and managing its dynamics.
- Manage project team dynamics and make creative and problem solving oriented decisions in teams.
- Develop a project plan for a research project.

Abstract:

No longer just a sub-discipline of engineering, project management is a discipline on its own. The management of projects is currently the dominant model in many organizations for strategy implementation, business transformation and new product development. Also, cultural industries are increasingly becoming project-based organizations.

Project success relies on the ability to deal with both technical and organizational issues. Project managers deal with developing a project plan integrating requirements, resources, interdependencies and timing. Nevertheless, risks are behind the corner and project success is linked with the ability to forecast and plan responses for unpredictable situations. Moreover, project managers, dealing with interdependent actors, face the issues of building the team but also of fostering teamwork and creativity and resolving conflicts.

Lecture Contents:

- The relevance of project management in cultural industries: why are projects important in cultural sectors? Why can we define cultural industries as project-based organizations?
- Getting started with some definitions: what is a project? What is the life cycle of a project? How do projects fit with processes in organizations? What is a project management plan? Who is the project manager and what are his/her responsibilities and competences? Who are the other relevant stakeholders?

- Planning, executing and monitoring a project: logics and techniques that support scope, time, cost and risk management.
- The project team: acquiring, developing and managing people within the project context.

Teaching Method:

The course is highly experiential and it combines a mix of methods: lectures, in-class exercises, case discussions, assignments.

Bibliography:

Course materials will be detailed in the schedule.

Additional readings:

- PMI, A Guide to the Project Management Body of Knowledge (PMBoK Guide).
- Project Management Toolkit for Arts and Culture Projects. ARTerial Network, 2011.
- Managing Art Projects with Societal Impact. 2016.

Final Exam:

Individual assignment that requires to write a project plan for the PhD research project.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Python for Data Science
Fabio Pinelli

20 Hours

Learning Outcomes:

At the end of the course, the student will have knowledge of the main python libraries and tools currently used in the data science community.

Abstract:

During the course we will explore the different tools used typically in the Machine Learning (ML) pipeline. We will explore classical techniques to explore the data, to process them in python.

We will use on real datasets most of the well known ML algorithms with their python/pytorch implementations.

Lecture Contents:

- Pandas (2h)
- Input/output
- data processing: selezione, join, groupby, pivot
- plot (matplotlib, seaborn)
- Introduction to sklearn (2h)
    - Feature and package of the library
- Unsupervised learning (2h)
    - K-means
    - DBscan
    - Optics
    - Hierarchical
- Supervised learning (2h)
    - Support vector machine
- Random Forest
    - Gradient boosting

- Pipeline analysis with sklearn (4h)
    - Missing value imputation
    - Scaling
    - Feature engineering
    - Dimensionality reduction (PCA)
    - Classification/Regression evaluation
- Pytorch and deep learning (6h)
    - Tensors
    - Fully connected NN
    - CNN
    - RNN - LSTM
    - VAE / Attention mechanism
    - Generative Adversarial Neural Networks
    - Other architectures
- Other utilities (2h)
- DB interface sql /nosql (mongodb)
- Dashboarding (superset (https://superset.apache.org/docs/intro), tableau)

Teaching Method:

The students will follow the code execution through Jupyter Notebook implemented in Google Colab, so they will be able to follow the execution of each piece of code

Bibliography:

Books:

+ Hands-on Machine Learning with Scikit-learn, Keras & TensorFlow

+ Programming PyTorch for Deep Learning

Material:

Slides and notebooks will be available to the students before the classes.

Final Exam:

No

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Prerequisites:

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

R and Stata for Data Science
Francesco Serti

20 Hours

Learning Outcomes:

((a) Knowledge of the most relevant functionalities in Stata and R to carry out data management and exploratory analysis.

(b) To achieve autonomy in the application of econometric and machine learning techniques to real data.

Abstract:

This course aims to provide students with Stata and R language fundamentals to conduct data management and exploratory analysis and implement various econometric and machine learning techniques to address typical research questions in economics.

Lecture Contents:

1) Introduction to R and STATA
    - The basics (objects, manipulation, basic statements, missing data)
    - Reading data from files
    - Probability distributions
    - Basic statistical models
    - Graphical procedures
    - Packages overview
2) Data Modeling for causal analysis
    - Regression analysis
    - Matching, Inverse Probability Weighting and doubly robust estimators
    - Regression Discontinuity
    - Instrumental Variables
    - Difference-in-Differences
    - Synthetic Control Method
3) Machine Learning (ML) tools for Econometrics
    - Predictive analysis with machine learning (shrinkage and tree-based methods)
    - ML to build counterfactuals (when no control group is available)

- ML to select control variables and/or instruments

- ML to study heterogeneity of treatment effects

Teaching Method:

After introducing R and Stata, the use of the main available packages for causal inference is explained by reviewing and replicating relevant papers in the applied economics and econometrics literature. The identification strategies and the estimators covered in parts 2) and 3) will be summarized in class, and they will be extensively explained during the course "Advanced Topics in Econometrics" (which will take place contemporaneously with this module).

Bibliography:

Lecture slides, R scripts and do-files will be distributed to the students before the classes. You can find below references to some of the papers and the books that will be used during the lessons (other references will be added during the course):

Books

James, G., Witten, D., Hastie, T., & Tibshirani, R. (forthcoming). An introduction to statistical learning - second edition (https://www.statlearning.com/).

Angrist, Joshua D. and Pischke, Jorn-Steffen. (2009). Mostly Harmless Econometrics: An Empiricist's Companion, Princeton University Press.

Papers

Abadie, A., Diamond, A., and Hainmueller, J. (2010). Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. Journal of the American Statistical Association, 105(490):493–505.

Abadie, A., Diamond, A., and Hainmueller, J. (2015). Comparative politics and the synthetic control method. American Journal of Political Science, 59(2):495–510.

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Abadie, A. and Imbens, G. (2011). Bias-corrected matching estimators for average treatment effects. Journal of Business and Economic Statistics, 29:1–11.

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Baker, A., Larcker, D. F., & Wang, C. C. (2021). How Much Should We Trust Staggered Difference-In-Differences Estimates?. Available at SSRN 3794018.

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Belloni, A., Chernozhukov, V., & Hansen, C. (2014). High-dimensional methods and inference on structural and treatment effects. *Journal of Economic Perspectives*, *28*(2), 29-50.

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Borusyak, K., Jaravel, X., & Spiess, J. (2021). Revisiting event study designs: Robust and efficient estimation.

Cattaneo, Idrobo and Titiunik, (2020). A Practical Introduction to Regression Discontinuity Designs: Foundations.

Cattaneo, Idrobo and Titiunik, (2021). A Practical Introduction to Regression Discontinuity Designs: Extensions.

Cengiz, D., Dube, A., Lindner, A., and Zipperer, B. (2019). The effect of minimum wages on low-wage jobs. Quarterly Journal of Economics, 134(3):1405–1454.

Cerqua, A., Di Stefano, R., Letta, M., & Miccoli, S. (2021). Local mortality estimates during the COVID-19 pandemic in Italy. Journal of Population Economics, 1-29.

Cheng, C. and Hoekstra, M. (2013). Does strengthening self-defense law deter crime or escalate violence? Evidence from expansions to castle doctrine. Journal of Human Resources, 48(3):821–854.

Chernozhukov, V., Denis Chetverikov, Mert Demirer, Esther Duflo, Christian Hansen, Whitney Newey, and James Robins (2018). Double/debiased machine learning for treatment and structural parameters. The Econometrics Journal, 21(1).

Chernozhukov, V., Iván Fernández-Val, and Ye Luo (2018). The sorted effects method: Discovering heterogeneous effects beyond their averages. Econometrica, 86(6):1911–1938.

Christensen, P., Francisco, P., Myers, E., & Souza, M. (forthcoming). Decomposing the wedge between projected and realized returns in energy efficiency programs. Review of Economics and Statistics.

Dehejia, R. H., & Wahba, S. (2002). Propensity score-matching methods for nonexperimental causal studies. Review of Economics and statistics, 84(1), 151-161.

Dueñas, M., Ortiz, V., Riccaboni, M., & Serti, F. (2021). Assessing the Impact of COVID-19 on Trade: a Machine Learning Counterfactual Analysis. *arXiv preprint arXiv:2104.04570*.

Goodman-Bacon, A. (2021). Difference-in-differences with variation in treatment timing. Journal of Econometrics.

Goldsmith-Pinkham, P., Isaac Sorkin, and Henry Swift (2020). Bartik instruments: What, when, why, and how. American Economic Review, 110(8):2586–2624.

Hainmueller, Jens (2012). Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies. Political Analysis, pages 25–46.

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LaLonde, R. J. (1986). Evaluating the econometric evaluations of training programs with experimental data. The American economic review, 604-620.

Negi, A., & Wooldridge, J. M. (2021). Revisiting regression adjustment in experiments with heterogeneous treatment effects. Econometric Reviews, 40(5), 504-534.

Ortiz Gimenez, V., & Serti, F. (2020). The economic cost of a referendum. The case of Brexit.

Sant'Anna Pedro and Jun Zhao (2020). Doubly robust difference-indifferences estimators. Journal of Econometrics, 219(1):101–122.

Sun Liyang and Sarah Abraham (2020). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. Journal of Econometrics.

Smith, J. A., & Todd, P. E. (2005). Does matching overcome LaLonde's critique of nonexperimental estimators?. Journal of econometrics, 125(1-2), 305-353.

Wager and Athey (2019). Estimation and Inference of Heterogeneous Treatment Effects using Random Forests.ts.

Final Exam:

There is no exam.

Prerequisites:

Econometrics

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Reinforcement Learning
Mario Zanon

30 Hours

Learning Outcomes:

The students will learn how Reinforcement Learning algorithms work and should be able to deploy them to solve real problems.

Abstract:

The problem of decision-making is ubiquitous and has therefore been studied in different domains, often with the intent to devise formal procedures that yield the best decision. Reinforcement Learning (RL) is one such technique, which can be seen both as a Machine Learning approach and as an Optimal Control approach. RL is based on the concept that an agent receives a reward as a consequence of the current situation (state) and the selected action. Because the action selected now influences the future state and, hence, the future rewards, this problem is non-trivial. RL has proven to be a very successful technique, managing, e.g., to beat Chess and Go champions (both human and algorithms).

The aim of this course is to discuss the fundamentals of RL, therefore giving the student a sound understanding of the problem is formulated and solved using state-of-the-art algorithms. Moreover, some more advanced topics will be mentioned to give a more complete picture to the interested students. Finally, the last part of the course will discuss how safety and stability guarantees can be introduced in RL by means of well-established techniques in control.

Lecture Contents:

The course is structured in the following lectures:

1. Introduction
2. Markov Chains, Markov Decision Processes, Dynamic Programming and the value functions
3. Policy Evaluation: how to assign a value to each policy based on the reward. Monte-Carlo and Temporal-Difference methods.
4. Control: how to optimize the policy. Monte-Carlo, Sarsa and Q-learning
5. Function Approximation: how to solve RL in practice.
6. Policy Gradient methods: parameterizing the policy directly
7. Safety and Stability: using Model Predictive Control to provide guarantees

Teaching Method:

Lectures and Exercise Sessions

Bibliography:

- R. S. Sutton and A. G. Barto. Reinforcement Learning: An Introduction (Second Edition). MIT Press, 2018. url: http://incompleteideas.net/book/RLbook2020.pdf
- D. P. Bertsekas. Dynamic Programming and Optimal Control, Vol I and II. Athena scientific, 2012
- D. P. Bertsekas and J. N. Tsitsiklis. Neuro-Dynamic Programming. Athena scientific, 1996
- M. L. Puterman. Markov Decision Processes. Wiley-Interscience, 1994
- C. Szepesvári. Algorithms for Reinforcement Learning. Morgan & Claypool Publishers, 2009. url: https://sites.ualberta.ca/~szepesva/papers/RLAlgsInMDPs.pdf

Final Exam:

Course attendance

Prerequisites:

Basic knowledge in dynamical systems, Markov chains, linear algebra, and optimal control can be helpful but is not required.

Research Seminars
Pietro Pietrini, Emiliano Ricciardi

24 Hours

Learning Outcomes:

PhD students will learn how to present their research projects, to support the rationale of their studies and to discuss with advisors, senior fellows and mates about the theoretical hypotheses and methodological approaches that will be exploited and employed in their research projects

Abstract:

These interactive lessons are made up of short lectures by senior or junior fellows of the Research Unit MOMILAB and PhD students of the CCSN track to present ideas and experimental setups of their research projects, or discuss preliminary or final findings of their research activities. The students are chaperoned through a detailed discussion and revision of all theoretical and methodological aspects of the research projects.

Lecture Contents:

Senior or junior MOMILAB fellows' and CCSN PhD students' research activities

Teaching Method:

Interactive seminars

Bibliography:

None

Final Exam:

None

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Research Topics in Computer Science
Rocco De Nicola

20 Hours

Learning Outcomes:

Various results on the most advanced frontiers of research.

Abstract:

This course amounts to a cycle of seminars about cutting-edge research fields in the domain of computer science. Distinguished and outstanding researchers will be invited to present their recent research activities and to give vision speech. The main goal is to explore open problems and active research areas which have the potential to inspire the work of junior researchers in particular.

Lecture Contents:

Free choice of the invited speakers.

Teaching Method:

Seminars followed by Q&A and open discussion.

Bibliography:

Invited speakers provide references during their talk.

Final Exam:

None

Prerequisites:

None

Scientific Writing, Dissemination and Evaluation
TBD

8 Hours

Course description will be available soon.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Socio-Economic Networks
Massimo Riccaboni

Hours: 20

Learning Outcomes:

To master the concepts developed in the course material in such a way that independent research can be carried out. Learn the socio-economic approach to the analysis of networks.

Abstract:

The topic of the course will be the analysis of socio-economic networks. The course will consist of three parts: (1) basic notions of social network analysis; (2) micro-level networks of individuals and firms; (3) meso and macro-level networks of sectors and countries. The first part will focus on some basic notions of social network analysis. Individual and inter-organizational networks will be analyzed in the second part, with a special focus on peer effects and the division of labor within and across firm boundaries. The third part on the empirics of meso and macro networks in economics will focus on international trade, human mobility, production, and finance. All parts will give you a brief overview of the literature, which predominantly adopted an econometric approach to network analysis.

Lecture Contents:

Section I: Graph theory and social network analysis

- Slot 1: Social networks: basic concepts; embeddedness, reflection problem; strong and weak ties (EK, chapters 2, 3)
- Slot 2: Homophily, preferential attachment, and balance (EK, chapters 4, 5, 18)
- Slot 3: Small world, cascading behavior and information cascades (EK, chapters 16, 19, 20)

Section II: Socio-economic networks: Individuals and Organizations

- Slot 4: Influence and peer effects in social networks (readings 1-4)
- Slot 5: Firms' collaborative agreements; networks of innovators (readings 5-8)

Section III: Empirics of Meso and Macro-Economic Networks

- Slot 6: Trade networks and gravity (9-12)
- Slot 7: Migration and human mobility (13-16)
- Slot 8: Financial networks and systemic risk (17-19)
- Slot 9: Production and knowledge networks (20-23)
- Slot 10: Complexity and fitness (24-26)

Teaching Method:

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Lecture-cum-Demonstration

Bibliography:

Main text: Easley D. and J. Kleinberg (2010) Networks, Crowds, and Markets: Reasoning About a Highly Connected World, Cambridge University Press

Additional reading materials will be provided by the instructor based on students' research interests.

Selected reading materials:

1. [BDF09] Bramoullé Y., Djebbari H., & Fortin B. (2009) "Identification of peer effects through social networks", *Journal of Econometrics*, 150 (1): 41-55, 2009.
2. [CPZ09] Calvó-Armengol, A., Patacchini, E., & Zenou, Y. (2009) "Peer effects and social networks in education", *The Review of Economic Studies*, 76(4), 1239-1267.
3. [AMS09] Aral, S., Muchnik, L., & Sundararajan A. (2009) "Distinguishing influence-based contagion from homophily-driven diffusion in dynamic networks", *Proceedings of the National Academy of Sciences*, 106(51), 21544-21549.
4. [AN17] Aral, S., & Nicolaides, C. (2017) "Exercise contagion in a global social network", *Nature communications*, 8(1), 1-8.
5. [PG06] Powell, W.W. & Grodal, S. (2006) "Networks of innovators", *The Oxford Handbook of Innovation*, Oxford University Press, pp. 56-85.
6. [FMC07] Fleming, L., Mingo, S. & Chen, D. (2007) "Collaborative brokerage, generative creativity, and creative success", Administrative Science Quarterly, 52(3), 443-475.
7. [AZW10] Azoulay, P., Zivin, J.G. & Wang J. (2010) "Superstar extinction", *The Quarterly Journal of Economics*, 125(2), 549-589.
8. [CMR13] Chessa, A., Morescalchi, A., Pammolli, F., Penner, O., Petersen, A.M. & Riccaboni, M. (2013) "Is Europe evolving toward an integrated research area?", *Science*, 339(6120), 650-651.
9. [R01] Rauch, J. E. (2001) "Business and social networks in international trade", *Journal of Economic Literature*, 39(4), 1177-1203.
10. [BKY18] Baier, S. L., Kerr, A. & Yotov, Y.V. (2018) "Gravity, distance, and international trade" in *Handbook of international trade and transportation*. Edward Elgar Publishing, Harvard.
11. [AK14] Armenter, R., & Koren, M. (2014). "A balls-and-bins model of trade", *American Economic Review*, 104(7), 2127-51.
12. [BCH19] Barjamovic, G., Chaney, T., Coşar, K., & Hortaçsu, A. (2019) "Trade, merchants, and the lost cities of the bronze age", *The Quarterly Journal of Economics*, 134(3), 1455-1503.
13. [AS14] Abel, G. J., & Sander, N. (2014) "Quantifying global international migration flows", Science, 343(6178), 1520-1522.
14. [M20] Munshi, K. (2020) "Social networks and migration", *Annual Review of Economics*, 12(1), 503-524.

15. [GHB08] Gonzalez, M. C., Hidalgo, C. A., & Barabasi, A. L. (2008) "Understanding individual human mobility patterns", *Nature*, 453(7196), 779-782.
16. [VR21] Verginer, L., & Riccaboni, M. (2021) "Talent goes to global cities: The world network of scientists' mobility", *Research Policy*, 50(1), 104127.
17. [GY16] Glasserman, P., & Young, H. P. (2016) "Contagion in financial networks", *Journal of Economic Literature*, 54(3), 779-831.
18. [EGJ14] Elliott, M., Golub, B., & Jackson, M. O. (2014) "Financial networks and contagion", *American Economic Review*, 104(10), 3115-53.
19. [AOT15] Acemoglu, D., Ozdaglar, A., & Tahbaz-Salehi, A. (2015) "Systemic risk and stability in financial networks", *American Economic Review*, 105(2), 564-608.
20. [ACT12] Acemoglu, D., Carvalho, V. M., Ozdaglar, A., & Tahbaz-Salehi, A. (2012), "The network origins of aggregate fluctuations", Econometrica, 80(5), 1977-2016.
21. [CZR15] Cerina, F., Zhu Z., Chessa A. & Riccaboni M. (2015) "World input-output network", PloS One, 10(7), e0134025.
22. [AAK16] Acemoglu, D., Akcigit, U., & Kerr, W. R. (2016) "Innovation network", *Proceedings of the National Academy of Sciences*, 113(41), 11483-11488.
23. [CT19] Carvalho, V. M., & Tahbaz-Salehi, A. (2019) "Production networks: A primer", *Annual Review of Economics*, 11, 635-663.
24. [H21] Hidalgo, C. A. (2021) "Economic complexity theory and applications", *Nature Reviews Physics*, 1-22.
25. [HBH07] Hidalgo, C. A., Klinger, B., Barabási, A. L., & Hausmann, R. (2007) "The product space conditions the development of nations", *Science*, 317(5837), 482-487.
26. [AHR18] Alabdulkareem, A., Frank, M. R., Sun, L., AlShebli, B., Hidalgo, C., & Rahwan, I. (2018) "Unpacking the polarization of workplace skills", *Science advances*, 4(7), eaao6030.

Final Exam:

- Referee Reports: 40% Select a recent working paper or a classical paper not covered in the class and write a referee report on it. The paper selected has to be approved by the instructor.

- Term Paper: 60% A research proposal with clearly stated questions, an adequate literature survey, and proposed approaches.

Prerequisites:

Introduction to Network Theory

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Stochastic Processes and Stochastic Calculus
Irene Crimaldi

20 Hours

Learning Outcomes:

By the end of this course, students will:

- be familiar with some important stochastic processes,
- be familiar with Ito stochastic calculus,
- be able to identify appropriate stochastic model(s) for a given research problem,
- appreciate the importance of mathematical formalization in solving probabilistic and statistical problems,
- be able to independently read mathematical and statistical literature on stochastic processes, stochastic calculus and their applications.

Abstract:

This course aims at introducing some important stochastic processes and Ito stochastic calculus. Some proofs are sketched or omitted in order to have more time for examples, applications and exercises.

Lecture Contents:

This course deals with the following topics:

- Poisson process (definition, properties and applications);
- Conditional expectation;
- Martingales and co. (definitions and basic properties, Burkholder transform, stopping theorem and some applications, predictable compensator and Doob decomposition, some convergence results, game theory interpretation);
- Introduction to stochastic processes with reinforcement;
- Wiener process (definitions, some properties, Donsker theorem, Kolmogorov-Smirnov test)
- Ito calculus (Ito stochastic integral, Ito processes and stochastic differential, Ito formula, stochastic differential equations, Ornstein-Uhlenbeck process, Geometric Brownian motion, Feynman-Kac Representation formula).

Teaching Method:

Frontal teaching (or Mixed mode)

Bibliography:

- Slides and other material provided by the lecturer
- S. M. Ross, Introduction to Probability Models, Academic press (2003)
- M. Mitzenmacher, E. Upfal, Probability and Computing, Cambridge Univ. press (2005)
- J. Jacod, P. Protter, Probability Essentials, Springer (2000)
- N. Lanchier, Stochastic Modeling, Springer (2017)
- G. Grimmett, D. Stirzaker, Probability and Random Processes, Oxford Univ. Press, third ed. (2001)
- D. Williams, Probability with martingales, Cambridge Univ. Press (1991)
- I. Karatzas, S. E. Shreve, Brownian motion and stochastic calculus, Springer (1991)
- O. Kallenberg, Foundations of Modern Probability, Springer (1997)
- C. W. Gardiner, Handbook of Stochastic Methods, Springer (2004)
- T. Björk, Arbitrage Theory in Continuous Time, Oxford Univ. Press (2009)
- U. Garibaldi, E. Scalas, Finitary probabilistic methods in econophysics, Cambridge Univ. Press (2010)

Final Exam:

Seminar with a short written report on the topic of the seminar

Prerequisites:

Mathematical analysis and linear algebra, foundations of probability theory and statistical inference

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Behavioral Strategy and Business Behavior
Nicola Lattanzi

20 Hours

Learning Outcomes:

Students will learn how to analyze business behavior, evaluate business strategies, and locate sources of potential competitive advantage from a perspective that, for the purpose of this course, encompasses the internal and dynamic fit of a strategy. Students will also learn how to identify human and organizational barriers that sustain or challenge the development and execution of strategies, and the pursuit of the competitive advantage.

Abstract:

The course will first discuss the strategic approaches businesses adopt, providing students with an understanding of business frameworks and strategic patterns. A successful business strategy is necessary for firms to build their own specific competitive advantage: the course will then discuss how firms pursue and sustain it over time, including the role that innovation takes in this process. The human being has a central role in businesses: this topic will be discussed following different approaches, including the limits of human beings in designing strategies and decision making, and the new role of virtual spaces and virtual humans in businesses. Finally, as our times are characterized by continuous flow of data, the course will conclude with the role that data science and network theory can provide for business to support and leverage their decision making and strategic choices.

Lecture Contents:

1. Fundamentals of business behavior
2. Fundamentals of strategy
3. Market and strategy: volatility and development
4. The strategic management
5. A focus on specific firms and competitive advantage
6. Business behavior and patterns of innovation
7. Behavioral strategy: rational approach, heuristic systems, and cognitive biases
8. Cyber-time and cyber-space for humans and virtual humans: business dynamics and organizations
9. Business behavior and behavioral strategy: fundamentals and case study. A short view on a critical business behavior
10. Data Science for business: network theory for strategy and management
11. The extra-ordinary life of patterns and trends: how to learn for a business organization?

Teaching Method:

Lectures, discussions, business cases, presentations. The teaching format is interactive: active discussion of the lectures' topics is expected from students.

Bibliography:

The lectures slides, along with a list of selected suggested readings, will be provided at the end of each lecture.

Final Exam:

Critical paper presentations in groups.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Introduction to sustainability and ecological economics
Angelo Facchini

20 Hours

Learning Outcomes:

This course aims to provide students with fundamental concepts of sustainability science and the economics view of the environment.

Upon completion, participants will have the knowledge and skills to:

1. Have a basic understanding of the principles of environmental and ecological economics, with a clear overview on the fundamental principles for the understanding of human-economyenvironment interaction
2. Have a basic understanding of environmental problems and environmental policies.
3. Have a first knowledge of the current research topics, directions, and funding opportunities.

Participants will also rely on the main topics regarding the European Green Deal and the Ecological transition..

Abstract:

What is sustainability? Which is the link between the economy and the Environment? Which are the main challenges and the main research topics? Which are the main factors that influence a transition to sustainability?

Providing the first insights to answer the above questions is the aim of this course. Lectures are devoted to

the fundamental topics in the field of sustainability science and environmental economics. This last is used as a ground to explain the main differences and similarities between ecological and environmental economics, that will be highlighted and discussed with practical examples.

The course is divided into the following modules:

1. **Introduction to sustainability science** (lectures 1-2)
2. **Basic principles of environmental and resource economics** (lectures 3-7)
3. **Methods and applications** (lectures 8-9)
4. **Advanced and research topics** (lecture 10)

Within each module, specific case studies (e.g. related to climate policies, pollution, resource use) will be

discussed and used to ease the comprehension of the course arguments. The lectures aim at encouraging

the participants to develop skills while reinforcing the concepts learned during the lessons.

Recent scientific papers will also be discussed to make the students work on cutting-edge research topics,

stimulating their attention. Participants will also be encouraged to formulate their research questions and

to cooperate on new research papers.

The course also encourages to develop a critical understanding of the iterative research process leading

from fundamental concepts to cutting-edge research topics, policies, and funding opportunities within the

recent European "Green Deal".

Lecture Contents:

Lecture 1 Environment and ethics

- Shades of green economics
- Environmentalism
- Technocentrism and Ecocentrism
- The human-environment relationship

Lecture 2 Basic principles of sustainability

- Economic growth, population growth, and the Environment
- Weak and strong sustainability: strategies and policy

instruments

- Environmental Kutznets curve

Lecture 3 The economic approach to the Environment

- Ecological Economics or environmental economics?
- The economic functions of the Environment
- Social efficiency: resources, allocation and environment

conservation

- External costs and market failures
- Coase's theorem and public goods

Lecture 4 Valuing the Environment 1

- Why value the Environment? (examples: pollination and

food security)

- Use, Nonuse, and Option value
- Recalls of Consumer Choice theory

Lecture 5 Valuing the Environment 2

- Consumer preferences and environmental goods
- Compensative and equivalent surplus
- Indirect methods: Hedonic price, travel cost, defensive expenditures
- Direct methods: Contingent evaluation
- Evaluation of environmental risk under uncertainty conditions

Lecture 6 The economic control of the environment

- Green taxes and standards
- Who pays? Elastic vs inelastic demand
- Problems with setting the taxes
- Subsides and refundable depots
- Trading environmental permits

Lecture 7 Basic concepts of resource management

- A resource taxonomy
- Renewable and non-renewable resources
- Hartwick Rule
- Stocks and sustainable return of renewable resources
- Finding the optimal stock (overfishing and blue whales)
- Property rights

Lecture 8 Energy: The transition from depletable to renewable resources

- Hubbert's peak
- Price controls of oil and gas
- Electricity
- Renewable energy sources (Photovoltaic, Wind, Hydro)
- Energy efficiency

Lecture 9 Principles of circular Economy

- Recyclable resources
- Efficient allocation
- Substitution
- Market for recycled materials

Lecture 10 Research topics

- Sustainable urban development
- Regional planning of energy sources
- Electric mobility
- Sustainability in the era of Big Data

Teaching Method:

Lecture-cum-Demonstration

Bibliography:

I. Musu, Introduzione all'economia dell'ambiente. Il Mulino, 2020.

R. Perman, Y. Ma, J. McGilvray, M. Common. Natural Resource and Environmental Economics, Pearson, 2003.

T. Tietenberg, L. Lewis. Environmental and Natural Resource Economics, Pearson Education, 2012.

R.K Turner, D. Pearce, I. Bateman, Environmental Economics: an elementary introduction, John Hopkins Univ. Press, 1994..

Final Exam:

No final exam

Prerequisites:

No prerequisites. The course is understandable by a broad audience. Technical and economic aspects will be treated gently.

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Theories of rationality
Gusatvo Cevolani, Camilla Francesca Colombo

10 Hours

Learning Outcomes:

Students who successfully complete the course will understand basic elements of probability and decision theory as principles of rational thinking. They will learn to recognize key issues for the study of human rationality and critically discuss their meaning with reference to relevant cases and examples. More generally, they will appreciate the historical and philosophical foundations of the analysis of human rationality and will be able to understand and critically assess di_erent inuential and competing models of rational behavior and decision-making.

Abstract:

What does being rational mean? In which sense and to which extent are humans rational? Are theories of rationality normative? How do they _t with empirical evidence about how humans actually reason and behave? This seminar aims at addressing these key questions. It provides an overview of the conceptions of rationality as developed within different disciplines {including philosophy, logic, psychology, (behavioral) economics and cognitive science in general {with the purpose of building bridges among them. We will outline a classical view of rationality as characterized by the principles of logic, probability, and decision theory. Against this standard background, we will discuss whether, and to what extent, humans do in practice comply with the relevant normative principles of reasoning. We will discuss what empirical evidence about human behaviour implies for the general study of rationality, and its applications at both the individual and social level. The discussion aims at providing philosophical, historical, and methodological insight for students of specific scientific disciplines (e.g., economics, psychology, neuroscience, biology etc.).

Lecture Contents:

Week	Date	Lecture	Topics
tba	tba	1	Introduction. Problems and concepts of rationality
tba	tba	2	Foundations of individual rationality: decision theory, scopes and limits
tba	tba	3	Foundations of collective rationality: game theory and evolutionary game theory
tba	tba	4	Normative and descriptive theories of rationality
tba	tba	5	Rationality and the foundations of behavioural and social sciences

Teaching Method:

Mixture of lectures and discussion seminar.

Bibliography:

Anand, Paul (1993). Foundations of Rational Choice Under Risk. Oxford University Press.

Bowles, S. and H. Gintis (2011). A Cooperative Species: Human Reciprocity and Its Evolution. Princeton University Press. Princeton University Press.

Bradley, Richard (2017). Decision Theory with a Human Face. Cambridge University Press.

Dhami, Sanjit S. (2016). The foundations of behavioral economic analysis. Oxford University Press.

Gigerenzer, Gerd (2008). Rationality for Mortals: How People Cope with Uncertainty. Oxford ; New York: Oxford University Press.

Hargreaves-Heap, S. (1992). The Theory of choice: a critical guide. Oxford, U.K.; Cambridge, Mass: Blackwell.

Kahneman, Daniel (2011). Thinking, Fast and Slow. 1st edition. New York: Farrar, Straus and Giroux.

Sugden, Robert (2003). \The Logic of Team Reasoning". In: Philosophical Explorations 6.3, pp. 165{181

Final Exam:

Active contribution from the participants is a prerequisite for passing the course.

Prerequisites:

None

IMT SCHOOL FOR ADVANCED STUDIES LUCCA

Temporary Organizing and Event Management in Cultural and Creative Industries
Yesim Tonga Uriarte

20 Hours

Learning Outcomes:

Expected learning outcomes can be outlined as follows:

1. To acquire an understanding of the role and purpose(s) of temporary organizing and events in CCIs;

2. To acquire an understanding of critical issues regarding techniques and strategies required to plan successful events;

3. To acquire an understanding of the problems and challenges of cultural organizations and potential institutionalization solutions for the future;

4. To acquire the knowledge and competencies required to assess the quality and success of events.

Abstract:

This interdisciplinary course will provide a critical understanding about temporary organizing and event management considering the specific characteristics of the arts and heritage field. The lectures examine problems and challenges of cultural organizations in the contemporary world and discuss potential institutionalization solutions for the future. The understanding of 'contemporary', 'sustainability' and 'success' regarding management, organization and programming within cultural organizations will be discussed. Particular attention will be dedicated to employee management, work dynamics and relations between cultural organizations and cities through case studies from the Cultural and Creative Industries (CCIs).

Lecture Contents:

- Principles of temporary organizing and event management: From concept to reality

Historical perspective of rituals and festive events, introduction to event management, size & type of event.

Understanding temporality, stability and change, institutional theory, project management, processes and practices, the relations of events and projects with the wider context and multiple environments.

- Events, values & ethics

Code of ethics, contextualizing / conceptualizing the event, related communities, aims, expectations, priorities and value schemes, developing the concept/theme, relations with the field/sector, relations with the location/host city.

- Tourism impacts of events

Issues, problems and policy aspects impacting event tourism, business and managerial skills for professional decision making.

- Relations of events with cities and impacts on the city image

Teaching Method:

The course teaching method is built on a combination of direct Instruction and inquiry-based learning, e.g. lecturing, class participation and presentation of students' projects.

Bibliography:

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- Bennett, A., Taylor, J., & Woodward, I. (2014). The Festivalization of Culture. Routledge.
- Engwall, M. (2003). No project is an island: Linking projects to history and context. Research Policy, 32(5), 789–808.
- Harvey, N., & Broadhurst, S. (2018). A Tale of Three Cities 2017: Art Basel, Venice Biennale, Frieze London. Body, Space & Technology, 17(1).
- Tonga Uriarte Y, DeFilippi R J, Riccaboni M, Catoni M L (2019). Projects, institutional logics and institutional work practices: The case of the Lucca Comics & Games Festival. International Journal of Project Management, 37(2), 318-330.
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Final Exam:

The evaluation process takes into account: (i) class participation including attendance in lectures and active participation in discussions during the class (40%); and (ii) presentations in the classroom, during which each student will discuss a case study (a cultural event or a cultural organization) (60%).

Prerequisites:

Being an AMCH student